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FROM THE EDITOR

Earthquake code cracked: Catastrophic earthquakes are predictable

In the last few years, earthquake prediction study has made remarkable progress. A global team of earthquake researchers who are engaged in forecasting was spontaneously formed while exchanging information prior to the devastating Chilean earthquake in September this year – the M8.3 Coquimbo Earthquake. As explained in the previous NCGT issue (v. 3, no. 3, p. 383-408, 2015), a synergetic, multi-parameter approach resulted in one of the most successful predictions.

Two short-term precursors played a crucial role in these efforts: 1) a jet stream anomaly detected by Taiwanese seismologist Hong-Chun Wu 96 days in advance; and 2) a psychrometric anomaly detected by local seismologists, represented by Ariel Césped of Chilisismos, who issued an official warning 21 days prior to the mainshock. Another warning was issued by Venkatanathan, who detected an outgoing longwave radiation (OLR) anomaly 16 days prior to the mainshock. These forecasts were supported by a long- to medium-term forecast issued by the International Earthquake and Volcano Prediction Center (IEVPC) based on Blot's energy transmigration concept more than one year prior to the event.

The same team's successful predictions have continued: two more major shocks in central and northern Chile; the M6.9 quake on 11 November 2015 off Coquimbo township, and the M6.2 quake on 27 November 2015 about 100 km south of Antofagasta, both with almost pinpoint accuracy. These successes have demonstrated the veracity of their approach in forecasting major earthquakes, and most importantly, it has proved that catastrophic earthquakes are predictable despite persistent claims to the contrary by seismological authorities.

During the forecasting efforts for the Chilean quakes, a new reliable precursory signal emerged: a jet stream velocity anomaly (Wu and Tikhonov, 2014). An objective evaluation by the present Editor shows that in the case of strong quakes with magnitude 6.0 or greater (and even many moderate ones, M4.5+) it appears almost without fail a few days to 100 days prior to the mainshock within 100 km of the epicenter. Although further improvement is necessary in magnitude determination, it is undoubtedly the most trustworthy short-term signal. In addition, we have many other proven precursory signals. They include: 1) VLF electromagnetic wave propagation established by Hayakawa (2012), which was commercially adopted several years ago in Japan; and 2) a unique method developed by Shanmugan of India using the variation in sunlight angle (http://earthquake.itgo.com/).

A fundamental factor that underlies the above success stories is an improved understanding of the earthquake generation mechanism, which is radically different from the conventional plate-tectonic model. It has become clear that the original, powerful thermal electromagnetic energy is sourced from the deep Earth – i.e. the outer core. The deep-to-shallow transmigration of the energy is controlled by fractures in the upper mantle, and the energy is trapped in the structural highs in the upper mantle and the crust – understanding the deep geological structure is therefore essential. The energy discharge from the traps is influenced by solar, lunar and other planetary forces (tide, interplanetary magnetic field, solar polar magnetic field, space weather, etc.). An earthquake is a thermal electromagnetic phenomenon. The theoretical background for the final energy release has been provided by the lithosphere-atmosphere-ionosphere-magnetosphere (LAIM) system theory established by Pulinets et al. (2015). Arun Bapat (2007) studied anomalous animal behavior and disturbances in electromagnetic communications before an earthquake hits. We now know what precursory signals are expected to appear at different stages in the run-up to major earthquakes.

Today we have accumulated enough documentation to declare that catastrophic earthquakes are predictable. The time has arrived to formulate an international program to systematically analyze global precursory signals and coordinate scattered researches and information, in order to save numerous human lives and mitigate disasters.

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LETTERS TO THE EDITOR

Dear Editor,

I too, congratulate you on progress with NCGT.

The link below will take you to a (large) PowerPoint presentation I have made on Caribbean and wider geology. It includes many data from recent years, such as ancient zircons in "intra-oceanic" arcs and their implications for Caribbean and other arcs. It addresses the (non-existent) "Andesite problem" and "Subduction factories".

I am sending you the link for your personal interest, but if you would like to share it with your NCGT colleagues in some way, that would be great:

https://dl.dropboxusercontent.com/u/53508877/Carib%20overview%20web%20page.pptx

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Dear Editor

I have recently joined Mongolian University of Science and Technology (MUST) as Senior Research Fellow. I have a new office at the Geoscience Center, and my current work is focusing on the Permian system (including the P-T boundary) in Mongolia, During the last 10 years I have collected a lot of data in Mongolia and very keen to get some hard hitting papers out. I will be supervising a few of Professor Gerel's MSc and PhD students at MUST. I will also be on the editorial board of the *Mongolian Geoscientist* shortly, editing the March 2016 edition.

Clearly I'm very honoured to join the NCGT editorial board with such a team of learned workers under your leadership. Nonetheless, as the old saying goes, "ex nihilo nihil fit", a lot of hard yakka awaits us in order to reach more fellow scientists and put plate tectonics to rest once and for all. I was talking to one Mongolian senior lecturer today who was shocked to hear that alternatives actually exist to the plate tectonic paradigm.

Happy to contribute to *NCGT Journal*, it is an extremely valuable forum. Would be interesting with a yearly NCGT conference to step progress up a notch.
Cheers,

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Re: Anthropic Global Warming, pages 544-560, NCGT Journal this issue

Our readers may like to know that I am having some absolutely unexpected reactions following the simple appearance of my very short one-page Italian interview on the anthropic global warming, even from quite a few really most authoritative people. They include a former minister, a former president of CNR, one of the best known and authoritative scientific journalists of the best known Italian newspaper, a member of the government in Prague, somebody related to the Church. Neither matters seem to settle.

I guess that the media-scoop will soon finish. Somebody commented the COP21 Paris event and claimed that "truth is the first victim on the war on Global Warming." Soon the public opinion will realize that it has been kidded. The rulers and politicians, who excessively naively joined to the generalized fashion, will be unmasked. I guess it will not be a pleasant time for them. However, it is well known that politicians know how to say and later to say no …. Several heads of state will change and the Paris “scoop-promises” will soon be forgotten, among some obvious and more or less harsh complaints etc.

22 December 2015
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ARTICLES

ORIENTATION OF ANCIENT CULTIC OBJECTS AND POLAR DRIFT

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Abstract: The article is devoted to reconstruction of the Polar Wander (i.e. changes of the rotation axis relative to the Earth's surface) in the postglacial period based on studies of orientation of ancient cultic objects. The timespan covered by the article is 9th millennium BC and the first half of the 5th millennium BC. Conclusions about the older period are based on orientation of *Göbekli Tepe, megalithic complex* in southeastern Anatolia. For the younger period, evidence come from circular enclosures of Central Europe, whose orientation to sunrise and sunset at winter solstice makes it possible not only to determine direction to the pole, but also the ancient geographical latitude, i.e. distance to the pole. But because of problems with chronology and inaccuracy in orientation of the studied objects, it is impossible to draw a true polar track. However, the most likely polar path for the early Holocene – from Hudson Bay through Greenland to the present polar location – is outlined.

Keywords: *Polar Drift, solar orientation, ancient cultic objects, early Holocene, climatic optimum*

Introduction

A study of Polar Drift for the recent past is a real challenge. In principle the palaeomagnetic method may be applied, but for such a short time span as that concerned with here the effect of geomagnetic secular variation would be difficult to eliminate; hence, ancient short-term geographic polar locations would be hard or impossible to establish by the palaeomagnetic method (see Tarling, 1987, p. 6-10). In other words, the palaeomagnetic method is satisfactory for solution of most general problems of geological history, but is not able to elucidate palaeogeographic details such those concerned with here.

In a previous article in this journal (Grigoriev, 2011), I demonstrated that by means of ancient megalithic monuments it is possible to draw a tentative polar path for the early Holocene. In the present article I try to substantiate the proposed drift path. Methodical limits are discussed.

Method

It is now generally accepted that ancient cultic structures were connected to astronomical events (Heggie, 1982; Ruggles, 2005). Commonly, points of sunrise or sunset at equinoxes and solstices, and also extreme points of minor and major lunar standstills, are discussed as targets for their orientation. The latter phenomenon is connected with the Sun, but as the Moon's orbit is tilted with respect to the ecliptic plane, these points displace about 5° to both sides from the points of sunrise and sunset at solstices. Therefore, a part of deviations from solar orientations is often explained by orientation to the moon only. At last, one tries to explain part of the cultic structures by orientation to stars which, because of their large number, allow any orientation to be explained.

Before the questions of method, I would like to discuss some theoretical problems. First of all, none of ancient objects with astronomical orientation was an observatory. It was ritual astronomy in which any direction was important because of its mythological content. And the importance of any astronomical event was just in this mythological content, and not in strict accuracy of structure orientation. Therefore it seems absolutely improbable that objects of one type with identical interior were directed to different events – for example, rise of a star and sunset, but it is a usual assumption in archaeo-astronomical studies. Except for Egyptian pyramids, stellar orientations have no convincing confirmations yet. Moreover, any star ascends always at the same point of the horizon; and it was therefore senseless to mark this direction.

A special problem with the moon in that it is incomparably more difficult to direct any object to that body than to the sun: the moon moves very quickly in the sky, and because of the Metonic cycles it is observed in similar position once in the period of 18.61 years. This means that we have to assume a long period of preliminary observations before building of many cultic objects which subsequently were often used for very short time, or perhaps only once in case of funeral structures. But the main problem is that after the building this foresight couldn't be used, as the Moon was already in another position.

Points of sunrise and sunset at solstices provoke no special problems: these are extreme points on the horizon reached by the Sun in the summer and winter, then they start to displace in the opposite direction. Connection of this movement of the Sun with change of seasons was apparently always understood, and these points must therefore have been of mythological significance.

It is more difficult to determine equinoxial directions. All people have an idea of east and west, but only rarely people are able to point to these directions even with a compass. Use of the sun at culmination for determination of direction gives an error about 5° (Schlosser and Cierny, 1996). But the main question is the following: why was it necessary to look for the point of equinox and furthermore to reflect it in megaliths, i.e. in a mythological system? People in ancient times observed the same picture in the sky as they do now: the Sun shines in daytime and the Moon at night. But this obvious fact (included in all mythological systems of the world) is duplicated by one more circumstance. The Sun and the Moon move in one sector of the sky. The Sun makes a big arc in the sky and has extreme points of rising and setting in the north in the summer. A situation with the full Moon is the same: it makes a big arc in the sky, but in winter time. The extreme points of their rising and setting are very close. This means that they interchange the position constantly, and it should always be perceived as a fight of two opposites. People always connected the Sun with heat and life, and the Moon – with cold and death. Correspondingly, a point in the east, where on one day the Sun and the full Moon rise (and a point of their setting in the west) could be perceived as a moment when one force started prevailing over another. And mythological respect just this point was significant, instead of an accurate astronomical point.

Therefore, in any concrete year just this point was important. This has been discussed by Silva and Pimenta (2012). It made possible deviations from east and west to both sides approximately 5°. Correspondingly, we can use these directions in case of large sampling and statistical stability, but there is no confidence with each individual object. In the absence of other data, this result can be used, but it is a hypothetical variant which needs to be checked. The most reliable directions are the solar sightings at solstices. And in case of two such directions on an object (or statistically reliable sampling of different contemporary objects) we can determine the north, south, west and east.

Moreover, as we know, on the equator the Sun rises strictly in the east and sets strictly in the west during the whole year. When we move to the north, the points of sunrise and sunset at the summer solstice displace to the north, and at winter solstice they do to the south. Respectively, the angle between points of sunrises and sunsets decreases. For example, at the latitudes of the Central and Northern Europe, with each degree to the north the angle between the directions to sunrise and sunset at winter solstice decreases from 1.3° to 4° (**Table 1**).

Table 1. The table shows the variation of azimuths to sunrise and sunset at winter solstice versus geographic latitude.

° Latitude	° Sunrise at winter solstice	° Sunset at winter solstice	°Δ
45	122.6	236.8	114.2
46	123.2	236.1	112.9
47	123.9	235.4	111.5
48	124.6	234.7	110.1
49	125.4	233.9	108.5
50	126.2	233	106.8
51	127.1	232.1	105
52	128.9	231.1	102.2
53	129.9	230.1	100.2
54	131.1	228.9	97.8

55	132.3	227.7	95.4
56	133.6	226.4	92.8
57	135.1	224.9	89.8
58	136.7	223.3	86.6
59	138.4	221.6	83.2
60	140.4	219.6	79.2

From this relationship, we can calculate ancient latitude by the formula:

C = Arc Cos (Sin B / Cos A), where A is the azimuth to a point of sunrise, B the sun's declination for a given day at a given latitude (at winter solstice declination is about -23°.5), and C latitude.

After calculation of latitude of the actual object it is easy to calculate distance to the pole, as length of each degree of latitude is about 111.11 km: L = (90° – C) × 111.11 km.

Thus, if we know the direction to the north, the latitude and distance, we are able to find a Pole point at the time of building of this object.

At first sight, considering a large number of megalithic constructions, we can easily find individual polar locations during the 5th – 3rd millennia BC. However, the reality is much more complicated.

Firstly, cult monuments had various functions. For example, it is impossible to exclude that in some instances a megalith was built for burial of a single person and was therefore directed to an actual point of sunrise or to a direction considered in general as east or west, without an accurate orientation. Thus, this function has to be taken into account, and it could give many deviations.

Secondly, use of publications of cultic objects is complicated by that they do not always specified which pole is used, geographical or magnetic.

Thirdly, solar position depends on altitude of the horizon. It can be calculated by means of maps, but more reliable results can be obtained only by measurement on the object.

Fourthly, we don't know which edge of the solar disk was important for a particular ancient culture: upper or lower. Different approaches in this case can give about 1° displacement on the horizon. Errors arising from refraction of light are close to it.

In case of directions to the west and east we have additional problems discussed above. Finally, it is not always possible to determine precisely the orientations on an object. For example, entrances into a structure can be too wide, and was not the only ritually significant direction. Perhaps even not a direct sunbeam, but the play of light and shadows on walls of the structure, was in some instances the most important.

Other problems are the chronology of archaeological objects. At first sight, it is enough to take objects analyzed by the radiocarbon method, but these objects were often used during a long time and therefore radiocarbon analyses give errors – to be reduced only statistically.

In the above-stated formula it is not the modern azimuth of sunrise that has to be used, but the azimuth calculated from the north reconstructed for the time of the ancient construction. This direction to the north can be calculated as perpendicular to the west-east direction, i.e. to equinoxial lines (bringing in the error discussed above), or it can be the line between sunrise and sunset at solstices. In this work the preference has been given to this last variant, but altitude of the horizon gives possible errors here. Therefore it has been determined. However, in isolated instances it was impossible to avoid the use of lines to the equinox.

Despite the many uncertainties involved, it is the intension of this paper to evaluate the polar wander track for the early Holocene by using cultic constructions. The results are discussed in conjunction with relevant palaeoclimate evidence.

Orientation of Göbekli Tepe

In my previous paper in this journal (Grigoriev, 2011), I suggested that during the last glaciation the pole was probably situated in the area north of Hudson Bay or the Canadian Archipelago, shifting in the Younger Dryas to Greenland. This polar change can be confirmed basing on the earliest megalithic complex *Göbekli Tepe* in South-eastern Anatolia, dated to the 9th millennium BC. It consists of several oval or roundish structures (**Figs. 1 and 2**) made from stone blocks. T-shaped stone pillars were inserted into walls, and a couple of high pillars are situated along a longitudinal axis.

Magli (2013) and Hale and Collins (2013) have assumed that the sides of these pillars pointed to the rise of Sirius, Schoch (2012) referred them to the constellations Taurus, Orion and Pleiades, while Collins (2013) thought they related to the setting of Deneb (α Cygni), and some difference in orientation has been explained by the Earth's precession. However the authors usually neglected structures A and F (**Fig. 2**) which have different orientations. In a recent study, De Lorenzis and Orofino (2015) agreed with Collins' conclusion about orientation of the majority of enclosures to the set of Deneb, having minor correction only to dates of building, and they tried to explain orientations of structures A and F. In their opinion, structure F (azimuth of sides of central pillars is 67.5° – 247.5°), was directed to the sunrise between summer solstice and autumn equinox in early August that coincided with a harvest holiday. And for structure A, they suggested lunar orientation to the minor lunar standstill.

Fig. 1. Reconstructed enclosure of *Göbekli Tepe (source: National Geographic).*

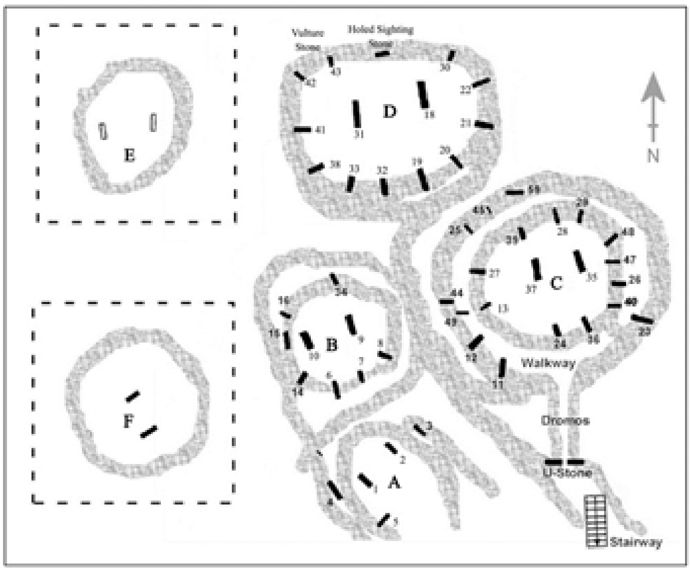

Fig. 2. Plan of cult structures of *Göbekli Tepe* (after Hale and Collins, 2013).

For *Göbekli Tepe, e*vidence for agriculture is absent, and it cannot be excluded that economy was limited to hunting and gathering (Neef, 2003); the author suggested that the sides of pillars are too short (on average about 2-2.5 m by 0.5-0.7 m) and therefore their top does not allow being a reliable sight for orientation to a celestial object although orientation along the sides was possible. But orientation of paired central pillars in some enclosures is slightly different; therefore, they could not be directed to one star. A most important point is the following: cultic objects of one type and identical internal design are likely to have had identical semantic sense; hence, they had to be included into one myth. Besides, structures are chronologically different, and we may not believe that there was some strange mighty transformation in ideology (being reflected in small changes of orientation) that did not influence on architecture of cult constructions.

Tab. 2. Orientation of structures of *Göbekli Tepe*.

Structure	°East-West	°Deviation	°Reconstructed North
Enclosure A	56.9-236.9	-33.1	326.9
Enclosure B	68.4-248.4	-21.6	338.4
Enclosure C	74.2-254.2	-15.8	344.2
Enclosure D	80.2-260.2	-9.8	350.2
Enclosure F		-22.5	337.5
Enclosure E	79.2-259.2	-10.8	349.2

I believe that the orientation was connected with one celestial body, and the most acceptable observing line was the line between pairs of central pillars. They are too wide to serve as a reliable sight and therefore were not suited for accurate observations of the moon or stars. Use of such powerful light source as the sun is more probable. As these pillars are higher than the enclosures, at sunrise or sunset the sunbeams would illuminate one pillar, and the shadow from it falling on another. Structure F is oriented perpendicularly. From the true direction west-east these orientations are turned from 10° to 33° counterclockwise. With respect to the orientation along the sides of pillars, this counterclockwise shift remains (**Fig. 3**). This means that for this object we see systematically repeated deviation in the counterclockwise sense.

It is possible that the structures of *Göbekli Tepe* were oriented not very accurate, but the systematic deviation allows us to tentatively assume that during this period the geographic pole was within the azimuths 327-350° (**Tab. 2**). As we discussed above, at equinox we can assume deviation in orientation of about 5°. Therefore, we consider a very approximate sector. Unfortunately, we are not able to calculate ancient geographic latitudes, such as the case with orientations at solstices. Thus, for this period we can only assume migration of the Pole somewhere near Greenland or the Canadian Archipelago. There are many radiocarbon dates from the *Göbekli Tepe* objects. All of them fall in the period of about 9700-8300 BC (Dietrich, 2011; Dietrich and Schmidt, 2010; Dietrich et al., 2013; Pustovoytov, 2002). The problem is that after the end of cultic functioning, all the structures were filled up. Therefore, charcoal or bones which got to the filling can reflect the end of existence of the object, but not its building. At the same time, materials from earlier layers could also be part of the filling debris. There are more reliable dates taken from plastering of structure D (9745-9314 BC), and also some dates from soil carbonates formed on the basis of walls and pillars after the start of deposition of cultural layer (Pustovoytov, 2002). I have used the earliest dates for each structure to avoid dates of samples from later filling though averaging all dates gives a similar picture. In this case, during the period between 9745 BC and 8306 BC, we encounter the change of putative azimuth to the north from 350.2° to 338.4°, with the turn counterclockwise. There is only one anomaly, structure A, with the azimuth 326.9° (deviation 33.1°). In principle, the general trend is about 30" a year.

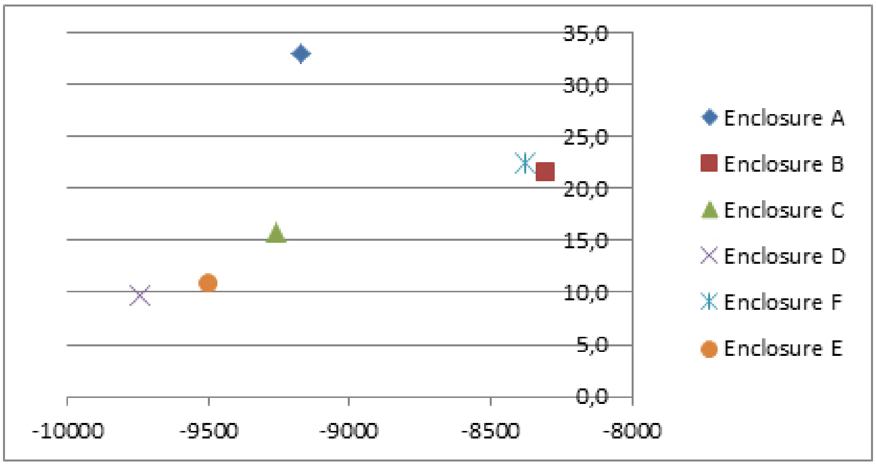

Fig. 3. Change of counterclockwise deviation of enclosures at *Göbekli Tepe*. The timeline is based on dates from works of Dietrich (2011).

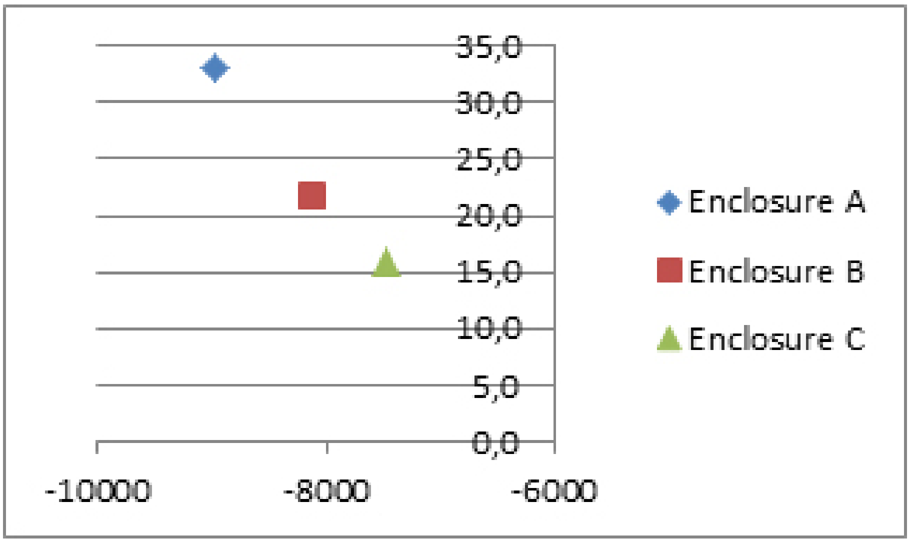

Fig. 4. Change of deviation clockwise of structures of *Göbekli Tepe*. The timeline is based on the analysis of soil carbonates – after Pustovoytov (2002).

If based only on the single dates of Pustovoytov the movement will be in the opposite direction with speed about 40" a year (**Fig. 4**). Here, we shall limit the discussion of early Holocene polar drift to the sector 338.4 – 350.2°, seen from south-eastern Anatolia – corresponding to palaeopolar locations somewhere around southern - northern parts of the Canadian Archipelago and/or Greenland.

It is remarkable that within the layer of the enclosures Göbekli Tepe, dry conditions of Younger Dryas are recorded. Then followed the transition to the wet and warm conditions of the climatic optimum of the Holocene (Pustovoytov and Taubald, 2002, p. 29; Pustovoytov et al., 2007, p. 327). Thus, according to this climatic trend, the shift of the pole from south to north within the actual geographic sector seems reasonable.

Rondels of Central Europe

At the beginning of the 5th millennium BC, new obviously astronomically oriented objects appeared already in Central Europe. These are in terms of large circular structures (or rondels) consisting of ditches and palisades with diameter of about 70-110 m; the ditches are several meters wide and up to five meter deep. There are several gates in the ditches and palisades. All researchers believe that these gates were directed to celestial objects, but opinions on concrete targets differ. Scientists are convinced that some of the gates are directed to sunrise or sunset at equinoxes and solstices. But only a small number of the objects show perfect consistency. Some researchers have associated the orientation of some of the rondels to different stars (e.g. Neugebauer-Maresch, 1995), but this approach has subjected to criticism by others (Pásztor et al., 2008; Pavúk and Karlovsky, 2008; Plath, 2011), and even the initial supporters of the ‘stars hypothesis’, for example Zotti et al. (2009), Zotti (2010), Zotti and Neubauer (2010, 2011 and 2013), have recently discarded the idea.

Others support the idea that the orientation of entrances are with respect to the moon (Pavúk and Karlovsky, 2008). However, instead of using the commonly applied directions from the center through an entrance, the lines through any arbitrary point are used, although some of the directions are fairly close to lunar sightings. But they can be also considered as deviation from solar orientations. Because of the Metonic cycles, the Moon occurs in the same position once every 18.61 years, and it is necessary to know an exact day for determination of the true direction as only three days later the angular difference can be as much as 8° (Pásztor et al., 2008).

One meter away from the point of observation in the center of a rondel of 50 m in diameter, the sighting angle changes by 2.3° (Zotti and Neubauer, 2013). Gates into the rondels are also too wide to be a reliable front sight for astronomical observations (Pavúk and Karlovsky, 2008); rondels were apparently places of cult ceremonies, not observatories, so people passing through the gates had the most general orientation to a rising or setting of a celestial body. Besides, as rondels were cultic objects, they had to be included into mythical system. Therefore, objects of one type cannot be directed to different celestial bodies, and the best candidate for orientations is the rising or setting Sun. This opinion is shared by many researchers, but deviations from solar orientations are obvious, and they are explained usually by inaccuracies of lines of observation, orientation on the so-called cross-quarter days between solstices and equinoxes, or on special agricultural days, by solar orientation combined with direction of slope (Zotti 2010; Zotti and Neubauer, 2010, 2011 and 2013). Orientation to the climbing Sun, 1-2 hours after sunrise, is sometimes offered (Pásztor et al., 2008); this is frequently offered to explain the deviations in orientation of European megaliths. Of course, polar drift could be another cause of directional deviations.

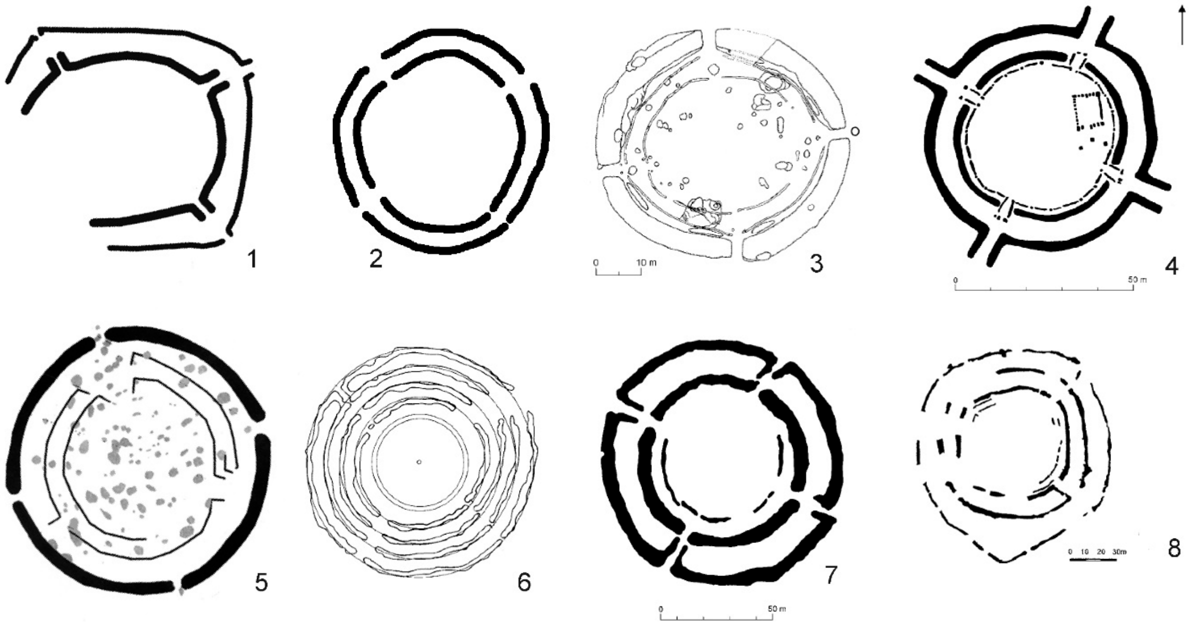

Fig. 5. Plans of rondels: 1 – Bajtava, 2 – Bochow, 3 – Tesetice-Kyjovice, 4 – Bučany, 5 – Prašník, 6 – Kyhna, 7 – Kleinrötz, 8 – Eythra.

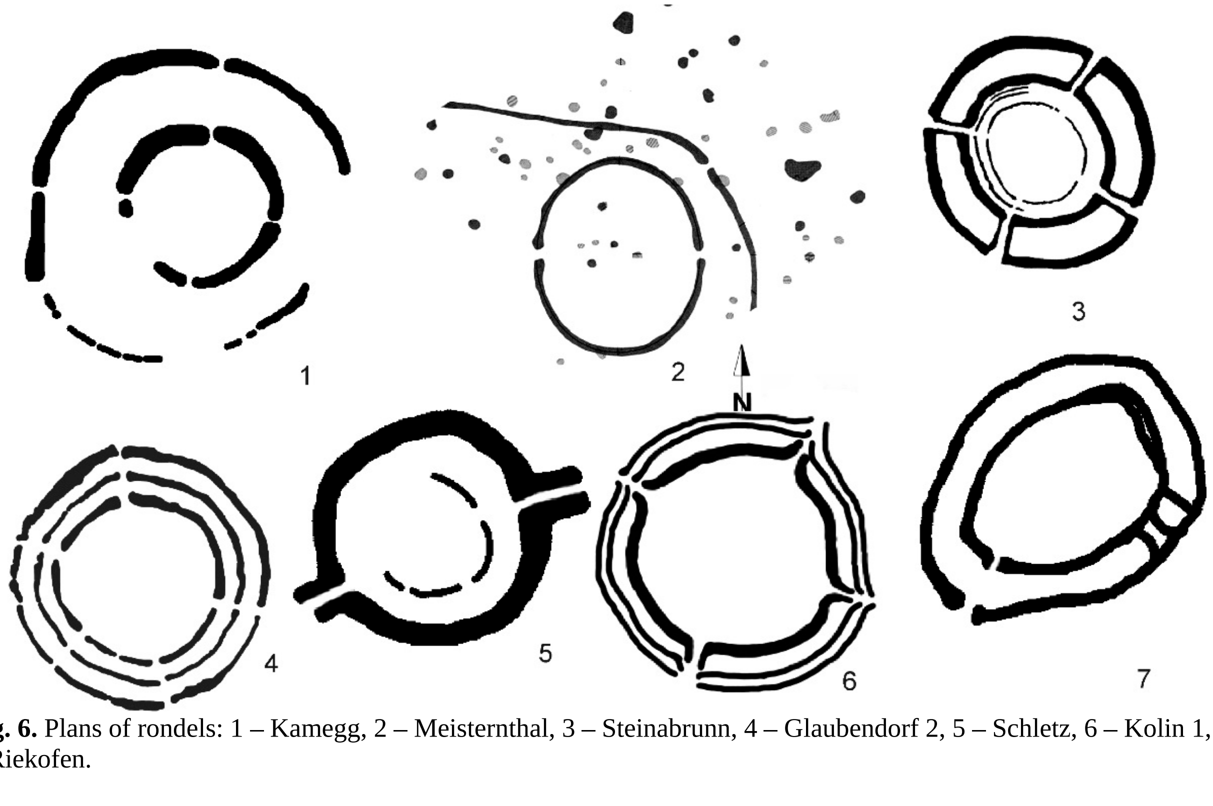

Fig. 6. Plans of rondels: 1 – Kamegg, 2 – Meisternthal, 3 – Steinabrunn, 4 – Glaubendorf 2, 5 – Schletz, 6 – Kolin 1, 7 – Riekofen.

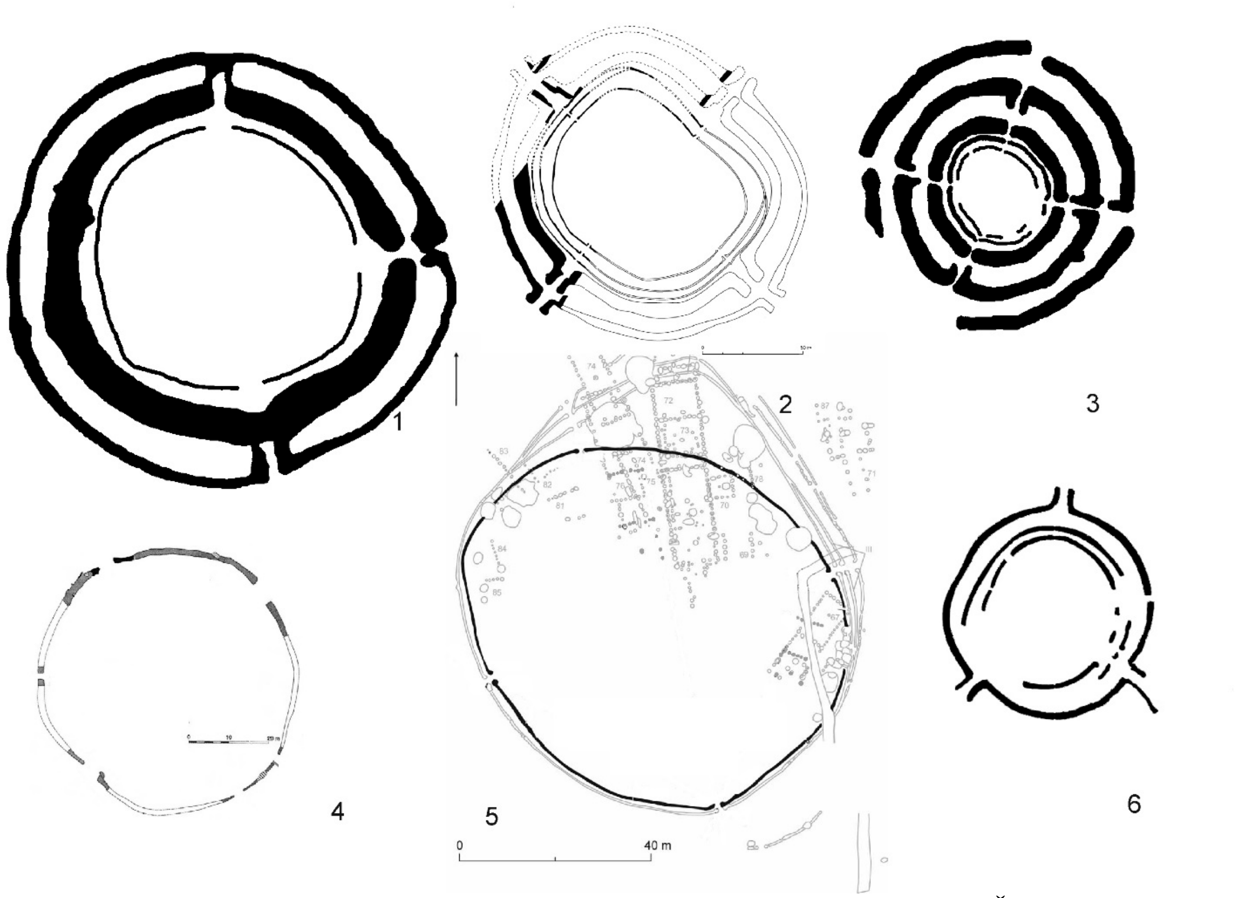

Fig. 7. Plans of rondels: 1 – Friebritz 1, 2 – Svodín 2, 3 – Immendorf, 4 – Ippesheim, 5 – Žlkovce, 6 – Goseck.

In the present study, only 27 rondels have been used (**Figs. 5-7**) – those described in publications by Pavúk and Karlovsky (2008), Pásztor et al. (2008), Plath (2011), Rídký (2011) and Meyer (2011). The majority of the considered rondels have 4 entrances – presumably directed to the sunrise and sunset at solstices. For the calculations the direction through the south-eastern entrance has been used; ritually, it was probably the most significant direction to the sunrise at winter solstice. For determination of the north, the line between SE and SW entrances was used. In some instances it was necessary to change this procedure, for example in case of the high horizon in the south-east and shifts of the point of sunrise. The altitude of the horizon along azimuths can be determined by means of a special program (see http://www.heywhatsthat.com/). The obtained data are listed in the **Table 2** and placed on the map (**Fig. 8**). If rondels were oriented to the equinox, it is possible to find only the direction to the north, but not distance to the pole. A hypothetical point of the pole for such objects has been plotted near other points with a similar azimuth. Therefore, unlike the points calculated from directions to solstices, these points are very approximate. Cases of deviation from the standard procedure are specified in notes to **Table 2**.

Table 2. Azimuths of gates of rondels and geographic latitude in the antiquity (reconstructed azimuths to the north and south-east are marked by the red color).

Object	°N	°NE		°E	°SE	°S	°SW	°W	°NW	Ancient latitude of the objects and distance to the pole
Schletz [1]	340			75				245		
Friebritz 1 [2]	353.5			83.5				263.5		
Glaubendorf 2 [3]	349				106.3 – 117.3	169	222		286.3	33°13'47" 6300 km
Riekofen	348.5				127 – 138.5		210			59°11'11" 3420 km
Kamegg	9			97.7				277.7		

Steinabrunn [4]	340	36.5			122 – 142		198		282.5	60°51'56" 3234 km
Immendorf	336	19			101 – 125		211		281	48°1'11" 4660 km
Ippesheim [5]	358.3	50.5			128.4 – 129.4		224.7	268.3		50°36' 4373.4 km
Künzing-Unternberg [6]	349				122 – 133		216		302	55°46'6" 3800 km.
Lochenice	341.5	25			118 – 136.5		205		298	58°4'8" 3544 km
Kolin 1	342.25	28			116.5– 134.25		208		296.5	56°38'46" 3702 km
Bochow	6.5	52			141 – 134.5		232		321	56°48'50" 3684 km
Němčičky	0.5	49.5			132 – 131.5		229		311.5	54°37'14" 3931 km
Goseck [7]	7 – 358.75				128,5 – 129.75		229			53°7'53" 4092 km
Svodín 2	357.5	42.5			132.5 – 135		222.5		312.5	57°8'30" 3647 km
Bučany	342.1	25.7			118.5 – 136.4		205.7		298.5	58°0'34" 3551 km
Tesetice-Kyjovice	352.7			81		172,7		261		
Eythra	0.5	49.5			132 – 131.2		229		311.5	54°22'38" 3954 km
Kleinrötz [8]	342.5	41			114 – 132		211		296.9	55°0'55" 3883 km
Meisternthal	1			91				271		
Prašník	342.5			73,4		162.5		253.4		
Kyhna	354.75	59			132.5 – 137.75		217		312,5	59°3'13" 3438.5 km
Žlkovce	339			73,2		159		253.2		
Sormás–Törökföldek-I	345			75						
Sé	345			75						
Dolních Beřkovic [9]	343									
Kujawy [10]	356-357									
Vera Island 9 [11]	3.8				133.8 – 137.6					58°41'57" 3478 km

Notes:

[1] The horizon in the west is very high, about 20°; therefore the sun would set at equinox southward. In the east the altitude of the horizon is about 10°, and the eastern gate could be displaced to the south. Therefore the difference between the gates in the east and west is 170°. Therefore, probable azimuth to the north is about 340°.

[2] The horizon in the east is about 4-5°, and we see deviation of the orientation in the opposite direction, counterclockwise; therefore it is not excluded that the deviation counterclockwise of azimuth to the north must be even more.

[3] Rondel has the gates situated along the line north – south, and also the gates in the north-west and south-east, in one line too. In this case the deviation from the north is -11°. There are also gate to the SW (222°) and if to calculate the direction to the north between the SW and SE, we will receive 344°, i.e., deviation about -16°. 3 This results from the fact that in the SE the altitude of the horizon is 1°, and in the SW – about 7.5°. Thus, actually the sun has to set further from the south. Respectively, the deviation from the north has to be less, and the deviation -11° is more probable.

[4] As the horizon height along the azimuth 122° is 5°, and along the azimuth 198° is only 1°, the sun ascended a little closer to the east, therefore the pole was located slightly further than it is calculated here.

[5] The north was calculated from the direction to the west. It has deviation of -1.7°. If to calculate it from the directions to the SE and SW gates, the deviation will be -3°. In this case the azimuth of sunrise at winter solstice was 131.4°. Rondel has also gates along the line 331.4° – 151.4°, but it is difficult to interpret this orientation.

[6] If to use other data (Rídký, 2011), we receive slightly different azimuths: NW-SE – 303-123°, NE-SW – 33-213°. Correspondently, the reconstructed azimuth of the north is 348°, its shift is -12°, and the sunrise at winter solstice was 135°. It causes some displacement of the Pole to the south, but insignificant, about 150 km.

[7] There are gate to the north with azimuth about 7°, but it is unclear, to which object they were directed. It is not excluded that this direction to the north was not astronomical, it was general direction. The azimuth 358.75° is the direction to the north calculated from azimuths of the SW and SE gates.

[8] The horizon in the east is high (NE – 5.75°, SE – 8.31°), and in the west it is low (SW – 1.04°, NW – 1.04°). Therefore the north has been received as perpendicular to the west. The last was calculated as a bisecting line between NW and SW gates.

[9] Rondel is displaced counterclockwise to 17° (Rídký, 2011).

[10] Kujawian long barrows have average deviation 3-4° counterclockwise from the line west – east (Iwaniszewski, 1995).

[11] In the previous works the azimuth for this site was incorrectly calculated as actual magnetic declination was not taken into account. There is magnetic anomaly on the island, with very large difference at short distances.

Fig. 8 shows inferred polar locations at the time of building of individual rondels; the systematic shift of the estimated Holocene polar group to the south of the present geographic pole – as well as its displacement to the west relative to Central Europe – may be an important geophysical facet. As the identical approach has been applied to all data, we can speak about a clear tendency which can be best explained by the Polar Drift. At least, the data suggest a polar drift from the Middle Eastern coast of Greenland to its modern location.

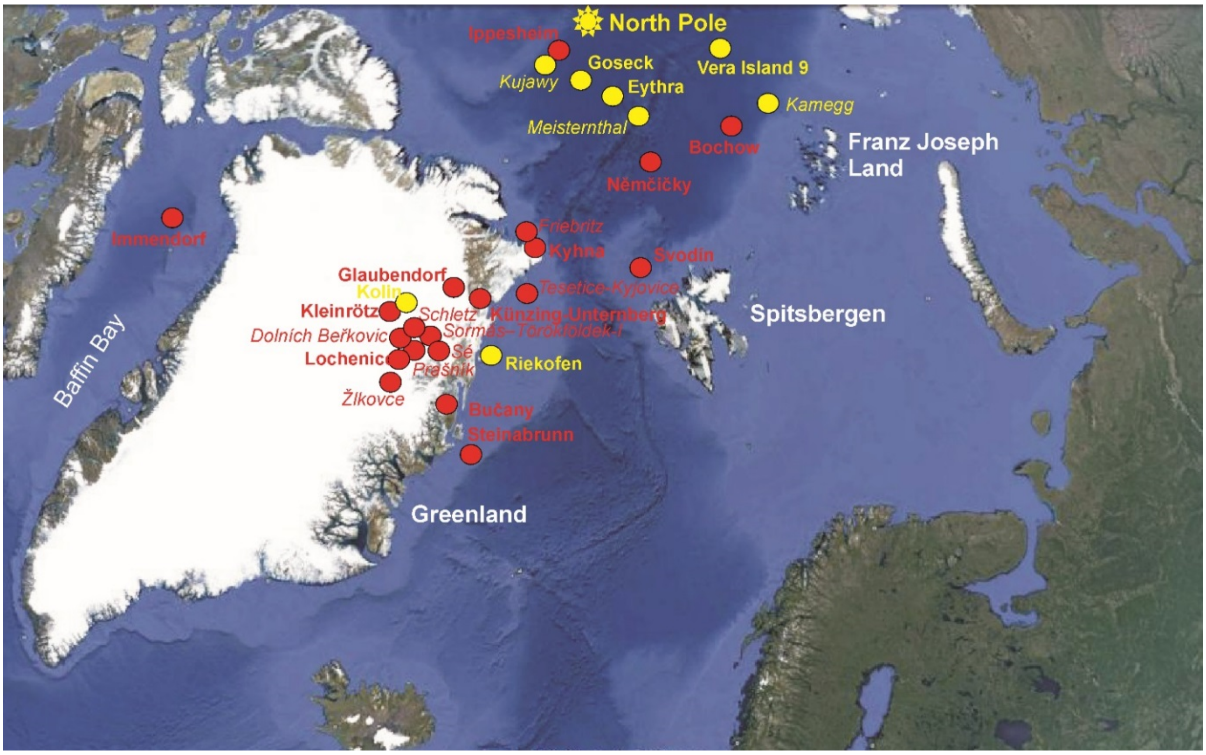

Fig. 8. Holocene polar locations reconstructed for time of building of rondels. Points based on both the direction (i.e. on the basis of orientations at solstices) and distance is shown in bold, while points based only on the direction (oriented at equinoxes) are italicized. Red points denote ages before 4650 BC while yellow points are after 4650 BC.

In addition to uncertainties in radiocarbon method itself, not all objects have been excavated and often they are dated by ceramic finds from the surface; these ceramics could therefore come from settlements located nearby (Plath, 2011). Therefore individual dates can yield imprecise results, and it is necessary therefore to consider the dates in series. For some rondels, serial dates were taken from the publication of Stadler and Ruttkay (2006), and calibration is carried out by means of the CalPal program. Earlier dates of a series are chosen because they better correspond to the date of the objects building. Other objects were dated by the recovered ceramics which can be connected with a particular archaeological culture or its phase. If in the publication there are mentions only of culture, an average date of the period of this culture or its phase is used. The obtained chronology of the objects listed in **Table 3**. The chronological ratio and dating of cultures and phases is taken from Stadler and Ruttkay (2006) and Sraka (2012); the results given in the table various archaeological objects belonging to a particular culture.

Table 3. Chronology of rondels of Central Europe.

Object	Culture/phase	Date of the culture/phase	C14 dates of the object	Probable date of building
Žlkovce	Lengyel I, II (Plath 2011)	Lengyel I 4850-4650 BC (Sraka 2012)		4750 BC 4500–4400 BC – date of later use
	Lengyel II, 4500–4400 (Pavúk & Karlovsky 2008)	4523-4375 – phase IIa (Stadler & Ruttkay 2006)	4500 BC (Pavúk & Karlovsky 2008)	
Lochenice	MMK (Lengyel) I, Stichbandkeramik IV	4850-4650 BC (Sraka 2012) StK IV – 4650-4570 BC (Stadler & Ruttkay 2006)		4750 BC Reuse after 4650 BC
Prašník	Lengyel I	4850-4650 BC (Sraka 2012)		4750 BC

	(Pažinová 2011; Rídký 2011)			
Glaubendorf	MOG Ia (Pavúk & Karlovsky 2008)	4680-4620 BC (Sraka 2012; Stadler & Ruttkay 2006)	5918-5745 BP (Stadler & Ruttkay 2006)	4750 BC Reuse 4650 BC
Ippesheim	Großgartacher Kultur		4900–4700	4800-4700 BC
Němčičky	MMK (Lengyel) Ia, Ib, IIa (Rídký 2008)	4850-4650 BC (Sraka 2012)		4750 BC
Bajtava	Lengyel I (Rídký 2011)	4850-4650 (Sraka 2012)		4750 BC
Sormás-Török-Földek I, II			4800-4610 (Barna & Pasztor 2010)	4705 BC
Steinabrunn			5863-5727 BP (Stadler & Ruttkay 2006)	4700 BC
Friebritz 1	Lengyel IB (Pavúk & Karlovsky 2008	4700-4620 BC (Sraka 2012)	5888-5747 BP (Stadler & Ruttkay 2006)	4700 BC
Bochow	Stichbandkeramik	4906-4525 BC (Meyer 2011)	5850 BP (Meyer 2011)	4700 BC
		3700 BC (Meyer 1999)		Early article, too young date
Immendorf			7767 BP 5850, 5817 BP (Stadler & Ruttkay 2006)	6589 BC (probably, date of a layer before the building) 4725-4670 BC
Schletz			5926-5762 BP (Stadler & Ruttkay 2006)	4700-4670 BC
Bučany	Lengyel I (Rídký 2011)	4850-4650 (Sraka 2012)		4750 BC
	Lengyel IB2 (Pažinová 2011)	4720-4620 BC (Sraka 2012)		4670 BC (perhaps this date is more accurate)
	Lengyel IB, MBK Ia, MOG Ia (Pavúk & Karlovsky 2008)	4700-4620 BC (Sraka 2012; Stadler & Ruttkay 2006)		4700 BC
Tešětice-Kyjovice	Lengyel IB (Pavúk & Karlovsky 2008)	4700-4620 BC (Sraka 2012)		4660 BC
	MMK (Lengyel) Ia, IIa, Stichbandkeramik III-IVa (Rídký 2011)	4850-4650 (Sraka 2012)		4700 BC
Kleinrötz	MMK (Lengyel) (Rídký 2011)	4800-4550 BC (Sraka 2012)		4675 BC
Künzing-Unternberg	MBK Ia http://www.unet.univie.ac.at	4688-4615 BC (Stadler & Ruttkay 2006)		4650 BC
Kamegg	MOG Ia, Ib End of phase Lengyel IB-MBK/MOG Ia. (Pavúk & Karlovsky 2008)		5844-5713 BP (Stadler & Ruttkay 2006) 4558 BC (Pavúk & Karlovsky 2008)	4625 BC
Eythra	Stichbandkeramik IV (Rídký 2011)		4650-4570 BC (Stadler & Ruttkay 2006)	4610 BC
Goseck	Stichbandkeramik IV (Rídký 2011)		4650-4570 BC (Stadler & Ruttkay 2006)	4610 BC
Kolin 1	Stichbandkeramik IV (Rídký 2011)	4650-4570 (Stadler, Ruttkay 2006)		4610 BC
Riekofen	Pollinger Kultur - Andreas Tillmann http://www.bingo-ev.de/~ks451/archaeol/riekofen.htm	4100-3900 BC		4000 BC
	Altheimer Group (Kreiner 1999)	3800-3300 BC		Reuse 3550 BC
Kujawy	Long barrows	4460-3380 BC (Iwaniszewski 1995)		3820 BC
Vera Island 9				3700 BC

As seen from **Table 3**, the suggested age of rondels vary, and adding to the uncertainty of astronomical orientation in each particular case it is difficult to establish the sequence of geographic polar progression from plotting the 28 polar estimates based on the age data of **Table 3**. But it is possible to see some general regularity. If 4650 BC is accepted as a proper reference date, we see that older constructions indicate polar points mainly to the west of its modern location, while the majority of younger polar estimates are grouped near the modern pole or slightly to the east of it. Anyway, early Holocene polar estimates occupy an area from North-eastern Greenland to the area to the north of Spitsbergen and Franz Josef Land; the youngest ones fall between the modern pole and Franz Joseph Land.

Departing from the overall polar age pattern are the younger rondels of Kolin 1 and Riekofen; as seen from **Fig. 8**, the estimated polar locations for these two cultic sites fall in the main group of early poles. In addition, there are also deviations in the older group – i.e. the Immendorf polar estimate in northern Baffin Bay, and the Bochow and Ippesheim poles within the concentrated group of younger results (around the modern pole). For the Immendorf pole, being markedly inconsistent with the general time-equivalent polar trend, it's deviation is probably due to incorrect assumptions or basic data, but one cannot exclude a dating error. However, it is possible to draw a tentative polar trend for an extended part of Holocene time – including the older cultic site of *Göbekli Tepe. The estimated 'first order' polar track for the past 10,000 years is shown in **Fig. 9**. Initial location of* geographic pole at *the transition to* Holocene time in the central part of Hudson Bay was suggested by Hapgood (1970, p. 124) and discussed in my previous article (Grigoriev, 2011, p. 102-103).

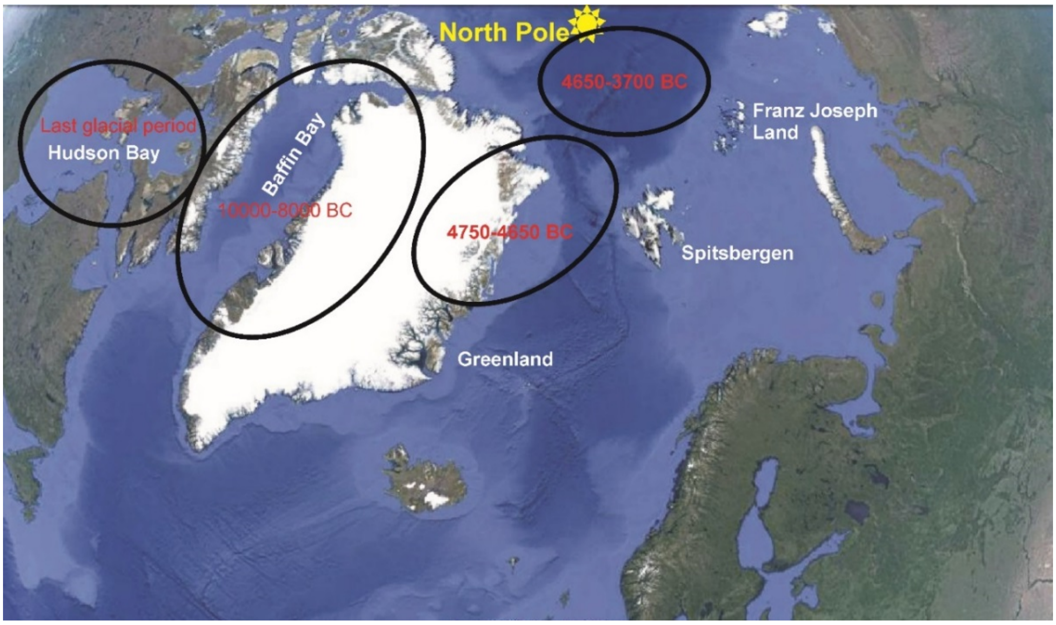

Fig. 9. The figure shows the estimated polar pattern for the early and middle Holocene time.

Polar drift and climatic changes

At first sight, the pole points reconstructed here for the period of the early 5th millennium BC contradict palaeoclimate evidence for this time. If the data outlined in this paper are taken at their face value the time-equivalent North Pole was either, probably for relatively short period of time, located close to its present pole, but its principal location was in NE Greenland; hence, for most of the considered time the pole was some 1000 km closer to Central Europe than today. But how could the regions of North/Central Europe be closer to the pole when the time interval concerned corresponds to a period of warmer climate – the Holocene climate optimum? For this period, however, higher temperatures have been recorded in Northern Europe – in summers in particular. On the contrary, in Southern Europe and in the Mediterranean climate was cooler, and in Central Europe noticeable trends were absent (Cheddadi et al., 1997; Davis et al., 2003). According to (Bonfils et al., 2004) the Middle Holocene summer solar radiation was 5% higher, and in the winter 5% lower than now. This is a quite normal situation at higher latitudes, but how can one account for the cool conditions in Southern Europe at a time when North Europe was experiencing relatively warmer conditions?

The answer to this ‘enigmatic’ problem is probably to be found in the evidence for polar wander – which long has been regarded as an episodic (Storetvedt, 1968, 1990 and 1997) and dynamic phenomenon (Storetvedt, 1968 and 1990). The main phases of relative polar wander – owing to episodic spatial changes of the Earth’s body relative to its axis of rotation – seem closely associated with principal geological time boundaries (Storetvedt, 1997 and 2003). Thus, when the Earth changes its spatial orientation the equatorial bulge and the Earth’s flattening will gradually shift relative to the Earth’s body. These changes will naturally pressurize the fluid and gas content of the asthenosphere and they accelerate their upward migration – finding escape routes to the surface, notably through the thinned oceanic crust. Similarly, the Holocene polar change is likely to have had a jerky character whereby warm upper mantle volatiles are likely to have had a pulse-like infiltration of the bottom water of the Holocene northern North Atlantic. It is natural therefore that the coastal regions around the northern North Atlantic would obtain a certain climatic amelioration (due to sea water circulation) compared to that of more southern and eastern regions of Europe.
Apart from the polar wander explanation proposed here, it has, for example, been hypothesized that a powerful western atmospheric circulation in the winter and weaker in the summer, caused by a blocking anti-cyclone near Scandinavia (Bonfils et al., 2004; Mauri et al., 2014), might have produced the climate optimum. However, it is necessary to remember that in Northern Europe temperatures were elevated by a mere 2°C. The same took place in Mongolia, but Central Siberia, Kazakhstan and further westward to the Black Sea the summer seems to have been cooler (Ljungqvist, 2011); referring to the relative polar locations at around 5000 BC (**Fig. 8**), all these regions are inland locations **not** influenced by the Atlantic air masses and its elevated sea temperatures. On the other hand, Mongolia along with other eastern territories had lower latitudes and may have had their milder climate due to the latitude-effect.

It is noteworthy that in Northern Europe temperatures comparable to modern summer temperatures set in at the beginning of Holocene, but they increased around 6000 BP. In Eastern Europe the increase in temperatures began already around 9000 BP (Davis et al., 2003), but according to Ljungqvist (2011) Western Canada and Alaska experienced relatively mild climate much earlier.

Hotinsky (1981) referred to three warm periods in Northern Eurasia coinciding with global temperature events: Boreal (8500 BP), Atlantic (5000 BP) and Sub-boreal (3500 BP) of which the Boreal warming was most intensive. On the Taimyr Peninsula in the north of Central Siberia (73-77˚N) tree trunks from Younger Dryas (12800-11500 BP) have been reported, and there are many finds of tree remains from the Middle Holocene. The peak of the Middle Holocene Optimum in Siberia dates at about 5860 BP when, in addition to forests, formation of bogs has been recorded. Average July temperatures were probably 8-10 °C higher than modern regional temperatures – reaching 10-12 °C; even warmer conditions have been reported from the eastern part of Taimyr (Belorusova, 1987). Cooling occurred already in the late Holocene, about 4000 BP (Belorusova, 1987). In the period 14300-9000 BP everywhere in Beringia (North-western America and North-eastern Siberia) forests spread, mainly, birch, but in America, during the maximum temperature event about 11000-9000 BP even poplar was present. In Siberia temperature conditions improve in the period 9500-8000 BP, then a cooling took place at the end of the Boreal period – replacing the temperature optimum of the Atlantic period (Lozhkin, 2006). It is remarkable that to the north at the easternmost end of Eurasia, on Wrangel Island, a population of mammoths thrived as late as 2000 BC (Vartanyan et al., 1995). The reported Holocene climate trend for Northern Eurasia (Siberia) makes sense only if we accept the Holocene polar track outlined by **Figs. 8 & 9.**

Furthermore, the more humid early Holocene conditions in Sahara perfectly correspond to this model too – explained by the higher latitude and, by inference, the associated western air masses. The end of the humid conditions in Sahara coincided with final melt of the Laurentide ice sheet of North America (Lamb 1982). Desertification in Arabia also coincides with it, as well as the emergence of El Niño which was absent in the early Holocene. Furthermore, resulting from the lower regional latitudes at that time (following from **Figs. 8 & 9**), formation of more humid and warm conditions in South Africa (Burroughs 2005) gains a reasonable explanation.

But Holocene climate variation may perhaps have other explanations. According to the Milankovich's (1930) model, for example, orbital changes caused changes of seasonal and meridional insolation so that increased variations in seasonal temperatures can be explained by a larger axial tilt of the Earth. Around 6000 years ago, the Earth's axial tilt is thought to have been larger, and the summer solstice was then closer to perihelion (Fischer and Jungclaus, 2011). It is possible to check these ad hoc propositions. Thus, a significant change of axial tilt would influence the orientation of cultic objects. In particular, the directions to summer solstices had to have more northern azimuths, and the directions to winter solstices would have more southern azimuths. However, we cannot refrain from the rather clear evidence that in early Holocene time the relative geographic pole was located in Arctic Canada-Central Greenland – drifting northeastward to its present location thereafter.

Anyway, the palaeoclimate problem concerned with here is fairly complex as it certainly was influenced not only by geographic latitude, but also by the closeness of glaciers and sea ices, circulation of the atmosphere, and the strong interaction with ocean currents and surface water temperatures (Bonfils et al., 2004; Fischer and Jungclaus, 2011) and changes in solar activity (Grigoriev, 2011). For a fully satisfactory consideration of this problem, a multidisciplinary approach is clearly needed – applying multivariate analysis (Bonfils et al., 2004).

Conclusions

According to **Fig. 9**, the early Holocene palaeo-pole was located in the region of Hudson Bay and from there it moved across Greenland and from there to the area north of Spitsbergen and Franz Joseph Land before ending in the region of the modern geographic pole. Like global geological processes in general, the suggested relative polar motion was probably episodic and closely associated with changes in Earth's rotation (Storetvedt, 1997 and 2003). Anyway, the Holocene pole moved along a wide arch in the counterclockwise sense – performing a movement corresponding to the direction of Earth's rotation. The jerky character of this motion would also result in pulse-like pressure increases in the gas and fluid 'filled' asthenosphere thereby forcing magma and a variety of gasses to surface levels. Indeed, studies in Greenland show that before the Atlantic period, intensity of eruptions was 5 times higher than in the last 2000 years (Zielinski et al., 1994).

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PLATFORMS: THERMAL AND GEOLOGICAL HISTORY

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Abstract: Thermal history for the scenario of radiogenic heat generation in the upper mantle beneath platforms has been analyzed in terms of the advection-polymorphism hypothesis (APH) pertaining to deep-seated processes in the Earth's tectonosphere over the past 4.2 billion years. Periodic heat and mass transfer toward the surface was found to be inevitable. Time intervals between successive heat and mass transfer episodes increase from 30 to 250 million years. The age of active events is correlated with dating results for magmatism and metamorphism on all continental platforms. The match is fairly good.

Keywords: *tectonosphere, deep-seated processes, heat and mass transfer in the upper mantle, periodicity of active events*

INTRODUCTION

The paper further specifies certain points of this author's article (Gordienko, 2015a) dealing with the advection-polymorphism hypothesis (APH) as applied to deep-seated processes. It may therefore contain some repeats.

Information on the energy source for deep-seated processes and types of heat and mass transfer that was discussed in earlier papers of the series (Gordienko, 2015a, 2015b, and 2015c) enables us to analyze thermal evolution of the tectonosphere (and its manifestations in the near-surface zone accessible to observations) for the entire geological history (approximately over the past 4.2 billion years of the Earth's existence). It depends on the level of heat generation (HG) in the upper mantle. We used in our calculations the lowest level of HG = $0.04\mu W/m^3$, which is presently typical of the upper mantle beneath continental platforms. This option provides the opportunity to perform a detailed and independent verification of the results. Erosion on platform shields exposed magmatic and metamorphic rocks of dissimilar age, and this makes it possible to follow the sequence of active events in a maximum age range. In regions with other HG levels – oceans and geosynclinal belts – such data are scarce so that verification cannot be complete.

In the description of the object of exploration, this author avoids using the term "craton" which he believes to be misleading as it implies tectonic and magmatic quiescence in the Phanerozoic. In reality, however, there have been intermittent activations in all regions covered by that notion ("craton"). The term "Precambrian platform" (hereafter referred to as "platform" – for the sake of brevity) means merely the absence of Phanerozoic geosynclines on the territory in question. Shields are parts of the platform almost or entirely devoid of a Phanerozoic sedimentary veneer.

COMPUTATION SCHEME

The thermal evolution model of the mantle beneath the region during the Precambrian is based on the assumption of the initial temperature (T) distribution in the tectonosphere about 4.2 billion years ago (corresponding to the solidus temperature, within the depth range of 50-450 km: $T_s = 1{,}013+3.914H - 0.0037H^2$, where H designates depth in km). Further variations in temperature are associated with conductive cooling through the surface, radiogenic heat emission (with the intensity changing with time, the present level being 0.8 $\mu W/m^3$ at depths from 0 to 21 km; 0.36 $\mu W/m^3$ at 21-42 km; 0.04 $\mu W/m^3$ at about 42-500 km; and 0.004 $\mu W/m^3$ at 500-1,500 km), and heat transfer toward the surface through advection during active episodes. The material moved in the shape of quanta of tectonic action (QTAs), with a diameter of 60±10 km. Minimum time intervals between them amounted to several tens of millions of years. Displacement of three QTAs was required for geosynclinal and rifting processes to take place. In the former case overheated material first rose to depths of 150-200 km, then to 100-150 km and, finally, to 50-100 km. It was replaced by relatively cool material from the corresponding depth ranges. The final episode of heat and mass transfer was accompanied by an intrusion into the crust of partially molten substance in quantities equivalent to a 7-8 km thick layer. Eclogitized basic rocks of the crust plunged into the subcrustal asthenosphere. The intrusion depth intervals ranged from 20 to 40 km. During rifting, the sequence of changes in the depths of immobilization of the ascended QTAs was opposite to that in the geosyncline: Initially, the upward intrusion reached the depths of 50-100 km (and into the crust) and then to 100-150 km and 150-200 km. In cases of single-episode activations, the displacements coincided with the initial stage of rifting.

A study of the composition of magmatic rocks on shields (Gordienko, 2015c; and others) has shown that, in the course of active Precambrian processes, depths of the top portion of the asthenosphere varied in the same manner as in Phanerozoic geosynclines and rifts, as predicted by simulation results. It is in this sense that the terms "geosyncline" or "rift," were ascribed to ancient processes even though tectonic ramifications of those events in the near-surface zone might have been different from the processes in the Phanerozoic.

The choice of type of an active process was coordinated with the type of the preceding thermal model. If, prior to its onset, the temperature exceeded solidus within a large depth range, greater than 200 km, the situation was considered suitable for triggering convection and geosynclinal process inside the asthenosphere. Also taken into account was the presence of a superadiabatic gradient in the asthenosphere or its part. It is precisely such part of the asthenosphere was considered fit for convective shuffling of the material and shaping up an ascending asthenolith. If the asthenosphere was thinner prior to the active process, the conditions were assumed to be favorable for rifting or for a single-episode activation. During rifting, the material was removed from the asthenosphere or from its portion about 59-100 km in thickness. In the absence of the asthenosphere or its insufficient thickness (less than 50 km), the situation was considered unsuitable for triggering active heat and mass transfer, so that computations (implying exclusively evolution of the background and smoothing earlier temperature anomalies) was continued until suitable conditions presented themselves.

Geological data on the history of active processes in the Precambrian on the territory of the Ukrainian (USh) and Baltic (BSh) shields indicate (Gordienko et al., 2005; Gordienko, 2009a) that about 3.0-3.5 billion years ago they simultaneously or nearly simultaneously encompassed the entire territory of the shield or its large part. Naturally, synchronous activations were not of the same type. This is inevitable due to significant differences, reaching about 20 percent, in heat generation within crustal and mantle rocks, differences that were detected on the shields (Gordienko et al., 2005; and others). In fact, however, this percentage appears plausible for crustal rocks only. No variations of such intensity could be as strongly validated for mantle HG. The aforementioned data are certainly incomplete, yet the assumption is not, at least, at variance with known evidence. Then there emerged zones of about 100 km in width (and possibly much bigger in length) in the vicinity of which, during their activation, "tectonic and magmatic calm" prevailed. The instant of such a change in the geometry of active regions during construction of a thermal model had not been set in advance but was determined in the course of computations. It was established that the continuation of the "territorial all-encompassing" activity becomes impossible at the assumed HG about 2.5 billion years ago, i.e. once the Proterozoic set in.

The computations were conducted in several stages using solutions to the direct geothermal problem, in particular, those reported by Gordienko et al., 2005.

1. In calculations of the variation in the initial temperature distribution owing to conductive cooling through the surface, we used the conventional formula for a cooling half-space. Test calculations have shown that it is sufficient to take into account the temperature in a layer about 1,500 km in thickness for an analysis of the tectonospheric model.

2. The temperature distribution obtained for every moment was complemented by effects of four one-dimensional radiogenic heat sources changing with time: a) upper part of the crust, b) lower part of the crust, c) upper mantle, and d) lower mantle. Variations in heat generation with time in each layer were accounted for by dividing the calculation periods into intervals with sustained HG within them. Their lengths increased toward contemporary time, which is due to the exponential dependence of the concentration of radioactive elements on time.

3. For each active episode of the region's history, results of advective displacements of the material were superposed on the obtained background models.

4. Effects of heat sources arising during the displacement of the polymorphous transition front were calculated as related to heat generation in the transformed layer.

5. At the initial phase of computations, the difference between the Earth's surface temperature in the past and present was taken into account.

6. We made an attempt to take in account the effect of the Earth's surface bombardments by large meteorites (see below).

The Earth's crustal thickness was believed to have been variable in the initial part of the time interval. As will be shown below, the early existence of the crust with a thickness commensurable with contemporary appears to be most unlikely for thermal considerations, even if we disregard the probable bombardment of the surface by large meteorites that sharply decreased just 3.8 billion years ago (**Fig. 1**; The Early History of the Earth, 1980).

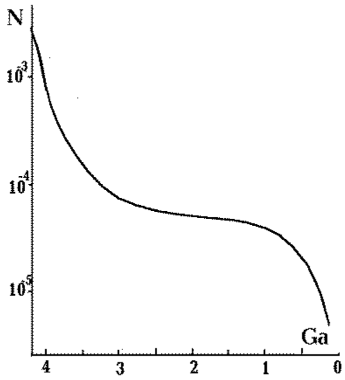

Fig. 1. Variation in the intensity of meteorite bombardment of the surface over the Earth's history, according to The Early History of the Earth, 1980. The data for 3-4 Ga are for the Moon. N stands for the number of craters with diameters larger than 4 km per 1 km^2.

According to petrological evidence, the primordial Earth's crust (about 4 billion years ago) had a composition and thickness (about 20 km, The Early History of the Earth, 1980) close to contemporary, but was not yet solid enough or differentiated the way the contemporary crust is. During the initial test calculations, the time of transition to a contemporary crust was dated as 3.8 billion years ago. The following information supports this finding. Basic granulites that formed 2.5 billion years ago in the lower crust at the depth of 42 km (T = 850^{o}C) were described in China. It follows that at that time the crust already possessed contemporary thickness (Geochemistry…, 1987). The Late Archean granulite rocks of the Indian Shield (aged about 2.8 billion years) formed in the crust at depths ranging from 18 to 28-30 km (T = 600-800^{o}C) (Geochemistry…, 1987). Among Archean rocks (aged up to 3-3.5 billion years) on the Ukrainian Shield one can come across basic granulites that formed at the depth of up to 35 km (Shcherbak, 2003; and others). Granulites that came into existence in the lower part of a thick crust (the thickness matching that of the contemporary crust) in the north of the Baltic Shield are aged about 3.5 billion years (The Early History of the Earth, 1980). The oldest of the known rocks on shields of various continents of the Earth (aged 3.7-3.8 billion years) clearly belong to a sufficiently well-developed continental crust except that that crust did not yet undergo differentiation into acidic upper portion and basic lower portion (Geochemistry…., 1987). On the Ukrainian Shield, "by the time of 4.2 billion years there had already existed a thick crust that might ensure granulite facies metamorphism" (Clark et al., 1988, p. 281). In all likelihood, the Archean crust was not much different from the contemporary crust one in terms of average composition, but included acidic and basic rocks of mantle origin, rocks that were not yet altered by anatectic processes. It could well be that heat generation in that crust did not change so radically with depth as is the case of the contemporary crust. Yet, this difference does not significantly affect the mantle temperatures being determined.

No fixed instant of emergence of the contemporary type of crust was used in the calculations. Different versions were considered, in which during the period prior to the formation and stabilization of the crust, a certain part of radiogenic heat sources it contained became distributed in the upper mantle layers several dozens of kilometers thick (Early History of the Earth…., 1980; and others). The change in the instant of emergence (and preservation throughout the remaining history) of the contemporary Earth's crust only resulted in certain variations of the type of models around that period of time. That effect is not too *conspicuous* in the distribution of temperatures in the tectonosphere 100-200 million years after the crust gained stability.

We used one value for the rocks' temperature conductivity: $7 \cdot 10^{-7} m^2/c$ and for the volumetric heat capacity: $4.2 \cdot 10^6 J/m^3 \, ^oC$ that were substantiated earlier (Gordienko, 1998; and others). Test calculations using appreciably larger values have shown that, had they been true, the mantle's thermal sources would have been exhausted too fast and that would have rendered active processes impossible as early as in the Proterozoic.

The data available in the literature on the elevated temperature at the Earth's surface in the Archean are rather ambiguous. It is commonly accepted that the overheating was quite significant, but its intensity and the time scale of the anomaly are assessed in different ways. It was assumed during calculations that the temperature close to contemporary (at any rate below 100^oC) set in after the abatement in the intensive bombardment of the surface with large meteorites about 3.8 billion years ago. Approximately 4.2-4.0 billion years ago, it amounted to about 500^0C, and then gradually abated to $100\text{-}200^0C$ (The Early History of the Earth, 1980; and others). A different approach is not, however, ruled out: "The existence of sedimentary rocks and, consequently, liquid water, starting from 3.8 billion years ago, is obvious" (Taylor et al., 1988, p. 359). As follows from subsequent calculations (see below), temperatures in the upper tectonosphere exceed solidus no matter what the approach might be. In this context, the effect of bombardment of the Earth's surface with large meteorites makes no difference either, as its thermal effect added up to the crust and upper mantle that already periodically underwent partial melting anyway.

Prior to crustal stabilization and reduction of the surface temperature, much water had still been in the mantle, and that reduced its solidus temperature by $150\text{-}200^oC$ up to the depth of about 150 km. The instant of transition to a "dry" mantle has to be taken into account in calculations to determine the location of the top of the asthenosphere. "A most compelling evidence provided by rocks is the obvious similarity between the processes of erosion and sedimentation over the past 3 billion years" (Garrels et al., 1974, p. 62 -- in Russian translation). In other words, by that time, the mantle had already lost the bulk of water, the water regime at the surface was similar to that in Phanerozoic, or probably earlier (see above). Proceeding from geological data for shields, the time of transition to usual sedimentation can be pushed back if we go by the age of the oldest sedimentary rocks – to about 3.0-3.5 billion years.

Information on the amount of energy being released or absorbed during compaction or decompaction of rocks in connection with polymorphous transformation at the bottom of the upper mantle makes it possible to estimate the effect during olivine transition to a mineral with the structure of spinel at $5.10^7 J/m^3$ (Gordienko, 1998). The effect of such a source on the temperature of the overlying medium turns out to be vanishingly small at the distance of several tens of kilometers away from the transition front and does not exceed several tens of degrees at the front proper. Variations in temperature hardly exceed the calculation error associated with the inaccuracy of values of tectonospheric rocks' thermal properties used in the calculations.

SIMULATION RESULTS

The starting thermal model conforms to the regime required for triggering a geosynclinal (in the aforementioned sense) process. Material in the depth range between 200 and 500 km is drawn into displacement. After the completion of the cycle, the conditions become suitable for triggering rifting, then -- another one, following which conditions become suitable again for forming a geosyncline, and so on. A consecutive chain of active processes on the entire territory of the shield and the reduction in heat generation lead to the exhaustion of the mantle's thermal resources. Further activity encompassing the entire territory became impossible about 2.5 billion years ago. Active events that took place closer to our days were considered to be confined to relatively narrow bands about 100 km in width beyond which, over a considerable distance, there have been no synchronous heat and mass transfer in the mantle.

It took 70 heat and mass transfer episodes over the period of 4.2-0.00 billion years for the advective evacuation of energy from the tectonosphere.

It is possible that the simulation does not represent the only feasible alternative of the quantity and sequence of active processes in the shield's tectonosphere. Several other alternatives of the process in the tectonosphere of the shield were also considered with dissimilar thermal properties of the medium and dissimilar choice of the course of the process whenever the thermal model failed to unambiguously give preference to a geosynclinal or rifting type of endogeneous regime, so as to make it possible to simulate their onset or extend the period of "tectonic quiescence" for further "maturation" of conditions favorable for triggering the next heat and mass transfer. In all cases the pattern turned out to be essentially the same.

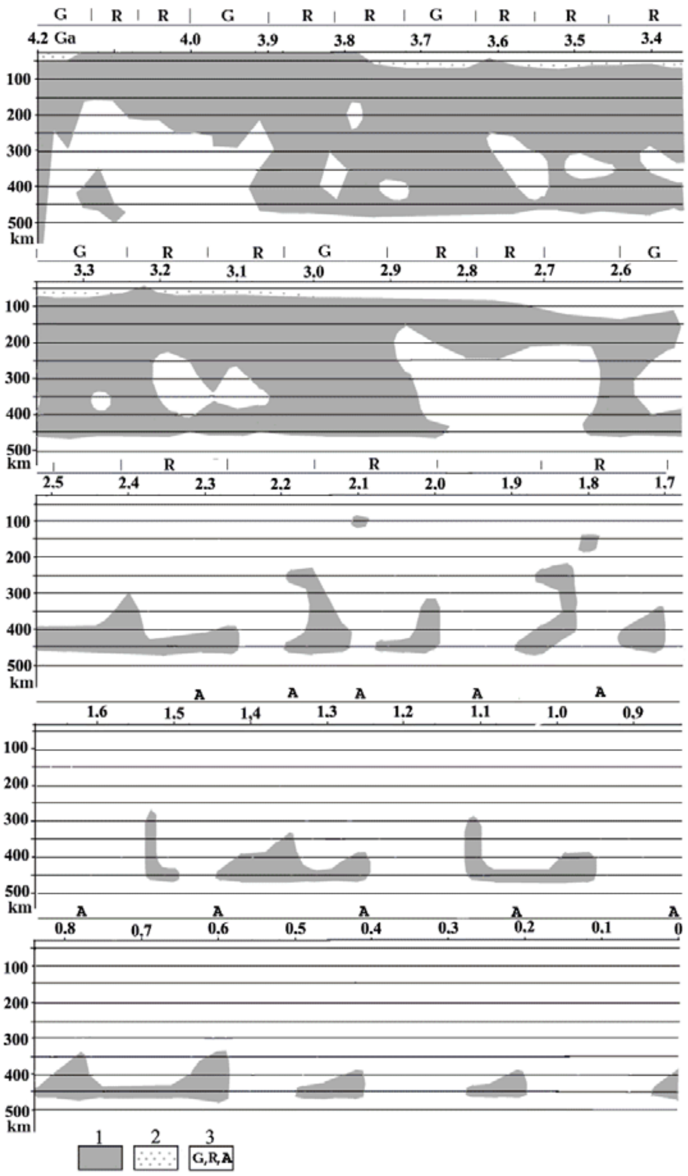

Fig. 2. Evolution of the asthenosphere during platform-type HG in the crust and upper mantle. 1 – Asthenosphere, 2 – upper part of the asthenosphere for a "liquid" mantle, 3 – types of endogeneous regime (G – geosynclinals, R – rifting, and A – single-episode activation)

Modelling results are presented in Fig. 2 in the form of asthenospheric evolution and in Table 1 showing variations of temperature (T) for various periods of the platform's geological history. The horizontal scale of the diagram shows the time of appearance of a particular type of model in Ga.

Table 1. Temperature evolution in the platform's upper mantle

H,km	T (^{0}C) for t (Ga)										
	4.2	4.1	4.0	3.9	3.8	3.7	3.6	3.5	3.4	3.3	3.2
50	1,200	1,400	1,210	1,310	1,260	1,050	1,220	1,060	1,170	960	1,100
100	1,370	1,650	1,620	1,530	1,560	1,510	1,610	1,570	1,570	1,460	1,620

150	1,510	1,550	1,680	1,620	1,640	1,770	1,740	1,810	1,760	1,780	1,770
200	1,650	1,470	1,710	1,680	1,630	1,860	1,740	1,840	1,800	1,890	1,720
250	1,760	1,640	1,760	1,750	1,760	1,880	1,720	1,810	1,800	1,890	1,730
300	1,850	1,740	1,820	1,840	1,880	1,910	1,860	1,820	1,810	1,910	1,790
350	1,930	1,770	1,860	1,930	1,930	1,950	1,980	1,890	1,890	1,950	1,850
400	1,980	1,910	1,890	1,980	1,990	2,010	2,060	2,020	2,020	2,010	1,990
450	2,020	2,060	1,940	2,050	2,080	2,100	2,130	2,100	2,100	2,070	2,090
500	2,310	2,310	2,160	2,190	2,200	2,210	2,210	2,210	2,210	2,200	2,200
H,km	3.1	3	2.9	2.8	2.7	2.6	2.5	2.4	2.3	2.2	2.1
50	1,030	890	960	960	900	800	910	790	800	820	1,030
100	1,520	1,390	1,450	1,460	1,350	1,230	1,300	1,200	1,190	1,220	1,380
150	1,740	1,730	1,550	1,730	1,580	1,520	1,510	1,440	1,460	1,470	1,490
200	1,780	1,870	1,660	1,780	1,660	1,680	1,620	1,580	1,610	1,630	1,590
250	1,750	1,890	1,780	1,760	1,740	1,770	1,720	1,740	1,730	1,760	1,660
300	1,800	1,920	1,890	1,790	1,820	1,860	1,820	1,850	1,800	1,840	1,720
350	1,910	1,950	1,960	1,820	1,870	1,930	1,910	1,930	1,880	1,920	1,850
400	2,010	2,040	2,020	1,880	1,950	2,000	2,010	2,040	1,970	1,960	1,890
450	2,070	2,070	2,060	1,960	2,000	2,050	2,050	2,070	2,070	2,020	1,970
500	2,190	2,180	2,150	2,130	2,120	2,120	2,120	2,150	2,150	2,130	2,130
H,km	2.0	1.9	1.8	1.7	1.6	1.5	1.4	1.3	1.2	1.1	1.0
50	750	730	840	710	700	880	680	760	800	650	650
100	1,180	1,150	1,330	1,150	1,130	1,250	1,100	1,150	1,200	1,060	1,070
150	1,440	1,430	1,550	1,430	1,400	1,400	1,380	1,370	1,410	1,360	1,360
200	1,600	1,600	1,620	1,620	1,600	1,580	1,570	1,550	1,550	1,560	1,560
250	1,730	1,750	1,690	1,740	1,730	1,720	1,710	1,680	1,710	1,730	1,690
300	1,820	1,820	1,740	1,830	1,820	1,700	1,800	1,730	1,810	1,860	1,800
350	1,930	1,900	1,860	1,940	1,870	1,780	1,890	1,700	1,860	1,,930	1,890
400	2,000	1,960	1,930	2,020	1,930	1,860	1,980	1,960	1,850	2,000	1,990
450	2,070	2,020	1,990	2,060	1,970	2,020	2,200	2,070	1,920	2,040	2,070
500	2,150	2,130	2,120	2,160	2,100	2,140	2,160	2,200	2,140	2,170	2,200
H,km	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0	
50	750	610	660	570	650	840	590	520	570	510	
100	1,160	1,030	1,070	980	1,060	1,180	1,000	930	1,000	920	
150	1,370	1,330	1,340	1,290	1,320	1,310	1,300	1,250	1,280	1,240	
200	1,550	1,540	1,520	1,510	1,510	1,500	1,500	1,480	1,480	1,470	
250	1,700	1,700	1,660	1,670	1,680	1,690	1,670	1,670	1,640	1,670	
300	1,800	1,820	1,750	1,810	1,790	1,800	1,800	1,830	1,760	1,830	
350	1,820	1,910	1,840	1,930	1,850	1,750	1,860	1,920	1,830	1,920	
400	1,850	1,980	1,950	2,020	1,900	1,690	1,910	1,990	1,880	1,980	
450	1,980	2,050	2,060	2,090	2,000	1,830	2,000	2,100	1,990	2,060	
500	2,160	2,170	2,190	2,190	2,150	2,140	2,140	2,160	2,120	2,150	

It has to be admitted that simulation results listed in **Fig. 2** represent a considerably smoothed pattern of depth variations at the top and bottom of the asthenosphere. They reflect a situation that took shape 10-40 million years following the heat- and mass transfer episode. Immediately after that, at the final stage of geosynclinal development and at the early stage of rifting, the top portion of the partial-melting layer ascended to the bottom of the crust, and in the central portion of the crust, there emerged a partial-melting layer of rocks in the amphibolite facies of metamorphism. In some cases, rocks in the lower (basic-granulite) crustal layer also underwent limited melting. The bottom of the asthenosphere also underwent considerable upheaval immediately after the next heat- and mass-transfer episode relative to that shown in **Fig. 2**.

We ought to make a few remarks regarding the crustal portion of the model. Even though it is not the main target of the calculations, it is closely associated with the mantle portion and reflects details of the process that can be verified by geological data.

The possibility of a multiple (30 times in the model under consideration) crust-mantle exchange is contingent on the situation in which eclogitized basic crustal rocks plunging into the mantle are replaced by chemically similar melts from the mantle. This creates conditions for the process to recur.

A more detailed analysis of events within the crust (Gordienko, 1998; Gordienko et al., 2005; and others) shows that the overheated mantle material does not form a single consolidated layer, but rather spreads within a depth range of 20-42 km with a downward increase in concentration. In the middle crustal layer, the concentration averages 25 percent and in the lower – 50 percent. In such a model (based on results of interpretation of heat flow anomalies in zones of Ukraine's recent active processes) the melting of rocks in the amphibolite facies of metamorphism is subject to the following limits: Melting can start from the depth where the rocks' temperature exceeds solidus values (600-650^{o}C at 10 km or deeper, growing to 950^{o}C toward the surface) up to the bottom of the transition layer still containing limited amounts of such rocks. On shields, this boundary lies at an average depth of 30 km (Gordienko et al., 2005; and others). For a typical development of the thermal process to take place, the upper boundary of the partial-melting zone in the crust should not rise above 18-20 km. At shallower depths, one can come across rocks resulting from intrusions into upper crustal levels of acid and intermediate magma from the layer at 20-30 km. There exist relatively short periods within geosynclinal and rifting activity cycles when solidus temperatures (1,050-1,100^{o}C) are exceeded in the lower (basic-granulite) portion of the crust. This phenomenon match a different type of magmatism (less acidic, plagiogranitic, and syenitic) in composition.

In the Archean (until the formation of a dry basic granulite lower crust), melting foci of an acid component could also occur at depths greater than 30 km.

Let us discuss the main results of modelling regarding the mantle in somewhat greater detail.

1. The temperature computation was initially performed without taking into account the anomalous temperature at the surface during the period of 3.8-4.2 billion years ago or meteorite bombardment. Nevertheless, it was revealed that solidus temperatures were higher than normal within the entire crust or its larger part. If we also add to this the effects of high temperature at the surface and meteorite bombardment, the existence of a stable Earth's crust during that period becomes all the more dubious. This is despite the fact that the presence of clastic ancient (up to 4.5 billion years) zircons on the shields indicates that the crust did not disappear in its entirety.

2. During the period from 3.8 to 3.5-3.0 billion years ago, the top portion of the asthenosphere must have been higher up by comparison with the level typical of "dry" mantle. It is possible that the lower part of the crust may have also undergone frequent melting.

3. During the period of 1.7-2.3 billion years ago, the alternation of geosynclinal and rifting processes in the tectonosphere of the shield gave way to single-episode activations essentially corresponding to the initial stage of rifting. The difference is in that the material during rifting comes from a thicker asthenosphere. It is the time which may be considered as a period of transition to a platform-type evolution.

4. During the period between 4.2 and 1.7 billion years ago, there existed a certain alternation pattern of types of endogenous regime in the tectonosphere of a future platform. According to that pattern, a geosynclinal cycle was followed by two or (less frequently) three rifting processes. In the case in question (**Fig. 2**), two (out of the six analyzed) situations were spotted in which a geosynclinal process was followed by three riftings. It cannot be ruled out that this feature in the model was due to a somewhat inaccurate choice of time when the crust of the shield acquired its contemporary appearance (3.8 billion years ago) and to difficulties involved in the choice of the type of regime that prevailed at the end of the period.

The result suggests the existence, in the early Precambrian (4.2-1.7 billion years ago), of "extensive cycles" that generally lasted 0.2-0.4 billion years, each cycle comprising 9 to12 single episodes of heat and mass transfer in the tectonosphere. There were no such "extensive cycles" in the Phanerozoic. This is probably what accounts for the difference between the "permobile stage" of tectonospheric evolution and the stage that followed it.

5. The time span dividing heat and mass transfer episodes in the course of geosynclinal, rifting, and then activation processes increases appreciably over the shield's geological history. Results of calculations were used to derive mean values of Δt within the time intervals of 4.2-4.0, 4.0-3.5, 3.5-3.0, 3.0-2.5, 2.5-2.0, 2.0-1.5, 1.5-1.0, 1.0-0.5, and 0.5-0 billion years ago. The resulting pattern is in fairly good agreement with that established for the Ukrainian Shield on the basis of geological evidence (Gordienko et al., 2005).

Processes in geosynclines and rifts match Δt values of 20-90 million years, i.e., they do not in principle differ from those typical of the Phanerozoic. The difference lies in the fact that activity cycles in the Phanerozoic are separated by considerable time intervals of tectonic quiescence, whereas active events in the Early Precambrian follow in succession, without or almost without gaps. The gaps first started 2.4-1.7 billion years ago. During the platform period, Δt values increased to 100-250 million years, and this has also been pointed out by many researchers regarding the Ukrainian Shield (Shcherbak et al., 2004 and others).

6. A contemporary thermal model of the shield's tectonosphere (***Fig. 2***) exhibits conditions for a successive active process to start. This result was not programmed in advance. It was rather obtained as an outcome of the entire preceding thermal history. It is certainly true that readiness for activation (which, according to the model, was preceded by an activation of Cimmerian age – ***Fig. 2***) was detected for the shield's block in which events proceeded precisely in the manner predicted in the model. The situation in adjacent blocks could well be different.

7. An analysis of magmatism on the shield during the time stretch of 1.7-4.2 billion years ago, when virtually the entire transport of mantle melts and fluids into the Earth's crust and onto the surface took place, indicates that the distribution of magma chambers near the top portion of yet another QTA or asthenosphere was irregular with depth. Approximately 10 percent of the material occurs at the depth of about 150 km, 35 percent at about 50 km, and 55 percent at about 100±25 km. It is precisely within the last depth interval that maximum changes in composition caused by the removal of incoherent elements of the mantle and reworking of its material by fluids must have taken place.

8. The computation of thermal models was performed for the depths reaching 1,000 km. It follows from its results that, as distinct from the temporary emergence of just a thin asthenosphere in the Proterozoic and Phanerozoic in the tectonosphere of the shield, it continues to exist in full beneath the zone of polymorphous transformations. The general cooling of the Earth through the surface and the cooling effect of the heat and mass transfer in the upper mantle do have an effect, but even insignificant heat generation actually makes up for those effects. The revealed feature is global in occurrence which is corroborated by geoelectrical data, including those for the Ukrainian Shield (Gordienko, 2015c; and others).

The conclusion about the impossibility of the existence of a stable crust 4.2-3.8 billion years ago was proven with full certainty through modeling. It is therefore not surprising that no significantly large fragments of the crust older than 3.8 billion years have so far been found on the shields of all continents. It is unlikely that they may be discovered in appreciable amounts now, even though older crust have occasionally been seen, and it cannot be ruled out that its blocks are simply not exposed at the surface. "Geological evidence observable on the Earth is not older than 3.8 billion years, even though the presence of zircon grains aged 4.1 billion years points to existence of older crustal rocks" (Taylor et al., 1988, p. 342 -- in Russian translation).

Geological data corroborate the location within the crust of the main range of depths where acid magma formed. "… migmatization…. ceases during transition to the granulite facies…. the origin of granites is in most cases confined to the median part of the crust (20-25 km)" (Archean..., 1987, pp. 202, 246). "It is assumed that they (granites – V. G.) were melted out at depths of 15-20 km" (Shcherbakov, 2005, p. 224).

However, numerous intrusions of acid and intermediate magma that took place in the Precambrian resulted in a situation in which, during periods of active processes, temperatures (600-650^{o}C) typical of those processes spread in some locations much closer to the surface and reached the depth of 10 km, above which the solidus temperature rises rapidly. Such a model turned out to be useful, in particular, in studying the situation that has taken shape over past millions of years in the crust of the Transcarpathian Trough

(Gordienko et al., 2005). Such events find expression in the presence of "…horizontal metamorphic zonality" (Shcherbakov, 2005, p. 250) near granite domes in the Ukrainian Shield. Their existence is also supported by the fact that "…temperatures in metamorphic strata grow faster than on granite basement elevations" (Schcherbakov, 2005, p. 253). Taking into account this additional (intracrustal) level of advection, whose presence has virtually no effect on the mantle temperature, estimated temperatures in the crust 3.5-1.0 billion years ago, right after mantle intrusions, prevail within the range reported by Gordienko (2015b). This range was compared versus the data on PT conditions of metamorphism in the crust of world shields that reflect the situations at maximum heating of the crust. The results agree with estimated data.

The volume of exchange of basic material between the crust and mantle required for triggering an advective transport of heat is very large. Following crustal stabilization (3.8-0 billion years ago) there have been 26 exchange episodes, more specifically, the amount of material equivalent to a layer 210-260 km in thickness moved into the crust and back (the average density of crustal basic rocks and eclogites is close to the average density of the upper mantle's overheated rocks: 3.25 and 3.45 g/cm^3, respectively). According to the (The Early History…., 1980 and Geochemistry…, 1987), a 255±45 km thick mantle layer was involved in the formation of the crust. Inasmuch as the concentration of the low-melting "basaltic component" of mantle pyrolite is estimated at 10-15 percent, it may be assumed that it used to be part of the crust several times. The differences in composition of basic rocks of mantle origin (alkaline and tholeitic eclogites) and eclogites (or basic granulites that make up eclogites plunging into the mantle) indicate that even after the crust stabilized, the process of its enrichment with Fe, Ti, Ca, and Si has continued (**Table 2**). The transport of radiogenic heat sources into the crust is continuing as well.

Table 2. Composition of typical crustal basalts and granulites on shields

Oxide	Contents (%)			Oxide	Contents (%)		
	Basalt	Granulite	Δ		Basalt	Granulite	Δ
SiO_2	49	48.5	0.5	MgO	8	10	-2
TiO_2	2.5	1	1.5	CaO	10.5	9.5	1
Al_2O_3	14	16.5	-2.5	Na_2O	2	2.5	-0.5
$FeO+Fe_2O_3$	12	10	2	K_2O	1	1	0

The above results are certainly not precise. They do not take into account changes in composition during transition from basic granulites to eclogites, contribution of the gas-fluid component of basalt magmatism, etc. For example, the composition of eclogite from the lower crust of the Massif Central, France (Taylor et al., 1988) differs notably from that shown in **Table 2** (SiO_2 – 48; TiO_2 – 1; Al_2O_3 – 18; $FeO+Fe_2O_3$ – 7; MgO – 8; CaO – 11; Na_2O – 2; and K_2O - 0.5). At the same time, eclogites in the mantle beneath the Pamirs have the following composition: SiO_2 - 43.4; TiO_2 -1.8; Al_2O_3 - 15.6; $FeO+Fe_2O_3$ -13.5; MgO - 6.3; CaO - 11.8; Na_2O - 2.6; and K_2O - 1.4 percent (Dmitriyev et al, 1983). To put it differently, it is only possible to outline the general trend of variations in principal components of the composition.

This conclusion is to a certain extent supported by the data on the Ukrainian Shield (Gordienko et al., 2005). It is shown that from activation to activation within the frameworks of a single development cycle of the Azov Region block, the mantle becomes enriched with MgO and Al_2O_3 and loses part of its SiO_2. On the other hand, the mantle loses some sodium, while calcium and iron contents remain stable.

Outside periods of activation in the Riphean-Phanerozoic (the past 1-1.5 billion years), temperatures in the upper mantle stabilize, varying with depth by just a few dozens of degrees (up to ±70^{o}C at depths of 100-200 km, the HG remaining within normal limits). The differences are even smaller in the Phanerozoic. This justifies the use of a unified thermal model reflecting the situation prior to the onset of Phanerozoic active processes (Gordienko et al., 2005; Gordienko, 2015b; and others).

A simulation study of deep-seated processes and thermal evolution of the tectonosphere has shown that at the contemporary level of knowledge, notwithstanding insufficient accuracy of information on many parameters necessary for the calculations, it is quite possible to obtain fairly definitive results. We succeeded in showing that the adopted pattern of deep-seated processes and the level of radiogenic heat generation makes it possible to obtain thermal models matching many geological data for shields. But the major verification of the model requires comparison between obtained results and the data on activation ages on platforms.

CORRELATION BETWEEN SIMULATION AND EXPERIMENTAL DATA

It is not an easy task to select materials in terms of ages of rocks from platforms (virtually, shields) that are suitable for comparison with results of modeling. One of the major problems is the aforementioned situation that took shape in the Proterozoic with simultaneously existing active and passive blocks. Their emergence is probably due to minor differences in the HG of mantle rocks in connection with which conditions for triggering active processes do not become “ripe” simultaneously throughout the shield. By generalizing the material for the entire shield we will inevitably obtain “extra” datings that may differ from adjacent ones more than can be accounted for by the error in measurements. This may affect the objectivity of the comparison. For that reason data should initially be selected on a large well-studied shield with a distinct separation into blocks. These considerations led the author to opt for the Baltic Shield (BSh) (Gordienko, 2009), rather than for the Ukrainian Shield (USh) (Gordienko et al., 2005).

The main source of Baltic Shield rock datings (Early History…, 2005) that we have used provides few data on the Svekofenian block and no data at all on the Dalslandian block. Thus, we had to confine our comparison to the Kola-Karelian block (KKB). Yet, we are talking about quite a large structure occupying an area of about 470,000 km2, which is about twice the territory of the Ukrainian Shield (the Fenno-Karelian part of the block is about 280,000 km2 in area).

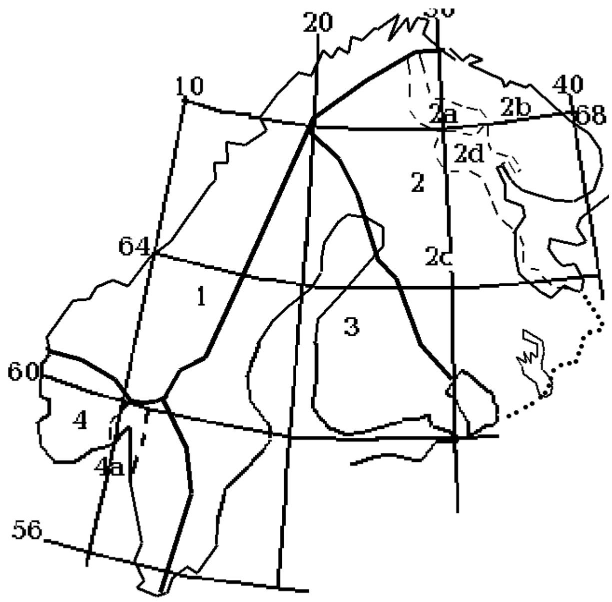

Fig. 3. Diagram showing location of Baltic Shield blocks (Early History…., 2005; and others)
1 – Caledonides. Blocks: 2 – Kola-Karelian (2a – Laplandian belt, 2b – Kola-Norwegian Province, 2c – Fenno-Karelian Region, 2d - White Sea Belt), 3 – Svekofenian, 4 – Dalslandian (4a -- Oslo graben). The dotted line marks the shield’s boundary on dry land.

Comparison of information on datings of Baltic Shield rocks as provided in various publications points to the need of employing the data from The Early History…, (2005), where results of previous studies are generalized and many datings are revised to conform to contemporary requirements.

Altogether about 350 age determinations for the Kola-Karelian block (KKB) were used in the analysis (much more than for the Ukrainian Shield); some of the datings are results of data smoothing in a single rock massif. The dating results cover a large interval of the time scale (3.55-1.75 billion years ago), with almost no “gaps,” but saturation of various time spans is sharply dissimilar.

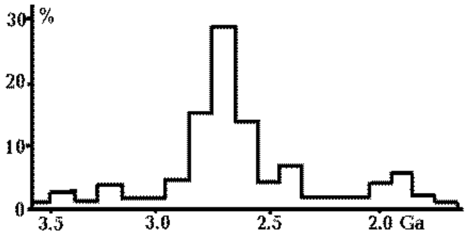

Fig. 4. Histogram showing distribution of numbers of age determinations for KKB rocks within time spans of 100 million years

The relative frequency of occurrence of particular datings is not directly associated with the prevalence of the corresponding rocks: A considerable amount of them fall into the category of intrusive formations occupying relatively small areas. It is obvious that in order to obtain discrete datings, which could be coordinated with estimated ages of activation, it is necessary to process the material first. To begin with, the true value of the error in age determinations should be established. The values of errors (Δt), cited in The Early History... (2005), apply to most of the dating results used. They are shown on the histogram (**Fig. 5**).

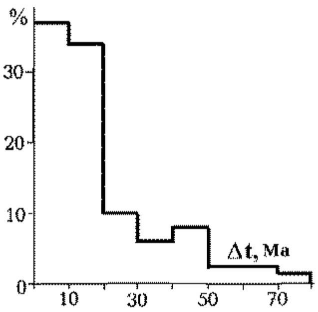

Fig. 5. Computational errors in dating rocks of the Kola-Karelian Block (The Early History..., 2005)

The distribution of Δt is far from being normal. It is only possible to assume that the majority of values (71%) fall within the limit of 10% ±10%, and this value can be used as a typical error. On the other hand, it is necessary to take into account a noticeable amount (15-20 percent) of results of age determinations with errors ranging within the limits of 50%±20%. It follows from the data that it makes sense to present all the dating results as numbers rounded off to 10 million years and view values in batches of age determinations that differ from the average value by 10 million years or less, as actually matching. Clearly, within age intervals of 1.75-2.35 and 3-3.55 billion years, for which information is relatively scanty, this approach will rule out problems with determination of ages suitable for comparison with simulation results.

For example:
1. Nonrecurrent (sporadic) dates separated from adjacent ones by 20 million years or more on the time scale and recurrent (coinciding) dates with the same parameters.
2. Average dates in groups in which all values differ from average ones by no more than 10 million years. There are 29 such groups out of 39 (**Table 3**). Part of them are also outside the mentioned time intervals.

Table 3. Model (M) and experimental age determinations for Early Precambrian rocks of the Baltic Shield Kola-Karelian block (KKB). Digits within parentheses indicate numbers of rounded-off age datings. Groups of dates in which deviations from average reach 20 million years are shown in boldface.

M	KKB	M	KKB	M	KKB
3,530	3,530	3,040	3,030		2,450±10 (13)
3,500	3,510±10 (2)	3,010	3,010±10 (2)	2,400	2,400±10 (3)
3,470	3,470	2,980	2,980±10 (4)	2,350	**2,350±10 (4)**
3,440	3,440±10 (2)	2,940	**2,940±10(10)**	2,280	2,280±10 (3)
3,410	3,410±0 (3)	2,900	2,900±10 (5)	2,240	2,240±10 (2)
3,370		2,860	**2,860±10 (27)**	2,200	2,210±0 (5)
3,330	3,330±10 (3)	2,820	2,820±10 (25)	2,150	2,160
3,300		2,780	**2,780±10 (34)**	2,120	2,120±10 (4)

3,270	3,250±10 (3)	2,740	2,740±10 (23)	2,060	2,050±10 (9)
3,230	3,230±10 (6)	2,700	**2,700±10 (48)**	2,000	1,990±10 (7)
3,200	3,210±0 (5)	2,650	**2,650±10 (25)**		**1,940±10 (18)**
3,170	3,160±10 (2)	2,600	**2,590±10 (6)**	1,850	1,870±10 (5)
3,140	3,140±10 (2)	2,550	**2,540±10 (5)**	1,800	1,780±10 (3)
3,100	3,100±0 (3)	2,500	**2,490±10 (15)**	1,750	1,750±10 (2)
3,070					

3. It may so happen that groups of data may comprise up to 25-30 percent of values diverging from average by a double error, i.e. by 20 million years (**Fig. 6**). It is natural that such deviations can be expected in relatively large volumes of samples within the time span of 2.35-3.0 billion years. This applies to 10 groups of experimental data (**Table 3**), which, just like those discusses above, can be viewed as characteristic of discreet periods in the shield's activation. The latter conclusion cannot, however, be considered completely well grounded: Inside groups of data selected from the continuous sequence of age determinations for KKB rocks one cannot observe irregularities in age clusters that might indicate a preferential age for the group (**Fig. 6**).

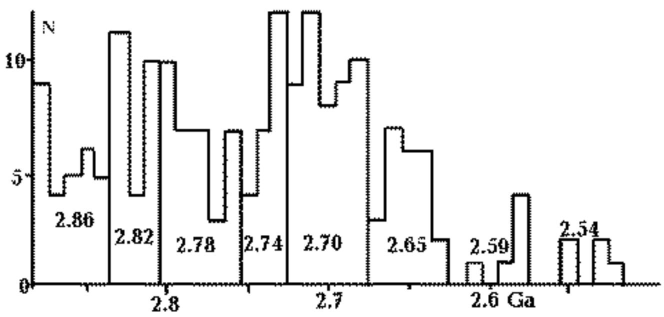

Fig. 6. Distribution of dates in groups selected from the bulk of ages for the Kola-Karelian block rocks.

This may be due not just to errors in the parameter determination, but also to certain differences between actual ages of the events in a single stage of activation of the tectonospheric shield in various areas of the block which are not infrequently spaced many hundreds of kilometers apart. For that reason, samples for large segments of the Kola-Karelian block (see Table 4) were made for the corresponding time span.

Table 4. Times (in millions of years) of active processes established for KKB segments

Model	Fenno-Karelian Region	White Sea Belt	Laplandian Belt	Kola-Norwegian Province
2,940	2,950±10(4)	2,950	2,930	2,930±0 (3)
2,900	2,900±10 (6)	2,890±10 (2)		2,900
2,860	**2,860±10 (12)**	2,850±10 (5)	2,870	2,870±10 (3)
2,820	**2,810±10 (21)**	2,820±10 (8)		2,830±10 (5)
2,780	2,780±10 (10)	2,790±0 (4)		2,790±10 (6)
2,740	**2,740±10 (27)**	2,730±10 (9)	2,750	**2,740±10 (6)**
2,700	**2,700±10 (23)**	**2,690±10 (10)**	2,700±10(3)	2,690±10 (5)
2,650	2,650±10 (8)	2,650±10 (5)	2,680	2,650±10 (6)
2,600	2,590	2,580±0 (4)		2,620±10 (2)
2,550	2,530±0 (2)		2,550	2,550
2,500	2,510		2,510±10(3)	2,500±10 (4)

It is obvious that the quantity of dating results, which have to be processed using clause 3 of the rules for identifying discrete dating results, has decreased and they are largely confined to the Fenno-Karelian Region occupying more than half of the block's area. If the same procedure is applied to separate domains inside the region (also using individual dating results shown in other tables in averaged form) (The Early History…., 2005), we get (Table 5) a nearly complete disappearance of unreliable ages of activations.

Table 5. Ages of activations (in millions of years) determined for segments of the Fenno-Karelian Region

Model	Voldozero domain	Central Karelian domain	Western Karelian domain
2,940	2,930±10(5)	2,930±10 (4)	2,930±10 (3)
2,900	2,890±10 (4)		2,890±10 (6)
2,860	2,860±10 (8)	2,850±10 (4)	2,850±10 (4)
2,820	2,830±10 (6)	2,820±10 (7)	2,810±10 (4)
2,780	2,780	2,790±10 (21)	2,770±10 (4)
2,740	2,730±10 (3)	**2,750±10 (30)**	2,720±10 (7)
2,700	2,700±10 (4)	2,690±10 (26)	2,700±10 (6)
2,650			2,640±10 (5)
2,600			2,590±10 (4)
2,550		2,530	2,560

Some additional information for determining the age of the Baltic Shield's Early Precambrian rocks can be obtained by analyzing dating results for the Svekofennian Block (**Table 6**), despite the fact that younger rocks prevail within it.

Table 6. Ages (in millions of years) of activations determined for the Baltic Shield's Svekofennian Block

Model	Svekofennian Block	Model	Svekofennian Block	Model	Svekofennian Block
2,860	2,850±0(2)	2,500	2,460	2,060	2,060
2,820		2,400		2,000	1,990±0 (5)
2,780		2,350			**1,960±10 (37)**
2,740		2,280			1,900±10 (7)
2,700	2,710	2,240	2,250	1,850	1,880±10 (26)
2,650		2,200	2,200	1,800	**1,800±10 (8)**
2,600		2,150	2,130	1,750	1,770
2,550		2,120	2,110		

It can be assumed that, by processing all dating results for the Kola-Karelian block listed in the publication (The Early History…., 2005), we managed to identify 43 episodes of the block's activation (**Table 3**). The overwhelming number of them (38) match age determinations obtained with the help of simulation procedures, with deviations not exceeding those that can be accounted for by experimental errors. In three cases, there are no analogues in experimental data to available simulation activations. Probably, rocks involved in those activation cycles have not survived or have not yet been discovered. A serious problem arises from the fact that two batches of experimental age determinations have been identified with a high degree of confidence, while relevant computed data contain no analogues to them. The point is that, in modelling, the onset of activation (a heat and mass transfer event) should be completely a function of the accumulation of the required energy and partial melting within a considerable depth range. At the same time, certain differences in time spans between neighboring activations established through modelling and those based on experimental data appear to be quite permissible. Yet, with a sufficiently good agreement between the total number of activations in the Early Precambrian Baltic Shield and observed evidence, a "superfluous" experimentally established event needs to be given a special explanation.

In the Azov block of the Ukrainian Shield, such "superflous" dating results at the boundaries with the Donets Basin and the Scythian plate were accounted for by the emergence of quanta of tectonic action (QTAs) in the Late Precambrian and Phanerozoic involving the mantle beneath regions adjacent to the relatively small block in whose own tectonosphere energy reserves had already been depleted so that they were no longer capable of triggering such frequent heat and mass transfer episodes (Gordienko et al., 2005). This explanation does not hold water for periods of 2,450 and 1,950 million years ago on the Baltic Shield. It is also hard to accept an alternative explanation according to which the absence of activations commensurable in terms of age with those obtained through modelling in a certain stretch of the time scale is balanced out by the presence of “excessive” activations in another stretch of the time scale. The time gaps between “skipped” and “excessive” episodes of heat and mass transfer are too long to enable an outburst of the “stockpiled” energy in the form of an additional process. As established in the course of simulation (see above), active processes, since about 2.5 million years ago, have not simultaneously encompassed the entire shield. They have occurred within separate relatively narrow blocks. Experimental data do not contradict this computed estimate. An analysis of information pertaining to parts of the Kola-Karelian block suggests that ages of about 2,45 and 2,4 million years have been established in different places and that, in all likelihood, a single activation took place, but not exactly at the same time. The impression of two consecutive processes was begotten in the course of drafting a unified dating scale for the entire Kola-Karelian block.

Table 7. Average values of ages (in millions of years) of active events in the Proterozoic within parts of the Kola-Karelian block of the Baltic Shield.

Model	Kola-Karelian block			
	Fenno-Karelian Region	White Sea Belt	Laplandian Belt	Kola-Norwegian Province
2,500	2,490		2,470	2,500
2,400	2,430	2,440	2,390	2,440
2,350	2,370	2,360	2,360	2,330
2,280			2,280	
2,240			2,240	
2,200	2,210		2,210	2,210
2,150			2,160	
2,120	2,120		2,110	2,120
2,060	2,050		2,050	2,040
2,000	1,990			1,990
	1,940	1,930	1,950	1,950
1,850	1,870	1,880	1,880	1,870
1,800	1,790			
1,750	1,770			1,750

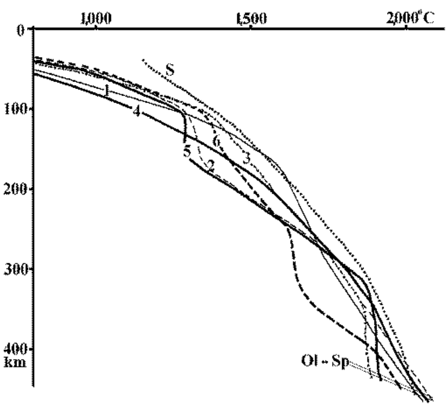

Fig. 7. Distribution of temperatures in the shield’s tectonosphere prior to activations: 2,500 (1), 2,000 (2), 1,950 (3), 1,850 (4), 1,800 (5), and 1,750 million years ago (6).

Experimental dating of about 1,950 million years ago was established alongside the preceding one (2,000 million years ago) in the Kola-Norwegian and Finno-Karelian parts of the block. In the former case the areas of dating coincide (Pechenga), but the age was determined with an error of 40-50 million years (The Early History…, 2005). In the latter case the sites where datings were conducted do not coincide, and it can be assumed that in the area where the estimate of 1,950 million years ago there had been no earlier activation. In the White Sea and Laplandian belts no preceding activations (aged 2,000 million years or older) have not been established. It could be reasoned that activation aged 1,950 million years in the areas in question followed the activation aged 2,060 million years or more. This conclusion would not be necessarily correct: The absence of known dating results does not point to the absence of activation.

If, however, the dating results in Pechenga do point to the presence of two activation events (2,000 and 2,050 million years ago) at the same site, it might be worthwhile considering the question of feasibility of such a course of events for the specific time span. Let us calculate thermal evolution of the 100 km-wide block's tectonosphere during the period between 2,100-1,750 million years ago.

This procedure could make sense since a single-episode advection in the upper mantle might well be two-levelled. The material from the lower levels of the upper mantle is transported to a depth of about 200 km, and there a new QTA forms before traveling to beneath the crust. It cannot be ruled out that its contribution might have saved a certain amount of energy so as to enable triggering an additional episode of the tectonospheric material transfer.

Calculations detected a zone of partial melting suitable for a single-episode activation at the depths of about 150-200 km by the time of 2,050 million years ago (**Fig. 7**). During the period of 2,000 million years ago, a partial melting zone is detected at the very bottom of the upper mantle, at the depth of about 380-470 km. Around 1,950 million years ago the partial melting zone was absent, but in the time span of about 90-140 km, the temperature differs from solidus by an average of 40^{o}C, which hardly exceeds the calculation error. If we assume that such conditions are favorable for the start of advection, then 100 million year later, there will emerge yet another small zone at the bottom of the upper mantle with temperatures higher than solidus (**Fig. 7**), a zone suitable for heat and mass transfer. About 1,800 million years ago, the temperature distribution throughout the upper mantle did not exceed solidus, but at the depths of 300-350 km it differed from solidus by just 30^{o}C. As the process continued toward 1,750 million years ago, the location where the temperatures of the mantle and solidus converged (the average difference being 70^{o}C) is spotted at the depths of 80-130 km.

Thus, activations within time periods envisaged by the basic model are difficult to reconcile with an additional episode of heat and mass transfer. In all likelihood, this estimated event should be dismissed as unrealistic. Variation in magnitude of radiogenic heat generation within reasonable limits is unlikely to fundamentally affect the situation, all the more so since there are no grounds for such an assumption: During the preceding period, a long sequence of dating results matching experimental ones was obtained, something which is impossible had there been a considerable error in the choice of a heat generation (HG) rate.

DATA CONTROL FOR CONTINENTAL SHIELDS

In addition to the aforementioned data for the Baltic Shield (BSh), information on the parameter t for the Canadian Shield (CSh) was used, as well as certain information on the territory of Greenland, Precambrian massifs of the Siberian Platform (SP), Guiana and Brazilian shields of the South American Platform (SAP), and the African Platform (AfP) (this combines the Nigerian-Mozambique and South African shields, the data for which are particularly abundant). It is shown that the much less abundant data for other shields of the continent are not at variance with those established for the AfP, for the Indian Shield (ISh), Sino-Korean Shield (SKSh), as well as for the Precambrian regions of the Australian (AP) and Antarctic (AnP) platforms. The location of regions (except for Antarctica's massifs free from ice) is shown in **Fig. 8**. Not included in the analysis are only the data for Precambrian rocks inside the majority of folded Phanerozoic areas. The relevant information (for the Appalachians, Cordilleras, Andes, etc.) does not contradict the data for adjacent shields, but in each particular case it is represented by relatively small data package largely pertaining to the Proterozoic.

It is noteworthy that the absence of contradictions between activation ages based on models and experimentally established dating results for rocks of the so far poorly studied Mid-Atlantic Ridge Precambrian basement within the age interval of 2.6-0.6 billion years ago was also shown before (Gordienko, 2014).

Thus, the material used appears to be quite adequate for substantiating the conclusion on applicability or non-applicability of the proposed approach to explaining known dating results. However, the reliability of the results of comparison is largely determined by the error t on which the possibility of pinpointing practically synchronous events depends.

This problem was earlier analyzed, on the qualitative level, by the authors of a generalizing study (Tugarinov et al., 1970): "It is likely that there may not have been exact synchronism between tectonic events that took place on different continents over the same period of time that we have selected. Within the limits of present-day accuracy of measurements, however, they can be presumed as synchronous" (Tugarinov et al., 1970, p. 378).

To assess the error in a single determination of the age of rocks, about 500 values of errors (Δt) cited in publications were used. They are listed in the form of a histogram in **Fig. 9** and encompass data for all regions over the entire period in question.

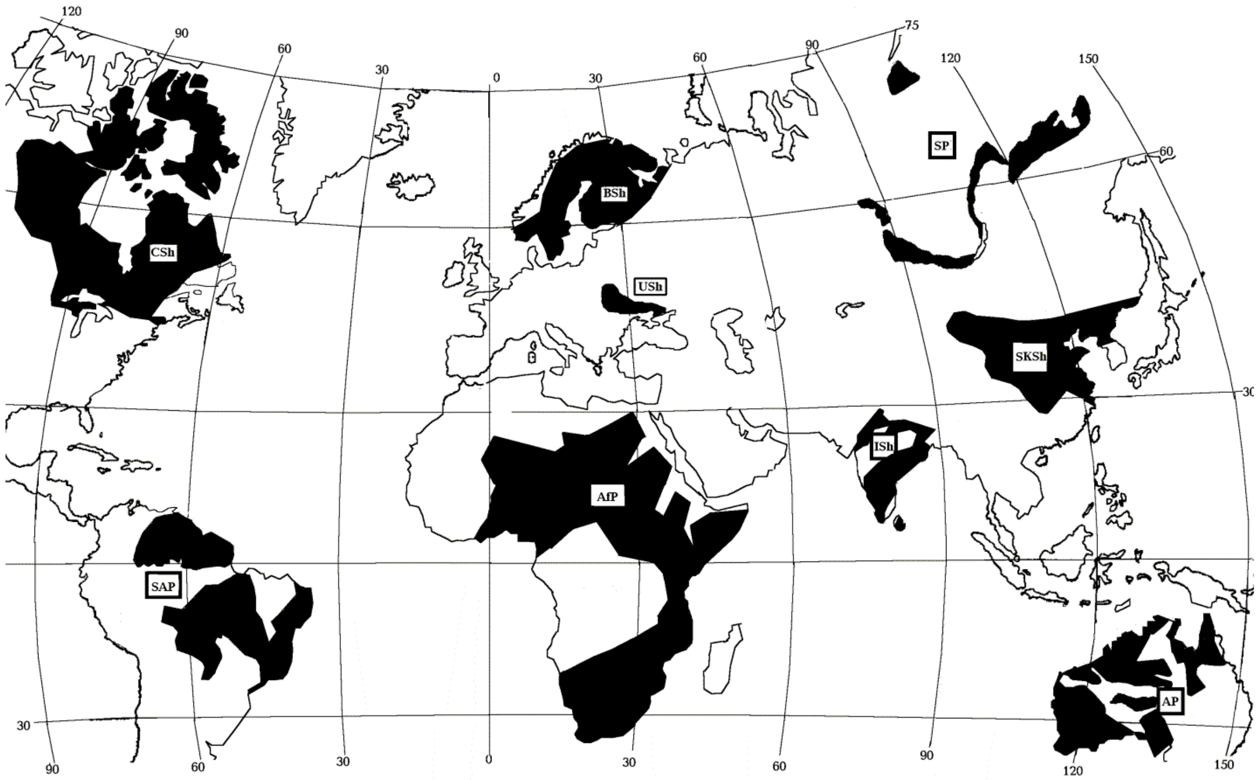

Fig. 8. Locations of Precambrian rock massifs the data on which have been used in this paper.

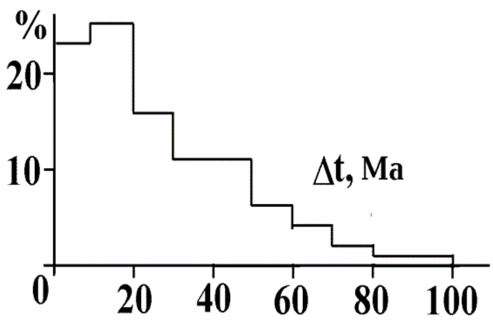

Fig. 9. Histogram showing distribution of errors in the determination of Precambrian rocks' age (Brown, 1970; The Early History…., 2005; Encyclopaedia, 1980; Gondwana Research; Khain, 1971, 1977, 1979; Precambrian….. 1968, 1976a, 1976b, 1977; Precambrian Research; Ryabchikov et al., 2002; Semikhatov, 1974; Smelov et al., 2006; Taylor et al., 1988; Tugarinov et al., 1970; Vernikovsky et al., 2006).

A typical error amounts to about 15 million years (i.e., it is somewhat larger than listed above for the Baltic Shield), but the distribution does not correspond to normal distribution, and therefore, this value can only be viewed as a minimal assessment of the error. Sample arrays comprising 5 to 10 or more values must include corresponding amounts of ages determined with errors two to three times larger. Consequently, in such cases groups of values with mean deviations from the average amounting to 20 million years can be viewed as pertaining to the same event.

In line with this assessment, the following in the consecutive series of t for the given region, including all known (more specifically, all those included in the analysis) values were identified as characteristic of an individual event.

1. Nonrepetitive (random) dates separated from neighboring ones on the time scale by at least 20 million years and recurrent (coincident) dates with the same parameters.
2. Average dates in groups where all values differ from average ones by no more than 15 million years.
3. Average dates in relatively large groups of data with deviations from average values by up to 20 million years. It should be taken into account that the magnitude of deviation could be associated not just with the error in the determination of the parameter, but also with certain differences in the actual ages of events in a single stage of tectonospheric activation in different areas of the region, which are in many cases separated by hundreds of kilometers.

Tables 8-17 summarize results of comparison between simulated and experimental data (in millions of years) for the Precambrian rock massifs listed above. ***M*** designates simulated (estimated) date; shown in parentheses is the number of t values in the group, provided that the number is larger than one.

Table 8. Comparison between simulated and experimental dating results for the Canadian Shield (CSh) Precambrian rocks

M	CSh	M	CSh	M	CSh
3,800	3,800±0(2)	3,140	3,150	2,240	2,240± 10(3)
3,770		3,100		2,200	2,190±0(3)
3,740		3,070	3,080±0(3)	2,150	2,160±10(3)
3,710	3,700±0(2)	3,040	3,040	2,120	2,110± 10(3)
3,680		3,010	3,000±0(2)	2,060	2,060±10(4)
3,650		2,980	2,980±10(2)	2,000	2,000±10(8)
3,620	3,620	2,940	2,940±10(2)		1,910±20(5)
3,590	3,590±10(2)	2,900	2,910±10(2)	1,850	1,850±20(20)
3,560	3,550	2,860	2,850±10(2)	1,800	1,800±10(12)
3,530		2,820	2,820±10(3)	1,750	1,750±20(20)
3,500	3,500±10(4)	2,780	2,780±10(3)		1,650 ±20(15)
3,470		2,740	2,740±10(7)		1,560±20(13)
3,440		2,700	2,700±10(11)	1,480	1,470±20(13)
3,410	3,410±0(2)	2,650	2,650±10(10)	1,350	1,330±20(8)
3,370		2,600	2,600 ±10(9)	1,250	1,260± 20(9)
3,330	3,350	2,550	2,550±10(10)		1,180±20(11)
3,300	3,300±0(3)	2,500	2,480±20(8)	1,100	1,080 ±20(19)
3,270	3,250	2,400	2,420±20(14)	950	960±20(8)
3,230	3,220	2,350	2,350±10(4)	790	770
3,200	3,200±0(2)	2,280	2,290±10(5)		670±20(4)
3,170				600	600 ±20(4)

Fig. 9. Comparison between simulated and experimental dating results for the Baltic Shield (BSh) Precambrian rocks

M	BSh	M	BSh	M	BSh
3,710	3,700	3,070		2,200	2,210±0 (5)
3,680		3,040	3,030	2,150	2,160
3,650		3,010	3,010±10 (2)	2,120	2,120±10 (6)
3,620		2,980	2,980±10 (4)	2,060	2,050±10 (9)
3,590		2,940	2,940±10(11)	2,000	1,990±10 (7)
3,560		2,900	2,900±10 (5)		1,940±10 (18)
3,530	3,530	2,860	2,860±10 (27)	1,850	1,860±20 (15)
3,500	3,510±10 (3)	2,820	2,820±10 (25)	1,800	1,790±20 (8)
3,470	3,470	2,780	2,780±10 (34)	1,750	1,740±10 (4)
3,440	3,440±10 (2)	2,740	2,740±10 (23)		1,610±20(14)
3,410	3,410±0 (3)	2,700	2,700±10 (48)		1,550±20 (6)

3,370		2,650	2,650±10 (25)	1,480	1,480±20 (5)
3,330	3,330±10 (4)	2,600	2,590±10 (7)	1,350	1,330±20(3)
3,300		2,550	2,540±10 (5)	1,250	1,230±20(7)
3,270	3,250±10 (3)	2,500	2,490±10 (15)	1,100	1,120±20(8)
3,230	3,230±10 (6)		2,440±10 (15)		1,060±20(5)
3,200	3,210±0 (5)	2,400	2,400±10 (4)	950	960±20(20)
3,170	3,160±10 (2)	2,350	2,350±10 (4)		850±10(6)
3,140	3,140±10 (2)	2,280	2,280±10 (3)	790	780±20(3)
3,100	3,100±0 (3)	2,240	2,240±10 (2)	600	600±20(6)

Table 10. Comparison between simulated and experimental dating results for the Ukrainian Shield (USh) Precambrian rocks

M	USh	M	USh	M	USh
3,680	3,680±0(2)	3,010	3,010±10(6)	2,000	2,000±10(18)
3,650	3,650 ±0(5)	2,980	2,980±10(5)		1,950±20(12)
3,620	3,620±10(3)	2,940	2,920	1,850	1,880±20(4)
3,590	3,600±0(3)	2,900	2,900±10(9)	1,800	1,800±0(7)
3,560	3,560	2,860	2,860±10(4)	1,750	1,750±10(7)
3,530		2,820	2,820±10(12)		1,690±10(2)
3,500	3,500±0(3)	2,780	2,790±10(7)		1,580±20(5)
3,470		2,740	2,740±10(3)	1,480	1,460±20(5)
3,440	3,450±10(3)	2,700	2,700 ±10(10)	1,350	1,350±20(3)
3,410	3,400±0(3)	2,650	2,660 ±10(6)	1,250	1,230±20(4)
3,370	3,370 ±20(3)	2,600	2,600±0(9)	1,100	1,100±0(2)
3,330		2,550	2,550	950	900±0(2)
3,300	3,310 ±10(10)	2,500	2,500	790	770
3,270	3,270±10(4)	2,400	2,430±10(4)	600	650
3,230	3,250	2,350	2,340±20(5)	400	380±10(2)
3,200	3,190±10(3)	2,280	2,290±10(5)	200	250
3,170	3,170±10(4)	2,240	2,240±0(2)		70
3,140	3,140±10(7)	2,200	2,200±0(3)	0	5
3,100	3,100±0(7)	2,150	2,150 ±10(10)		
3,070	3,070±0(5)	2,120	2,110 ±10(9)		
3,040	3,040±10(5)	2,060	2,060±10(15)		

Table 11. Comparison between simulated and experimental dating results for the Siberian Platform (SP) Precambrian rocks

M	SP	M	SP	M	SP
3,500	3,500	2,900	2,910±10(2)	2,000	2,000±10(7)
3,470		2,860	2,860±0(2)		1,930±20(18)
3,440		2,820	2,800	1,850	1,860±20(17)
3,410		2,780	2,770	1,800	1,810±20(8)
3,370		2,740	2,750	1,750	1,750±10(11)
3,330	3,350	2,700	2,700±0(3)		1,680±20(8)
3,300	3,300	2,650	2,660±10(2)		1,580±10(3)
3,270	3,250	2,600	2,600	1,480	1,500±20(7)
3,230	3,230	2,550	2,550		1,400±0(4)
3,200	3,200	2,500	2,490±10(4)	1,350	1,330±10(4)
3,170	3,160	2,400	2,410±10(4)	1,250	1,250±20(9)
3,140		2,350	2,350±20(2)	1,100	1,100±20(14)
3,100	3,100±0(4)	2,280	2,300±0(3)	950	960±20(6)
3,070		2,240	2,240±10(2)		870±20(10)
3,040		2,200	2,200±0(3)	790	790 ±20(15)
3,010	3,000±0(2)	2150	2,140±10(4)		720 ±20(13)
2,980	2,970±10(3)	2120	2,110±10(5)		640±10(10)

2,940	2,940±10(2)	2060	2,060±20(4)	600	580±10(5)

Table 12. Comparison between simulated and experimental dating results for Precambrian rocks of the South American Platform (SAP)

M	SAP	M	SAP	M	SAP
3,500	3,500±0(2)	2,900	2,900±0(2)	2,060	2,060±20(11)
3,470	3,470	2,860		2,000	2,010±10(10)
3,440	3,450	2,820	2,800		1,960±10(9)
3,410	3,400±0(3)	2,780	2,780±10(2)	1,850	1,860±20(13)
3,370		2,740	2,740±10(2)	1,800	1,800±10(9)
3,330		2,700	2,700±0(6)	1,750	1,750±20(7)
3,300	3,300	2,650	2,670		1,670±20(10)
3,270	3,260±10(2)	2,600	2,600±0(3)		1,530±10(4)
3,230	3,230±20(2)	2,550	2,540±10(2)	1,480	1,490±10(3)
3,200	3,200±0(2)	2,500	2,490±20(4)	1,350	1,350±20(11)
3,170	3,170±10(4)	2,400	2,430±20(3)	1,250	1,210±10(9)
3,140	3,150	2,350	2,350±10(4)	1,100	1,100±20(6)
3,100	3,100±0(2)	2,280	2,300±10(4)	950	980±20(7)
3,070		2,240	2,250±10(3)		890
3,040	3,040±0(2)	2,200	2,200±10(5)	790	780±20(5)
3,010	3,010±10(2)	2,150	2,150±10(7)		670±20(8)
2,980	2,990	2,120	2,120±10(8)	600	570±20(8)
2,940	2,930				

Table 13. Comparison between simulated and experimental dating results for the African Platform (AfP) Precambrian rocks

M	AfP	M	AfP	M	AfP
3,740	3,750	3,070	3,070±10(2)	2,150	2,150±10(3)
3,710	3,700	3,040	3,040±0(3)	2,120	2,110±10(6)
3,680	3,670	3,010	3,000±0(4)	2,060	2,060 ±20(6)
3,650		2,980	2,980±10(3)	2,000	1,990 ±10(9)
3,620		2,940	2,950±10(2)		1,930 ±20(9)
3,590	3,600±0(2)	2,900	2,900 ±0(5)	1,850	1,860±20(8)
3,560	3,560±0(2)	2,860	2,870±10(3)	1,800	1,800±10(10)
3,530	3,530±10(2)	2,820	2,810±10(6)	1,750	1,740±20(7)
3,500	3,500±0(2)	2,780	2,780±10(3)		1,620±20(4)
3,470	3,480±10(3)	2,740	2,740±20(3)		1,530±20(3)
3,440	3,440±10(3)	2,700	2,700 ±10(5)	1,480	1,430±20(3)
3,410	3,410±10(3)	2,650	2,650±10(8)	1,350	1,330±20(5)
3,370	3,380±10(2)	2,600	2,600±10(5)	1,250	1,250 ±20(7)
3,330	3,330 ±10(2	2,550	2,550 ±10(6)		1,200±10(2)
3,300	3,300±10(3)	2,500	2,500 ±10(4)	1,100	1,090±10(7)
3,270	3,260±0(2)	2,400	2,410±20(10)	950	950 ±20(8)
3,230	3,230±10(4)	2,350	2,350±10(4)		850±20(6)
3,200	3,200±0(5)	2,280	2,290±10(6)	790	770±20(6)
3,170	3,180	2,240	2,240±10(3)		670±20(5)
3,140	3,150	2,200	2,200±10(6)	600	570±20(8)
3,100	3,100±0(4)				

Table 14. Comparison between simulated and experimental dating results for the Indian Shield (ISh) Precambrian rocks

M	ISH	M	ISH	M	ISH
3,590	3,600	2,980	2,970	2,060	2,030
3,560		2,940	2,920±0(2)	2,000	2,000

3,530		2,900	2,900±0(2)		1,950±10(4)
3,500	3,500±0(3)	2,860	2,850	1,850	1,870±20(2)
3,470		2,820	2,800±0(3)	1,800	1,810±10(3)
3,440	3,440	2,780		1,750	1,720±20(4)
3,410	3,410±0(2)	2,740	2,750		1,580±20(11)
3,370	3,350	2,700	2,700±10(5)	1,480	1,480±20(6)
3,330	3,330±10(2)	2,650	2,630	1,350	1,350±20(6)
3,300	3,300±0(2)	2,600	2,600±10(3)	1,250	1,240± 20(7)
3,270	3,260±0(2)	2,550	2,560±0(2)	1,100	1,100±20(11)
3,230	3,230±20(2)	2,500	2,490±10(6)	950	970±20(20)
3,200	3,200±0(4)	2,400	2,400±10(5)		890±20(5)
3,170		2,350	2,310±10(3)	790	790±20(8)
3,140	3,120±0(2)	2,280			730±20(4)
3,100	3,100	2,240			670±10(2)
3,070	3,070	2,200	2,200	600	620±20(5)
3,040		2,150	2,140		
3,010	3,000	2,120	2,100±0(3)		

Table 15. Comparison between simulated and experimental dating results for the Sino-Korean Shield (SKSh) Precambrian rocks

M	SKSh	M	SKSh	M	SKSh
3,680	3,670	3,010	3,000±0(2)	2,060	2,060±20(3)
3,650	3,550	2,980		2,000	2,000±10(8)
3,620		2,940	2,950		1,930±20(12)
3,590	3,600	2,900	2,900±0(4)	1,850	1,860±10(16)
3,560		2,860	2,850	1,800	1,800±0(11)
3,530	3,530	2,820		1,750	1,740±20(4)
3,500	3,500	2,780	2,800±0(3)		1,650±20(6)
3,470		2,740	2,740±10(5)	1,480	1,520±20(2)
3,440		2,700	2,700± 0(2)		1,400±0(2)
3,410	3,400±0(2)	2,650	2,650±10(2)	1,350	1,370±10(2)
3,370		2,600	2,600	1,250	1,290±0(2)
3,330	3,340	2,550	2,550±10(5)	1,100	1,160
3,300	3,300±0(2)	2,500	2,500±0(5)		1,020±10(2)
3,270		2,400	2,420±20(5)	950	
3,230	3,240	2,350	2,360±20(3)		880±0(3)
3,200	3,200	2,280	2,300±0(2)	790	780±10(5)
3,170	3,170	2,240	2,240±0(2)		740±0(2)
3,140		2,200	2,200±10(6)		670±20(4)
3,100		2,150	2,160±10(3)	600	600±10(3)
3,070		2,120	2,110±10(5)		
3,040	3,050				

Table 16. Comparison between simulated and experimental dating results for the Australian Platform (AP) Precambrian rocks

M	AP	M	AP	M	AP
3,740	3,750±0(2)	3,070		2,150	2,160
3,710	3,710±10(2)	3,040	3,050	2,120	2,130
3,680	3,680±0(2)	3,010	3,000±0(5)	2,060	2,050±20(3)
3,650	3,650	2,980	2,970	2,000	2,000±10(3)
3,620	3,620	2,940	2,940±10(2)		1,940±10(4)
3,590	3,600±0(3)	2,900	2,900	1,850	1,840±10(6)
3,560		2,860	2,860 ±10(3)	1,800	1,800±10(8)
3,530		2,820	2,810±0(4)	1,750	1,740±10(15)

3,500	3,500±0(3)	2,780	2,780±10(3)		1,660±20(18)
3,470	3,470	2,740	2,740±10(6)		1,550±20(21)
3,440	3,440±0(2)	2,700	2,700±10(12)	1,480	1,480±20(12)
3,410	3,400±0(2)	2,650	2,660±0(5)	1,350	1,350±20(12)
3,370	3,350	2,600	2,600±0(5)	1,250	1,220±20(11)
3,330	3,330±10(2)	2,550	2,550±10(3)	1,100	1,150 ±20(13)
3,300	3,300	2,500	2,480±10(3)	950	980±20(10)
3,270	3,250±0(3)	2,400	2,400±10(3)		900±20(4)
3,230		2,350	2,360	790	790±10(5)
3,200	3,200±0(2)	2,280	2,300		730±10(8)
3,170	3,180	2,240	2,250±0(2)		690±10(5)
3,140	3,120	2,200	2,200±0(2)	600	600±20(5)
3,100	3,100				

Table 17. Comparison between simulated and experimental dating results for the Antarctica Platform (AnP) Precambrian rocks

M	AnP	M	AnP	M	AnP
3,470	3,470	2,900		2,000	2,000
3,440		2,860	2,840±0(2)		1,900±0(2)
3,410		2,820	2,820±10(4)	1,850	1,860±10(2)
3,370	3,380±0(2)	2,780	2,790±10(4)	1,800	1,800±0(2)
3,330	3,350	2,740		1,750	1,740 ±20(8)
3,300	3,300	2,700			1,620±20(8)
3,270	3,270	2,650	2,640±10(2)		1,560
3,230		2,600	2,600	1,480	1,490±10(2)
3,200	3,200±0(2)	2,550	2,540±10(2)	1,350	1,370 ±20(5)
3,170	3,170±0(2)	2,500	2,500±10(9)	1,250	1,270±20(5)
3,140	3,150	2,400	2,420±20(7)	1,100	1,120±20(20)
3,100	3,100	2,350		950	960±20(7)
3,070	3,070±0(3)	2,280	2,300		880±10(2)
3,040		2,200	2,200±0(3)	790	800
3,010	3,000	2,150			700
2,980	2,980	2,120	2,100±0(2)	600	620 ±0(2)
2,940		2,060	2,060±0(2)		

On Precambrian massifs of the majority of continents the recorded part of geological history started from 3.6 to 3.8 billion years ago which matches simulation results. As regards SAP, SP, and AnP, the data of single age determinations of about 3.7-3.8 billion years, separated from main arrays of information by large gaps, have not been shown. Also confirmed is the existence of a pre-geological stage of development as earlier indicated by many authors. In primary clastic rocks of some shields (USh, CSh, AP, ISh, and others) zircons aged 4.0-4.5 billion years have been encountered. They pertain to the period of an unstable crust from which by now no noticeable formations have remained on the erosional truncation. In the majority of cases they are no older than 4.2 billion years.

According to the model, the “territorial all-encompassing” activity on shields became impossible about 2.5 billion years ago. Active events closer to contemporary were viewed as ones that occurred within relatively narrow strips about 100 km in width beyond which simultaneous heat and mass transfer in the mantle was absent over large distances. This estimate agrees with conclusions reached by Tugarinov et al. (1970) on the differentiation of the processes on Precambrian massifs during that period: “Primary cores of practically all contemporary continents took shape directly after the end of the Rhodesian tectono-magmatic epoch (i.e., 2.4-2.5 GA – Gordienko). It is precisely then that relatively large blocks first acquired their distinctive features, and subsequently, geosynclinal zones could no longer be spotted on them….” (Tugarinov et al., 1970, p. 393).

According to modelling results, after 2.0±0.3 billion years ago, alternation of geosynclinal and rifting processes in the tectonosphere of shields gave way to conditions favorable for single-episode activations. This conclusion agrees with the data obtained for various continents: "…. starting from 2,000 million years ago, for the first time in the Earth's history, there emerged platform-type plutons" (Tugarinov et al., 1970, p. 393).

Some of the simulation dating results have no analogs among experimental data. This applies to 15± 5% values greater than 2 billion years and may well be accounted for by insufficient degree of exploration of rocks or their poor state of integrity.

For more recent periods, all estimated dates have analogs among experimentally derived ages. At the same time, there appear values of t which are absent in simulation results. This phenomenon can be explained in the following way (Gordienko, 2009a, 2009b; Gordienko et al., 2005). The permobilic stage in geological history consists in a sequence of geosynclinal and rifting activations separated by time spans which can be correlated in duration with gaps between stages of development of geosynclines or rifts. Activations encompassed the entire future platform. They might in the future be separated (the closer to the Phanerozoic the more frequently) by longer periods of "tectono-magmatic quiescence" in each of the blocks with individual histories of development. In simulation results, this is reflected in the appearance of time gaps without heat and mass transfer 2.5-2.4, 2.0-1.85, 1.75-1.48 and 0.79-0.60 billion years ago. In experimental data, representing generalization of information for many blocks of shields and platforms, such gaps in the dating sequence are absent due to the absence of synchronicity in the processes taking place in various parts of the regions. That is how "extra" t values, as compared with simulation results, appear in **Tables 8-17**.

The above assumption can be verified with the help of data shown in **Fig. 10**.

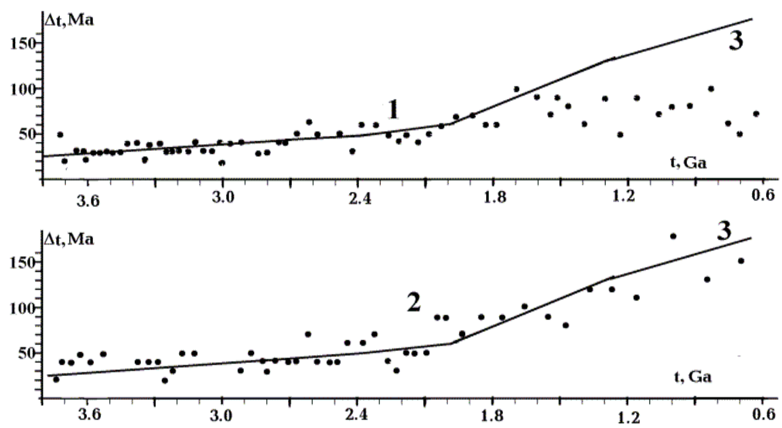

Fig. 10. Time intervals (Δt) between active Precambrian events as a function of rocks' age (t).
1 and 2 – experimental data averaged 1) for shields and platforms; 2) for separate blocks; 3) estimated data

Fig. 10 shows estimated Δt values outside aforementioned intervals that presumably separate cycles of geosynclinal and rifting activity. In the upper part of **Fig. 10**, experimentally derived intervals between periods of activity based on averaged t values from **Tables 7-16** are correlated with estimated Δt. In the lower part of **Fig. 10**, correlated with estimated values are gaps between periods of activity averaged for relatively narrow blocks: The Azov Massif (in the Ukrainian Shield), the Laplandian and White Sea zones (on the Baltic Shield), parts of the Slave Craton (Canadian Shield), and the Yilgarn and Goler shields (Australian Platform). In both cases, agreement has been registered for the permobilic period and for some time after it – until about 1.8-2.0 billion years ago. For younger ages, differences in the geological history of individual blocks are becoming increasingly significant and conformity with estimated Δt values (determined within this time interval precisely for a single block) cannot be reached for the shields in general. Conformity between estimated and experimental data is fairly good if comparison is performed with data for individual blocks.

It was shown in a study by Gordienko (2009b) that thermal energy discharged through radioactive decay of the assumed (platform) level is most likely insufficient to ensure additional heat and mass transfer episode between active periods 2.0 and 1.85 billion years ago. This process could only occur in those blocks in which there had been no event aged 2.0 billion years. Later, the time of heat generation (HG) decreases and intervals of about 50 million years between activations are all the more unrealistic. Let us consider the possibility of coming across “extra” dating values in individual blocks of Precambrian platforms within the period of 1.8-0.6 billion years ago provided that one of the estimated activations whose age is listed in Tables 8-17 (**Fig. 11**) is missing.

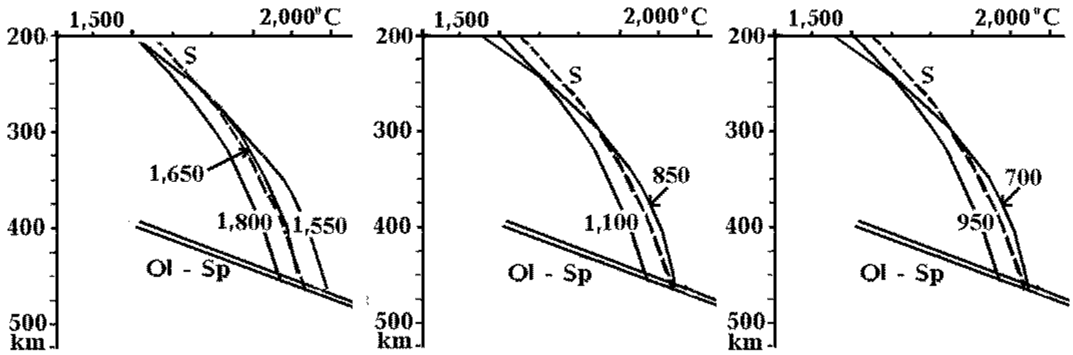

Fig. 11. Estimated temperatures in the upper mantle for Middle and Late Proterozoic. Numbers next to the graphs stand for time in millions of years ago; S is the solidus temperature.

It is obvious that, in the absence of activation 1.75 billion years ago, a process 1.65 billion years ago becomes possible (in other words, a thick zone of partial melting emerges, a zone capable of becoming a source of material and energy for a heat and mass transfer event to be triggered). If this does not happen, then, 100 million years later, there will be enough stored energy for triggering two active episodes (for example, 1.55 and 1.45 billion years ago). If an activation 0.95 billion years ago is omitted, this would lead to a possible process 0.85 billion years ago, and so on.

HEAT GENERATION (HG) VARIATIONS IN MANTLE ROCKS

The analysis of the geological history of platforms presented in the paper was performed for a specific level of heat generation in mantle rocks. This approach has its limitations. The overwhelming majority of samples studied were collected from the mantle of regions where there was no geosynclinal folding in the Proterozoic. With regard to other samples, nothing certain can be said in this respect.

Two circumstances make it possible to suggest that HG in the mantle of Precambrian platforms may deviate appreciably from the adopted average (0.04 $\mu W/m^3$) over large territories.

1. Expansive zones of reduced heat flows (HF) have been spotted on platforms. In a number of cases those anomalies might be associated with near-surface distortions. One of them is located on the Eastern European Platform, and this author took part in determining some of the low heat flows there. There are reasons to believe that they reflect an anomaly in the deep-seated heat flow (Gordienko et al., 2007) (**Fig. 12**).

Fig. 12. Segment of the HF map for Central and Eastern Europe. HF contours are in mW/m^2

In the southern part of the negative heat flow anomaly near the Ukraine/Belarus border (on the Pripyat Swell), the HF level – about 30-35 mW/m^2 – is by approximately 10 mW/m^2 lower than typical of platforms. The available data on the crustal velocity profile, given the usual type of correlation between seismic wave velocities and heat generation, do not enable us to account for the HF level decrease at normal HF from the mantle. Heat generation in mantle rocks has to be reduced by approximately 20 percent.

An assessment of the tectonospheric thermal history for such a version of HG is described by Gordienko et al (2005). It turned out that, in such a region, during the period of 3.6-0.00 billion years there may have been 16 heat and mass transfer episodes, whereas this number is 49 in a region with normal HG. Contemporary estimated temperatures in the tectonosphere also differ (**Fig. 13**). This difference can be corroborated by comparison between estimated T and the data of geothermometry.

Agreement between estimated and experimental data proves that the approach is valid. Estimated temperatures at the bottom of the upper mantle practically coincide (**Fig. 13**).

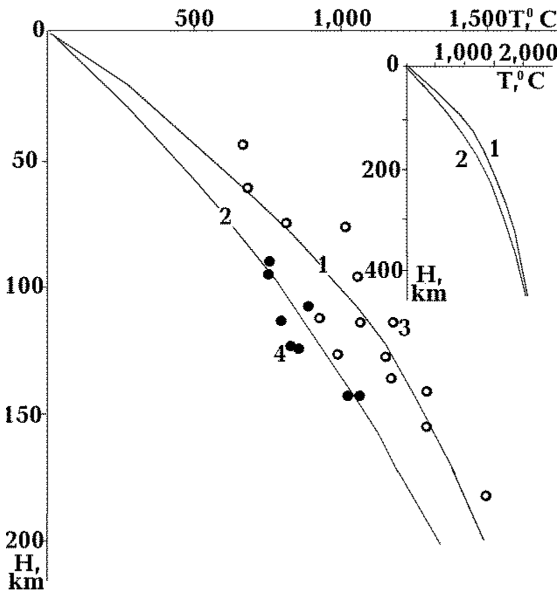

Fig.13. Comparison of estimated temperatures (T) with geothermometry data pertaining to the upper mantle of the Ukrainian Shield and the Pripyat Swell.

Estimated T: 1 – Ukrainian Shield, 2 – Pripyat Swell; Geothermometry data: 3) Ukrainian Shield, 4 – Pripyat Swell

2. Frequently encountered on platforms are regions with HG values at the level of 50mW/m^2. This provides no grounds to believe that heat generation in rocks, which originated in the upper mantle, as

more intensive. Such minor disturbances may have different causes.

As shown above, results of assessments for normal HG in the upper mantle rocks show that geosynclinal processes during the period of 2.4-0.6 billion years ago were unlikely. A total of 19 heat and mass transfer events took place within that period in rift structures and in zones of single-episode activation.

The presence of geosynclinal folded zones of Proterozoic age on large territories of Precambrian platforms is an argument in favor of the existence of regions with more extensive heat generation in upper mantle rocks (**Fig. 14**). Various data point to the existence of six to 12 epochs of folding. Precise determinations based on available information are not possible. Some of the folded zones may be confined to Precambrian massifs within Phanerozoic geosynclinal belts, not all of them overlapping on Precambrian platforms (Bogdanov et al., 1968; Larin, 2012; Stille, 1968; and others). Therefore, closer to the actual picture might be a minimum estimate of the number of geocynclinal cycles. Eighteen episodes of mantle heat and mass transfer during the period of 2.4-0.6 billion years ago are associated with them.

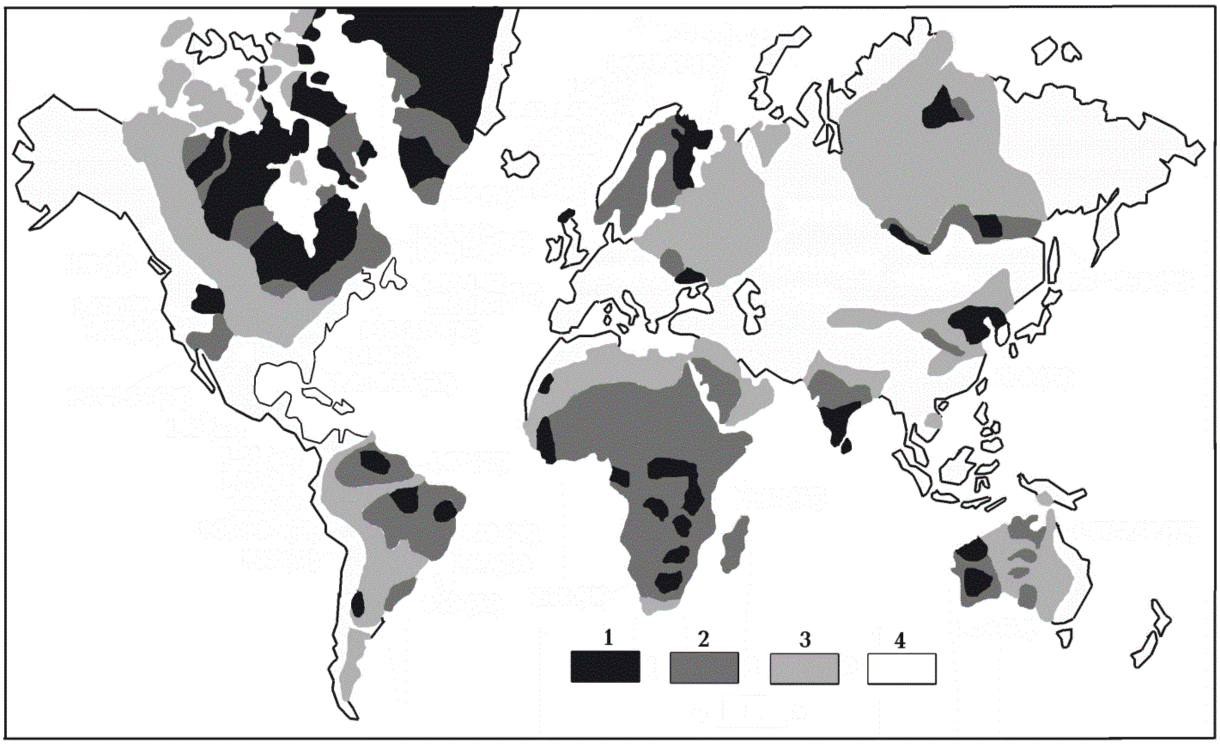

Fig. 14. Map showing location of geosynclines of dissimilar age on continents (Larin, 2012; and others).
Shields: 1 –Archean folded zones, 2 – Archean and Proterozoic folded zones, 3 – Precambrian platforms with sedimentary veneers, 4 – Phanerozoic folded zones

On territories in question, over the same period of time, there occurred at least six stages of formation of platform-type batholiths probably indicating the cessation of the geosynclinal stage in the region's history (Larin, 2012). There is no doubt that after we use results of more detailed studies on those platform blocks, traces of several single-episode activations, probably rifting processes, could be detected. A hypothetical number of heat and mass transfer episodes could come to about 30.

Obviously, the effect of HG variations in upper mantle rocks beneath Precambrian continental platforms is fairly distinct, despite the poor level of knowledge of the problem.

CONCLUSIONS

Thus, correlation between estimated and experimentally established ages of activations in the Precambrian can be considered proven for platforms of all continents. Calculations of thermal history that have been conducted enable us to numerically determine the dates of active events and variations in their characteristics and frequency. The investigation that was carried out is essentially a physical substantiation of Stille's canon.

Acknowlegements: The author wishes to express special thanks to Mrs. Rita Schneider for translating this paper from Russian.

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"ICE" (PLUTO) AND "FLAME" (SUN): TECTONIC SIMILARITIES OF DRASTICALLY DIFFERENT COSMIC GLOBES

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Abstract: Comparative wave planetology states that all cosmic bodies moving in elliptical orbits with periodically changing accelerations are exposed to action of warping standing waves of various lengths. The longest fundamental wave 1 divides bodies into two segments-hemispheres: uplifting and subsiding ones. This dichotomous tectonics manifests themselves in bodies of various sizes, masses, compositions, and inner energies. The most contrasting cases are the smallest icy planet – Pluto and enormous gaseous boiling globe – Sun. The first overtone wave 2 divides bodies into hypsometrically different tectonic sectors also well observable on surfaces of both globes. "Orbits make structures" also means that tectonic granulations, sizes of which are proportional to orbital periods, are detected on both bodies. The most important structuring energy is the external orbital energy.

Keywords: *Sun, Pluto, elliptical orbits, tectonic segments, sectors, granules*

Introduction

Comparative wave planetology states that due to moving all celestial bodies in keplerian non-round orbits with changing accelerations are warped by waves. The waves have standing character, intersecting ortho- and diagonal interfering directions and various lengths. The waves and their produced tectonic blocks manifest themselves in bodies of various sizes, states and compositions. That is why a comparison of such very different cosmic bodies – a small icy planet and giant gaseous star – is very impressive. Intensive scientific observations currently available for Sun and Pluto (brilliant "New Horizons" project data of 2015!) allow to make unexpected comparisons of structural features of these drastically different bodies. Moreover, the discovered similarities may build useful bridges between two natural sciences: planetology and helioscience.

Methods and materials

Immense geophysical materials and images of all cosmic bodies of the Solar system obtained by numerous cosmic projects of USA, Russia, European countries, Japan and China are used to describe observations in this article. Particularly, important information comes from the magnificent cosmic project NASA "*New Horizons*" showing us the farthest up to now and smallest and coldest planet lacking inner energy and having the richest relative tectonics and geomorphology (Stern et al., 2015).

Results and discussion

The main point of the comparative wave planetology (Kochemasov, 2012 and 2015) is a notation: "Structures of celestial bodies are functions of their orbits" or "Orbits make structures". In more detailed form this notion can be unfolded into the following theorems: 1. Celestial bodies are dichotomous; 2. Celestial bodies are sectoral; 3. Celestial bodies are granular; 4. Angular momenta of different level blocks tend to be equal; 5. Celestial body tends to make equal angular momenta of equatorial and out of equator zones by regulation of masses and distances to the rotation axis (Kochemasov, 2012 and 2015). Tectonic dichotomy or "wave 1 –structure" or "2πR-structure" is easily observed on Earth, Moon, and Mars as an opposition of pressed in subsided segments (hemispheres) and bulging out antipodean uplifting segments (hemispheres). Small celestial bodies such as satellites and asteroids represent this regularity even more vividly: they have an oblong convexo-concave shape (often shape of a bean). Sectoral structures (πR- or wave 2-structures) complicate the fundamental dichotomous shape by sectors-facets – regularly disposed subsided and uplifted tectonic blocks.

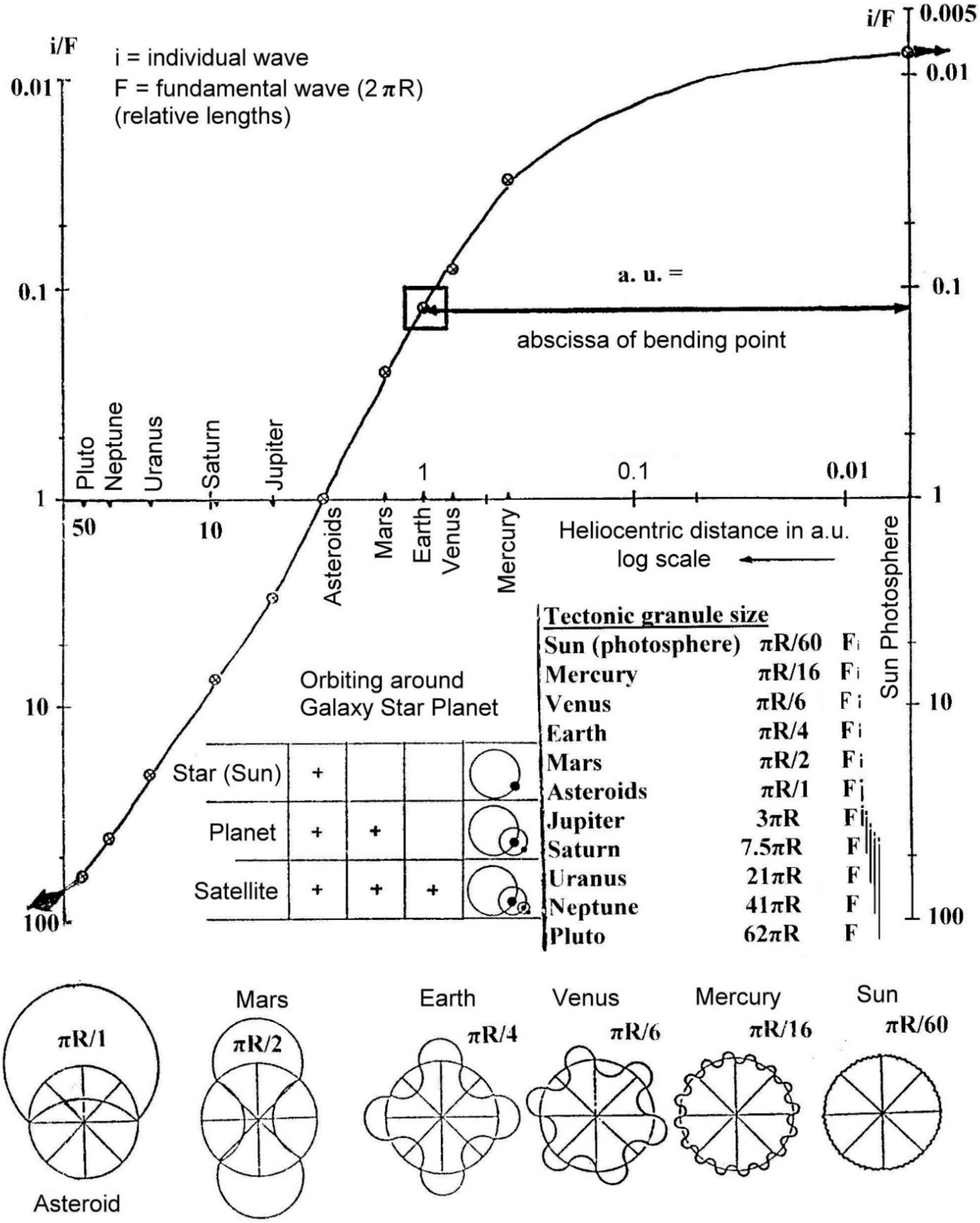


Fig. 1. Cosmogonic curve (two logarithmic). In the lower part, geometric representation of tectonic granulations from Sun to asteroids.

Tectonic granules, size of which is inversely correlated with orbiting frequencies of celestial bodies (**Fig. 1**), usually are observed on surfaces as equally sized shoulder-to-shoulder rounded blocks disposed in crossing lines (lineations) and grids. These lineations normally represent traces of standing warping waves of various lengths and having four intercrossing directions (ortho- and diagonal) in rotating bodies. These waves arise in response to moving bodies in elliptical keplerian orbits with periodically changing accelerations

(Kochemasov, 2012 and 2015).

The listed main tectonic principles are universal and equally applied to various cosmic bodies. Comparison of various surface structures of two bodies of the solar system, nearly 5 billion kilometers apart and representing the smallest planetary icy body vs the giant boiling gaseous star, became possible after the very successful NASA's *New Horizons* project (Stern, 2015). A flyby of Pluto on 14 July 2015 gave numerous images of this small frozen globe with surprisingly diverse tectonics and geomorphology. This discovery requires a thorough revision of the modern planetology. It is worth to remark that the first mention of similar structures of icy bodies and gaseous hot giant based on the wave planetology was made earlier by the present author (Kochemasov, 1996).

The main principles of the comparative wave planetology listed above are clearly manifested in recently obtained materials of Pluto. First of all, the dichotomous two face nature of Pluto was seen in its distant images (**Figs. 2-4**). Very bright its northern half rather abruptly changes by black areas along the equator and down to latitudes ~15˚ south. Farther south black areas mildly transfer to some brighter and whiter areas up to the horizon. The southern hemisphere not illuminated by Sun up to now is not characterized by available images. It is known that bright areas are covered by light (not dense) ices and dark areas (most probably depressions) are filled with denser tholines (complex compounds as result of UV reworking of hydrocarbons).

A sectoral structure superimposed on tectonic dichotomy is developed very sharply (**Figs. 5-7**). As on Earth and Mars there is an opposition of slightly different bright sectors (differently uplifted on Earth) separated by dark sectors (differently subsided on Earth). Different compositions of the sectors are obvious in black-and white images but even sharply developed in false color images (**Fig. 6**).

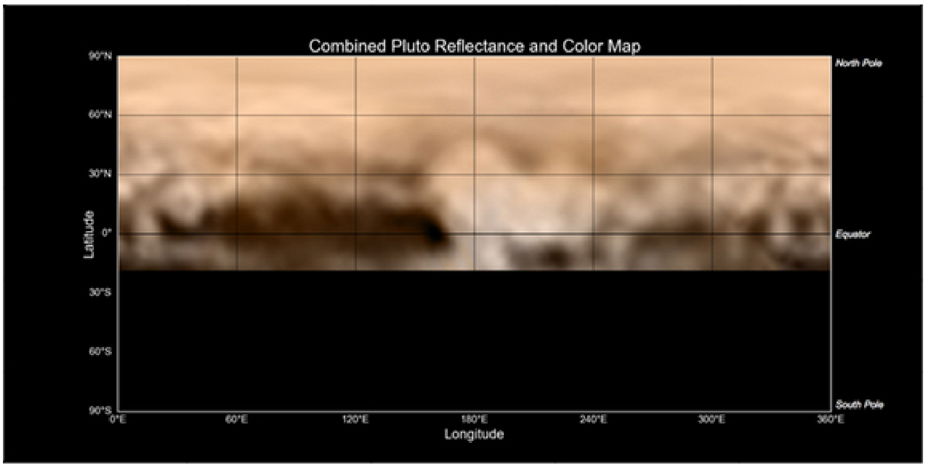


Fig. 2. Pluto. New-horizons-pluto-map. The south dark hemisphere is not mapped.

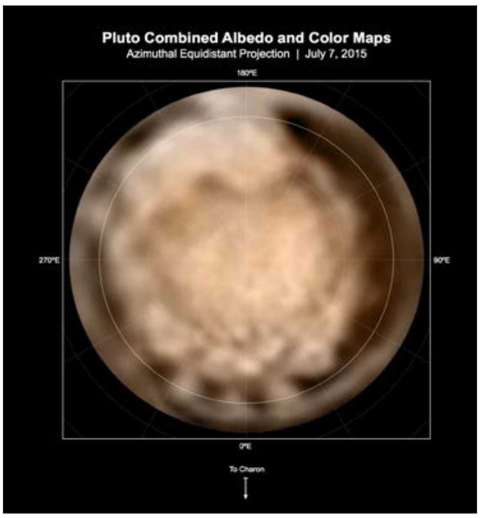
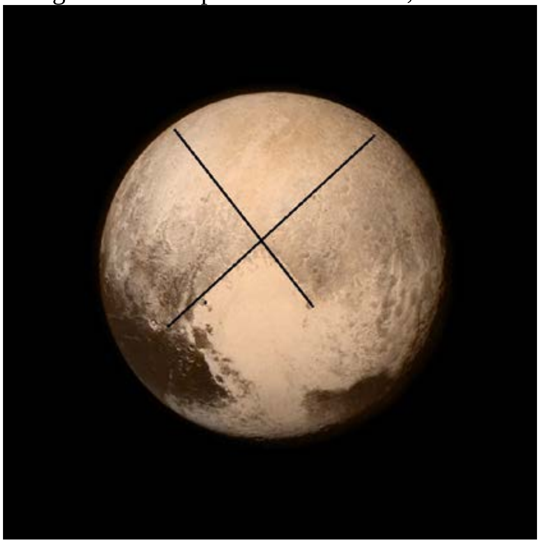


Fig. 3. Pluto map. View from north, PIA19706.

Fig.4. Pluto. 071215_Pluto-Alone.



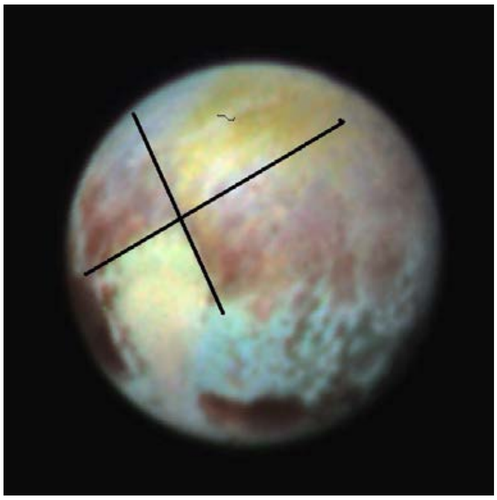
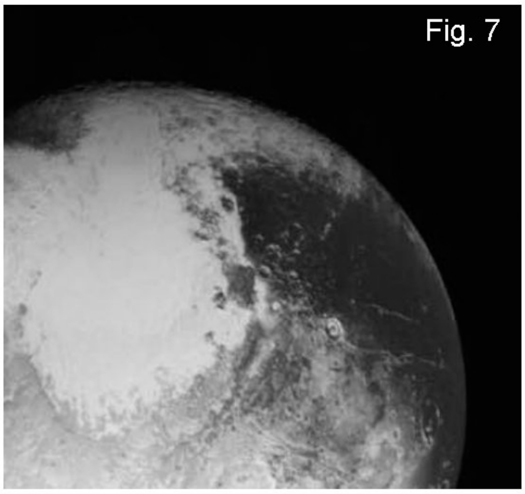


Fig. 5. 150713-Pluto-last-before-flyby-1.

Fig. 6. Pluto, false color, 1340903185541595237.



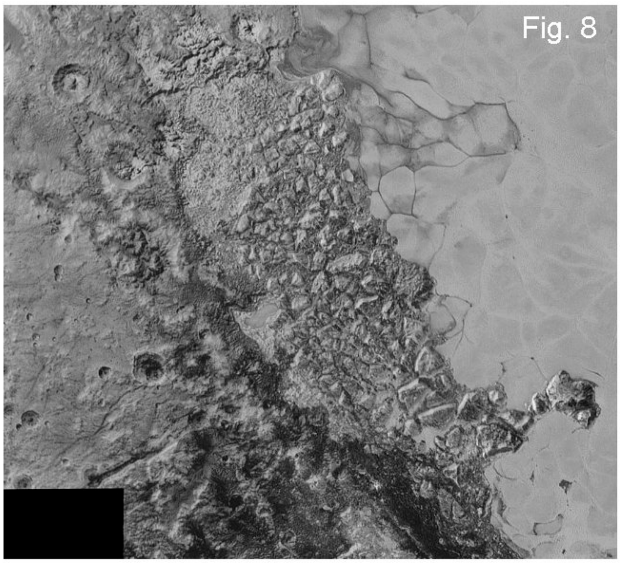
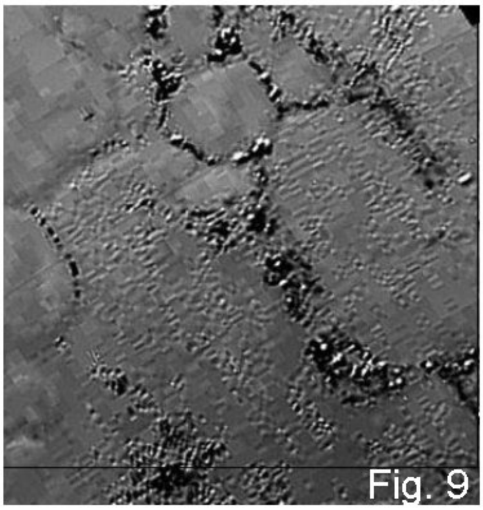


Fig. 7. Pluto. Bright and dark sectors. lor_0299148167_0x632_sci_3.
Fig. 8. Pluto. Bifurcation of icy tectonic granules sizes (about 20 and 0.25 km). 470 km across.



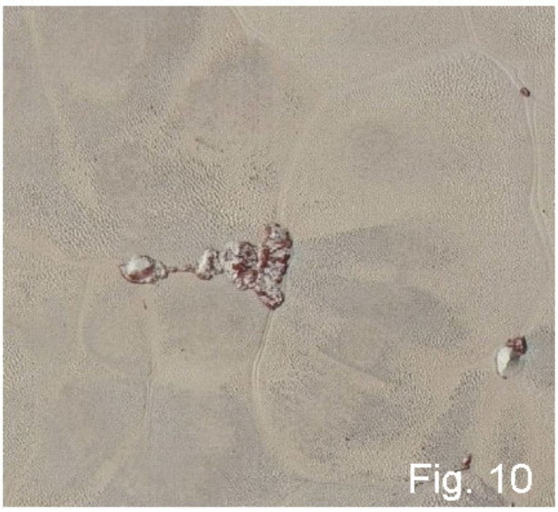


Fig. 9. Pluto. Bifurcation of icy granule sizes. 150714-sputnikplanum-1.

Fig. 10. Pluto. Smallest wave granulation (0.25 km) on icy surface of Sputnik Planum. detail_lorri_rider.

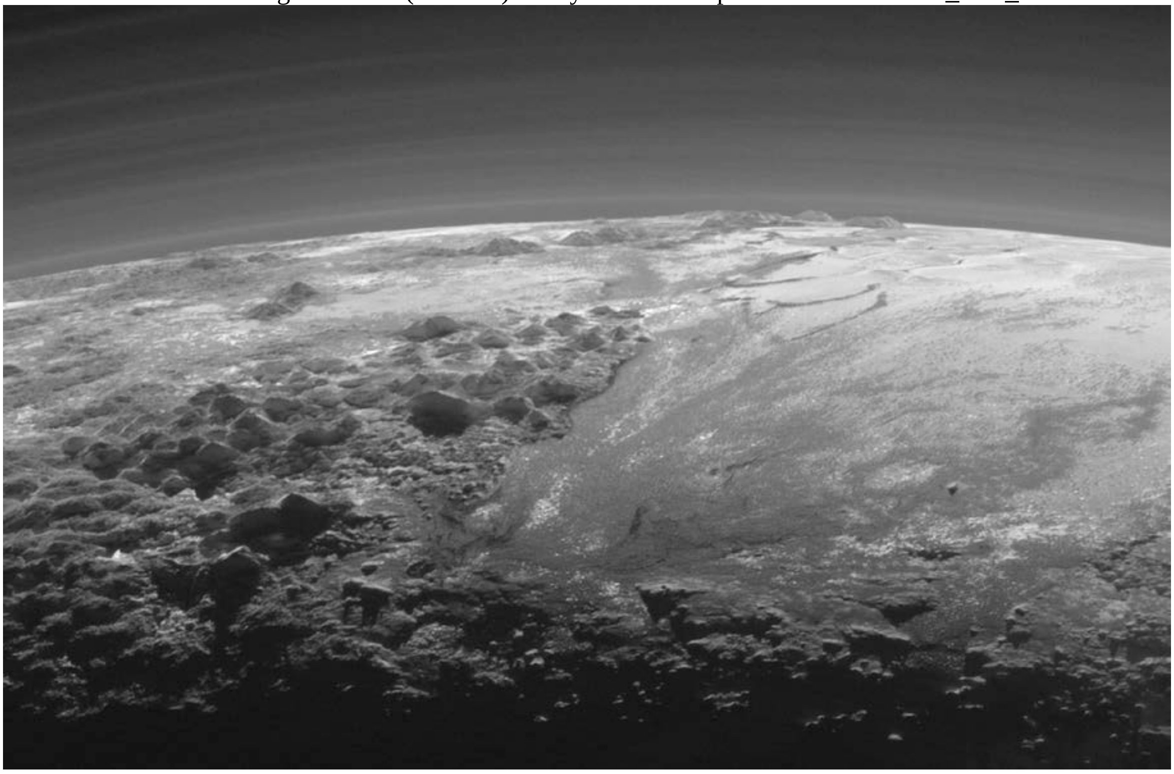
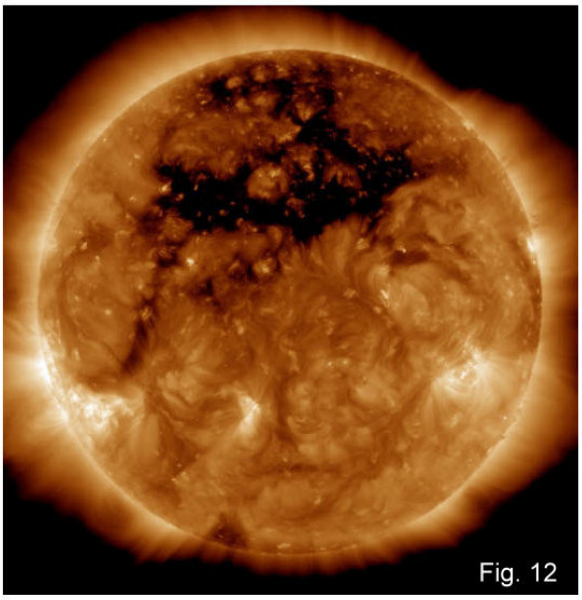


Fig. 11. Pluto. Smooth icy surface of Sputnik Planum sector. PIA19947

Granular tectonics of Pluto superimposed on segments and sectors is characterized by bifurcation of sizes. According to the "granule size – orbital frequency" correlation Pluto's granule size is too big to be observed (**Fig. 1**). But rotation – orbiting with frequency 1/6.39 days around the barycenter of the Pluto-Charon system gives granule size 16.3 km (πR/228). These granules as polygons about 20 km across are visible especially on the brightest and highest sector of Sputnik Planum. Another widespread granule size is about 0.25 km (**Figs. 8-10**). It is calculated by modulation of frequency 1/6.39 days by orbital frequency 1/248 years=1/90465 days to obtain side frequency 1/14157 and corresponding to it granule size 0.263 km.



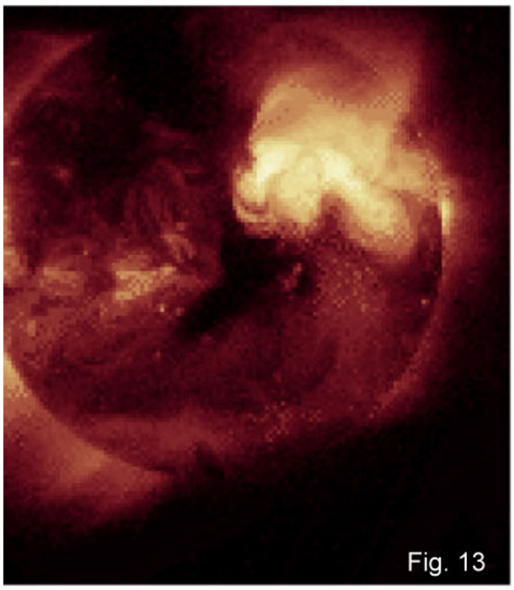
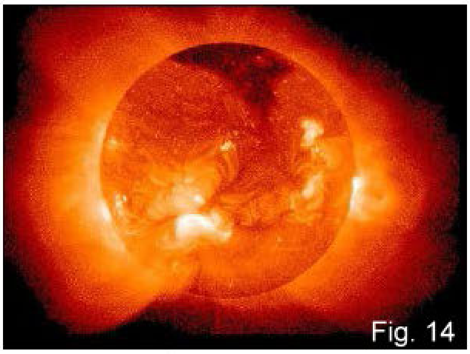
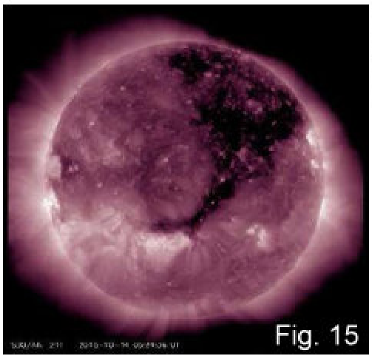


Fig. 12. Sun. Coronal-hole—Oct-10-2015. Difference between NW and SE halves.
Fig. 13. Sun. Xraysun-gif. Phyx 103-0, The Sun. In this photograph, the solar poles are distinguished by a relative absence of supergranulation. Northern and southern halves are different. Two sectors (dark hole and bright) are visible in the northern half.





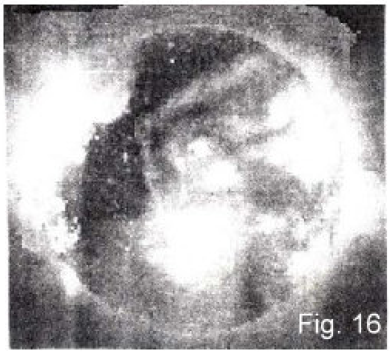
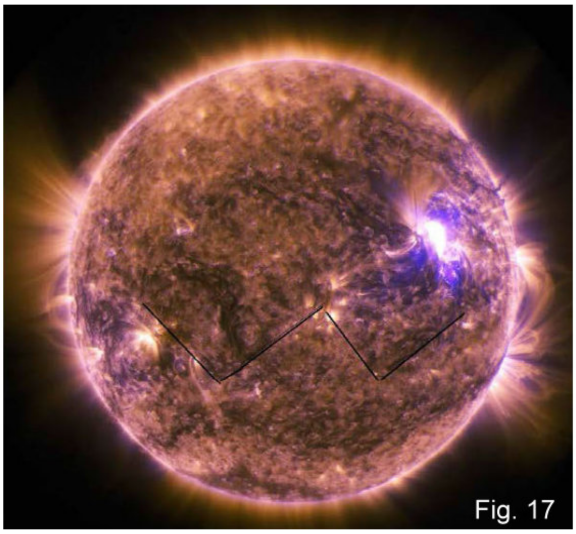


Fig. 14. The Sun in the X-ray band.
Fig. 15. Sun. Sector of “huge-coronal-hole”.
Fig. 16. Sun in line of extra UV, λ=193Å. 10 January 2002. «SOHO» project. Dark sectors.



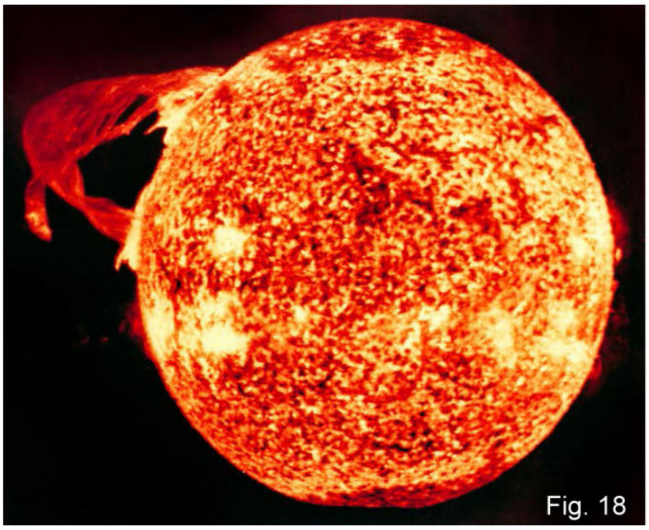
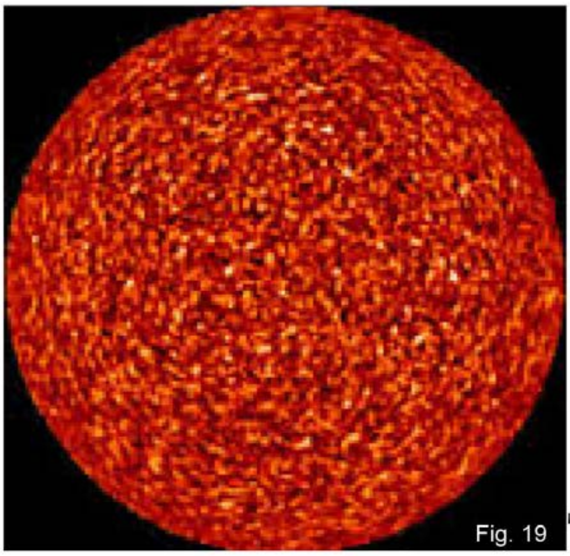


Fig. 17. Sun. 20150625_082600_blend131.171. Sectors outlines.
Fig. 18. Sun’s supergranulation. 74-23458.jpg. Photo-s74-23458, spaceflight.nasa.gov. The photo of the Sun, taken from Skylab on December 19, 1973, shows one of the most spectacular solar flares ever recorded.



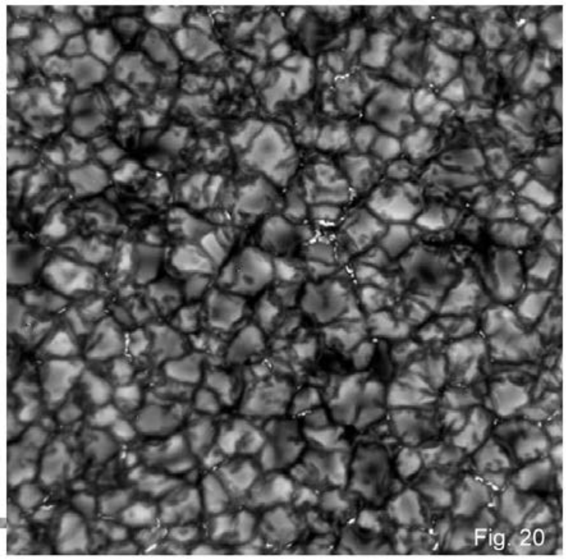


Fig. 19. Sun’s supergranulation. Day Star Filters-Ultra narrow Band, www.daystarfilters.com. Mount Wilson Solar Observatory.
Fig. 20. Sun’s supergranulation. www.ficica.uniroma2.it – High resolution solar photosphere G-band image obtained

by Andrea Ferri. Temperature 6000 K.
Now, one can compare images of the Pluto's structures (**Figs. 2-11**) with the Sun's (**Figs. 12-20**).

In the **Figs. 12-15** the Sun demonstrates rather clear difference between northern and southern hemispheres detected in short waves (X-ray and UV). This witness the dichotomous nature of the giant globe – coronal holes distribution is uneven between hemispheres but changes with time. The "Ulysses" project solar data confirm sharp and deep boundaries between "holes" and adjacent areas even in a such boiling gaseous body (Smith et al., 1995). The cold sectors (coronal holes) are sources of fast metal-poor solar wind, hot sectors, vice versa, radiate slow metal-rich solar wind (Smith et al,. 1995; Kochemasov, 1996). In the **Figs. 13-17** are clearly seen dark sectors having wedge-like outlines and sharp boundaries. In fastly rotating gaseous (plasma) media sectors position is not stable.

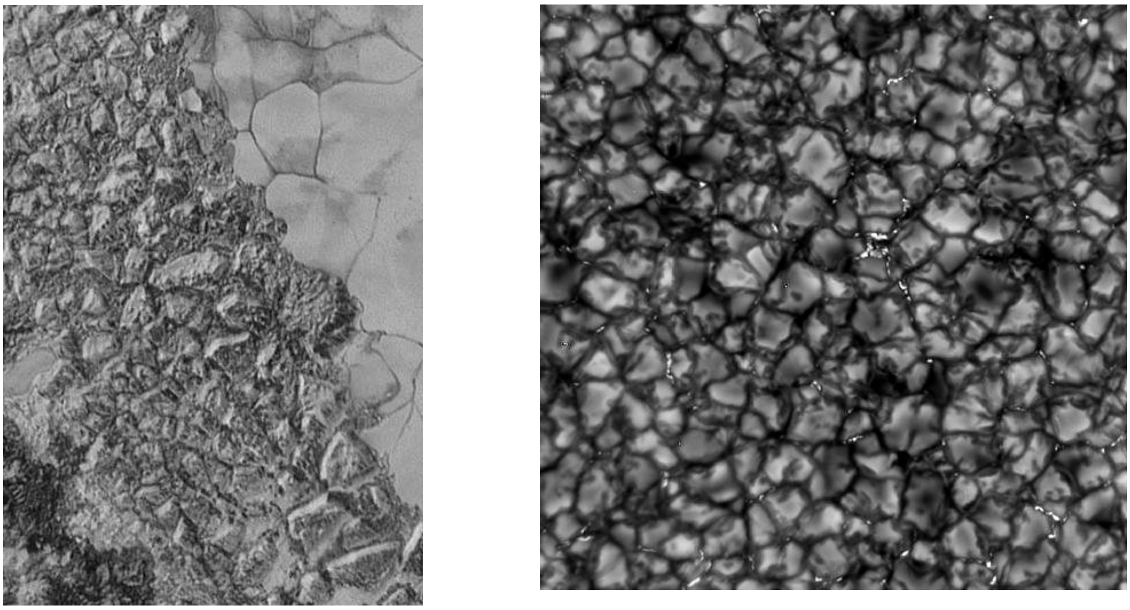


Fig. 21. Comparison of wave born structures of Pluto (left, Fig. 8) and Sun's photosphere (Fig. 20).

The solar supergranulation is a long-known (since 1930s) phenomenon. Its photospheric size about 30 to 40 thousands kilometers ($\pi R/60$) perfectly fits into the correlated sequence of orbital frequencies – tectonic granule sizes (**Fig. 1**). The Sun's rotation period about 1 month (25-36 days) is in this calculation the photosphere orbital period around the center of the solar system.

Conclusion

One style of tectonic organization of such drastically different cosmic bodies as small icy Pluto (R= 1186 km) and the hottest gaseous giant Sun (R= 695,000 km) separated in space by about 5 billion kilometers proves that there is one common structuring principle – the wave structuring. Orbiting energies of bodies moving in keplerian elliptical orbits with periodically changing accelerations are sources of this structuring. This concerns cold small bodies as Pluto almost without inner energy and the giant hot star as our Sun with enormous inner nuclear energy. Shown above solar tectonic features - various sizes blocks influence and structurize giant flux of energy coming outside. Useful structural links between bodies of the Solar system (including Sun) could help in developing theories in several natural sciences: geology, planetology, and heliosciences.

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NORTH TUSCANY (ITALY): A POTENTIAL RELATIONSHIP BETWEEN SEISMIC SWARMS AND VIOLENT RAINSTORMS?

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Abstract: The attempt to associate earthquakes with atmospheric phenomena dates back to the mists of time. The ancient Greeks, including Democritus and Aristotle, attempted several times to link seismic events with torrential rain, eruptions of hot water and violent shifts of air between the subsoil and the atmosphere. A geographically restricted area in North Tuscany (Italy) affected by seismic swarms, like that from 21 June to 1 November 2013, with 2,453 shocks, and struck periodically by catastrophic floods, offered an open-air laboratory to develop a theoretical model that relates distensive tectonics with seismicity and the interaction between variations in atmospheric pressure with that exerted along the fault planes. Conversely, seismically active tectonic discontinuities release gases that interact locally with the atmosphere. It is suggested that the combination of physical processes may generate a feedback system.

***Keywords**: stratwarning, earthquake prediction, Lunigiana seismic area, V-Shaped, seismic swarms*

INTRODUCTION

From 21 June to 1 November 2013, North Tuscany **(Fig. 1**) was struck by a long seismic sequence in the area known as The Lunigiana and Lunigiana zone (**Fig. 2**) with surface hypocentres in an area between the Provinces of Massa and Lucca (Margheriti et al., 2014), featuring 2,453 earthquakes in just under 130 days: 2,422 (Ml<3.0), 26 (3.0<=Ml<4.0), 4 (4.0<=Ml<5.0) and 1 (Ml>5.0).

The epicentre area is part of a region historically prone to earthquakes with maximum macro-seismic intensities, calculated using the Mercalli scale, from the year 1000 onwards, where the epicentres are concentrated mainly in specific areas of the Garfagnana and Lunigiana zone, characterized by active fault systems (graben). Among the highest energy seisms that have occurred near Fivizzano, straddling the Provinces of Massa Carrara and Lucca, mention may made of the earthquakes of 7 May 1481 (M5.6), and 7 September 1920, M6.5 according to INGV catalogue CPTI04, the latter being particularly destructive (Camassi and Stucchi, 1997).

Fig. 1. Index map, the square shows the area under investigation.

Fig. 2. Map of the seismic swarm in the Lunigiana and Garfagnana zone. (see: www.ingv.it/).

From a geological point of view, the seismic sequences of the Garfagnana and Lunigiana confirm the current distensive regime of the Apennine hinterland, along faults of the relay-ramp type with a N-S distension. The distensive regime can be identified from the tectonic valleys of the Vara and Magra Rivers, flanked by portions of the highest landscape, the horsts of the Garfagnana made up of the Apuan Alps and the Apennines. These structural elements are delimited and separated from one another by distensive faults in normal movement (Bernini and Papani, 2002). In the case of the Garfagnana graben, the main fault is the one called “Liguride”, inclined NE by around 30° and extending down to a depth of around 15km. This structure is, on a regional scale, a slip fault, where the lithosphere is in extension NE-SW. It is also associated with secondary opposing faults (inclined SW) that terminate against the main one (Elter et al., 2003; Di Naccio et al., 2013; Boccaletti et al., 2011).

Over the last three years, the area under investigation has been affected by violent floods that have caused landslides, overflows, electricity blackouts, destruction to the tune of millions of Euro, evacuation and also casualties. The violent rainstorms of 10 and 11 November 2012, of the V-Shaped type, released over 200mm of water in around 2 hours, with local accumulations of 300 mm in the hills just behind the city of Massa Carrara. Also the flood of 28 November 2012 caused high rainfall levels: 40mm in 15 minutes, 109 mm in 45 minutes, 134 mm in 60 minutes, and an overall accumulation of 200 mm of water in just under two hours. Equally intense were the rainfalls of 25 October 2011 with 520 mm falling in less than 6 hours (**Fig. 3**).

METHODS and DATA

The study was based on the finding and comparison of data from the websites of the INGV – *Istituto Nazionale di Geofisica e Vulcanologia* (www.ingv.it/), and the *Servizio Idrologico della Regione Toscana* (http://www.sir.toscana.it/).

Seismicity and variation in atmospheric parameters in the area under investigation

Interactions between earthquakes an atmospheric perturbations were studied on a vast scale by Sytinsky (1997). Analogous correspondences between the two phenomena were also observed in the area under investigation, albeit on a reduced scale. One example is the recent seism that occurred on 30 November 2015, whose epicentre was on the coast near Pisa, in north-west Tuscany (www.ingv.it), followed by variations in meteorological parameters (http://daltonsminima.altervista.org/).

Day	Time (UTC)	Lat.	Long.	Magnitude	Depth (km)	Zone
2015-11-30	20:42:44	43.63 N	10.26 E	Ml 2.1	8.0	Pisa

Figure 3 shows the meteorological parameters (temperature, wind and humidity) which underwent an oscillation shortly after the seism had occurred, to then return to following the previous trend, after this variation (http://daltonsminima.altervista.org/).

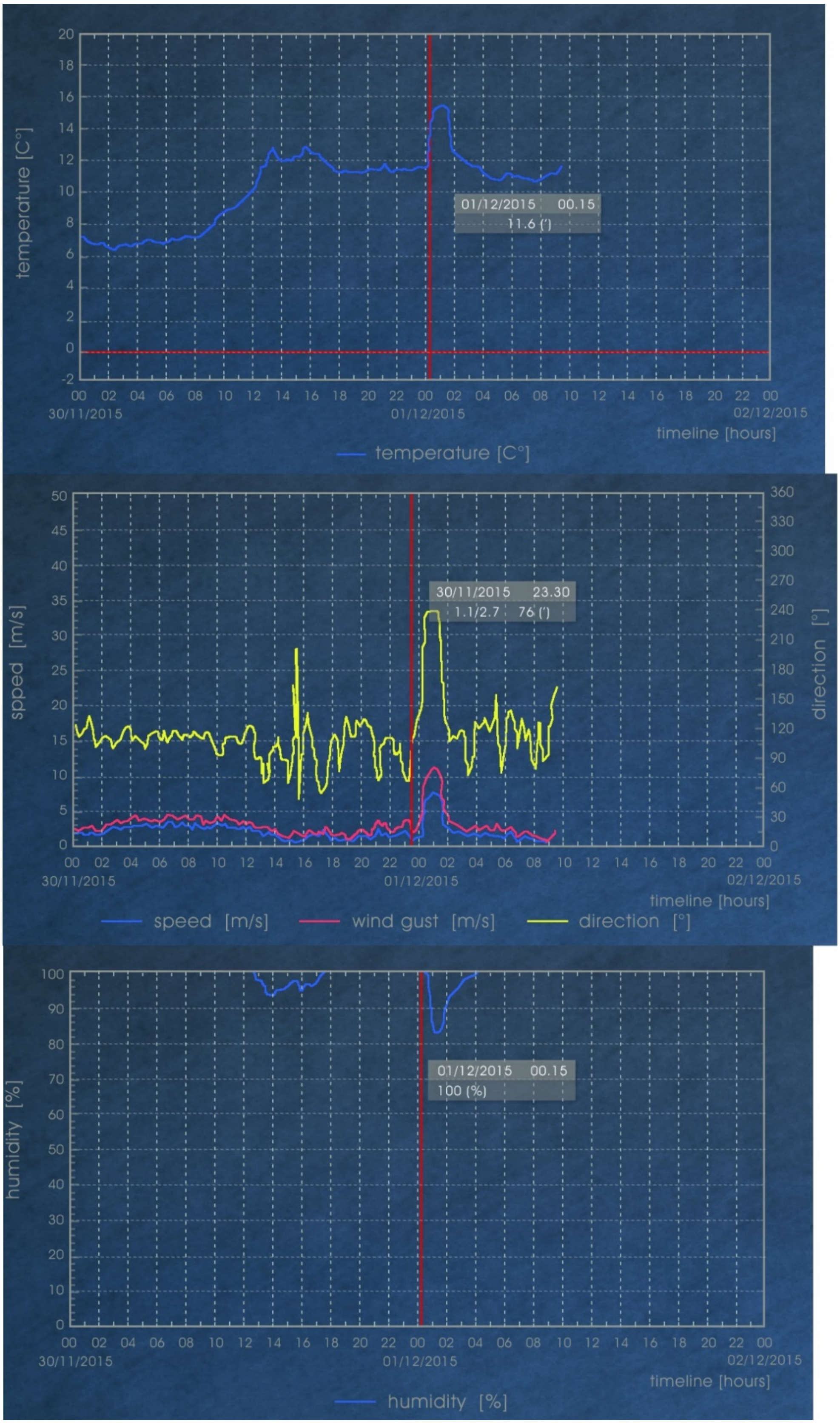

Fig. 3. Variation in meteorological parameters (temperature, wind and humidity) measured in the epicentre area approximately two hours after the earthquake on 30 November 2015. (http://daltonsminima.altervista.org/)

The epicentral area of this seism with a magnitude of M2.1, also saw atmospheric turbulence (**Figure 4)**, near the mouth of the River Arno (http://it.sat24.com/it/), where there was a clear and rapid passage from a mass of cold air to one of hot air. In the hours following the seism (on 1 December 2015), the high pressure value, with reference to the Z500 geo-potential height, was centred close to the Pisan coast, the site of electrical interactions and corresponding to the earthquake's epicenter area (http://daltonsminima.altervista.org/).

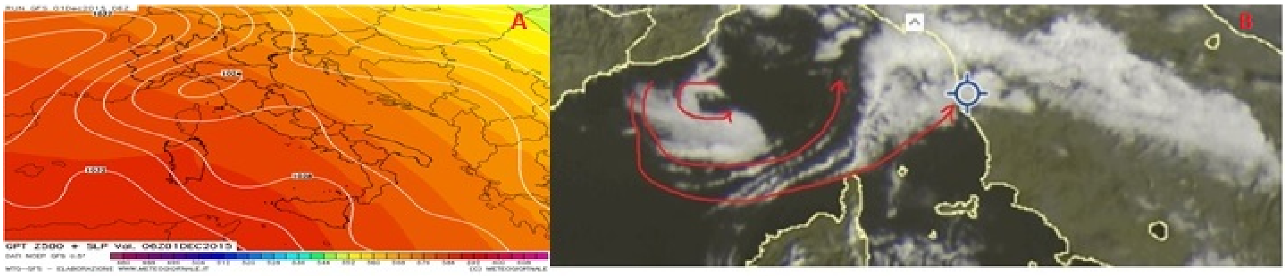

Fig. 4. Analysis of the Z500 geopotential heights in the stratosphere, centered over the epicenter area on the Pisan coast on 1 December 2015 (A) and atmospheric turbulence (B), near the mouth of the River Arno, before the seism of 30 November 2015 (http://daltonsminima.altervista.org/)

In accordance with the observations advanced by Sytinsky (1997), also on the occasion of the strong earthquake of 21 June 2013, with a magnitude of M5.2, and the ensuing seismic sequence, three days after the mainshock, the epicenter area saw stormy precipitations, the only ones to occur in June of 2013. (http://www.ilmeteo.it/portale/archivio-meteo/Fivizzano/2013/Giugno/)

Day	Time (UTC)	Lat.	Long.	Magnitude	Depth (km)	Zone
21/06/2013	10:33:57	44.153	10.135	Ml 5.2	5.1	Apuane Alps, Massa, Lucca

In the case of the earthquakes analysed in the area under investigation, it is frequent to see perturbations of the atmospheric circulation that manifest both locally and on a wider-reaching scale, with readjustments of the thermobaric field and abrupt changes in meteorological elements.

The unexpected variations in meteorological parameters, which sometimes evolve into so-called “water bombs”, are concentrated in the north-east of Tuscany (**Fig. 3**), the same location affected by a moderate seismicity which, rarely, can even give rise to destructive earthquakes, as in the case of the seism of magnitude M6.4 on 7 September 1920, which caused 300 casualties and hundreds of wounded.

DISCUSSION

The intensification of catastrophic events caused by so-called “*bombe d’acqua*” (“water bombs”) with a consequent risk of flooding, along with the intensification of seismicity in the same area over the last few years, suggests that there may be a cause/effect relationship going on, or at any rate that there is a link between the two phenomena.

On the one hand, it could be surmised that atmospheric pressure hitting the ground of the area in question might provoke an imbalance between the forces involved (Mikuno, 1968; Watada, 2006), on the other, that the intense seismic activity, characterized by light but repeated shocks, may be releasing fine dust and gas such as methane, carbon dioxide, hydrogen and others into the atmosphere that can interact locally with the atmospheric conditions.

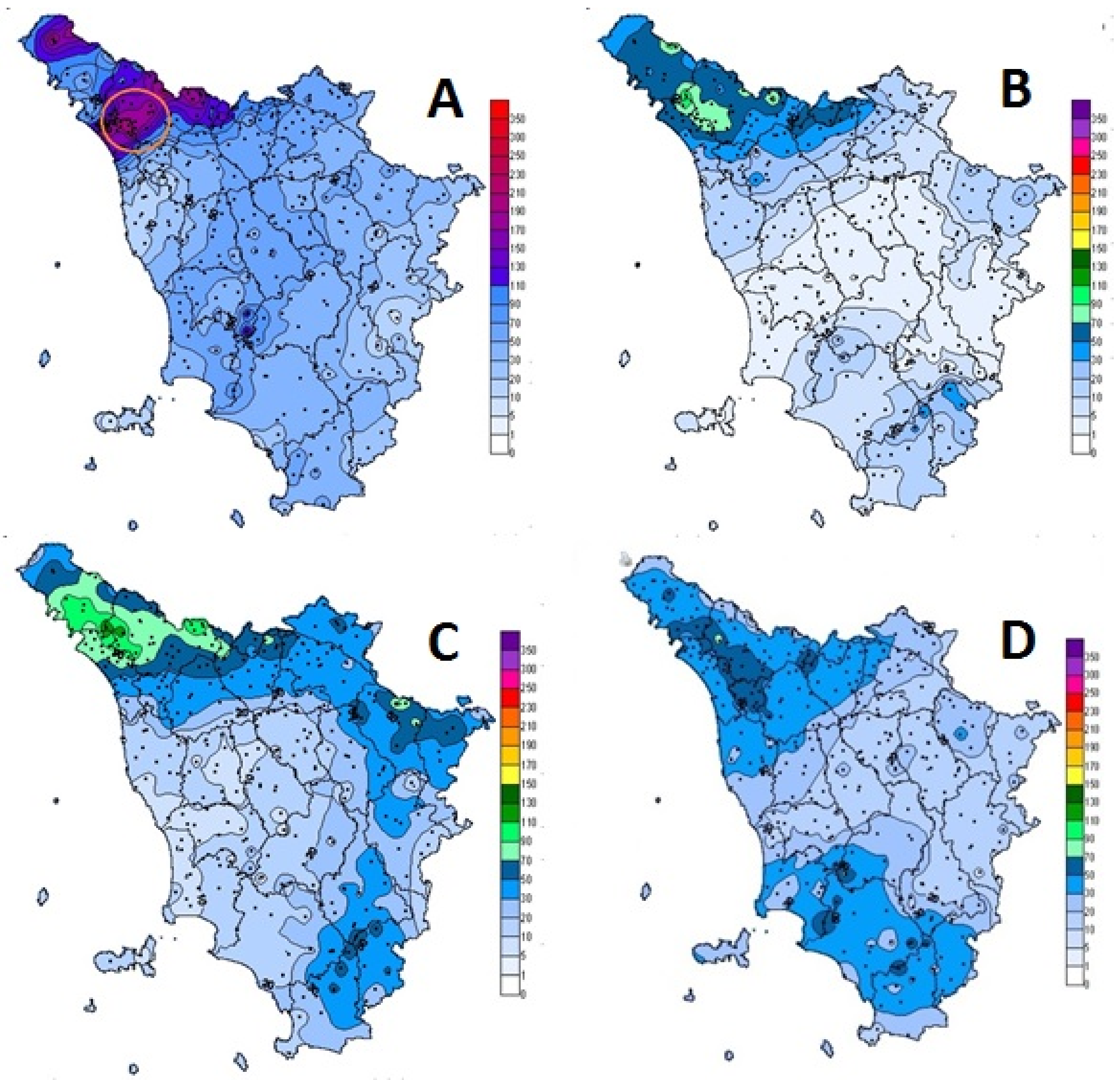

Fig. 5. Concentration of rainstorms in North Tuscany: 26 October 2011 (A), 3 November 2012 (B), 7-20 January 2013 (C), 10 February 2014 (D). The circle top left (A) indicates the area subject to violent rainstorms, seismic swarms, and potentially destructive earthquakes.

A relationship between baric variations and seismic activity, with earthquakes of a magnitude greater than M3, had already been described by Sytinsky (1997). With studies carried out on atmospheric processes during strong earthquakes, Sytinsky demonstrated that during these (±2 days), there were equally strong perturbations in the global atmospheric circulation that manifested with major rearrangements of the pressure fields, as well as changes in the meteorological parameters at different stations chosen randomly in the northern and southern hemispheres.

The interaction between tectonic stresses, the gases emitted in areas undergoing crust stress, the production of ions in the atmosphere, detectable instrumentally and associated with pre-seismic signals, have been described by various authors (Pulinets, 2007; Pulinets and Boyarchuk, 2004), as have the possible formation of nano-particles and filamentous structures of varying origin, caused by a combination of meteoric phenomena associated with electrical discharge, and the ions present in the air (Courty and Martinez, 2015). In fact, the area under investigation lies confined by two orographic barriers, the Apuan Alps and the Tosco-Emilian Apennines (**Fig. 6**), sitting on the edge of the morphological "basin" formed by the depression of the tectonic valleys in the distensive regime of the Magra, Vara and Serchio rivers (Bernini and Papani, 2002).

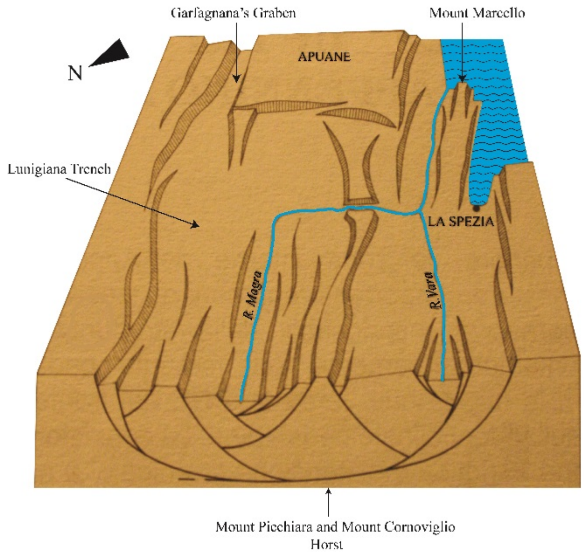

Fig. 6. Perspective diagram of the horst graben structures of northern Tuscany highlighting the main faults that have been recognized in the Lunigiana-Garfagnana area (taken from Bernini and Papani, 2002, modified).

To analyze the relationship between the variations in atmospheric pressure and the stresses exerted in the subsoil, it is necessary to simplify, in order to make a theoretical calculation, the tectonic structure of the graben to a sequence of flat-parallel faults emerging along the valley axis. The resulting diagram (**Fig. 7**) is that of an inclined plane with superimposed elements separated by flat, parallel surfaces.

$$P_{//} = \delta\, D \sin(\vartheta)\, g$$
$$P_{\perp} = \delta\, D \cos(\vartheta)\, g + P_A \pm \Delta P_{A1}$$
$$Ff \propto P_{\perp}$$
$$\Delta F_f / F_f = \Delta P_{A1} / P_{\perp}$$

where $\mathbf{P_{//}}$ is the pressure that acts parallel to the fault surface, $\mathbf{P_{\perp}}$ is the pressure that acts perpendicularly to the fault surface, **D** is the depth, ($\boldsymbol{\vartheta}$) the angle between the normal pressure component with respect to the fault plane and the pressure perpendicular to the ground, **g** is the acceleration of gravity, $\mathbf{P_A}$ the atmospheric pressure calculated at sea level and $\mathbf{\Delta P_{A1}}$ the variation in pressure exerted on the area under consideration (hypothesized with a theoretical value of 50hPa), and **δ** is the average density media of the surface rocks.

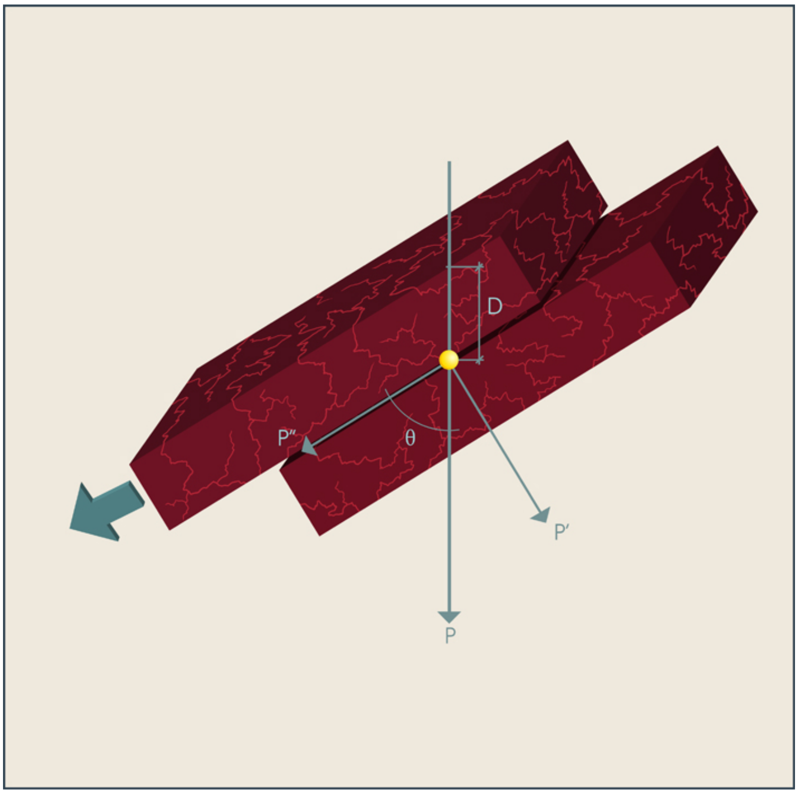

Fig. 7. Theoretical scheme of the forces induced by atmospheric pressure undergone by a fault plane at a depth of 1m. In the Figure, to make things clearer, **$P_{//}$ = P'' and $P_{\perp}$ = P'** have been used.

In order to discuss the data, the value of **$P^{\perp}$** was considered, since **$P_{//}$** does not affect the variation in weight, being considered, in a theoretical calculation, a "block" on top of that underneath. Instead, **$P_{//}$** is the force of friction that must be overcome to dislocate the rock.

In this case, it would coincide in turn with the dimensional parameter **μs**, i.e. the static friction coefficient. The value of the friction coefficient is linked to the nature of the contact surface between two bodies and, in particular, to their degree of roughness and the angle (**ϑ**).

If we perform the calculation, bearing in mind a value of atmospheric pressure = 1013hPa, the immersion angle of the "Ligurian" fault of 30°, an average density of $2.6kg/m^3$, and a surface depth of 1m, we obtain a percentage variation in surface pressure of around 5%. This value becomes negligible at depths greater than 1km. Nonetheless, over time, rapid variations in atmospheric pressure can impact the overall balance of rock until it begins to affect the static friction in the underlying fault surfaces.

In addition, if we consider the relationship: $\Delta P_{A1}/P^{\perp}$ that can be expressed as $\Delta P_{A1}/\ \delta\ D \cos(\vartheta)\ g + P_{A} \pm \Delta P_{A1}$, it can be deduced that, where there are no significant pressure variations in the area under investigation, the relationship tends to zero, hence, without affecting the friction conditions along the fault plane.

To perform the calculation we must consider the real case of atmospheric phenomena that most provoke variations in pressure at ground level. At least 3 cases can be considered: i.e. Foehn winds, stratwarmings and major storms. In the first case, we have masses of air that, when they encounter an orographic barrier (as in the case being investigated), are forced to rise over it. The masses of air therefore tend to cool, condensing the water vapour they contain and provoking bad weather on windward slopes, with overcast skies, rain and snow, at times even copious. This meteorological behaviour is known by the name of Stau, corresponding on the opposite side to the Foehn. Stratwarning, as the name says, is an anomalous warming of the stratosphere, usually occurring during the winter. This phenomenon, most likely determined by solar activity, provokes a dramatic increase in pressure in the portion of atmosphere beneath, generating a powerful anti-cyclone at ground level, where variations in pressure of 50hPa can occur. These are very rapid variations, rare enough but possible. Instead, the third case is the violent rainstorms known locally as "water bombs"– *bombe d'acqua*.

Given that the area under investigation is surrounded by a determined region, considerations on the stresses at stake made until now are of a "static" type and occur in a given time. Instead, in reality, we must be aware that baric variations also change at ground level, i.e. in space. By combining the concepts we obtain a three-dimensional model that is fairly close to reality.

One further element to be considered to establish variations in equilibrium conditions in faults, is water. In fact, it has been surmised that the amount of water that falls to the ground during the heavy showers analyzed in this study could create variations in pressure near the faults and, at the same time, contribute to diminishing the friction coefficient in tectonically vulnerable areas.

Conversely, it has been surmised that frequent and prolonged seismic activity in the same area can release into the atmosphere gassy and particle compounds (climate forcing), ozone, methane, particulate and nitrous oxide, that have an influence on increases in the solar energy, including heat which the Earth retains, as well as the solar energy reflected into space.

It is also surmised that the gases released along the main tectonic structures, which mainly saturate the fault breccias (ground gas), and gas emitted by mineral sources, characterized by high concentrations of H_2 and He and low concentrations of CO_2, as suggested by experiments carried out in Japan (Sugisaki et al., 1983), may influence the local micro-climate.

Experiments in Japan and China have shown that anomalies in hydrogen and other gases at ground level accord with seismically active tectonic discontinuities (Wakita et al., 1980), and also correspond to tectonic structures active over the last 1,500 years (Sugisaki et al., 1983). Hydrogen gas anomalies, persisting along the major fracture systems that are also visible on the surface, have suggested that this kind of gas may serve as a seismic precursor (Sato et al., 1986; King, 1986).

CONCLUSION

The considerations made in this study are valid for variations in atmospheric pressure on dry land, since this does not occur on the sea beds, given that the water moves towards the area and offsets the pressure. Given that the friction is proportional to the pressure that acts perpendicularly to the fault plane ($F_f \propto P^{\perp}$) it can be concluded that a variation of 5% calculated at surface level, if repeated over time, may affect the forces of friction in rock. The variables at stake are many, such as, for example, the presence of water in the surface layers and in the depths. Nonetheless, it is believed that we need not consider one single event as the trigger effect. Rather, it is the sum of variations in a determined time that impact a fault's equilibrium, exerted by a reduction in pressure on one side of a block, provoking an imbalance between the forces in question.

Acknowledgements: I would like to express heartfelt thanks to Dr. Alessandro Ferrari and Dr. Michele Casati for their suggestions and constructive discussions, indispensable in compiling this study.

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SEISMOGEODYNAMICS OF THE HAZARA-KASHMIR TRANSVERSE TROUGH, PAKISTAN

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Abstract: Hazara-Kashmir Transverse Trough, also termed as Hazara–Kashmir Syntaxis, is a seismically active region where the Alpine–Himalayan Fold Belt bends towards the east. The Kashmir Earthquake on October 8, 2005 jolted the area, which formed a co-seismic rupture (75 km in length) in the epicentral zone. Most of the proposed tectonic models of the Indus–Kohistan Seismic Zone have been related to the subduction of the Indian Plate under the Eurasian Plates. However, the presence of deep-seated faults and a thick waveguide layer with different physio-chemical properties requires the re-evaluation of the seismo-geodynamics of the Hazara-Kashmir Transverse Trough. The present study shows that block folding, in accordance with oscillatory movements in the Transverse Trough, is the source of kinematic energy. The seismogeodynamics of the Hazara-Kashmir Transverse Trough is similar to the Sibi Transverse Trough.

Keywords: *seismo-geodynamics, waveguide, deep seated faults, oscillatory movements, block folding*

INTRODUCTION

The Kashmir Earthquake (M7.6) jolted the Hazara–Kashmir Transverse Trough on October 8, 2005 and claimed ~80,000 lives (**Fig. 1**). A 75 km coseismic rupture and 25,000 coseismic landslides (Dunning et. al., 2007) destroyed infrastructures in the epicentral zone. The huge casualties and damage of infrastructures during the Kashmir disaster attracted indigenous and international specialists to elucidate reasons for the strong seismic burst on October 8, 2005 in the Hazara–Kashmir Syntaxis.

Geologists and seismologists addressed different aspects of the seismicity. Some suggested tectonic models that generated energy in accordance with regional horizontal compression at the Hazara-Kashmir Syntaxis. Many scientists linked the 2005 Kashmir Earthquake with the surface fault systems (Main Boundary Thrust, Jhelum Fault, Muzaffarabad Thrust Fault and others, **Fig. 2**), for example Avouac et al. (2006), Aydan (2006), Bendick et al. (2007), Berryman et al. (2014), EMSC (2005), Ghaffar and Abbas (2010), Hussain et al. (2009), Jan et al. (2008), Kondo et. al. (2008), Schneider (2006), Tahirkheli (2005), Yeats et al. (2006), Zaré and Karimi-Paridari (2008) and Zaré et al. (2009). While Gahalaut (2006), Khan et al., (2009), Monalisa et al. (2005, 2008, 2009a and 2009b) and Purnachandra et al. (2006) associated the Kashmir Earthquake with the Indus Kohistan Seismic Zone (**Figs. 2 and 8),** while Seeber and Armbruster (1979), Mona Liza et al. (2009) and Khan et al. (2009) hypothesized northwestwardly extension of the Indus Kohistan Seismic Zone up to the Main Mantle Thrust (**Fig. 2**; Tahirkheli et al., 1979). Finally Blot and Choi (2005) suggested energy transmigration linked to the Hindu Kush and the Indus Kohistan Seismic Zones (**Fig. 4**).

However, the presence of steep lateral and transverse deep-seated faults (transect lines 1 and 3 in **Fig. 3,** and profiles in **Fig. 5**) in the Hazara-Kashmir Syntaxis region (Verma and Prasad, 1987; Ali and Mujtaba, 1992; Khan and Ali, 1997) are neglected in tectonic models of seismicity despite their significant role in developing tectonic structures (Belousov, 1976).

The deep-seated faults facilitate geodynamic processes by providing channels for mantle materials to transmigrate and thus affect the crust. The physio-chemical properties change during the formation of mid and lower crustal horizons, where folding processes create energy (Belousov, 1976). The accumulation of energy depends on the physico-chemical (brittle–ductile) properties of the midcrustal horizons. The brittle–ductile characteristics of the Earth's crust and the Moho-discontinuity are reflected in the inversion values of seismic waves, gravity and resistivity fields. Such geophysical anomalies of midcrustal horizons are termed as waveguide (Belousov, 1976; Pykhalov and Richter, 2014).

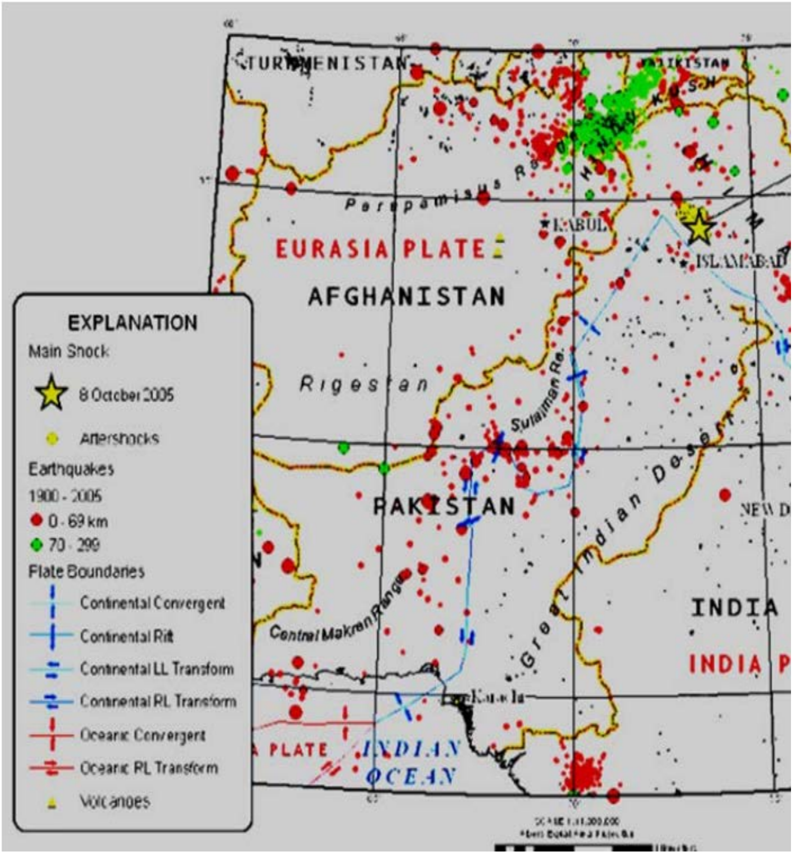

Fig. 1. Seismicity map of Pakistan. Blue line is boundary between Indian and Eurasian plates (EERI Special Earthquake Report – February 2006).

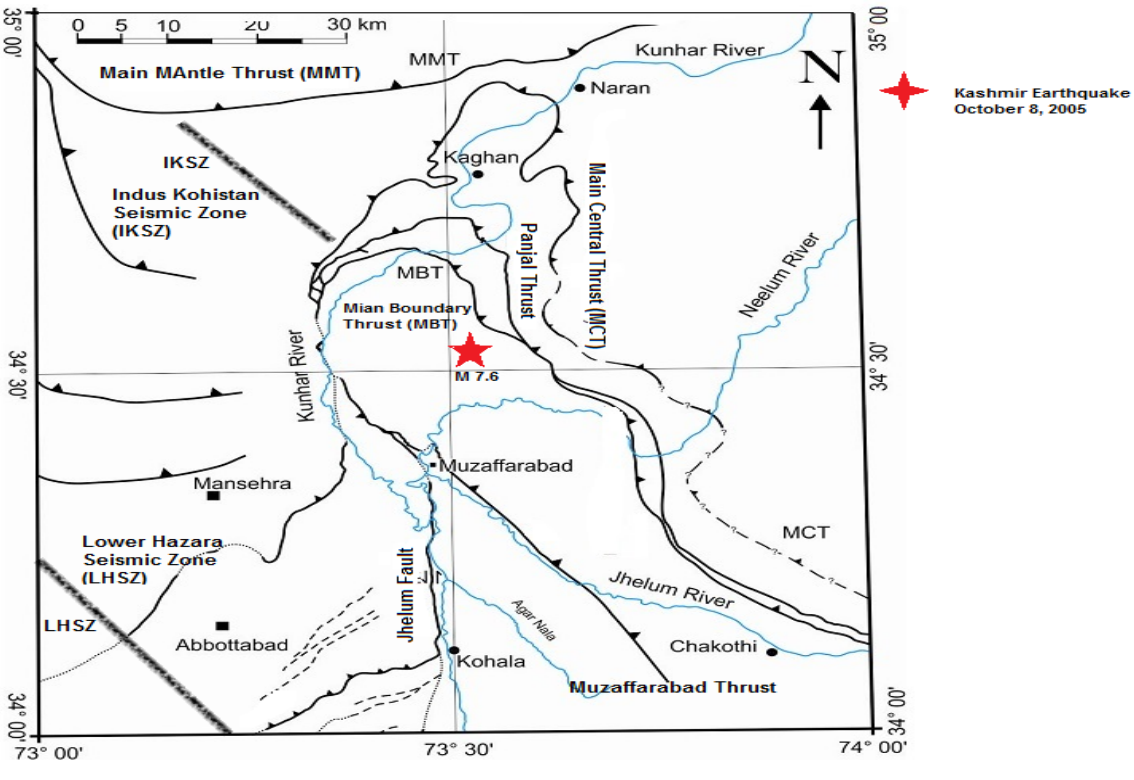

Fig. 2. Surface faults (Turab, 2012), and epicentre of Kashmir Earthquake, October 8, 2005, and IKSZ and LHSZ.

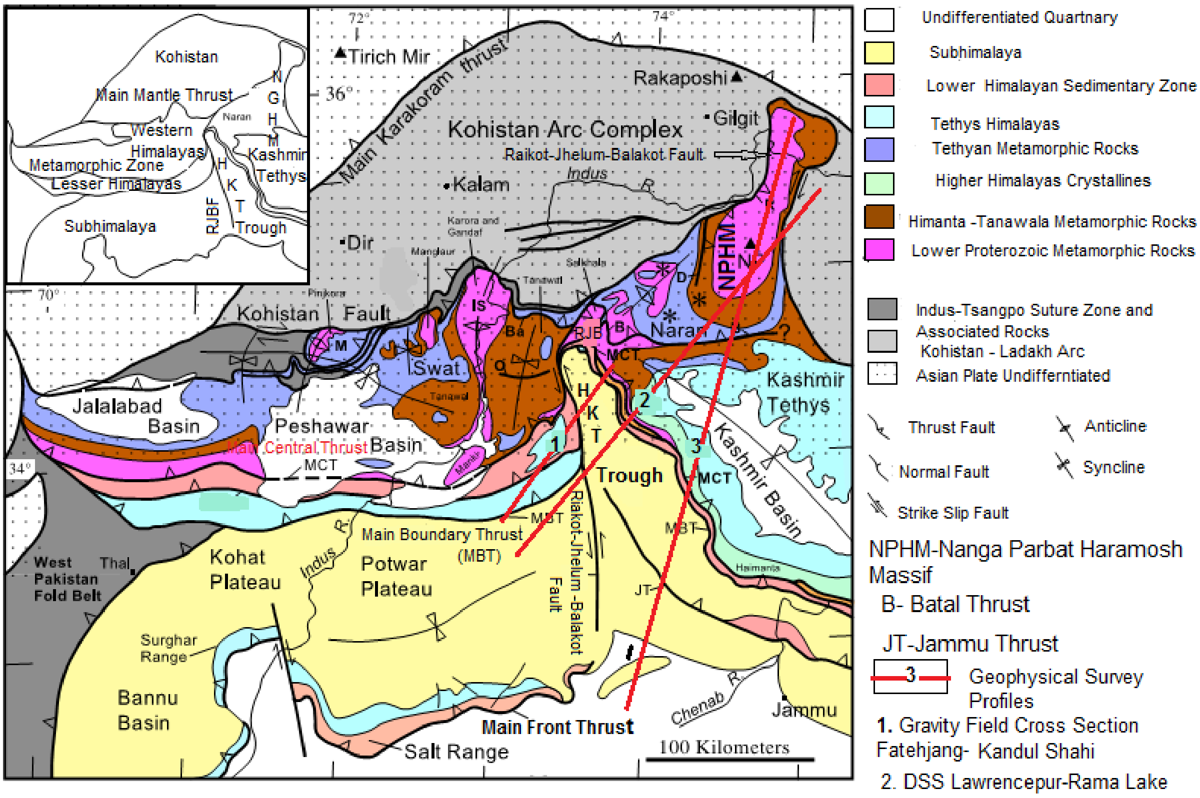

Fig. 3. Tectonic Map of the NW Himalayas (DiPietro and Mouase, 2004). The Kohistan Arc Complex is developed on the Hazara Massif (Arsentyev et al., 1978). HKT Trough – Hazara-Kashmir Transverse Trough.

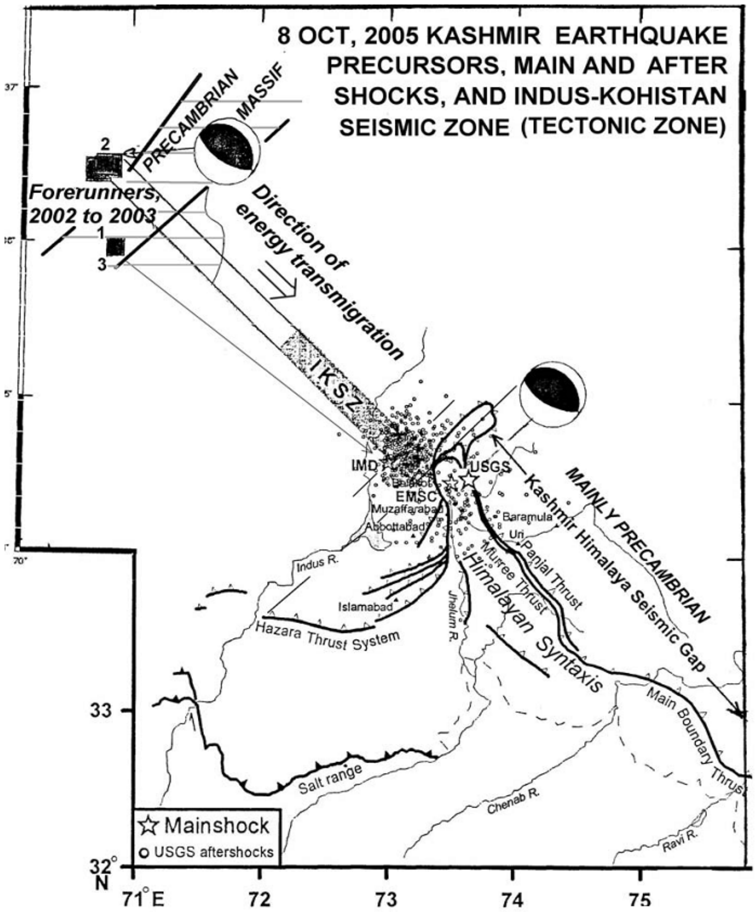

Fig. 4. Tectonic link between the major earthquakes in 2002-2003, Hindu Kush and shallow earthquakes of the 2005 Kashmir Earthquake (Blot and Choi, 2005).

The deep seismic sounding profile (Belousov et al., 1978) running through the Hazara-Kashmir Syntaxis determined the mid-crustal waveguide layers (**Fig. 6**). Therefore, the objective of the present research is to evaluate the seismo-geodynamics of the Hazara-Kashmir Transverse Trough in accordance with deep structures. Also I will correlate the seismo-geodynamics of the Hazara-Kashmir Transverse Trough with the Sibi Transverse Trough (**Fig. 7**). The energy reservoir models of the Hazara-Kashmir Transverse Trough (**Fig. 3**) will be presented in a future work.

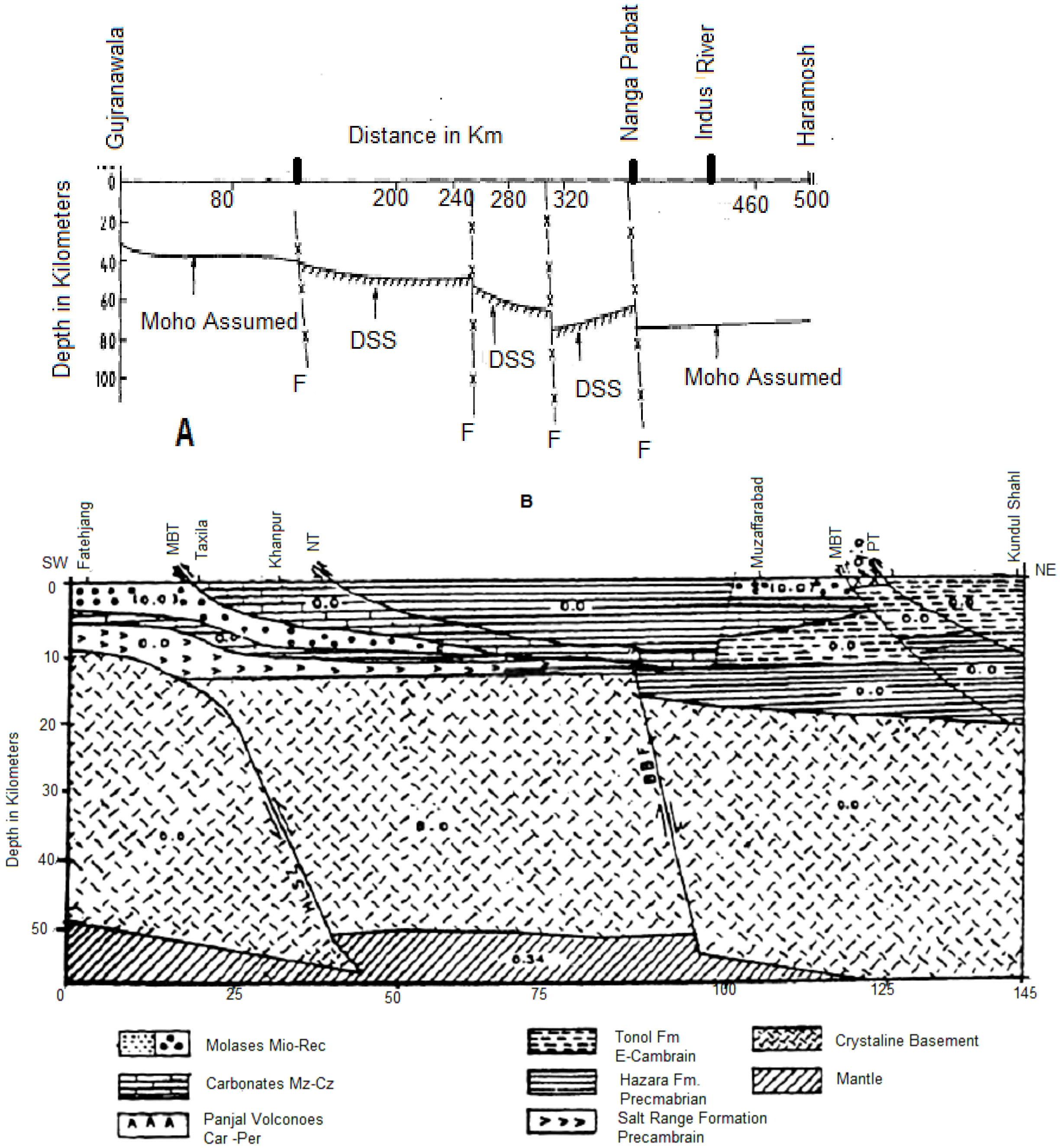

Fig. 5. Crustal configuration along the DSS profile from Naoshera to Nanga Parbat (A), Line 1 in Fig. 2, (Verma and Prasad, 1987) and gravity profile from Fatehjang to Kundul Shahi (B), Line 2 in Fig. 2 (Khan and Ali, 1997). BBF-Bagah Blind fault, HLSZ -Hazara Lower Seismic Zone, MBT- Main Mantle Thrust, and PT- Panjal Fault.

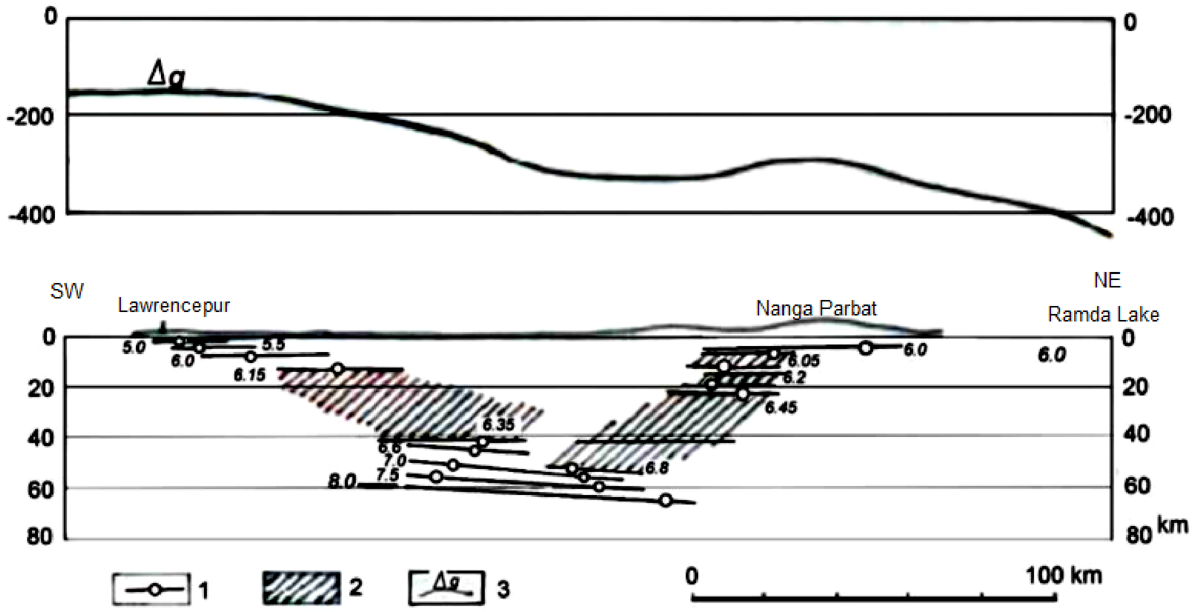

Fig.6. Bouger anomaly curve and velocity along Lawrencepur and Ramada Lake (after Belousov et al., 1978). 1. Velocity layers, 2. Waveguide layer, 3. Bouger anomaly Δg (upper figure). For locality of profile, see Fig. 2 (Line 3).

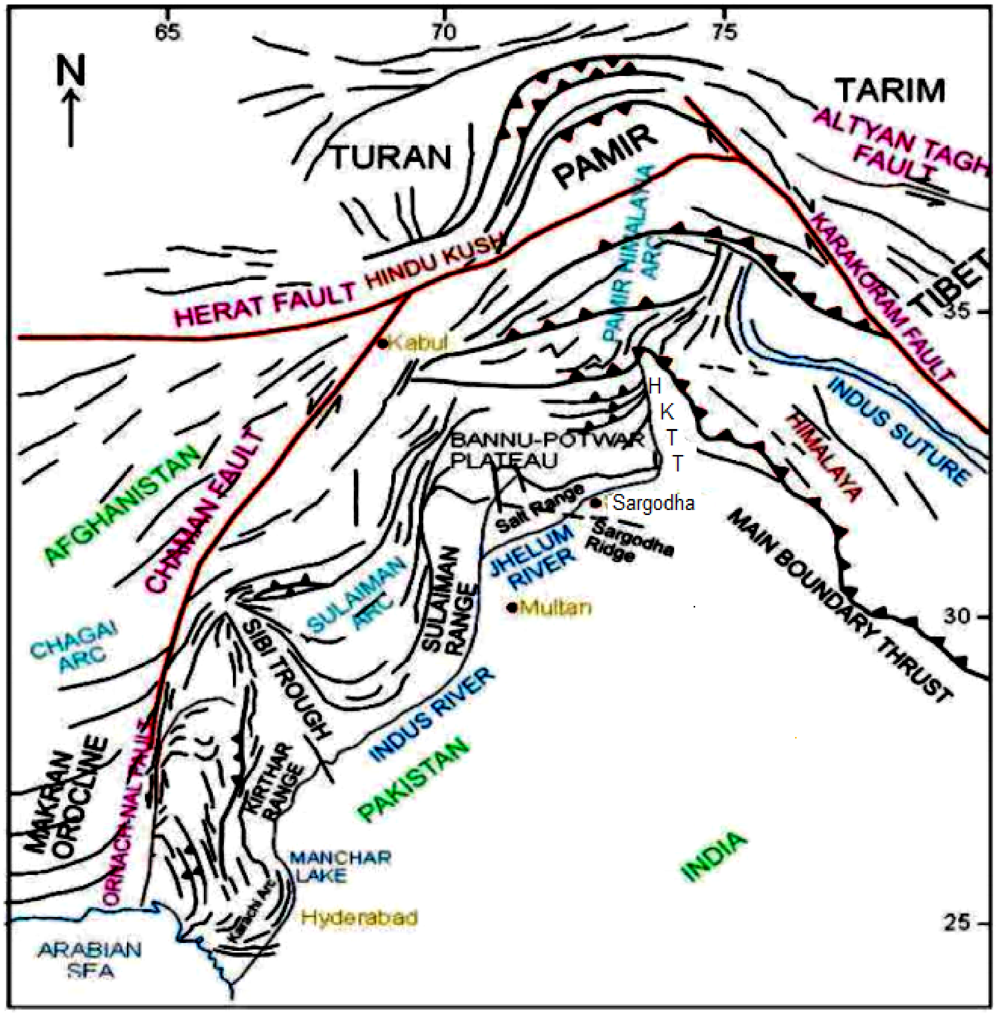

Fig. 7. Tectonic Map of Pakistan. HKTT – Hazara-Kashmir Transverse Trough. Note similar tectonic position of the Sibi Trough. Courtesy: Geological Survey of Pakistan.

SEISMICITY

The historical and modern seismicity of the Hazara–Kashmir Syntaxis is documented in earthquake catalogues of Hindustan (Oldham, 1893), Afghanistan, Pakistan, South Iran and Himalayas (Quittmeyer and Jacob, 1979), and in catalogues of Pakistan earthquakes (M≤ 5.0) data from Russian and Edinburgh observatories (Magsi, 1983). The low magnitude earthquakes are also included in the seismicity maps of the Hazara–Kashmir Syntaxis after the October 8, 2005 Kashmir Earthquake (PMD and NOSAR, 2007). Quittmeyer et al. (1979) and Kayal (2008) categorized the northwestern Himalaya's seismicity, including that of the Hazara-Kashmir Syntaxis, as part of the Main Himalayan Seismic Zone. Whereas, Seeber and Armbruster (1979) linked the seismicity with the Lower Hazara Seismic Zone (LHSZ) and the Indus Kohistan Seismic Zone (IKSZ) parallel to each other in a decollement vs. basement model of the region in accordance with underthrusting of Indian plate under Eurasian plate (**Fig. 8**).

Khan et al. (2008) and Mona Lisa et al. (2009) associate the Kashmir Earthquake with the Indus Kohistan Seismic Zone and suggest northwestern continuity of the Indus Kohistan Seismic Zone to the Main Mantle Thrust (Tahirkheli et al., 1979). Khan et al. (2008) also consider that the cause of the Kashmir Earthquake (M7.6) and seismicity in the Indus Kohistan Seismic Zone to be an orthogonal part of the convergence, and which control basement tectonics that trigger the seismic burst. Blot and Choi (2005) support the existence of the Indus Kohistan Seismic Zone and believe a further northwestern extension of the Indus Kohistan seismic zones towards Hindu Kush. They reject the underthrusting of Indian Plate along the basement fault under the Eurasian Plate (Seeber and Armbruster, 1979). The earthquake epi-center map (**Fig. 1**) shows the northwestern orientation parallel to the axis of the Hazara–Kashmir Transverse Trough which resembles to the seismicity of the Sibi Trough (**Fig. 7**; Magsi, 2014). The hypocenter distribution illustrates the lower seismogenic horizon being more active than the upper seismogenic horizon (Magsi, 2013).

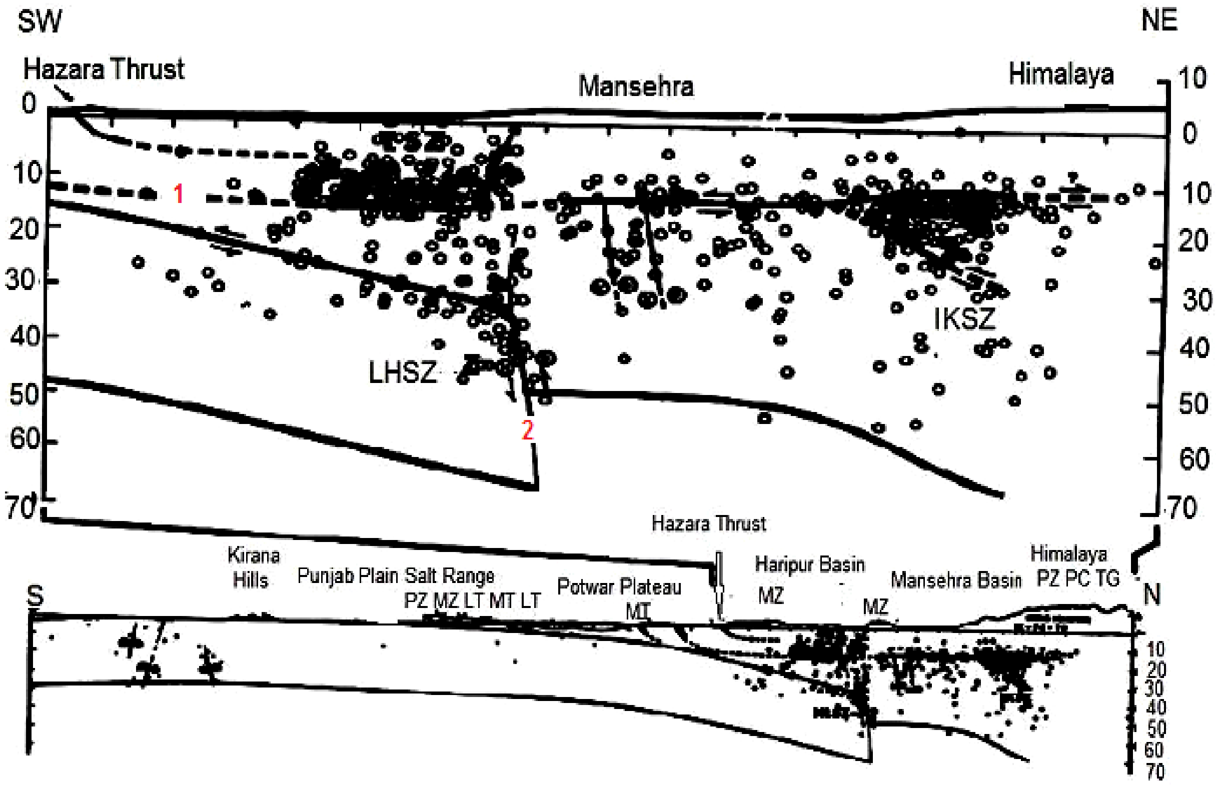

Fig. 8. Seismicity of the Hazara Arc and the Indus Kohistan Seismic Zone: decollement (1) vs basement fault (2) fault; IKSZ – Indus Kohistan Seismic Zone), LHSZ – Lower Hazara Seismic Zone, UT, MT, LT – Upper, Middle and Lower Tertiary, MZ = Mesozoic, PZ = Palaeozoic, PC = Precambrian, TG = Tertiary granite (Seeber et al., 1979).

TECTONICS

The Hazara-Kashmir Syntaxis (Calkins et al., 1975; Sarwar and De Jong, 1979) is an important tectonic element of the internal arc system of the Pamir-Punjab Syntaxis (Khain, 2000; Burtman, 2013). However Gavrilov (2014) splits the Pamir-Punjab Syntaxis into a Pamir Arc, Hindu Kush Arc and Tibet-Himalayan mega-arc. The Tibet-Himalayas mega-arc runs between the Hindu Kush Arc and the East China Mega-arc and covers the Hazara-Kashmir Syntaxis. Treloar (1989) and William (1989) divided the Hazara–Kashmir Syntaxis into three blocks named the Besham Nappe, the Hazara Nappe and the Kashmir Syntaxis. The Thakot Shear Zone is the boundary between the Besham Nappe and the Hazara Nappe. The Balakot Bagh Shear Zone is the boundary between the Hazara Nappe and the Kashmir Syntaxis (**Fig. 9**). While Khan et al. (2008) divided the Hazara–Kashmir Syntaxis into the Besham Syntaxis and the Hazara Syntaxis, Mona Liza et al. (2009) categorized the Besham Syntaxis as a dome structure.

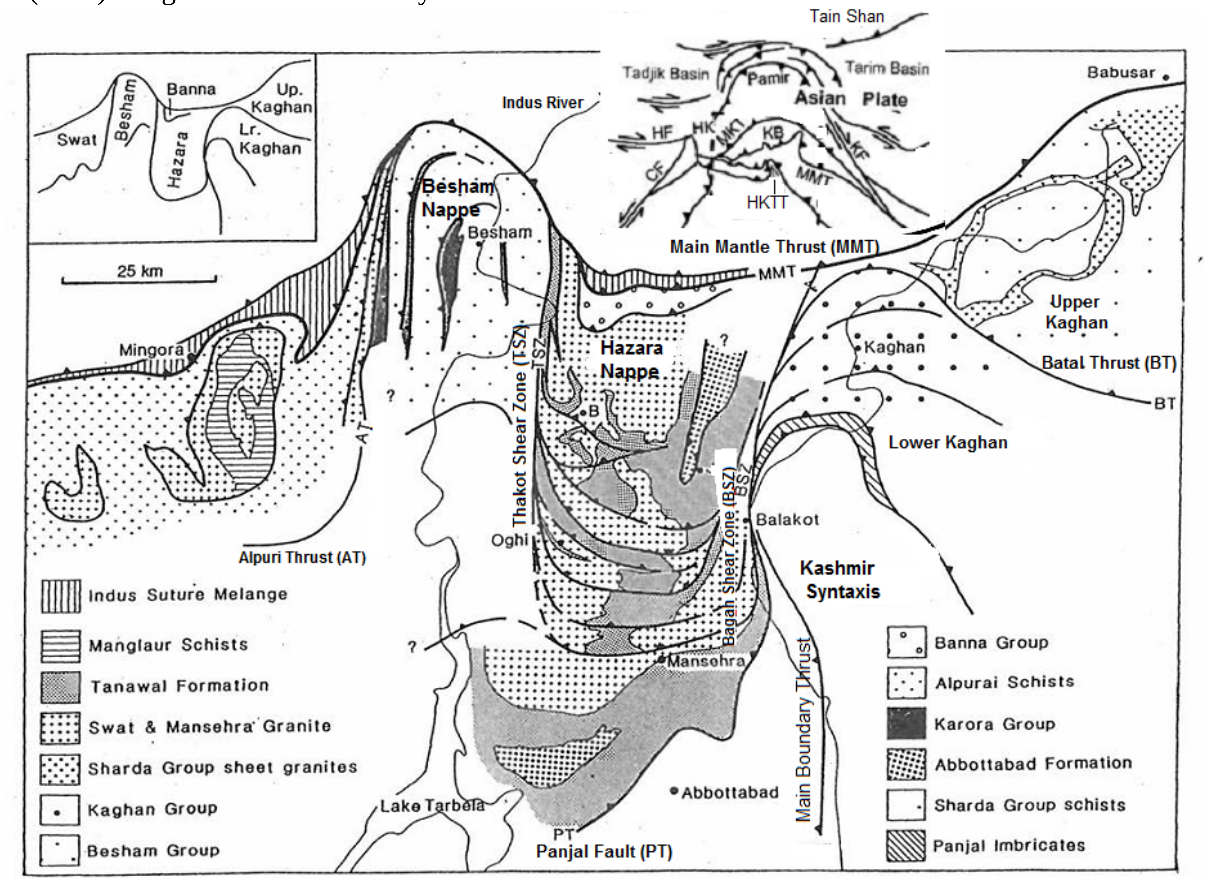

Fig. 9. Geological map of the Swat to Kagan section of the Indian Plate within North Pakistan to show (inset) the location of major crustal nappes (after Treloar, 1989).

Calkins et al. (1975), Deiso (1979), Sarwar and Jong (1979), DiPitero and Pogue (2004), Hussain et al. (2008), Tahirkheli et al. (1979), Tahirkheli and Jan (1997), Treloar (1989), and William (1989) associated tectonic development of the Hazara–Kashmir Syntaxis with the underthrusting of the Indian Plate under the Eurasian Plate with an important role of the Chaman Sinistral and the Karakoram Dextral Strike Slip Faults in kinematics of the syntaxis (Burtman, 2013). Khan et al. (2008) suggested the Hazara-Kashmir Syntaxis developed as a result of the large clockwise and small counter clockwise rotation related to the Indian Plate. These clockwise and counter clockwise rotations have a centre at the intersection of the Main Mantle Thrust and the Indus Kohistan Seismic Zone. However, the nature of deep seated steeply dipping faults trajectory shows different tectonic structures which offset the Moho-discontinuity (Verma and Prasad, 1987; Ali and Mujtaba, 1992; Khan and Ali, 1997). The uniformity of meso-Proterozoic formation of the Afghanistan and Hazara Massif (Arseptyev et al., 1978) and the lack in deformity of younger Tertiary sediments of the southern Pamir (Khamrabaev, 1982) do not support the underthrusting model of the Indian Plate under the Eurasian Plate.

Leichenkov (2013) suggested the breakup of the Gondwana platform into a future Indian Ocean in Late

Carboniferous – Early Permian. Earlier, Zanchi and Gaetani (2011) postulated rifting of Perigondwanan fringe during the mid-Devonian – early Permian time. But the evidence of Jurassic land, tectonic blocks and transcontinental lineament of Indian Ocean (Lomakin, 2009; Lomakin, 2011; Lomakin and Ivanov, 2012; Lomakin et al., 2011), weak folding due to compression condition in Balochistan Centre Massif and decrease of the Hazara–Kashmir Trough area in Devonian–Early Carboniferous (Voskresensky et al., 1971), do not support the fragmentation of Gondwana platform as suggested by Zanchi and Gaetani (2011). Schevchenko (2014) also disagrees with the plate tectonic model of the Alpine-Indonesian Fold Belt. According to Schevchenko (2014) the Alpine-Indonesian fold Belt has been a stable independent structure throughout its tectonic development and geological zoning history. The above-mentioned facts also reject the plate tectonic model for the Hazara-Kashmir Syntaxis and the adjoining area. Actually the Hazara–Kashmir Transverse Trough (**Fig. 3**) is fragmented as perpendicular blocks (Voskresensky et al., 1971), which separated the Kashmir Tethys from the Western Himalayas (DiPitero and Mouse, 2004). The Hazara-Kashmir Transverse Trough experienced changed dynamics under the influence of oscillatory movements during multiphase tectonic developments since the meso-Proterozoic Era (Jan and Khan, 1981; Magsi, 1983).

The author considers that the Hazara-Kashmir Syntaxis and the adjoining areas are similar to the Sibi Transverse Foredeep between the Kirthar and Suleiman Fold Belts (**Fig. 7**). The thrust of part of arc margins in neighbouring intermountain and foothill basins is thus due to block folding (Belousov, 1976). The thrusting along the Main Boundary Thrust (Murree Thrust) which encircles the Hazara-Kashmir Syntaxis is possibly due to the arc margin thrusting (Gavrilov, 2014).

DiPitero and Mouse (2004) joined the Balakot Bagh Shear Zone and Jhelum Fault as a single tectonic element controlling the western flank of the Hazara-Kashmir Syntaxis. The author postulates that the Jhelum-Balakot Sinistral Strike Slip Fault is actually a trans-platform, deep-seated fault which runs from the Epi-mid-Proterozoic Indian Platform towards the meso-Proterozoic Hazara Central Massif making a junction of the Jhelum, the Murree Thrust Fault and the Raikot Fault. This fault system forms the boundary between the Indian Platform Spur and the Hazara Massif, and also between the Hazara Central Massif and the meso-Proterozoic Nanga Parbat-Haramosh Regenerated Massif. The Batal Thrust, the Muzaffarabad Thrust, and the Main Central Thrust (Panjal Thrust), which merge into subvertical deep seated faults (Bossart et al., 1989), occur in the eastern flank of the Hazara-Kashmir Syntaxis.

DEEP STRUCTURES

The tectonic processes shaping the continental crust particularly influence the physico-chemical characteristics of mid-crustal layers where granite-metamorphic rocks form the mid-crustal layers. The presence or absence of fluids also make the mid-crustal layers either brittle or ductile. The brittle and ductile layers of middle crust are reflected in velocity and density inversions. These inversion velocities, or low velocity of P and S wave horizons, are categorized as a waveguide (Pykhalov and Richter, 2014; Belousov et al., 1978) or as an anisotropy (Artemieva, 2011), whereas gravitational minimum and high thermal flux zones indicate the presence of granitic fluid in mid-crustal horizons. Such a waveguide was interpreted under the Hazara-Kashmir Syntaxis along the deep seismic sounding Attock-Astor profile (Belousov et al., 1978), which transects from the Hazara-Kashmir Syntaxis to the Nanga Parbat-Haramosh Massif through the Kagan High Himalayan Crystalline Tectonostratigraphic Zone (**Figs. 3 and 9**; DiPterio and Pogue, 2004). The thickness of waveguide (**Fig. 6)** increases towards the Kagan High Himalayan Crystalline Zone from the south (Hazara Zone) to the north (Nanga Parbat Zone). However, the inversion velocity difference between the Hazara Zone side (6.15 - 6.35 km/sec) and the Nanga Parbat zone side (6.45 - 6.8 km/sec) makes it possible to postulate that midcrustal horizons, under the Kagan High Himalayas Crystalline Zone and the Hazara–Kashmir Syntaxis, have different physico-chemical characteristics.

The above-mentioned waveguide consists of eventually two waveguides; a vertical deep structure (deep-seated fault) separates the Hazara-Kashmir Syntaxis from the Kagan High Himalayan Crystalline tectono-stratigraphic zone. It also controls crustal formation processes. Thickness of the Hazara Zone and the Nanga Parbat Zone waveguides are 33 km and 42 km, respectively. The difference between depth of the Hazara waveguide (lower inversion velocity 6.35 km/s) and the Nanga Parbat waveguide (lower inversion velocity 6.8 km/s) naturally show the northward dip of Moho-discontinuity (8.0 km/s) (**Fig. 6**). The lower crustal horizons with velocity of 7.0 km/s and 7.5 km/s illustrate the smooth inclination towards Nanga Parbat with an increasing depth towards Nanga Parbat (Belousov et al., 1978). The Nanga Parbat waveguide, which is about 9 km thick, gives an impression that the dip of the Moho-discontinuity (Menke, 1976) might be due to a natural subsidence due to the increase in thickness of the waveguide layer.

The vertical basement block movement under the Hazara-Kashmir Syntaxis (Khan and Ali, 1997) allows the postulate that vertical deep-seated faults (Verma and Prasad, 1987 and 1989) separate and control the mid-crustal formation processes of the southern and northern waveguides. The depth of thrust faults in the region is a maximum of 20 km, whereas normal or reverse deep-seated faults offset the Moho-discontinuity and reach the upper mantle (Verma and Prasad, 1987 and 1989). The deep seated faults allow vertical block movements.

The presence of a salt formation in the western flank and its absence in the eastern flank of the Hazara-Kashmir Syntaxis (HKS) also confirms the significance of deep fault-controlled depositional environments on both sides of the HKS. The formation of the mid-crustal horizons can be explained by a combination of injection folding with viscous flow under ductile conditions (Gomez-Rivas et al., 2015) and block movements along faults or shear fractures of crystalline basement (Belousov, 1976). According to Belousov (1976) injection folding can occur without the involvement of basement. In the author's opinion the Raikot-Jhelum-Balakot Fault (RJBF) penetrating into the mantle (Belousov et al., 1978; Khan and Ali, 1997) is probably the boundary between the Hazara Massif and the Nanga Parbat-Haramosh Massif. The RJBF bends at the contact of the Hazara Massif and the epi-mid-Proterozoic Indian Platform and runs in a SE direction to the epi-mid-Proterozoic Indian Platform. Therefore, the author classifies the Raikot Fault as a deep seated fault which controls the mid crustal formation and thus the sources of the fluids (Park et al., 2000). The Jhelum–Balakot is also a deep seated fault controlling structures of the Hazara Kashmir Syntaxis. Belousov (1976) categorized such faults as deep reverse faults.

DISCUSSION AND CONCLUSION

The proposed tectonic models of the Kashmir Earthquake on October 8, 2005 are mostly based on the decollement vs. detachment fault model (Seeber and Armbruster, 1979) in accordance with the underthrusting of Indian Plate under the Eurasian Plate (Burtman, 2013). However the deep structures of NW Himalayas (Verma and Prasad, 1987 and 1989) and geological data of the Indian Ocean (Likeman, 2009; Likeman and Ivanov, 2012 and 2011; Likeman et al., 2011) and Pamir Arc (Gavrilov, 2014) do not support the underthrusting of the Indian plate under the Eurasia Plate. The thrusting of arc margins on neighbouring tectonic elements is due to block folding (Belousov, 1976). According to Belousov (1976) the block folding usually occurs in the transverse foredeeps of orogenic belts like the Hazara-Kashmir Transverse Trough (Deiso, 1976). This block folding formed the Besham Dome (Mona Liza et al., 2009) and the Hazara Nappe and Kashmir Syntaxis (Treloar, 1989). The high seismicity, including the October 2005 Kashmir Earthquake (M 7.6), is associated with shear folding caused by warping movement (Belousov, 1976).

The 3D earthquake focus (Gorshkov, 1981) forms the mid-crustal seismogenic layer (Magsi, 2013). The physio-chemical properties of seismogenic horizons create favourable conditions for accumulation of kinematic energy. Leakage of kinematic energy results in a seismic burst, its orientation of force and shape as well as co-seismic ruptures. While the magnitude of a seismic burst is proportional to its 3-D volume, the volume of accumulation depends on the intensity of deformation of the crustal horizon (Magsi, 1985). The Hazara-Kashmir Transverse Trough is under the control of deep-seated faults like the Sibi Transverse Trough. Both transverse troughs have the same NW axis. The axis of seismicity of both the Hazara-Kashmir and the Sibi Transverse Troughs also runs parallel to the NW direction. Therefore, the seismic activity of the Hazara-Kashmir Transverse Trough and the Sibi Transverse Trough is not associated with a decollement in accordance with the underthrusting of the Indian Plate under the Eurasian Plate. The regional deep-seated faults have influence on the block folding of transverse trough and on energy accumulation in the brittle and ductile envelop. According to Shchukin (2008), these deep processes involve a huge volume of heterogeneity of the Earth's crust and the upper mantle in generating the energy. The analysis of seismo-tectonic models of the Hazara-Kashmir Syntaxis and adjoining areas also exhibits the disagreement between earthquake focus models and surface geology. For example the aftershock orientation (Pennington, 1979) and seismo-tectonic model of the earthquake focus (**Fig. 10**) of the Pattan

Earthquake (M6.2), December 28, 1974 (Magsi, 2014), shows a disagreement between the surface geology and the focal mechanism solution (Pennington, 1979) – where the focal mechanism illustrates thrust faulting.

The Transverse Troughs under the influence of the oscillatory movements play a significant role in geological history of the Alpine-Himalayan Fold Belt. Its axis bends at the Hazara Kashmir and Sibi Transverses Troughs; both are seismically active with same seismo-geodynamic characteristics.

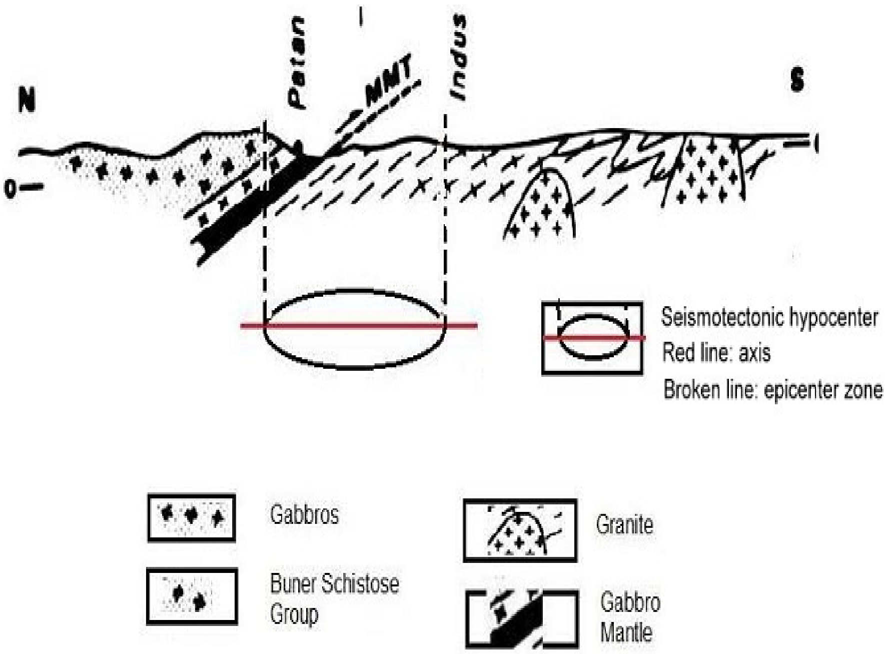

Fig. 10. Model of seismotectonic hypocentre of the Pattan Earthquake on December 28, 1978. Geological cross section of the Pattan Area (Tahirkheli et al., 1979). MMT= Main Mantle Thrust.

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DEGASSING AND EXPANDING EARTH: NEW MODEL OF GLOBAL TECTONICS

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Abstract: In this article a new concept of global tectonics – the degassing and expanding Earth model is exposed. The expansion of the Earth created the main global regularities in the Earth's structure: the arc of the earthquake epicenters and volcanoes forming the Pacific Ring; the symmetrical shape of the mid-oceanic rifts relative to the South Pole; and the asymmetric structure of the Antarctica and the Arctic Ocean. The different types of the continental and oceanic lithosphere are accounted for by the spatially irregular degassing of the Earth. The thick acid continental crust and the continental "roots" of the depleted mantle lithosphere were formed in the areas of the stronger deep fluid advection. The depleted mantle material has a lower density, which was the main factor responsible for the formation of the continents -- their uplifting. Within the contemporary oceans, the fluid flows were weak and only sporadic spots of the transition-type crust appeared among the primary basic crust. The Earth's core with high hydrogen and helium content is the main source of the deep fluids. Degassing of hydrogen is presently most intense along the mid-oceanic ridges and other rift zones which are traced as a global system of deep destructions.

Keywords: *origin of the crustal types, deep continental roots, oceanic lithosphere, mid-oceanic ridges, deep fluids, degassing and expansion of the Earth*

Introduction

Many recent contributions to the New Concepts of Global Tectonics address a long history of debates on the plate tectonic concept and suggest some new models of global tectonics. More and more geological and geophysical evidence demonstrates the growing inconsistency between the plate tectonics and empirical data. These discussions are ongoing in every new NCGT issue. The main conclusion suggested by these publications is that plate tectonics fails to be a basic paradigm of global geodynamics.

Many other concepts have also been discussed. It was noted that all of them provide important solutions for a number of the geodynamic problems; however, these solutions most frequently concern only particular geodynamic processes without addressing the global aspects. For instance, Beloussov (1971 and 1990) developed the models of the different endogenic regimes which are observed on the continents. Meyerhoff et al. (1996) proposed the formation mechanism for some linear structures. The concepts of the expanding Earth consider the ocean formation in the same way as plate tectonics but without the unrealistic large plate subduction. The new astronomical data enabled Avsyuk et al. (2007) and Barkin (2002) to explain some individual cycles of the tectonic processes. The plume tectonics demonstrates the importance of the deep material advection in addition to the role played by the convection.

Among all these concepts, the wrench tectonics by Storetvedt (1997 and 2003) appeared most elaborate since this concept was extensively published and named the global tectonics theory. This concept is based on the interpretation of the palaeomagnetic data by the rotation of the continents, but it does not consider the other global problems of geodynamics. Moreover, besides the rotation of the continents, the wrench tectonics suggests problematic large polar wander motions.

The key purpose of any global tectonic concept is to explain the origin of global structural features in the tectonosphere such as its division into the continents and oceans, different nature of the oceans with the active and passive margins, the observed regularities in the structure of the seismically active zones and mid-oceanic ridges, etc. The problem is to find a common energy source for all the transformations of the tectonosphere and to link all the structural peculiarities into a single system of cause and result relationships.

In my previous papers (2005, 2011 and 2012a), I tried to solve these problems with the fluid-rotation model of global tectonics. The model demonstrated the importance of the deep fluids and Earth's degassing in different tectonic processes. But for explaining the palaeomagnetic data I assumed the upper mantle rotation around the core instead of the polar wander. At the same time, David Pratt (2013a) showed that "geological, geophysical, palaeontology and palaeoclimatic data do not require large-scale plate motion or polar wander. They point to non-drifting continents and stable poles". This challenged the wrench tectonic concept and my upper mantle rotation model. It was clear that different new models should be developed.

During the last few years, I have reanalyzed all the experimental data on the tectonosphere's structure (mainly the geophysical and deep drilling data) and the last NCGT publications and made principal corrections to my fluid-rotation model. I have excluded the mantle rotation from this model, which provided a better agreement with the data described in Pratt (2013a) and with the new regularities revealed in the Earth's structure. This new corrected model is presented below. I called it degassing and expanding Earth model of global tectonics because this model treats the energy of the degassing and the expansion of the Earth as the key sources of the most tectonic processes.

The main regularities in the structure of the upper spheres of the Earth

At present, the Earth's surface and its upper spheres, the crust and upper mantle, have been studied in detail in different fields of the Earth science. It is shown that, despite the overall complex structure of these spheres, there are still a number of well-defined regularities identified in the surface topography, crustal structure, and its relationship with the upper mantle. Some regularities have not found a clear explanation, which significantly complicates the further development of the Earth science. The difference in the structure between the Pacific and the other oceans is one of the unsolved problems.

The structure of the Pacific Ocean

The Pacific Ocean covers a large part of the Earth's surface which is often referred to as the Pacific hemisphere. The division into two major segments (hemispheres) is the main structural feature of the Earth on the global scale. On the surface, these segments differ by the predominant relief, lowered within the Pacific Ocean and uplifted within the continental hemisphere. This feature is not exclusively Earth specific. The same structure is also typical of the other planets, which are also divided into two hemispheres with the predominant higher and lower topographies (Araki et al, 2009; fig.1 in Pavlenkova, 2012a and figs 3-8 in Kochemasov, 2015).

The two Earth's hemispheres are separated by the ring of the deep troughs with a high concentration of the earthquakes. These are the Benioff zones (Benioff, 1954), which are not chaotic but form a regular arc (Wilson, 1954). Almost at a right angle, the Pacific Ring intersects another global ring of the earthquake epicenters – the Mediterranean-Asian one (**Fig. 1**). The geological studies have shown that the Pacific Ring accommodates a variety of the Meso-Cenozoic displays of the tectono-magmatic activity, and this region was called the Circum-Pacific Mobile Belt or the Pacific Ring of Fire (fig. 1 in Yano, 2014). This ring also has a regular circular form.

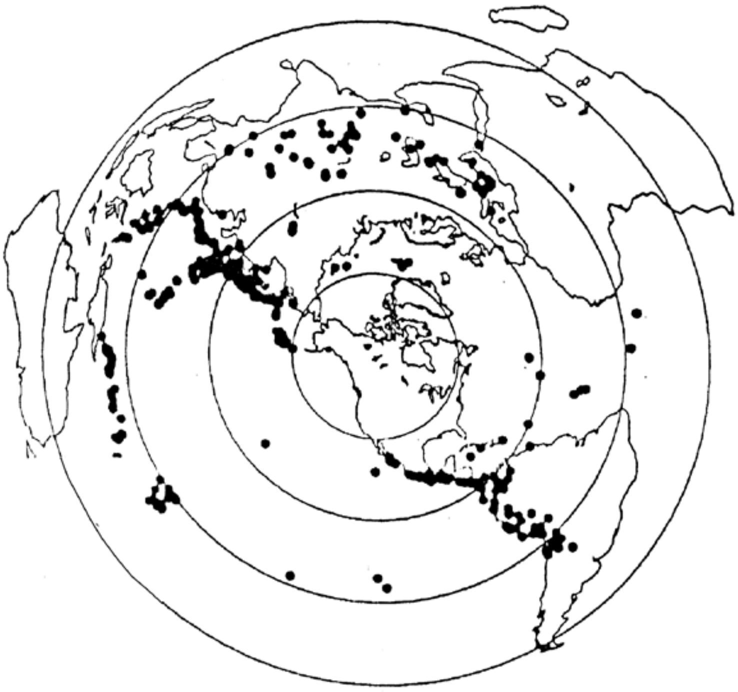

Fig. 1. Two global rings of the earthquake epicenters (Wilson, 1954; Bostock, 1997): the Pacific Ring with the regular round form is intersected almost at a right angle by the Mediterranean-Asian ring.

Tracing these seismically active zones by the high-velocity seismic anomalies across the whole mantle was an important recent discovery of the seismological research (Bijwaard et al., 1998). Such anomalies are not only observed on the Pacific sides but revealed at the boundaries of the large geological structures, on the passive margins of the continents and within the continents (**Fig. 2**). Within the active margins of the Pacific Ocean, these anomalies are most clearly expressed and can be traced to the depths of more than 2000 km.

The plate tectonic concept interprets the tectonically active Pacific margins as the subduction zones or the zones where the oceanic lithosphere is diving beneath the continents, which compensate the oceanic crust formation in the mid-oceanic ridges. However, the regular shape of the Pacific Ring and the absence of the mid-ocean ridge within this ring are inconsistent with this interpretation. We may only talk about a ring of seismically active zones or zones of deep destructions. Their large depths and the location in the areas of the higher seismic velocities confirm the assumption that they are not “slabs” of the oceanic lithosphere, but zones of deep folding and strong deformations.

The large depth of the Pacific Ring is highlighted by the pattern of the gravity field determined from the satellite measurements. Two circular gravity anomalies -- the positive and negative ones -- are observed around the Pacific (Choi and Pavlenkova, 2009). The ring of the positive anomalies can be accounted for by the topography since it covers the mountainous regions surrounding the ocean. A similar explanation for the negative anomaly is impossible because it intersects completely different regions: the central part of Eurasia, Indian Ocean, and eastern parts of the North and South Americas. Such a global anomaly could probably be associated with the deep heterogeneity of the Earth.

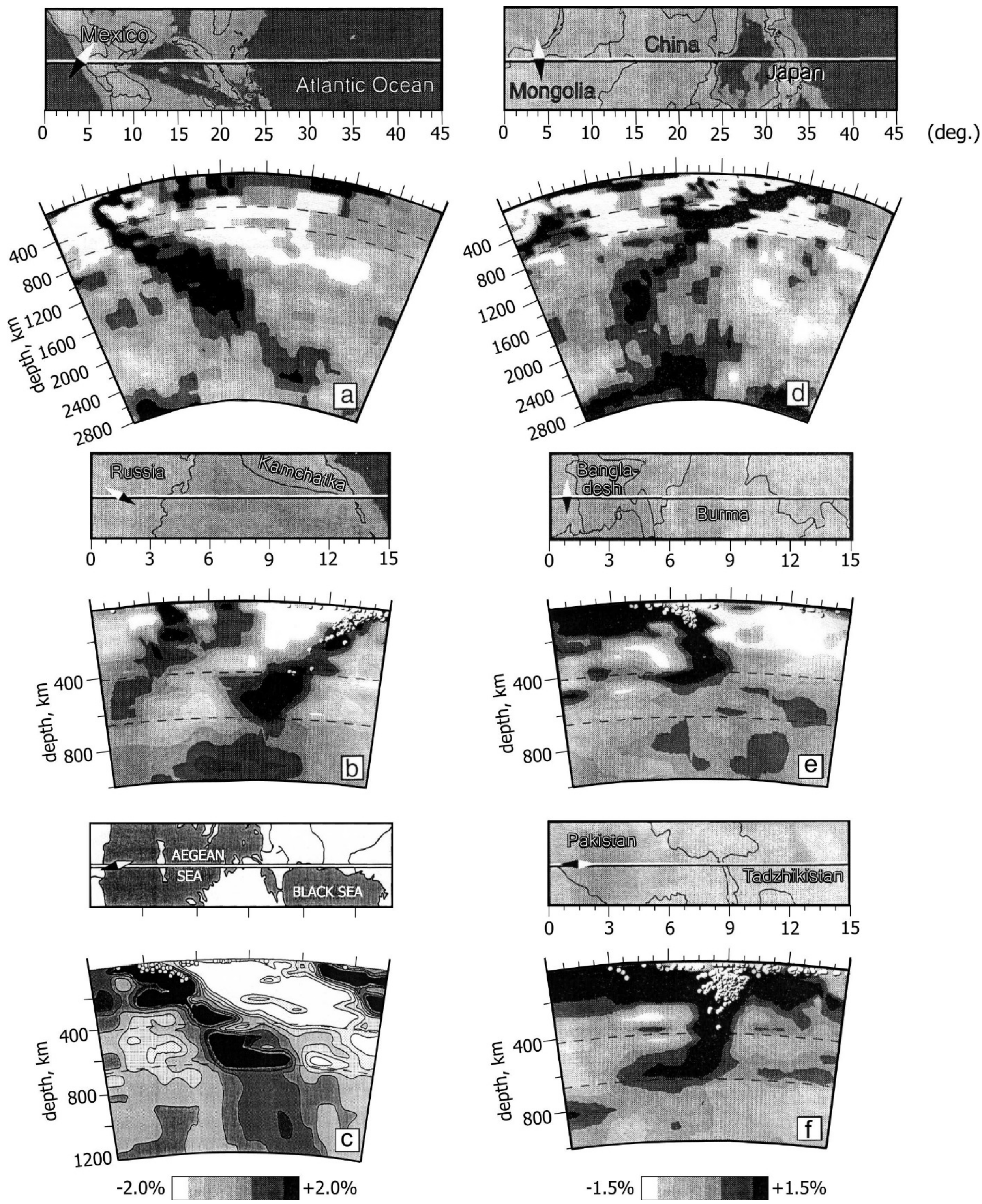

Fig. 2. Tomographic models of the mantle along the lines shown in the upper figures (Bijwaard et al., 1998). (a) Mexico – Atlantic Ocean, (b) Russia – Kamchatka, (c) Aegean Sea – Black Sea, (d) China –Japan, (e) Bangladesh – Burma, (f) Pakistan – Tadzhikistan. The most realistic interpretation is to treat these zones as the channels of the fluid flows from the core. The anomalous high velocities can result from the higher stresses, or velocity anisotropy, or the fragments of the core material.

There are also extensive empirical data demonstrating the difference in the age, geological history, and structure of the crust within the Pacific Ocean compared to other oceans, which means the different nature of the Pacific and Indo-Atlantic segments of the Earth (Pushcharovsky, 1997). The main conclusion is that the Pacific Ocean is a global element of the Earth and its origin cannot be explained in the same way as the other oceans.

The structure of the Atlantic and Indian oceans. The system of mid-oceanic ridges.

The continental margins of the Atlantic and Indian Oceans are passive, without the Benioff zones, and their mid-ocean ridges are really the mid-oceanic zones. The most important global feature of these ridges is their planetary-scale geographical configuration. Namely, these regions form a symmetrical system around the South Pole, which consists of a circum-Antarctic ring with a series of the rifts and disturbed zones diverging along the meridians with almost identical distances between them, 90^0. These rifts are the seismic active zones and, as is shown by the monitoring of the ozone layer structure, they are now the zones of active hydrogen degassing (**Fig. 3**). Three of these zones are observed in the southern hemisphere along the mid-ocean ridges and can further be tracked as the active tectonic zones stretching through the continents to the Arctic. The fourth zone follows along the meridian 155° from the western shelf of the Australian continent, then along the Philippine Trough, the Sakhalin Island, and the north-east Asian fault to the Arctic mid-oceanic ridge (Syvorotkin, 2002).

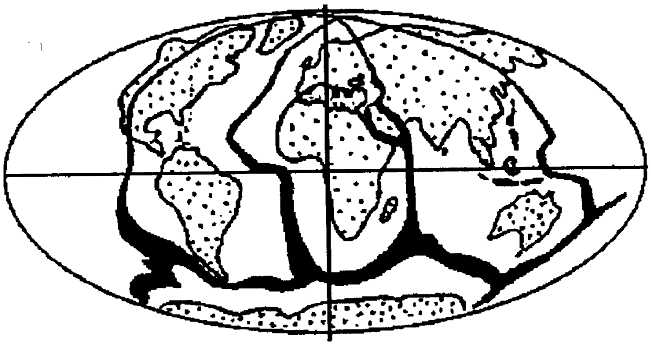

Fig. 3. Regular system of the planetary rifts which are the major channels of the Earth degassing (Syvorotkin, 2002). The rifts of the oceanic ridges form a ring surrounding the Antarctica continent with the branches along meridians with approximately identical distance of 90° between them.

The regular system of these Earth's structural elements is highlighted by the symmetry of the Arctic Ocean relative to the Antarctica, which are remarkably similar in size and shape but opposite in the sense of topography.

There are many other examples of the general regularity and symmetry in the structure of the Earth and there are many other tectonic lineaments which are traced from the oceans to the continents. For example, in the western part of the Pacific Ocean, several magnetic anomalies continue from the continents to the ocean. These data were used by Beloussov (1990) to criticise the plate tectonic concept (Ioganson, 2014). The Angola-Brazilian Geotraverse also shows that the magnetic anomalies in the western part of Africa also continue into the entire Angola deep-water basin (Pogrebitsky, 1996). The satellite imagery has significantly increased the number of such lineaments and revealed their longer lengths.

All these regularities confirm the absence of the large chaotic movements made by the individual parts of the Earth's spheres (continents or lithosphere plates) relative to each other. This is the most important conclusion for the development of any concept of global geodynamics.

The crustal and upper mantle structure of the continents and oceans

The seismic studies show the continents and oceans to have a significantly different structure of the tectonosphere (the crust and upper mantle). The continental crust is characterized by a large thickness, up to 50-60 km. Its consolidated part consists of three layers with the average thicknesses of 10-15 km and seismic velocities 6.0-6.4 km/s, 6.5-6.7 km/s, and 6.8-7.2 km/s in the upper, middle, and lower crust, respectively. The compositions of the layers were thoroughly studied based on the deep drilling and xenolith data: these are the granite-gneiss upper crust, granulite-gneiss middle crust and the granulite-basic lower crust (Kola deep borehole…, 1984; Downes, 1993).

The oceanic crust is usually thin (up to 10 km) and has an average velocity of 6.7-7.0 km/s. It was proposed by the plate tectonics that such crust was composed by basalts and had the same young age as the covering sediments (not older than the Cretaceous). But the deep-water drilling has shown that this crust was much older (sometimes Archean-Proterozoic) and was composed mainly by gabbro even in the mid-oceanic ridges. All this data, including the detailed description of the drill cores, the rock age and composition, are summarized in Bluman (2011). Three main layers were distinguished in the 10-15 km depth oceanic crust. The first layer has a seismic velocity of 2.0 km/s and is composed of sediments. The second, 2-3 km thick layer consists of the pillow basalts (velocities are 2.5-3.8 km/s) and the dyke complex (4.0-6.0 km/s). The third layer with a thickness of 5-10 km is the isotropic gabbro with the velocities of 6.5-6.8 km/s and the cumulative gabbro with velocities of 6.9-7.3 km/s. In some regions, the fourth layer of serpentinite composition is observed (7.4-7.9 km/s).

The recent geological and geophysical studies also revealed the large oceanic areas with thick (15-30 km) crust. The internal structure of these crusts gives grounds for dividing them into two transitional types, subcontinental and suboceanic (Beloussov and Pavlenkova, 1984; fig. 1a in Pavlenkova, 2012b). The subcontinental crust comprises the three main layers of the continental crust; however, the upper granite-gneiss layer is thin (3-5 km), and the lower basic layer with a velocity of 6.8-7.2 km/s makes up the bulk of the crust. The "suboceanic" crust has no granite-gneiss layer; it is a thick basic crust (**Fig. 4a**).

The transition crusts are usually observed in the continents beneath the rifts and deep sedimentary basins. In the oceans, they were discovered by seismic studies beneath the submarine plateaus and aseismic ridges. Within the continent margins, the crust often pertains to the subcontinental or continental type. The northern margin of Eurasia (Kashubin et al., 2013) and the enormous northwestern margin of the Australia (Ray et al, 2008) are the examples.

New interesting data on the crustal types were obtained in the Arctic. The oceanic type of the crust is only established in the narrow mid-oceanic ridge zone (Gakkel Ridge) (**Fig. 4a**). A thick (more than 40 km) continental crust covers the bulk of the territories of Eurasian and North American continents. Within their margins, the crust also belongs to the continental type but has slightly smaller thickness (on average, about 30-35 km). The crust in the central Arctic has the transitional type: the Lomonosov ridge crust differs from the continental type by the lower thickness (about 20 km); the crust beneath the Mendeleev and Alpha Ridges has an average thickness of 30 km with a thin (about 5 km) granite-gneiss layer (**Figs. 5 and 6**) (Zamanskii et al., 2003; Funk et al., 2011; Kashubin et al., 2013). Within the Arctic shelf of Eurasia, the large basins with the depths of 15-20 km are also characterized by the different crustal types. The continental crust is observed in the North Barents Basin, the subcontinental crustal type is identified in the South Kara Basin, and the suboceanic crust established within the South Barents Basin (**Fig. 7**).

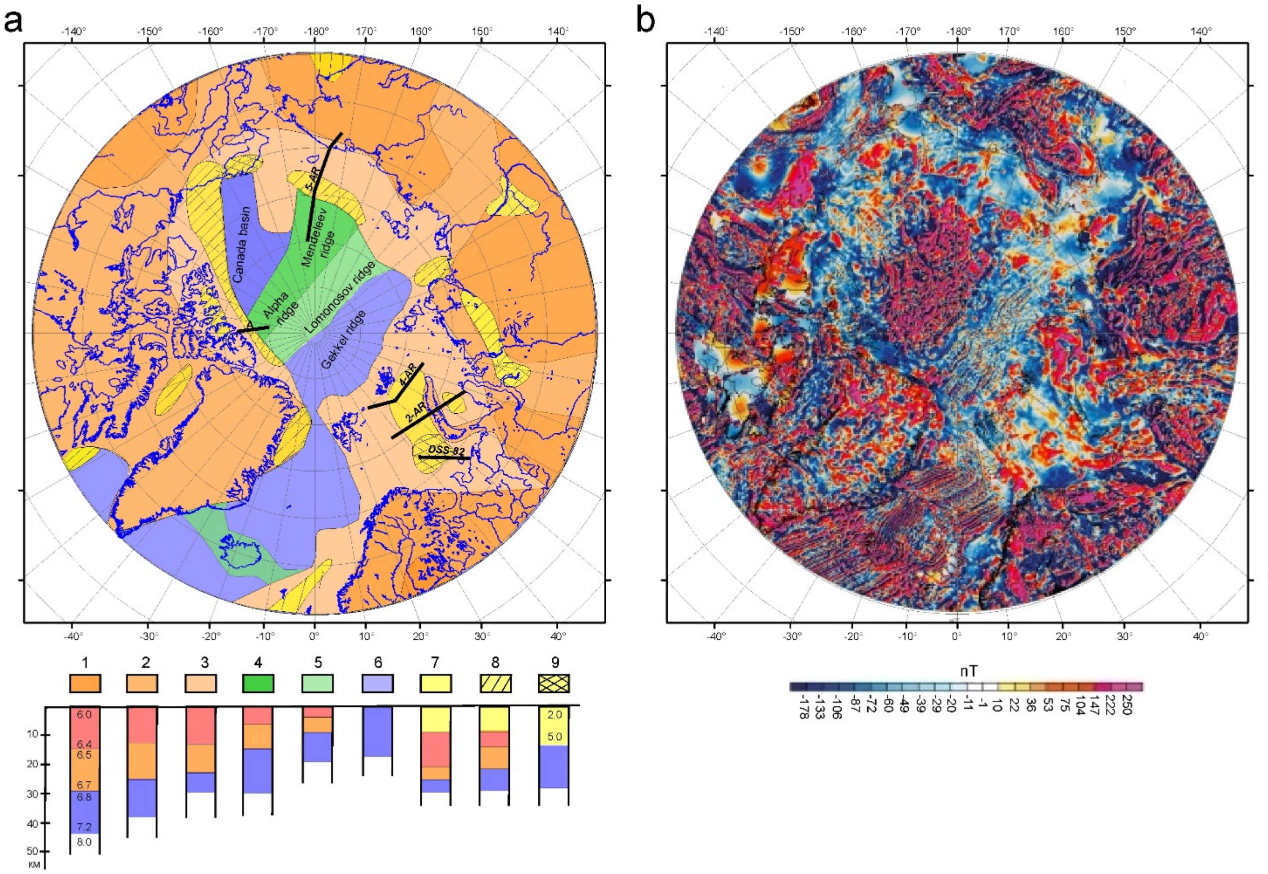

Fig. 4. (a) Geodynamic scheme of the Circum-Arctic. The crustal types: 1-3 – continental, 4-5 – subcontinental, suboceanic, 7-9 – deep basin crustal types: 7 – continental, 8 – subcontinental, 9 – suboceanic. The black lines show the seismic profiles discussed below.
(b) The map of the magnetic field (Gaina et al., 2011).

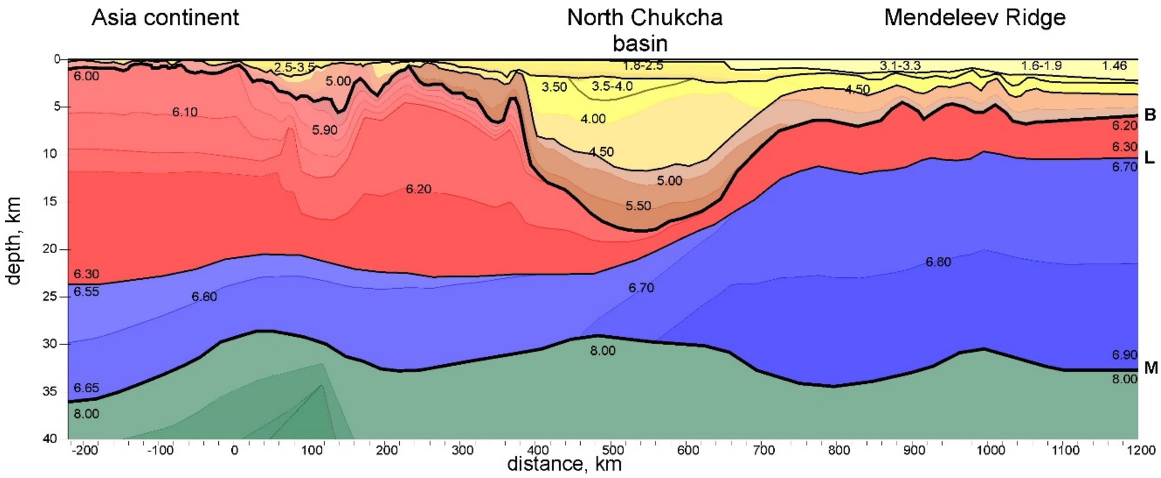

Fig. 5. Seismic velocity model of the crust along the profile 5-AR which crosses the boundary between the Asian continent and the Mendeleev Ridge in the Arctic Ocean (Kashubin et al., 2013). The numbers indicate the P- wave velocities in km/s, and M is crustal bottom. The profile location is shown in Fig. 4a.

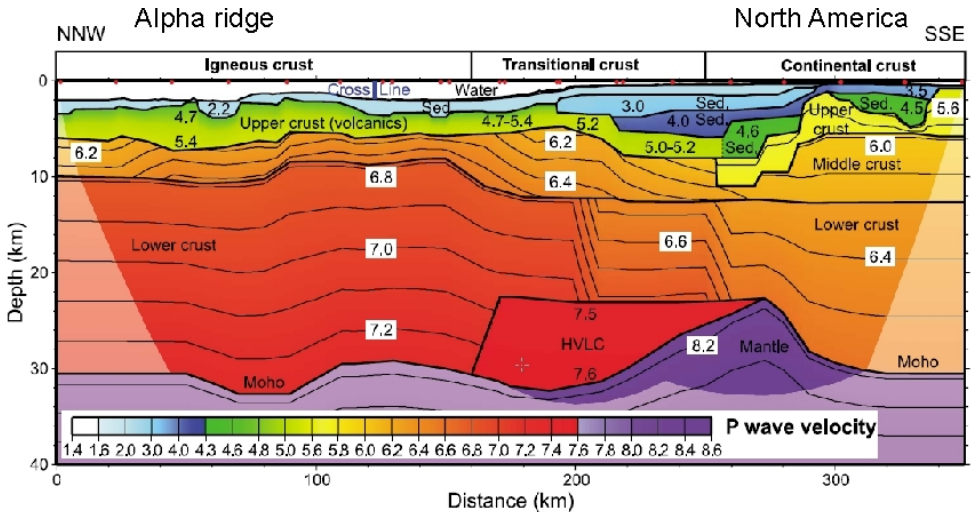

Fig. 6. The crustal seismic velocity model along the profile A which crosses the boundary between the North America and Alpha ridge in the Arctic Ocean (Funk et al., 2011). The profile location is shown in Fig. 4a. HVLC – high velocity lower crust.

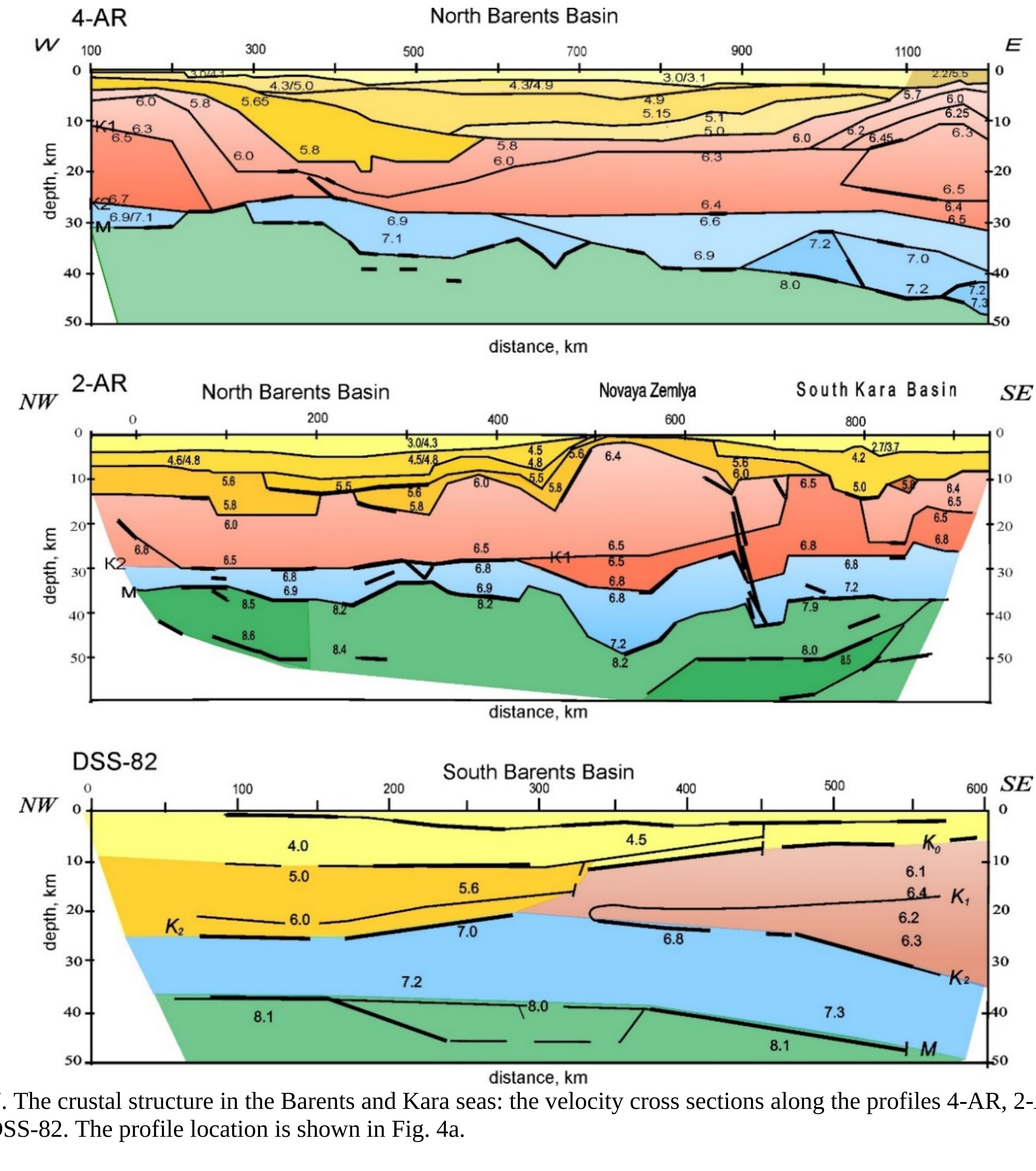

Fig. 7. The crustal structure in the Barents and Kara seas: the velocity cross sections along the profiles 4-AR, 2-AR and DSS-82. The profile location is shown in Fig. 4a.

A clear correlation is observed in the Arctic Ocean between the crustal types and the intensity and structure of the magnetic anomalies (**Fig. 4b**). The continents with the typical continental crust are characterized by very intense magnetic fields with large local anomalies of different signs and irregular shapes. The thinner continental crust of the continental margins is expressed by the less intense local magnetic anomalies. In the central part of the ocean, the subcontinental crust acquires the specific features of the continental magnetic field.

The similar correlation between the magnetic fields and crustal structure is observed in the other oceans. The only exception is the mid-ocean ridges where the thin oceanic crust is typically collocated with the extended linear magnetic anomalies. In the other parts of the oceans, the magnetic field is complicated and very often close to the continental type with the large local anomalies of different signs and irregular shapes (**Fig. 8**; Korhonen et al., 2007). The seismic and geological studies in these regions revealed the transitional crust. Beneath the Southern Agulhas Plateau, the subcontinental crust has a thickness of 20-25 km and the 5-km upper crust has the granite-granulite-gneiss velocities (6.2-6.6 km/s), whereas in the lower crust the velocities are 7.0-7.4 km/s (Allen and Tucholke, 1981; Gohl and Uenzelmann-Neben, 2001). In the Atlantic Ocean, the transitional crust is observed beneath the Farrero-Iceland Ridge (Bott et al., 1974; Pavlenkova, and Zverev, 1981; Richardson et al., 1998). The seismic velocities typical of the continental material are identified in the upper crust of the Ontong Java Plateau (Furumoto et al., 1976; Hussong et al., 1979) and in the northern part of the Kerguelen Plateau (Charvis et al., 1995; Operto and Charvis, 1996). The southern part of Kerguelen has the suboceanic crust. In the Pacific Ocean, the fragments of the subcontinental crust cover the extreme east of the ocean (Pratt, 2000; Choi, 2007; Choi and Vasiliev, 2008; Vasiliev et al., 2012).

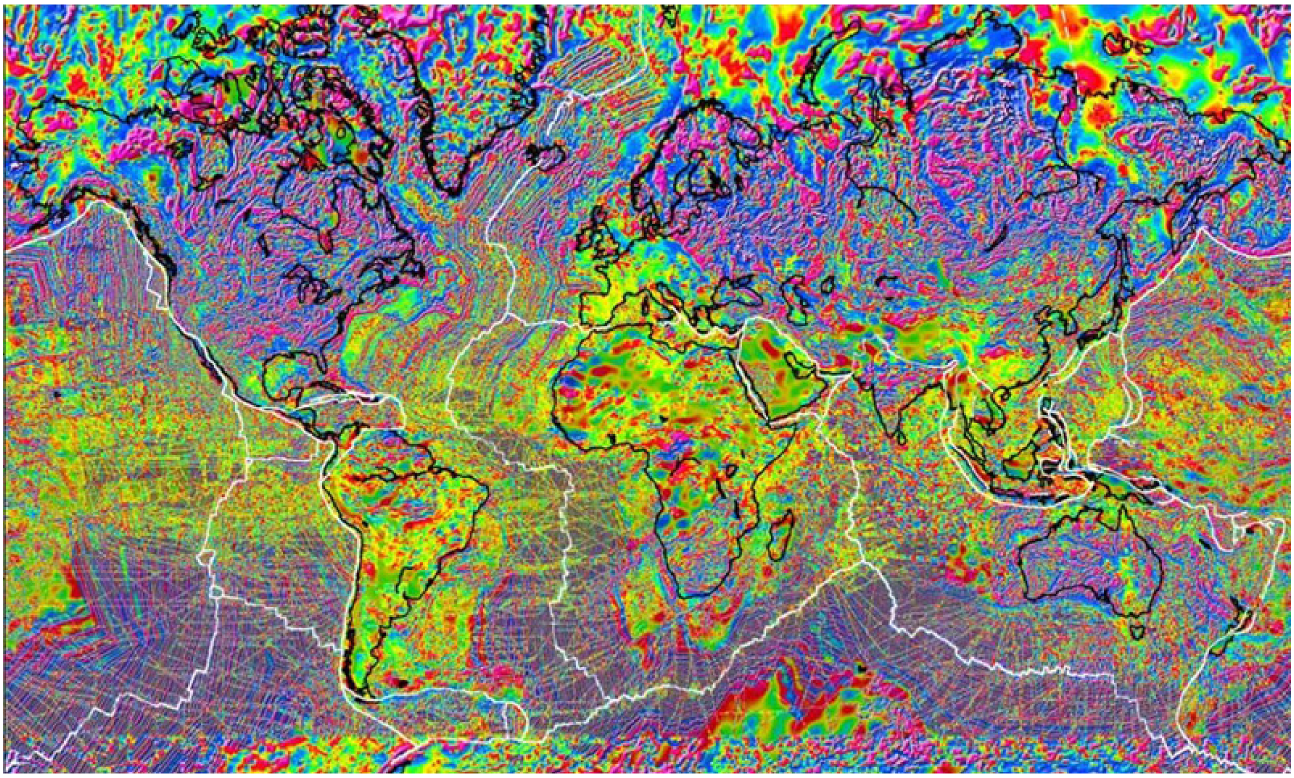

Fig. 8. The map of global magnetic anomalies (Korhonen et al., 2007).

Thus, various crustal types are observed across the Earth's surface, and it is barely possible to make simple conclusions about the difference between the crustal structure of the continents and oceans in as few as two terms – the continental and oceanic crust.

The clear distinction is revealed between the oceanic and continental upper mantles. They differ by composition. This follows from their different magmas: the alkaline magma is typical of the continents and the tholeiite magma, of the oceans (Lutz, 1980; Beloussov, 1990). At present, the composition of the upper mantle of the continents has been closely studied from the xenolith data (O'Reilly and Griffin, 2006; Boyd et al., 1997; Glebovitsky et al., 2001). In the Siberian craton, most of the sampled xenoliths are common peridotites such as harzburgite and lherzolite. It means that the upper mantle of the continents is significantly depleted (relative to the primitive mantle) in CaO, Al_2O_3 and FeO (Walter, 1998; Griffin et al., 2008; Ionov et al., 2002 and 2010).

The seismological and seismic studies reported the large high-velocity anomalies beneath the continents, which were called the continental roots or keels (Jordan, 1979; Gossler and Kind, 1996; Pavlenkova, 1996). The nature of these high-velocity anomalies was determined by a combination of the different geological and geophysical data. The laboratory data on the physical properties of the mantle rocks show that their seismic velocities mainly depend on temperature and, to a lesser degree, on the composition. That suggests that the continental roots are the result of the lower heat regimes in the upper mantle. The same conclusions were obtained from the heat flow and xenolith data. The average heat flow does not differ much between the continents and ocean. However, the bulk of the continental heat flow is produced by the radio-active elements abundant in the granite-gneiss crustal layer, and the role of the continental upper mantle in the heat production is very small (Gordienko, 1980; Gordienko and Pavlenkova, 1985). As a result, according to the heat flow data, the thickness of the continental lithosphere with the velocities of 8.1-8.5 km/s is 250-350 km; the average mantle lithosphere velocities in the oceans are 7.8-8.1 km/s and the thickness of the lithosphere here is about 100-150 km (Artemieva and Mooney, 2001). The xenolith data enabled the geophysicists to determine the temperature regime in the upper mantle. The results confirmed that the high-velocity continental roots are the low-temperature blocks of the lithosphere mantle (Kuskov and Kronrod, 2007; Kuskov et al., 2014).

However, the continental lithosphere is not only observed beneath the continents. The continental mantle blocks were revealed in the oceans (O'Reilly et al., 2009). The isotopic-geochemical investigations of the oceanic island basalts and the studies of the nature and age of the oceanic sill domains have shown 'the protracted stable and isolated existence of the geochemical deep "reservoirs" on isotopic geochemical "marks". The ancient age of the mantle rocks of these blocks has been established (Alard et al., 2005; Liu et al., 2008).

Thus, the deep-water drilling, detailed geochemical, petrophysical and deep geophysical studies of the last decades reveal many new data on the structure, the composition and the age of the oceanic and continental crust and upper mantle (tectonosphere). (1) Large areas of the oceans are covered by the old oceanic crust and by the crust of the subcontinental type; (2) the deep lithosphere root of the continents is composed with the low temperature and lower density depleted matter. And now the most important problem of the global tectonics is how these different crusts and lithospheres were formed?

The main present-day concepts of the origin of the different crustal types

Several processes were suggested to account for the Earth's crust formation. According to the plate tectonic and some expanding Earth concepts, the oceanic crust is associated with rifting which breaks the continental plates and creates the deep gaps which are then filled by the mantle material. This origin of the oceanic crust remains the most feasible mechanism for the mid-oceanic ridges but that does not explain the old oceanic crust formation. The origin of the transition type crust is also more challenging. The formation of the thick (15-20 km) suboceanic crust in the oceans is often associated with the intense volcanism (Mahoney and Coffin, 1997; Richardson et al., 1998; Bryan et al., 2010) or with the underplating (augmentation of the crust from below by the accretion of basalt intrusions). The origin of the transitional crust in the continents is also often attributed to rifting and volcanism (White and McKenzie, 1989). For instance, rifting plays an important role in the formation of the suboceanic crust in the continental rifts such as the Baikal or the Red Sea rifts.

The linear form of some deep basins is also often associated with their formation along the rifts or large fault zones. The basins which are traced around the central part of the Arctic Ocean (**Fig. 4a**) are the examples. The seismic cross-sections (**Figs. 5 and 6**) show that the basins are located between the crustal blocks where the continental crust with a 20-km thick granite-gneiss layer (velocity 6.0-6.4 km/s) sharply changes into the subcontinental type with a thin granite-gneiss layer (5 km). This supports the basins formation along the fault zones. However, large intrusions of the mantle rocks were not revealed in these fault zones; therefore, these basins do not have an ordinary rifting-related origin. The reduction of the crustal thickness beneath such basins is in some cases explained by the eclogitization of the lower crust (Artyushkov and Poselov, 2010).

The origin of the subcontinental crust is most frequently accounted for by the destruction and transformation of the continental crust. This is indeed the case within some continental margins and oceanic plateaus. The deep drilling shows that their upper crust often consists of the continental rocks which are covered by the same basalts as on the continents (Udintsev and Koreneva, 1982; Gaggero and Cortesogno, 1997; and others). For instance, along the eastern segment of Greenland, at a depth of about 4000 m and up to a distance to 60 km off the shore, the onshore and offshore basalt flows and sills are observed. They are recovered by the volcanic fragments and shallow water material of the granite-metamorphic Pre-Cambrian rocks (Bluman, 2011). The extensive zone of the flood basalts is also distinguished in the eastern part of the North Atlantic where these basalts cover the Faroese islands. The similar basalt areas are also identified in the other oceans. Within the passive margin of the South America (the submarine Santos and Campo plateaus and the Rio-Grande uplift), the flood basalts are traced up to a distance to 600 km off the shore.

Basification of the continental crust is the main process responsible for its transformation into the transition type (Beloussov, 1971 and 1990; Ollier and Pain, 1980). Basification implies the enrichment of the crust by the rocks of basic composition due to the advection of the mantle material and the alteration of the continental rocks at higher temperature and pressure. The geological studies confirmed the reality of this transformation which is indeed observed in different parts of the Earth (Frolova et al., 1992; Bijward and Spakman, 1999).

The basification of the continental crust is also most probable in the case of the formation of the deep sedimentary basins in the continents. This can be illustrated by the crustal structure of the basins in the Barents-Kara margin. Initially, it was assumed that the South Barents and North Barents Sea basins extending along the Novaya Zemlya Island (**Fig. 4a**) have a rifting-related origin. However, the seismic studies revealed fundamental differences in the crustal structure of these two basins. The pure continental crustal type was established for the North Barents Basin, whereas the crust within the South Barents Basin was referred to the suboceanic type (**Fig. 7**). The isometric shape and the steep slopes are the common structural features of these basins. At a depth of about 15- 20 km, the basins' bottoms are flat, and the basement surfaces often manifest themselves by almost horizontal seismic boundaries. This structure does not support the rifting-related origin of the basins. It can be assumed that these basins are located above the long-lived channels conveying the mantle flows which slowly transport additional material and heat into the crust and, thus, cause metamorphization of the rocks and phase transitions. The observed differences between the North Barents subcontinental and South Barents suboceanic crust do not mean their different origin: the suboceanic crust could be formed due to the more intense basification by the mantle flows.

More complicated data on the transformation of the continental crust are obtained in the South Atlantic Ocean. In this region, an unusual correlation is observed between the crustal structure and the magnetic field. In the central part of the ocean, the mid-ocean ridge with the thin oceanic crust and linear magnetic anomalies is traced (**Fig. 9a**). The continents surrounding the ocean are characterized by the continental crust with the corresponding continental magnetic fields. However, the continental pattern of the magnetic field continues by 200-300 km into the ocean offshore Africa and South America (James, 2012).

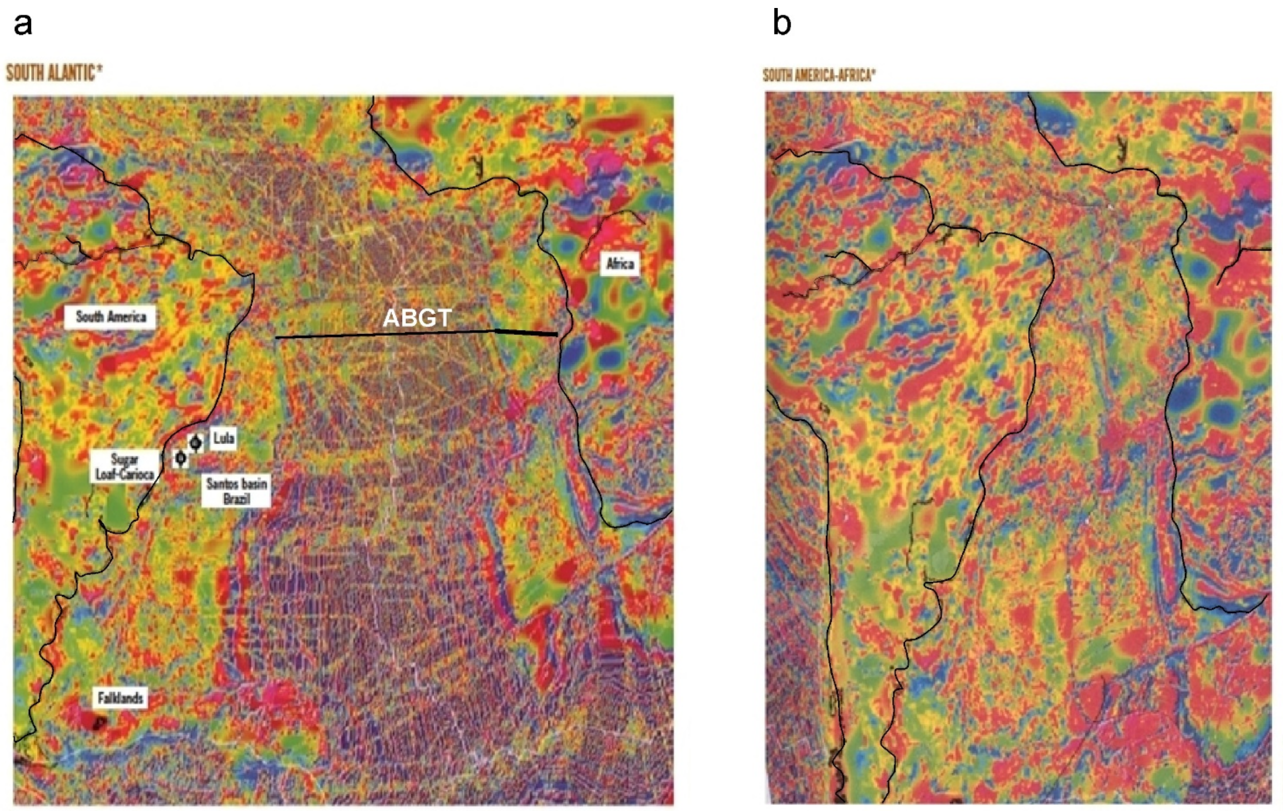

Fig. 9. (a) The observed magnetic fields in the South Atlantic Ocean, and (b) the transformed magnetic field without the mid-oceanic ridge area of linear anomalies (James, 2009 and 2012). ABGT – Angola-Brazil Geotraverse. The thick line shows the segment of the geotraverse for which the crustal model is presented in Fig. 10.

It could be expected that these offshore zones had the continental or subcontinental crust. However, the deep seismic studies along the Angola-Brazil geotraverse have shown that the crust in these zones is typically oceanic with a thickness of 10-12 km and seismic velocities of 6.6-6.8 km/s (Pavlenkova et al., 1993; fig.7 in Pavlenkova, 2012a). Only the upper mantle in this zone is structurally different from the other part of the geotraverse: here, the seismic boundaries are inclined to the continent and the seismic velocities are anomalously high (above 8.5 km/s, **Fig. 10**). The seismic tomography data confirmed the high velocities in the eastern part of the Atlantic upper mantle (Begg et al., 2009). These studies revealed the thick (300-400 km) high-velocity domains in the western part of the African continent, which extend into the Atlantic Ocean (**Fig. 11**). These domains were interpreted as “depleted, buoyant roots that formed in the Archean and have been metasomatised over time, but have remained attached to the overlaying crust”. These continental roots continue into the Atlantic Ocean as the “geochemical reservoirs isolated and preserved in the convecting mantle” (O’Reylly et al., 2009).

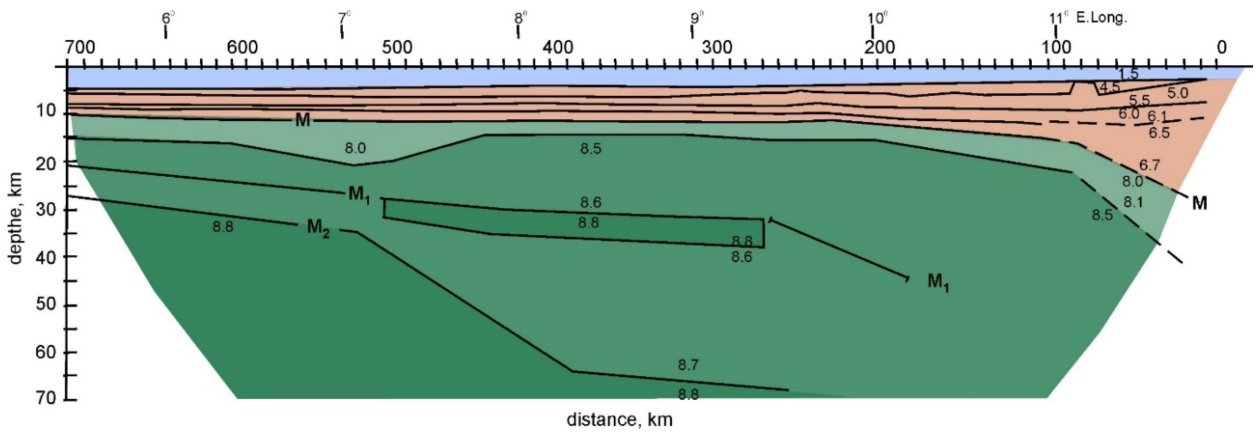

Fig. 10. The velocity cross-section along the eastern part of the Angola-Brazil geotraverse.

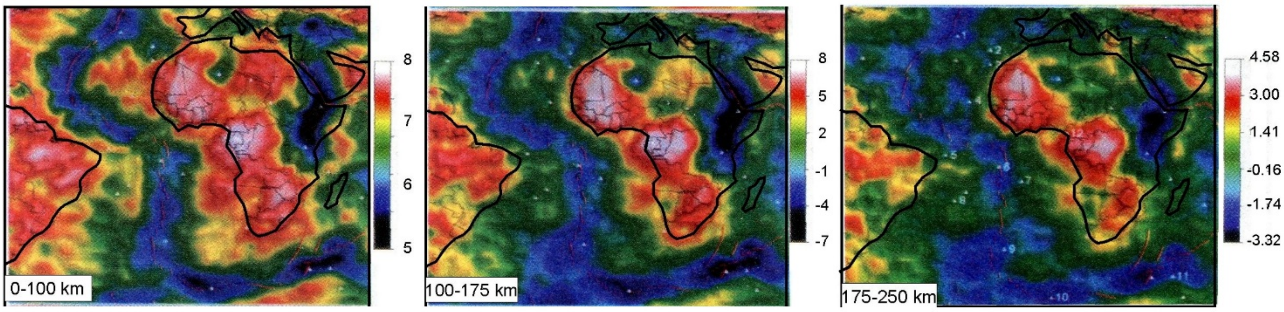

Fig. 11. The upper mantle tomographic model of the South Atlantic. The reference velocity Vs=4.5 km/s (O'Reilly et al., 2009).

A more plausible explanation for the data observed in this region is that the African and South American continents had larger dimensions with the corresponding continental magnetic fields and formed a single continent. The reconstruction of this continent along the margins of the continental type magnetic fields (James, 2009 and 2012) provides the good "Pangaean" fit (**Fig. 9b**). The contours of these large continents match perfectly and the magnetic fields draw a natural continuation of their structural features from one continent to another. It is reasonable to suppose that in the central part of this united continent, the crust had the continental type. However, the contemporary crust is oceanic. Hence, it is unclear how could it occur during the spreading of the original continents that the crustal thickness decreased to one third or one fourth its initial value, the granite-gneiss layer was completely destroyed, however the upper mantle structure and the magnetic field remained unchanged?

There is another, a more global problem. The most processes of the transitional crust formation which were described above assume that this crustal type was transformed from the continental crust which initially covered the entire surface of the Earth. However, the question is whether these processes can explain the formation of such crustal type across the large oceanic regions covering about a half of the Earth's surface. Lutz (1994) has noted that the continental crust transformation should form large amounts of alkalis and other elements which very rarely occur in the oceanic regions. Consequently the transitional crust may present not the transformed continental crust but the original one.

Thus, all the described processes (rifting, intense volcanism, mantle intrusions, and rock transformation) play some role in the formation of the different crustal types. But the new extensive geological and geophysical data show that even the classical oceanic crust has not merely resulted from rifting or volcanism but has undergone a long evolution. The deep-water drilling revealed not only the old age of the oceanic crust but also its more complicated composition even in the areas of the mid-oceanic ridges (Elton, 1997; Bluman, 2011; NCGT Journals). It was established that the isotropic gabbro of the third oceanic layer with seismic velocities of 6.5-6.8 km/s and a typical chemical composition of gabbro have a bubble or porphyry (point) structure. Such structure is characteristic for the metamorphic and not for magmatic rocks. The 1.3-km thick layer composed of these rocks was penetrated by the well in the Indian mid-oceanic ridge (Dick et al., 2000). These crystalline mafic-ultramafic rocks have an ancient age (1.6-3.7 billion years); their granulite phase metamorphism corresponds to 6-10 kbar pressure and 700-1000^0 temperature. This means that these rocks could not be generated as intrusive in the thin oceanic crust (Boris Kim, *personal information*). Some researchers suggest that these metamorphic rocks of the gneiss basic composition belonged to the third layer of the continental crust and could have been tectonically displaced from their generation locations to the upper layers of the crust and to the ocean floor surface (Pagrebitskiy and Truchalev, 2002; Khortov et al., 2014).

Thus, up to now the origin of the old oceanic crust covered the large areas of the Earth's surface, especially, in the Pacific hemisphere, is an unsolved problem. In my previous papers (Pavlenkova, 2005 and 2012a) I proposed a possible solution of the problem, based on the important role of the deep fluids in formation of the different crustal types. The recent geological and geophysical data, especially, the data on the role of Earth's degassing in transformation of the planet upper spheres, confirm this idea and give possibility to present the following model of the different crust formation.

The Earth's degassing model of the different crustal type formation.
All the data about the complex structure of the Earth's crust lead to the assumption that the continental, oceanic and transitional crusts were formed as a result of the different endogenous regimes in the upper mantle. The advection of the deep fluids (Earth's degassing), which was irregular in space and time, could have been the main source of such processes and different regimes. The advection could initiate the differentiation of the mantle material and, accordingly, lead to the growth of the different types of the primary crusts over the Earth's surface. The basis for this assumption was laid by the Lutz's studies (1980 and 1994) which showed that the rocks of the continental crust were formed from the mantle matter saturated with deep fluids. The latter supplied high energy from the large depths and provided the additional important elements for the evolution of the continental crust (for instance, the radio-active elements). The deep fluids were not only vital for the growth of the continental crust but also for its granitization. The latter took place most rapidly in the conditions of the high fluid flows which brought the necessary extra energy for this process. The granitization enhances the resistance of the rocks to the various geochemical effects and protects the continental crust from the destruction.

Thus, it can be hypothesized that the different crustal types are associated with fluid advection which is irregular in size and intensity: the creation of the thick silica crust occurred in the areas of the intense deep fluid flows, whereas in the regions of the contemporary oceans the fluid flows were weak and only the old mafic oceanic crust or separate spots of the subcontinental crust were formed.

The consistent growth of the continental crust in the areas of deep fluid flows does not exclude the reverse process of crustal destruction or transformation. The fluids bring the energy for the phase transitions and enhance their activity. The powerful streams of the high-energy deep fluids cause the melting of the mantle rocks and their intrusion into the crust. These processes lead to basification and eclogitization of the continental crust and its transformation into the transitional type.

The important role of the fluid advection can be illustrated by the structural particularities of the 10-15 km depth sedimentary basins in the platform regions. The basins have usually the rounded shapes and the plane basement surface. Some examples are described above (**Fig. 7**). The shapes and structural positions of the basins give the grounds to believe that they are located above the long-lived channels of the slow mantle flows which bring the additional material and heat into the crust from the large depths and, thus, initiate the metamorphism and phase transitions of the crustal rocks. The slow deep fluid advection explains the platform regime and circular form of the basins.

Determining the whole history of crustal formation in the different geological provinces is a challenging task. Its solution requires the detailed geological and geophysical data about the crustal age, structure and composition. Identifying the origin of the oceanic crust in the whole oceanic areas and discriminating between the primary old crust with the metamorphic gabbro composition and the young rifting crust with the cumulative gabbro of the magmatic origin is most difficult. The old primary oceanic crust can be expected to be predominant in the Pacific Ocean. In the oceans with the large mid-oceanic ridges (Atlantic and Indian Oceans), the young crust of the rifting-related origin can be observed between the old crusts. Thus, the ancient age and the metamorphic structure of the oceanic crusts suggest a long history of their formation with two main stages. The first stage mainly comprised the formation of the old oceanic and subcontinental crust and their complicated transformation; and at the second stage, the younger intrusive oceanic crust was created in the rifts which cut the old crust.

Different origin can be proposed for the transitional crusts within the continental margins and beneath the large oceanic plateaus. These crusts might either pertain to the primary transitional crust or the transformed continental crust. The latter was only reliably determined on the continental margins where the products of the granitic layer destruction were found (Frolova et al., 1992). However, such kind of the products is rarely found in the oceans and it is more probable, that the old oceanic crust in most of parts of the oceans is the primary crust. It is unclear, what is the origin of the subcontinental crust in the Arctic Ocean? This crust appears to be an original part of the old American-Eurasian continental hemisphere destroyed by rifting, mantle intrusions, etc. It is also possible that the subcontinental crust in this region is primary, and their higher density was the main cause of the Arctic oceanic basin formation.

Thus, the observed different crustal types are the results of several geodynamic processes: the growth of the continental crust during the differentiation of the mantle material, crustal transformations under the changes in the deep fluids flow and temperature regime, and destruction by rifting or by other tectonic movements. More detailed studies of the geological history and crustal structure for each crustal block are necessary to solve their origin problem. Some clues on this problem can be gleaned from the upper mantle structure characterizing the different endogenous regimes and energy sources responsible for crustal formation.

The continental "roots" and the problem of formation of the continents and oceans

As noted above, the continental and oceanic upper mantle differs in the thickness, seismic velocities and composition of the lithospheres. The continents have the thick lithospheric "roots" observed in the form of the 250-350-km deep anomalies of the higher seismic velocities (Jordan, 1974; Vinnik at al., 1996; Pavlenkova and Pavlenkova, 2014).

As noted above, the nature of these anomalies is now quite clear: they are explained by the lower temperatures beneath the continents. The upper mantle composition may be determined from the gravity data. This follows from the laboratory data on the physical properties of the mantle rocks at high pressure and temperature (**Fig. 12**). These data show a small differences in seismic velocities between the depleted material (garnet harzburgite, garnet lherzolite, average garnet peridotite) composing the continental lithosphere and the primitive mantle typical of the other regions (Jones et al., 2009; Poudjorm Djamani et al., 2001; Poupinet et al., 2003; James et al., 2004). At the same time, seismic velocities strongly depend on temperature.

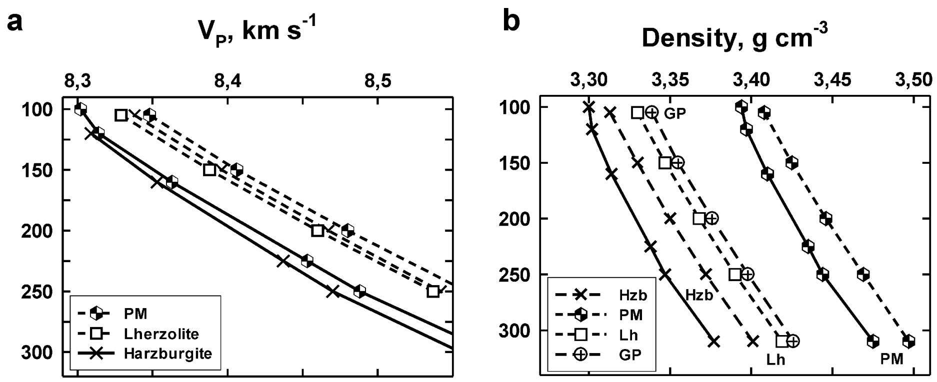

Fig. 12. The comparison of the P-velocities (a) and densities (b) for garnet harzburgite (Hzb), garnet lherzolite (Lh), average garnet peridotite (GP) and primitive mantle (PM) calculated along the conductive geotherms 35 mW m-2 (dashed lines) and 40 mW m-2 (solid lines). Note that densities of the primitive mantle are by 2-3% higher than for the depleted rocks (Kuskov et al., 2014).

These changes in the composition of the upper mantle have a weaker impact on seismic velocities, however they decrease the densities. **Fig. 12** shows that the density increase with depth does not compensate its decrease associated with the composition of the rocks. As a result, the "roots" of the depleted and cold continental lithosphere have a lower density than the primitive upper mantle. This is an important factor for the dynamical behavior of the mantle: the decrease in density provides a higher stability of the Archean craton lithosphere during its further evolution.

The origin of the depleted mantle observed beneath the continents, may be explained in two ways. In plate tectonics, the depletion of the craton lithosphere is often related to the very hot upper mantle regime in the Archean (King, 2005; Michaut et al., 2007; Berry et al., 2008). These conditions caused intense melting and extraction of komatiites and basaltic components from the upper mantle material. However, it is unclear why these old roots have not been destroyed by the convection in the mantle and by the lithosphere spreading during the long geological history. This problem was discussed in (O'Railly et al., 2006). "High-resolution global seismic tomography (Vs) models reveal high-velocity domains beneath cratonic crust in Africa that extend to depths of 300–400 km. These high-velocity domains show a distinct contrast with the characteristics of "normal" asthenosphere and are interpreted as depleted, buoyant roots that formed in the

Archean and have been metasomatic changed over time, but have remained attached to the overlying crust. Such deep roots are impediments to free horizontal convection in the upper mantle. The movement of magmas and other fluids in such regions may be more vertically constrained (a shallow lava lamp regime), creating a geodynamic environment conducive to interaction of such magmas with the boundaries of deep mantle domains that would carry old “crustal” geochemical signatures”.

Letnikov (1999 and 2006) solved this problem in another way. He suggested that the continental root formation was a long process of the removal of the silica, alkalis, fluids and incompatible elements from the mantle into the crust by the deep fluids flows during the whole geological history. This process should lead to changes in the composition of the crust (formation of the continental crust) and to the depletion of the mantle rocks, their crystallization, and formation of the thick continental lithosphere. The further gradual cooling makes the uppermost mantle more stable and contributes to the formation of a less permeable and more stable continental lithosphere compared to the oceanic regions.

The process of the lithospheric depletion and the corresponding decrease in density can also provide a new solution for the problem of the continents and oceans formation, the most debatable problem of global tectonics. The deep-water oceanic basins with the Cretaceous-Pleistocene sedimentary cover were considered as young structures appeared as the result of the Earth’s surface subsidence during the spreading of the lithospheric plates. However, the oceanic crust is old and, during the long geological history, it could cover the large areas of the Earth’s surface not divided yet into continents and oceans. Only after the continental crust creation and the mantle material depletion in the large regions of the deep fluid flows, the low-density lithosphere was formed and this low density initiated the lithosphere emerging due to the isostasy laws. It was the main cause of the continents' formation.

The growth of the lithospheric “roots” and the formation of the continents was a long cyclic process which depended on the intensity of the deep fluid flows and on the cycles of the planetary tectonic activity. Initially, in the Archean only the shields with the thick crust and some spots of the depleted mantle appeared as the small continents. Then, the platform lithosphere was slowly developing during a long time. The situation changed in the Late Paleozoic and Early Mesozoic when the internal energy of the Earth has strongly increased which resulted in the formation of the large rift zones, oceanic ridges and plateau-basalt eruptions all over the entire Earth’s surface (Mahoney and Coffin, 1997; Bell et al., 2003). The corresponding high temperature in the upper spheres of the Earth and the increase in their plasticity promoted the more intensive isostatic compensation of the upper mantle heterogeneity and the rise (emergence) of the lower-density continental lithospheres. At the same time, the uplifting of the continents was enhanced by the subsidence of the Earth’s surface in the spreading regions. This was the main stage of the continents and oceanic basin formation.

The differences in the topography between the areas with the different depletion rates of the mantle matter can be observed at present inside the continents. For example, the lithosphere of the Siberian craton in Eurasia is thicker and more depleted than the West Siberian lithosphere (Pavlenkova and Pavlenkova, 2014). As a result, the craton has a higher topography and is outlined by a large gravity minimum. The crust of the West Siberian plate is similar to that of the cratonic crust (in the thickness and seismic velocities in the consolidated crust), and the large sedimentary basin could only be formed by the slower uplifting of the plate's lithosphere (which is less depleted) during the emergence of the Eurasian cratons.

There are as well other examples when the crustal structure could play an important role in the continent formation (Hoshino, 2014). The deep drilling in the continental margins revealed the transitional crusts which are covered by the same basalts as on the neighboring continents and by the volcanic fragments and shallow water materials of granite-metamorphic Pre-Cambrian rocks. This crustal type is identified in the eastern part of Greenland, eastern part of the North Atlantic, within the passive margin of the South America (Udintsev and Koreneva, 1982; Gaggero and Cortesogno, 1997; Bluman, 2011). In these cases, it can be hypothesized that the transition crusts were the primary ones and their higher density, compared to the continental crust, was the main cause of the slower uplifting of the corresponding continental margins and oceanic plateaus during the continent formation.

Thus, the depletion of the mantle lithosphere resulting in the decrease of its density was the main cause of the continent formation. The large thickness of the less dense continental lithosphere led to its uplifting (emergence) relative to the oceanic lithosphere. The rate of ascent also depended on the crustal structure: the transition crust, which has a higher density, prevented some continental block from rising.

As far as the energy source of all the described tectonic processes is concerned, the main role here belongs to the Earth's degassing. The growth of the lower-density granite-gneiss crust and depleted lithosphere and their resulting isostatic uplifting were created by the advection of the deep fluids (Earth's degassing). The latter can be considered as the most important energy source in the global tectonics.

Degassing of the Earth as the main source of the tectogenesis.

A large body of the geological, geophysical, geochemical and astronomical studies have shown that an important feature of the Earth which distinguishes it from the other planets is a high fluid content, in particular, the high content of hydrogen and helium in the Earth's core (Larin, 1995; Williams, Hemley, 2001; Gilat, Vol, 2005). At present, the Earth's degassing is not a hypothesis but the observed process studied by the different geological and geophysical methods. The fact that the Earth is still degassing is reliable (Williams and Hemley, 2001; Porcelli and Turekian, 2003).

The most complete experimental data on the hydrogen degassing are based on studying the structure of the ozone layer which is destroyed by the intense hydrogen flows (Syvorotkin, 2002). These studies showed that the hydrogen degassing continues at present and is most active in the southern hemisphere, where it forms the large ozone hole over the Antarctica. The hydrogen degassing is also directly measured in the different parts of the Earth's surface (Larin, 1995). Many other measurements have confirmed that the large energy release by the different tectonic processes is always accompanied by the H- and He-degassing.

The laboratory experiments with the ultra-high PT-conditions (Gilat and Vol, 2005) show that solid solutions of H and He, and the compounds of He with H, 0, Si and metals can be present in the Earth's core and mantle. These "exotic" compounds (which can be referred to as "hard deep fluids") are uplifted step by step (for each PT-condition) to the Earth's surface through H- and He-trickling from the solid core, convecting in the liquid core, flux-melting the solid mantle, and generating the gas-liquid plumes accompanied by the intense energy release. The internal heat flow measurements (^{3}He degassing) and calculations lead to the conclusion that up to half of the present rate of heat flow from the Earth's surface is contributed by the chain of the H and He-related reactions.

The physical properties of the deep fluids and processes of their transportation into the upper spheres of the Earth were studied in the Irkutsk Institute of Earth Crust RAS, where the unique experiments were carried out in the autoclaves, at the high-pressure installations, and in the gas high-pressure bombs (Letnikov, 1999, 2000 and 2006). It was shown that the fluids in the mantle are mainly the gas mixtures and the high compressibility of the gases is one of their remarkable features. The increase in pressure strongly contracts the volume of the gases and increases their density. That is why the large thermal energy is contained in a small volume of the compressed gases and therefore the deep fluids carry the bulk of the thermal energy to the Earth's surface.

The experiments also demonstrated a high permeability of the deep fluids which percolate through any matter. A new mechanism of the fluid transportation at the large depths was discovered: a fluid transfer along the planes of schistose rocks (fluid sliding on the planes on the molecular level). The mass volume of this transfer by a few orders of magnitude exceeds the volume transfer along the shallow fracture zones where the plastic deformation is changed by the brittle one and where the fluids pass from the thin film to the volume state and migrate through the pores and fissures.

The high fluid permeability at the large depths can explain the nature of the Benioff zones (plate tectonics subduction zones), which are tracked by the high-velocity mantle anomalies extending into the lower mantle (**Fig. 2**). The Benioff zones are, apparently, the zones of the high stresses and the corresponding profound transformation of the mantle material (schistose rocks). These areas are highly permeable for fluids and, therefore, they can serve as the channels of their intense streams. The depth of these zones supports the assumption that the source of the deep fluids can be located in the liquid core.

The fluid streams can also explain the high seismicity of the Benioff zones at large depths and the observed mechanism of the earthquakes. These earthquakes frequently have the explosive nature and are clustered at certain depths, for instance, at a depth of 100 and 200 km (**Fig. 13**).The explosions could probably be associated with the compressed and dense fluids entering the low-pressure and low-temperature region since the gas phase transitions can be accompanied by the explosive effects.

The Benioff zones are not only the channels conveying the intense fluid flows. The intense hydrogen flows are observed within the mid-ocean ridges (**Fig. 3**) and in the other disturbed tectonosphere areas (Syvorotkin, 2002; Larin, 1995). The highly permeable zones including the fracture zones and the low-velocity layers in the middle crust and mantle lithosphere form a large system of the degassing flows. This system of the fluid channels could activate the intense deep fluid advection in the different parts of the Earth from one source.

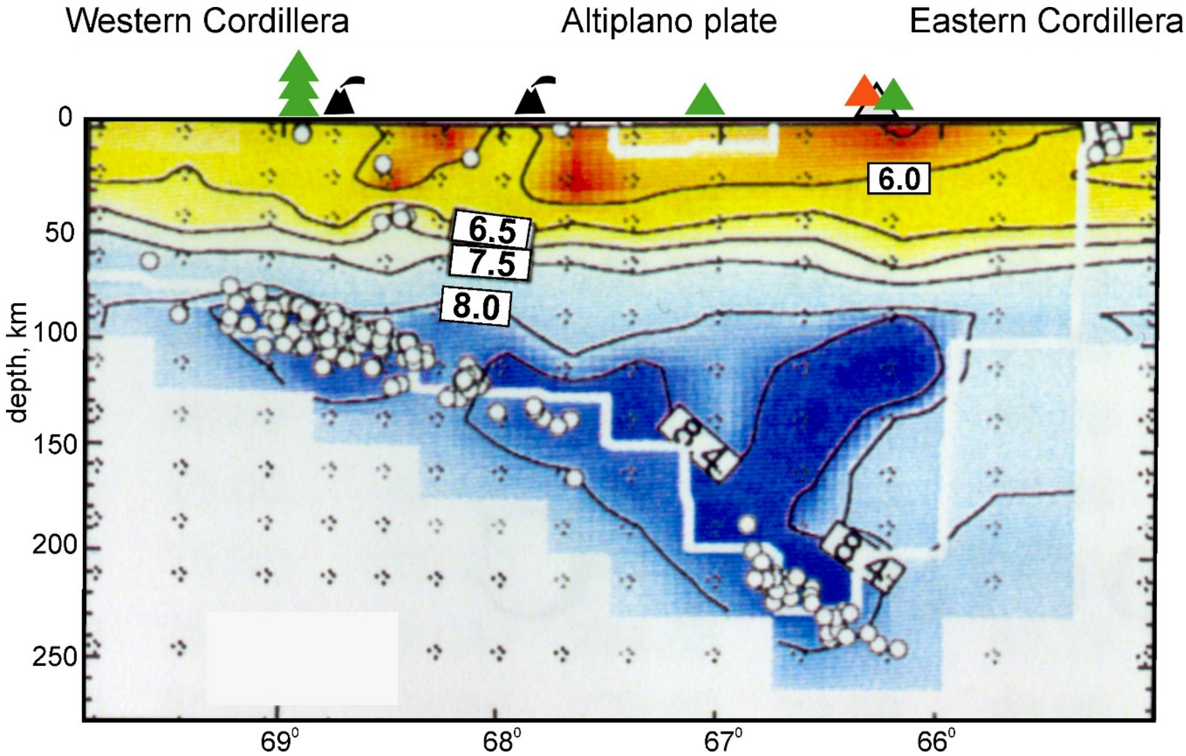

Fig. 13. The velocity model (km/s) and deep earthquake (white points) distribution for the lithosphere of the Argentine Puna Plateau (Schurr et al., 1999; Romanyuk and Tkachev, 2006). The triangles mark the locations of the different mineral deposits.

All the described features of the deep fluids made them a unique "source of internal energy which: (a) are quickly focused, e.g. earthquakes and volcanic eruptions; (b) are of very high density; (c) provide very high velocities of energy release; (d) have very high density of the energy transport and relatively small losses during transportation over long distances; (f) are quasi-constantly released and practically limitless" (Gilat and Vol, 2005).

The high intensity of this advection and the rate of its implementation closely agree with the plume tectonic concept which is extensively developed at present. The transformation of the fluids due to the changes in their temperature and pressure cause high energy release at some depths, melting of the mantle material, and generation of the large plumes. The fluid advection can also explain the formation mechanism of the so-called "hot spots" and their mobility, which is not associated with the motion of the lithosphere plates over these points but is rather due to the motion of the fluid flows along the developed fracture zones.

The functional variety is another unique property of the deep fluids. Namely, the fluid system concentrates the different elements with broadly varying physical and chemical parameters, carry them to a significant distance in the different transfer forms, actively interacts with the rocks, and change them (Letnikov, 1999). Many processes of the mineral and rock formation occur with the participation of the fluids. As has been shown above, the degassing of the fluids results in the formation of the granite-gneiss crust and depleted lithosphere. The protracted process of silica, fluids, and non-coherent elements removing from the upper mantle results in the mantle material crystallization. As soon as the fluid content in the hard rocks becomes significantly lower, the changes in the rheological properties of the material can induce the concentration of the fluids and non-coherent elements in front of the crystallization and at the other critical P-T levels and cause the formation of the 'fluid asthenolites' and other low velocity layers.

This origin scenario can be assumed for the low velocity layers revealed in the continental lithosphere at a depth of 100 km (figs. 1 and 2 in Pavlenkova and Pavlenkova, 2014). The interpretation of these layers as the zones of partial melting is invalid in the old platform areas where the partial melting ("thermal asthenosphere") is supposed at the depths of 250-300 km (Artemieva and Mooney, 2001). The origin of these layers is most probably associated with the change in the mechanical properties of the mantle material and the increase in the fluid content (Menzies and Chazot, 1995). This hypothesis is supported by the data indicating that in many regions, these uppermost mantle layers are characterized by the higher electrical conductivity (Jones at al., 2009).

The similar origin can also be suggested for the regional seismic boundaries in the mantle lithosphere. These boundaries were an unexpected result of the detailed seismic profiling (Pavlenkova, 2011) because it appeared unrealistic to find the regular and strong velocity contrasts in the upper mantle whose velocities are insensitive to the material composition (**Fig. 12**). The temperature change cannot create strong velocity contrasts either. None of the discovered boundaries is a first-order discontinuity: the waves from these boundaries pertain to the complicated multi-phase groups of oscillations. Such boundaries might appear as the physical boundaries marked by the sharp changes in the different physical or mechanical properties of the material (porosity, permeability, fissuring, transition from the solid to liquid state through creep, transition to the state of true plasticity, and other physical transformations). The increase or decrease in porosity is invariably followed by the change in the fluid content, which can trigger the different physicochemical transformations of the material such as the new degrees of metamorphism (Letnikov, 2000 and 2006), and initiate partial melting and mobility of the material at relatively low temperature (Kern, 1982 and 1993).

The deep fluid advection can also explain the observed structure of the upper mantle in the oceans. For instance, beneath the South Atlantic mid-oceanic ridge, the mantle structure more closely agrees with the fluid advection then convection. The Angola Brazilian geotraverse has not revealed the asthenospheric bulge created by the suggested upward convective flow (fig. 7 in Pavlenkova, 2012a). The seismic studies in the ridge area identified a few low velocity zones separated by the high-velocity layers (8.2-8.4 km/s) untypical of the asthenosphere. This structure could be created by the concentration of the deep fluids in the layers with higher permeability or at the certain pressure and temperature levels associated with the fluid phase transformations.

The Earth's degassing can also explain the cyclic development of the tectonosphere with a global change of the active tectonic periods by the stable ones. For instance, the cycles of folding and flattening out during the mountain formation are described by Ollier (2003), and the periods of the large-scale sedimentation over large areas (surface subduction) were determined in (Ermakov, 2015). The cyclic recurrence is typical of the Earth's degassing and may cause many other periodic geological events. The degassing cyclic activity and the changes in the intensity and direction of the deep fluid flows can also account for the paleomagnetic data about the magnetic poles mobility without involving the unrealistic large movements of the continents.

The list of the structural features of the tectonosphere and geodynamic processes which are closely related to the fluid advection and degassing of the Earth can be continued (Gasparik, 1992; Keith, 1993; Porcelli, Turekian, 2003, etc.). The mapping of the global distribution of the major oil/gas and mineral deposits shows these areas clustering within the deep zones of destruction and high hydrogen degassing (Thompson, 1992; Dmitrievsky and Valjaev, 2002; Kirkham and Rafer, 2003; Runkvist, 2006; Storetvedt and

Longhinos, 2012).

Thus, the Earth's degassing is the most important energy source for the global tectonics. The peculiarities of the fluid advection not only help to explain the global tectonic features described above (the different crustal and lithospheric types, the origin of the continents and oceans, etc.) but account for many other geodynamic processes. None of the other kinds of the internal energy (convection or advection of the deep material, etc.) is commensurate with the fluid advection in terms on the amount of the transferred energy and its relatively small losses during the transportation over long distances. No other energy sources can provide such fast processes as the formation of asthenoliths and plumes, activation of tectonic processes within a local area and within a relatively short period of time observed in the reality.

However, it does not mean that the deep fluids advection can solve all geotectonic problems. For instance, the origin of the observed regular form of the deep fault system including the mid-oceanic ridges and zones of high seismicity needs some other explanations and additional sources of energy.

The origin of the systems of the Earth's destruction zone; the model of the Earth's expansion

As has been shown above, certain distinct regularities are observed in the structure of the Earth's tectosphere: the circum shapes of the Pacific mobile belt and the Alpine-Himalayan belt (**Fig. 1**), the symmetry of the mid-oceanic rifts with respect to the South Pole (**Fig. 3**), and the asymmetric structure of the Antarctica and Arctic. These regularities are objective facts on the scale of the Earth's global features, and their origin should be explained by the global tectonics concepts.

Two theoretical models can explain the regular circular shapes of the Pacific and Alpine-Himalayan belts --- the Earth' expansion and contraction models (Shen, 1984; Bucher, 1956). The both models are based on the concept of the Earth origin from the meteorite material with the subsequent transformation of their interior structure by melting and differentiation. The Earth's expansion model assumes that the formation of the highly dense core resulted in the increase of the volume of the upper (less dense) spheres, which lead to the overall increase of the Earth's radius. The contraction model is based on the estimates of the Earth's cooling effect after the melting stage.

In general, any estimates of the probable Earth's expansion or contraction are problematic because up to now, we do not exactly know the origin of the Earth and its interior composition. Besides the meteorite concept, also a variety of quite different scenarios of the Earth formation have been suggested, for instance, from the "gas giants" or from "the star material" (Herndon, 2013; Krivitsky, 2013). The latter can initiate the large expansion and compression of the Earth. Some of the Earth's expansion hypotheses were based on the probable increase of the planetary masses or the gravity constant.

However, among all these concepts and hypotheses, the Earth's expansion model is at present better substantiated by the laboratory studies of the transformation of the mantle material and its differentiation under the high P-T conditions (Letnikov, 1999, 2000 and 2006). The studies confirmed the real changes in the volume and density of the material under this transformation and the importance of the deep fluids in this transformation. The following global process is suggested. "After melting in the conditions of mostly reduced fluids, the Earth chemistry included two distinct groups of light and heavy elements with high and low oxygen compounds, respectively. Light elements, with their density lower than in Fe and with their oxygen affinity higher than in FeO, accumulated in the essentially oxygenic upper sphere composed of silicates and oxides. Heavy elements with low oxygen affinity and the native Fe sank to the Earth's center and formed the iron core. Thus, the Earth's proto-material differentiation created the oxygen-free core with enormous amounts of H_2, CO, CH_4, S, H_2S in the liquid iron and other almost 3000 km thick mantle in which the constitutional minerals contain 75-80% oxygen. The next transformations of the mantle matter are the protracted process of silica, fluids and non-coherent elements subtraction from the mantle materials which results in formation the depleted uppermost mantle and its crystallization" (Letnikov, 1999). All these processes increase the thickness of the upper spheres of the Earth, which have lower density, and can result in the Earth's expansion.

The similar origin of the Earth expansion concept based on the transformation of the planet inner structure was proposed by (Shen, 1984) and a possible rate of the expanding was estimated, about10% of the volume or 2-3% of the radius.

As far as the Earth compression concepts are concerned, they do not contradict the expansion concepts because the geological history provides the extensive evidence of the cyclic development of the upper spheres: there were the stages of active tectonics with the high temperature regimes which caused the upper mantle melting (expansion stage) and the stages of the stable tectonics with the tectonosphere cooling. These variations in the tectonic activity were described above and explained by the cyclic recurrence of the Earth's degassing.

In the Earth's science, both the expansion and contraction concepts are used for the geological data interpretation. The Earth's contraction is considered as the main cause of the formation of the large orogenic belts, the expansion can create a large system of rifts and other destruction zone in the oceans and continents. In some cases, it is very difficult to estimate, which processes are more reliable. Moreover, it is impossible to evaluate their rates. For instance, Ollier (2003) showed that many mountains, which were considered as a result of the compression, can be explained by the expansion since they frequently have the horst and graben structure. There are lots of the other geological data which revealed a complex evolution of the crustal deformations including the opposite processes of extension and compression.

In the geosciences during the last century most of the Earth expansion concepts assumed all the oceans to be the result of the expansion. Among these concepts, the studies of the German scientist Hilgenberg (1993) were the most popular. According to this concept the expansion increases the Earth's radius almost twofold. A series of his globes with the different radii is well known and it is a symbol of many publications and presentations concerning the Earth's expansion concepts (Scalera and Jacob, 2003). These globes are also exposed in the geological museum of the Moscow State University. However, at the university, another Earth's expansion concept was developed by Milanovsky (1980); who emphasized the pulsed development of the Earth with the alternating expansions and contractions.

The expansion concepts that consider all the oceans as a result of the continent spreading do not differ much from the plate tectonics. They only exclude the unrealistic large subduction of the oceanic plates. And in the same way as plate tectonics, they contradict to all described above data on the circular shape of the global destruction zones. As shown above, the Pacific hemisphere is the original part of the Earth with its own geological history. Only the Pacific tectonically active ring outlined this hemisphere as a global fracture zone can have the expansion origin.

This conclusion is the main point of the Earth expanding model, proposed in (Pavlenkova, 2005) and described below. And it is a principal difference of this model from the other expanding concepts described in Scalera and Jacob (2003). Only the systems of linear oceanic rifts, except the Pacific and other oceans, may be the results of the Earth's expanding. This can be confirmed by the symmetrical structure of the rift systems which form a ring around Antarctica with a series of the rifts and disturbed zones diverging along the meridians with nearly equal distances between them, 90^0 (**Fig. 17**; Pavlenkova, 2012a & c). Unfortunately, this regular planetary system has not been previously discussed in the geological publications, perhaps because the complicated crustal structure often masked (concealed) these regularities.

The mid-oceanic ridge system which is symmetrical about the South Pole suggests a more intense tectosphere extension of the South hemisphere. This assumption agrees with the astronomical data that the radius of the southern hemisphere is currently larger than the radius of the northern hemisphere, and this difference continues to increase (Barkin, 2002; fig. 12 in Pavlenkova, 2012a). The initial impression of these data is that 'the excess radius of just 10 meters in the southern hemisphere obviously can't explain the global oceanic ridge system' (David Pratt, *personal communication,* September 2015). However, the increase in this radius does not reflect the real expansion of the hemisphere because the gravitation balances any large changes in the shape of the Earth. Any extra increase in the volume of some parts of the Earth causes the expansion of the whole planet**.** The observed differences in the Earth's radius only highlight the additional extension forces in the southern hemisphere. Barkin (2002) has shown that the extra forces can be the result of the Moon rotation around the Earth. His theoretical calculations indicated that the Moon creates the additional tension in the Earth's interior, which try to move its hard core southwards. This additional tension initiates the breaking of the lithosphere (rift zone formation) not around the whole planet surface but mainly in the southern hemisphere. In this case the created rifts should be symmetrical about the South Pole. And it is necessary to note that the curve "b" in the discussed figure does not describe the rate of the Earth expansion, and it does not mean that the northern hemisphere radius decreases. The curve shows the observed deviation of the real planet form from the regular ellipse. And it means that the hemispheres are expanding with different rates, and the observed deviation of the planet form from the regular form increases in the southern hemisphere and decreases in the northern one. Another point, it is not possible to estimate the expanding rate of the planet only from weight of the rifts. The formed fracture zones may initiate the local convections in the upper mantle which increase the lithosphere spreading in these local zones.

The extension and breakup of the upper geospheres are not necessarily confined to the mid-oceanic zone alone, they may occur in any other areas of the Earth and during the whole history of the planet. At first, when the brittle lithosphere did not cover the whole Earth's surface, the expansion resulted in the ancient weak crust extension and transformation, in formation of the local basins (geosynclines), in spreading of the old platform blocks and so on. For example, as a result of such tensions the old continental crust between the African and South American shields (**Fig. 3**) might be extended and transformed into the thin oceanic crust, and at the next stage the mid-oceanic rifts crossed this old crust creating the young crust belts. The many stage extension might have created all other observed combination (alternation) of the old and young oceanic crusts with the transition crusts. Neither plate tectonics nor the former Earth expansion concepts can explain such combination.

The described changes in the size of the Earth cannot affect the observed regularities in the lithosphere structure. The probable expansion of the Earth (by at most 10-15%) does not contradict to "the extensive geological, geophysical, and paleoclimatic data", which were considered by Pratt (2013) as the main evidences against the plate-tectonics and the Earth expansion concepts.

Thus, the existence of a regular system of the global fault zones, the shape of the Pacific Ring, and the symmetry of the mid-oceanic rift systems are the main geological and geophysical arguments for the proposed Earth expansion model. There are sufficient empirical data to consider the increase in the volume of the Earth's material during its differentiation and transformation as a main cause of the expansion. But it is now difficult to determine the real rate of the Earth's extension.

Conclusions. The degassing and expanding Earth's model of the global tectonics.

The described geological and geophysical data give enable us to suggest the degassing and expanding model of the tectonosphere formation. The model yields the solutions to the following key problems of global tectonics:

(1) How were the different crustal types (continental, oceanic, and intermediate) created?

(2) How were the continents and oceans formed?

(3) What is the origin of the specific structure of the Pacific Ocean with the tectonically active continental margin?

(4) What is the origin of the regular system of the mid-oceanic ridges?

In this model, the Earth degassing is the main energy source. The spatially irregular degassing results in the formation of the different types of the lithosphere. The geochemical studies show that the continental crust was formed from the mantle material with the high fluid content (Lutz, 1980 and 1999). This means that the thick continental crust was created in the regions of the higher deep fluid flows; however, in the areas of the weaker flows (Pacific area), the primary oceanic crust was preserved, and only some separate spots of the transition crust appeared.

The deep fluids are also vitally important for the depletion of the continental upper mantle (Letnikov, 1999, 2000 and 2006) and, as a result, to the decrease in its density (Kuskov at al., 2014; Pavlenkova and Pavlenkova, 2014; Yegorova and Pavlenkova, 2014). The latter yields the solution of the main global tectonic problem, namely, how the continents and oceans were formed? The increase in the thickness of the lower-density lithosphere led to its uplifting with respect to the oceanic lithosphere.

The clearly pronounced regularities observed in the structure of the tectonosphere (regular round shape of the Pacific active margins and the symmetry of the mid-oceanic ridge system relative to the South Pole) are explained by the Earth's expansion. This ordering can be formed at two main stages. Primarily, the Pacific active ring was formed; then, the mid-oceanic ridges were developed as a result of the more intense extension of the lithosphere in the southern hemisphere.

The suggested global tectonic model is consistent with some processes described by the other geodynamic concepts: the longtime connection of the deep mantle processes with tectonics (endogenous regimes), the folding at the lithosphere plate boundaries (plate tectonics), the intense magmatism (plume tectonics), the rotation of some lithosphere blocks (wrench tectonics), the mantle material flows along the weak zones (surge tectonics), etc. However, all these motions are limited in the scale and intensity: they should not destroy the described regularities in the tectonosphere structure. The Earth's degassing is a common energy source for all these and many other processes (convection in the mantle, magnetic pole mobility, etc.).

The degassing and expanding Earth's model is based on the large factual data on the continental and oceanic lithosphere structure and on the revealed global regularities in their structure. The most important points of the suggested model are (1) the primary origin of the old oceanic, continental and transition crustal types due to the spatially irregular deep fluid advection, (2) the formation of the tectonically active Pacific ring and the mid-oceanic fracture zones as a result of the Earth's expansion, (3) the formation of the continents and oceans after the uplifting of the less dense depleted continental lithosphere, and (4) the main energy source of the tectogenesis is the Earth's degassing.

P.S. The main ideas of the suggested model (the Earth's degassing and expansion) were previously described in the fluid-rotation concept of global tectonics (Pavlenkova, 2005; 2012a & c). However, for explaining the paleomagnetic data, the cited concept assumed the rotation of the mantle around the core instead of the unrealistic large polar wander proposed by Storetvedt (1997 and 2003). After Pratt's articles (2013) and the analysis of the extensive additional data (including the last NCGT publications), it has become clear that the mantle rotation contradicts the regularities of the main structural elements of the Earth, especially the asymmetry of the Arctic Ocean and the Antarctica; hence, the mantle rotation was excluded from the new model presented above. The explanation of the paleomagnetic data can be found not in the motion of the lithospheric plates, or the entire mantle, or in the polar wander, but in changes of the direction and intensity of the deep fluid flows in the rotating Earth.

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DISCUSSION

GEOSCIENTIFIC URBAN LEGENDS

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"[A well-trained rationalist] will obey the mental image of his master, he will conform to the standards of argumentation he has learned, he will adhere to these standards no matter how great the confusion in which he finds himself, and he will be quite incapable of realizing that what he regards as the 'voice of reason' is but a causal after-effect of the training he had received."

Paul Feyerabend, in: *Against Method* (1988, p. 17)

"Whenever there is a breakthrough, a really important new discovery, this means that the experts have been proved wrong, and that the facts, the objective facts, were different from what the experts expected them to be."

Karl Popper, in: *A World of Propensities* (1990, p. 33)

Synopsis: According to Rekdal (2014, p. 638), "*Many of the messages presented in respectable scientific publications are, in fact, based on various forms of rumours. Some of these rumours appear so frequently, and in such complex, colourful, and entertaining ways that we may speak of them as academic urban legends*". Rekdal further submits that the explanation for this phenomenon is usually that authors have "*lazily, sloppily, or fraudulently*" used selected second order sources – easily introducing false or twisted information which the review process has not discovered. The same disturbing pattern is readily exposed in the saga of continental drift/plate tectonics. Though critical facts contradicted Wegener's drift hypothesis, which during the 1960s was 'upgraded' by plate tectonic mechanisms, a multitude of human factors were unable to stop it from an ultimate triumphal procession. With hindsight it is safe to say that this scientific transition was largely a fashion-like trendy contraption – being without significant problem-solving capacity. In this article, I discuss how a complex mix of early disregarded critical observations, professional alienation, competition and socio-political pressure gave rise to a kind of 'unconscious' professional state during the run up to the plate tectonic revolution. Henceforth, the Earth sciences had fallen victim of an overarching urban legend – a colourful story that during the last half century has brought global geology astray.

Keywords: *academic laziness, wishful thinking, omissions, social pressure, fictitious knowledge*

Faulty Towers of Science

> "*There is a popular misconception that science is an impersonal, dispassionate, and thoroughly objective enterprise. Whereas most other human activities are dominated by fashions, fads, and personalities, science is supposed to be constrained by agreed rules of procedures and rigorous tests. It is the results that count, not the people who produce them.* ***This is, of course, manifest nonsense*** [my italics].
>
> *Science is a people-driven activity like all human endeavor, and just as subject to fashion and whim. In this case fashion is set not so much by choice of subject matter, but by the way scientists think about the world. Each age adopts its particular approach to scientific problems, usually following the trail blazed by certain dominant figures who both set the agenda and define the best methods to tackle it*" (Davies, 1995).

This candid description of the human aspects of science, given above by physics professor Paul Davies, is indeed overwhelmingly demonstrated by the 20th century development of mobilistic global geology which in the late 1960s culminated in terms of the plate tectonic (PT) revolution. This 'new global tectonics' spread like an infectious epidemic and soon became the ruling dogma of the Earth sciences. In retrospect is not difficult to see that the new global hypothesis – being critically dependent on the validity of Wegener's Gondwana assembly, was crooked right from the beginning. When palaeomagnetism in the mid-1950s re-opened the debate on continental drift, Wegener's disregard of essential palaeoclimate observations from

Antarctica remained overlooked and his Gondwana configuration taken for granted. Hence, in less than a decade lateral continental drift, along with its plate tectonic sub-mechanisms, developed into a penetrating urban legend – an all-embracing global model dominated by wishful thinking, auxiliary mechanisms and ad hoc fixes. In a recent essay in this journal – *When global tectonics became a 'pathological science'* (Storetvedt, 2014) – I described a number of important cases of counter evidence, negligence and misunderstandings which accumulated during the first decade following the plate tectonics revolution at the end of the 1960s. Here I discuss some critical cases of pervasive human weaknesses and professional alienation that became decisive turning points during the run up to this 'coup d'état'.

For the growing number of young aspiring geophysicists in the early 1960s (including myself), the traditional arguments against Wegener's continental drift were casually mentioned, but commonly regarded as out of date 'tactics' by the old boys. In the new progressive climate of opinion, it became important to give the 'new global tectonics' a polished façade. The answer was given, so nature had to adapt to the new promising view, not the vice versa. An advancing popular opinion will always be a very strong power although thinking in grooves may evolve in unclear ways depending not least on the wishes and persuasive powers of a few dominant individuals. Anyway, lateral continental drift was a glorious story to convey to my students; con-arguments were not saleable. Wegener's book had traditionally caught little interest in Bergen, so in my time as a student and young researcher knowledge about continental drift had to be found in 'second order' texts – primarily from Arthur Holmes' textbook *Principles of Physical Geology* (Holmes 1944, and later editions). When I many years later found du Toit's book *Our Wandering Continents* (du Toit 1937) in the University library, having originally been part of a professorial book collection in the geological institute, it was characterized by not having been opened at all. Arthur Holmes and Alexander du Toit had been the two principal supporters of Wegener before World War II.

Wishful thinking prevails over conflicting evidence

Holmes presented Wegener's model in a rather polished and sympathetic way, ignoring critical counter evidence. The Gondwana assembly was an essential element in the pre-Mesozoic continental configuration, with Antarctica in a pivotal position at the southern geographic pole. However, since the turn of the century, accumulated fossil and rock evidence for palaeoclimate had indicated strongly that Antarctica had had a prolonged Lower Palaeozoic to Lower Tertiary history of tropical to warm intermediate climate – not the ice-house conditions which Wegener, and later Holmes, took for granted. For the drift model, the wide range of palaeoclimate evidence from Antarctica was quite destructive, but both Wegener and Holmes basically ignored the increasing number of critical contradictory observations that had been collected by British, Swedish and Norwegian expeditions since the late 19th century. Nevertheless, the chapter on continental drift in Holmes' textbook seems to have been the principal reference source for the leading British palaeomagnetists when they opted for Wegener's continental drift in the mid-late 1950's (see also below).

Fig. 1 display Permo-Carboniferous glaciated regions of the southern continents as depicted by Wegener (1929) and Holmes (1954). Traces of late Palaeozoic glaciation had, by the early decades of the 20th century, been reported from southern South America, southern Australia, India, NW Siberia, Central Asia and North America, but the most predominant occurrences of ice activity had been found in South Africa with widespread glacial deposits over extensive regions also in pre-Carboniferous times (cf. Holmes, 1954, p. 504). More recently, geological and palaeomagnetic evidence for long term polar to sub-polar position of Africa have been reviewed by Havlíček (1974); thus, from Ordovician to Late Palaeozoic times the Earth apparently made a number of progressive spatial reorientations (polar wander events) during which the relative geographic pole moved southward across the continent – from NW Africa (western Sahara) to South Africa. During the same time span, the corresponding palaeo-equators – running across the northern hemisphere – made a number of episodic southward shifts, from the Arctic to Central Europe, a palaeo-climatic pattern to which Wegener paid much attention. Thus, if Wegener had extended the late Palaeozoic palaeo-equator (which ran E-W across Central Europe) around the globe, keeping the continents in their present relative positions, it would have passed the region of Antarctica, and the corresponding South Pole would be located in the region of South Africa. In that case, the fossil evidence for a tropical to sub-tropical climate in Antarctica would have got a simple explanation. In other words, the late Palaeozoic climate system was similarly arranged as that of the present day: the palaeo-poles would be located about 90 degrees of latitude away from their corresponding palaeo-equator.

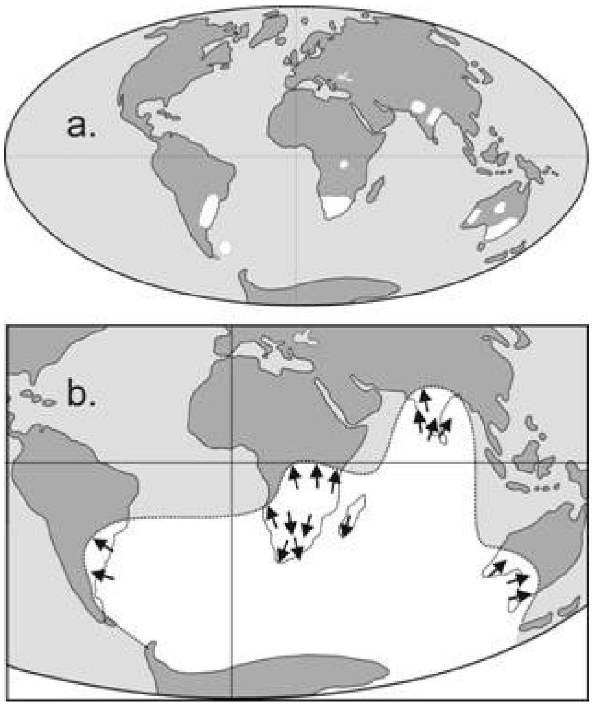

Fig. 1. Permo-Carboniferous glacial centres of the southern hemisphere (white) as had been reported by the late 1920s; a) is after Wegener (1929) and b) is from Holmes (1954). The crucial aspect of the drift hypothesis was that these ice centres had once been united – forming a Gondwana continental assemblage, and subsequently split apart during post-Palaeozoic times. The glaciated Gondwana was thought to have been grouped around Antarctica which was given a nodal polar position despite the fact that all palaeoclimatic data from that land mass suggested tropical conditions during the Palaeozoic – and subtropical conditions as late as the Lower Tertiary. The fact that glacial traces had been reported also from the Northern Hemisphere was again disregarded. In other words, there was something fundamentally wrong with the drift-related Gondwana proposition. Note also the difference between the two presentations; though they both show Antarctica without glacial activity, the one by Holmes (b) gives the impression of having a persuasive intent.

In his efforts to match the contours of the adjoining Atlantic margins, Wegener (1929) had repeatedly been accused of having taken undue liberties with the crust; he had stretched and bent the crust as needed – or simply – eliminated parts of it, in order to achieve his preconceived continental match. In Wegener's model, the South Atlantic was just an enormously widened rift the edges of which were once directly connected; if so, comparison of the geological structure of the adjacent continental margins ought to provide a clear-cut test. Wegener (1929) referred frequently to the work of du Toit (1927) who had done extensive work on the geological comparison of South America and Africa. Du Toit, however, concluded that in order to allow for differences in observed rock facies of the opposing continental margins a pre-drift separation of at least 400-800 km was required. This meant that the geological resemblance across the South Atlantic was not that obvious after all. If du Toit had to allow for a continental separation of 400-800 km or more, to obtain a 'sensible geological match' between the adjoining South Atlantic continents, how could he really set an upper limit to the suggested initial gap between the two land masses? Though Wegener in principle accepted du Toit's reservations regarding the initial close continental contact, he nevertheless argued that the bilateral agreement of geological features across the South Atlantic "*is just as if we were to refit the torn pieces of a newspaper by matching their edges*" (Wegener, 1929 and 1966, p. 77). This was hardly anything but an emotional statement – not more than a socio-political attempt to bolster his pre-conceived Gondwana assembly.

On the other hand, Wegener (1929) seems not to have been completely unaware of the continental matching problems, such as those presented by the Azores region. In fact, he regarded the large Azorean massif as a real obstacle to a complete 'closing-up' of the Central Atlantic – prior to his alleged continental separation. He argued that geological information from these islands indicated that they had a continental substratum.

From the work of Hartung (1860), it had been known for decades that pebbles of a variety of continental rocks – including granite, mica-schist, quartzite, sandstone and limestone – were scattered throughout the archipelago. In addition, the 1883 *Talisman* expedition, through deep sea dredging in a wide region just north of the islands, had obtained a multitude of continental metamorphics and Lower Palaeozoic fossiliferous sediments, so the accumulated rock evidence was indeed suggestive of a wider area around the Azorean archipelago being continental in origin. However, due to the revival of Wegenerian drift in the 1950s palaeomagnetic data combined with a complete closure of the Atlantic were in the forefront of attention; by now, taking up geological counter arguments were not in vogue and therefore not debated; one didn't bother wasting time on 'old-fashioned' arguments. Wegener's classical 1929-book was cited in practically every palaeomagnetic paper, though hardly anybody had read it (see below). If the book, along with relevant palaeoclimate evidence from Antarctica – readily available in the scientific archives – had been carefully studied, the fundamental problems with Wegener's Gondwana configuration would most likely have been unveiled.

Palaeomagnetism embraces Wegener's hypothesis – but its basic problems ignored

In Britain, the work of P.M.S. Blackett and S.K. Runcorn had led to the supposition that the origin of the main component of the geomagnetic field was closely tied to the Earth's rotation; it was hypothesized that the main field, after averaging out transient (secular) variations, originated from a dipole aligned co-axially with the Earth's rotation axis. Runcorn (1954 and 1955) explained the coincidence of the mean geomagnetic and rotational axes as due to the dominance of the Coriolis Effect in the outer fluid core. Granted the validity of the geocentric dipole field assumption throughout geological time, presuming that secular variation had effectively been averaged out during rock consolidation, a palaeomagnetic pole position would correspond to the location of the relative geographic pole for the geological epoch concerned. On this basis, the swiftly increasing palaeomagnetic database of the 1950s showed time-progressive polar paths for individual continents – in addition to discrepancies between the polar curves for separate continents. These results brought continental drift and polar wandering back into the limelight of geophysical discussion. First of all, it seemed that the Earth's body had changed its spatial orientation through geological time – for which quantitative reasoning by Gold (1955) endorsed additional support. But despite an unsatisfactory scatter in palaeomagnetic data the incongruity of the various polar paths suggested that some kind of relative continental motions had also taken place.

However, at around 1955 the Runcorn group was hesitant to accepting drift (Runcorn 1955). Thus, the view of Creer et al. (1957) "*was that polar wander was the simpler hypothesis, involving fewer degrees of freedom than continental drift, and the one easier to reconcile with the present model of the Earth*". But data from other continents (than Europe) were complicating the picture. Comparison of palaeomagnetic poles from Britain and India suggested to some workers that significant relative drift had taken place (Blackett, 1956; Clegg et al., 1954 and 1956; Deutsch et al., 1958; Deutsch, 1958). A large-scale northward drift of India (away from Antarctica, cf. Fig. 1) was a significant element in Wegener's hypothesized southern continental assembly – Gondwana, and all of a sudden Wegener's drift system was in the forefront of the discussion. In this conversion process, Creer et al. (1957) alluded to the possibility that Europe and North America might have been geographically closer in pre-Jurassic time than they are today. Furthermore, in a synthesis of global palaeomagnetic poles, Irving (1956) concluded that "*prior to Tertiary times the pole has not only shifted its positions with respect to certain land-masses, but also that these land-masses have moved relative to one another*". In terms of continental mobility, only Wegener's lateral drift system was not considered (see also below).

In other words, palaeomagnetism was beginning to sustain Wegener's twin-hypothesis of continental drift and polar wandering. However, right from the early start there were problems in matching pre-drift segments of the polar curves – for attaining Wegener's pre-drift unification of the land masses. But faced with the growing palaeomagnetic matching problems, **why did not the leading British geophysicists of the 1950s consider alternative models for continental mobility**? For example, the latitude-dependent inertia forces, associated with changes in Earth rotation, might well have affected the global lithosphere through a system of lithospheric torsions, thereby producing the observed discrepancies in polar wander paths, but this ready alternative was not thought of (K.M. Creer, personal communication March 1996). The main reason for this lack of alternative thinking was most likely the competition between the Blackett (London) and Runcorn (Cambridge) groups; from their study in India, the Blackett group favoured large-scale continental drift, an idea that soon also the Runcorn group (from 1956 located in Newcastle) wholeheartedly endorsed. But this change of opinion, in favour of Wegener's hypothesis, had a very shaky foundation – filled with unsettled problems.

Despite their preference for drift, the Blackett group was aware of an important ambiguity in their data (see below). If India had changed its azimuthal orientation by a significant *in situ* clockwise rotation, after cooling of the investigated Deccan lava sequence, an original downward pointing magnetization (in the Eurasian frame) would attain the present discrepant southward and upward pointing magnetization – thereby giving the wrong impression of having originally had a relatively high latitude southern hemisphere origin (see Storetvedt, 1997 and 2003 for detailed discussion). In May 1992, I had the opportunity to discuss the internal discussions and attitude within the Imperial College group with one of the principal investigators of the India project – the late Ernst (Ernie) Deutsch of Memorial University, St. John's. What Ernie told me fits extremely well with the range of psychosocial and political factors in science described by Paul Davies – cited in the opening paragraph of the present paper. In my 2003-book *Global Wrench Tectonics,* I summarized my discussion with Ernie as follows:

- Why, I had asked, had they preferred an extravagant northward translation of India instead of a simple *in situ* rotation, the latter requiring by far the least driving force? Ernie readily admitted that, in retrospect, he could clearly see that their preferred conclusion had been coloured by a combination of ignorance (on the geological part), prejudice, rivalry with the Newcastle group (which originally had been more inclined towards polar wander than drift) and geopolitics. He said that the workers in the Imperial College investigation were all physicists, and none of them had had anything but superficial insight into the geological arguments that Wegener and Du Toit had used in advancing their hypotheses of a large-scale northward drifting of India. They just had taken for granted that the geological arguments applied were correct, he said. In any case, it was safer to associate the Deccan palaeomagnetic data with an old idea, albeit a controversial one, than to link them to the rotation alternative which most likely would only add further confusion and, hence, confer no credit on the workers involved. In his honest and thought-provoking remarks, Ernie went on to explain that in the mid -1950s palaeomagnetism was a new and minor geophysical discipline in need of a wider exposure. To associate rock magnetism with a revolutionary and long-debated scientific idea, perhaps triggering news headlines such as *New Physical Measurements Confirm Controversial Geological Theory*, would create just that boost the young research field so badly needed. -

The palaeomagnetic conclusion in favour of a mega-scale northward drift of India clearly had a shaky foundation, and yet it soon came to play a most decisive role in the trendy mobilistic edifice which poured ahead, and which during the next decade completely transformed the Earth sciences. Above all, it is important to acknowledge that palaeomagnetism did not provide conclusive evidence for large-scale translation of India as commonly alleged. Nevertheless, palaeomagnetism had turned global tectonics into a mobilistic business – broadly consistent with Wegener's proposal. Hence, a formerly practically disbanded idea had, for falsified and misunderstood reasons, been imbued with new life and vitality. The traditional geological counterarguments, disfavouring a close pre-drift continental amalgamation, were as relevant as before, but by now they had been bypassed and superseded by a new and supposedly more trustworthy geophysical discipline – palaeomagnetism. In hindsight, it is easy to see that by the late 1950s a new global tectonic paradigm was forcing its way forward; nothing could apparently stop it! The *primus motor* in this transformation process was S.K. Runcorn who with his ceaseless lecture tours around the world managed to gradually break down the traditional opposition to mobile continents, and in 1962 he edited a landmark volume entitled *Continental Drift.* This multi-authored book opened with Keith Runcorn's major article 'Palaeomagnetic Evidence for Continental Drift and its Geophysical Cause', followed by one on 'Palaeoclimatology and Continental Drift' by Neil Opdyke. A simplified version of Runcorn's polar trails is shown in **Fig. 2.**

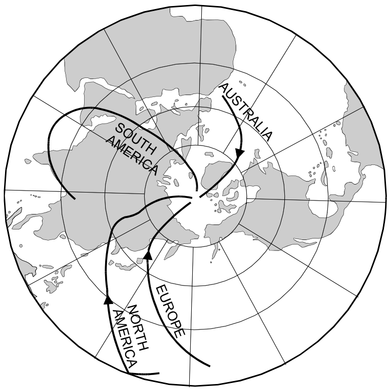

Fig. 2. Schematic polar wandering curves simplified after Runcorn (1962).

To reconcile the global palaeomagnetic results, relative movements between the land masses were clearly needed. And because the majority of available data came from Europe and North America, the discrepancy between their polar paths was in the forefront of the discussion. Runcorn (1962) concluded that the data seemed broadly concurrent with Wegener's hypothesis. However, there were problems in adapting the North Atlantic polar curves by simple lateral (E-W) continental adjustment. There was a tendency of corresponding polar estimates for the two continents, notably for the Palaeozoic, to having a latitudinal offset – North American poles were displaced to the south relative to the European ones. In hindsight, there was an indication a certain amount of relative clockwise '*in situ*' rotation of North America relative to Europe; in that perspective, the southward fanning-out shape of the North Atlantic basin could be accounted for, but nobody seems to have noted this solution.

A decade later, Roy (1972) did a more systematic study of the polar curves for the North Atlantic continents confirming the early indication of North America having been subjected to a clockwise rotational swing relative to Europe. But by then lateral continental drift had become an unquestioned dogma, so when I, during discussions with colleagues, mentioned the alarming outcome of Jean Roy's analysis the reaction was just a shrug of shoulders. Nevertheless, matching of other continental polar trails, according to the Wegener's model, soon turned out to be a general problem. It was obvious that at least some continents had been subjected to '*in situ'* rotation. For example, in addition to the favoured major northward translation of India, the London palaeomagnetists had to include a certain azimuthal rotation, and Australia had apparently undergone substantial (counter clockwise) rotation (Irving, 1957, 1958 and 1964). During a memorial symposium for Runcorn in Newcastle in February 1996, I discussed the many well-known physiographic and palaeomagnetic complications, versus classical continental drift, with Professor Ken Creer. He confirmed that palaeomagnetists had not explored alternative mobilistic schemes (other than Wegener's) at the critical time in the late 50s and early 60s.

Mobility constraints disregarded

In the early 1960s there was apparently too much inertia in lateral continental drift to take notice of contrary observations; the opportunity of reopening the debate was, in many ways, over. Nevertheless, a number of authors had unveiled a series of kinematic paradoxes and other problems with conventional drift, without having captured other than superficial attention. Indeed, it is a paradox that once an idea has gained foothold in a science community, fundamental problems pertaining to that idea are either ignored or not seen at all. Nevertheless, Heezen (1959), referring to principal kinematic problems related to lateral drift, argued that "*The locations of the Mid-Oceanic Ridge, oft cited as a remnant of the original continental rift, opposes continental drift since it seems to acquire that the continents drift in several directions at the same time. A possible way out of this dilemma is to postulate an expanding Earth*".

Earth expansion had also been the way out for Carey (1958); both Carey and Heezen referred to cases of major difficulty in the context of conventional drift. The supreme example was the geometric-kinematic riddles that arise for Antarctica; this continent is surrounded by oceanic ridges but is without any signs of undergoing compression. The kinematic-tectonic problems become even more acute for Africa and Antarctica combined – sometimes being referred to as the Africa/Antarctica paradox. However, if the Earth was undergoing expansion while remaining constant in size, newly added crust would have to be found in the oceans – most likely along mid-ocean rift valleys. If so, these ridges ought to constitute ridge-parallel dyke-in-dyke complexes, but subsequent deep sea drilling revealed that such two-dimensional intrusive complexes are practically absent in the deep sea crust (cf. Storetvedt, 1997 and 2003).

In his reconfiguration of the Earth's crust, Wegener had put great emphasis on selected palaeoclimate observations. Thus, in connection with the rapidly growing palaeomagnetic data base, Runcorn convened a palaeoclimate conference in Newcastle, January 1963. From this conference I remember in particular arguments against a close pre-drift arrangement of the adjoining Atlantic continents brought up by the Norwegian palaeontologist and zoo geographer Professor Niels Spjeldnæs. By compiling the global distribution of Ordovician biological provinces he had concluded that the various fauna provinces basically represented climatic zones (Spjeldnæs, 1961). At the Newcastle conference he pointed out that Wegener's pre-drift juxtaposition of North America and NW Africa was inconsistent with respect to palaeoclimate evidence: it did not make sense to place the Lower-Middle Palaeozoic tropical conditions of eastern North America in close contact with the corresponding palaeo-polar and glaciated region of NW Africa. In his demonstrated close relationship between global Ordovician fauna and climate, one of the Ordovician Polar Regions was in Central Sahara and the other in the north-central Pacific (**Fig. 3**). In his discussion, Spjeldnæs referred to a palaeomagnetic paper by Runcorn (1959) which 'advertised' continental drift, and in his Atlantic configuration he seems to some extent to have been influenced by that article. For example, in his relative position of South America he included NE Brazil within the polar region while the limited glacial evidence came from the south-eastern Atlantic margin of the continent (cf. **Fig. 1**). Thus, a somewhat wider South Atlantic, but without its present southward fanning-out shape, would therefore be consistent with Spjeldnæs' reconstruction.

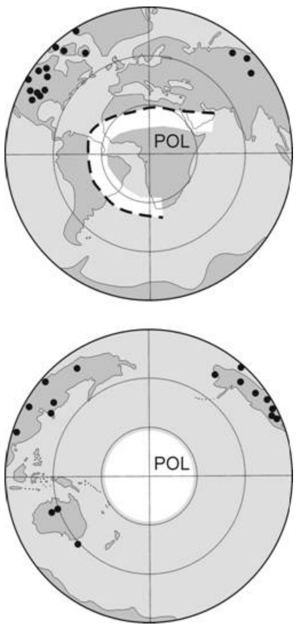

Fig. 3. Reconstruction of the global palaeoclimatic system based on Upper Ordovician fauna provinces – simplified after Spjeldnæs (1961). Filled symbols correspond to inferred tropical fauna. Note that the Atlantic continents (upper figure) are placed closer together than in the current geographical situation although the biological data did not justify it (see text). The corresponding palaeoclimate situation for the 'Pacific hemisphere' is depicted in the lower figure. These palaeoclimatic reconstructions gave further support to the palaeomagnetic evidence for polar wander. Thus, during the Middle Palaeozoic the relative geographical poles were located near the present equator – at around Southwest Africa and in the Central Pacific respectively. At that time the tropical belt passed the present Arctic and Antarctic regions. In other words, Spjeldnæs' data indicated that after the Middle Palaeozoic the Earth's body had changed its spatial orientation (relative to the astronomical rotation axis) in the order of 90˚ of latitude – being broadly consistent with the palaeomagnetic 'N-S' trending polar tracks for the Atlantic continents which had been devised for the actual time range.

Spjeldnæs' evidence was clearly at variance with the idea of a significant closure of the Atlantic; by placing the palaeo-pole in Sahara, and accepting a relatively wide Central Atlantic, the corresponding palaeo-equator would pass along eastern North America and in close proximity to the present north polar region and Central Asia for which there were ample evidence for hot-warm conditions during the Palaeozoic. Though Spjeldnæs' global compilation of Ordovician fossil data was clearly at variance with the close pre-drift match of North America and NW Africa, I cannot remember that this important aspect triggered anything but casual comments; even at this non-tectonic conference, continental drift apparently formed such an important backdrop at the conference so bringing up contradictory opinion was apparently not appropriate. In fact, Spjeldnæs' data could easily be interpreted in terms of a quasi-stable continental arrangement; moderate relative motions could have taken place, but, above all, his data clearly supported the classical phenomenon of polar wander. Since Ordovician time an accumulated 70°-90° of spatial shift of the whole planetary body (or perhaps some outer brittle layer) had taken place relative to the axis of rotation. In other words, Spjeldnæs' data were consistent with a statement of Creer et al. (1957) a few years earlier that "*polar wander was the simpler hypothesis, involving fewer degrees of freedom than continental drift, and the one easier to reconcile with the present model of the Earth*".

By the early 1960s, convection driven continental drift had become a hot topic and, in fact, this dual-hypothesis concept was in the initial stages of becoming a geoscientific urban legend. Looking into the question of driving forces, MacDonald (1964), using a combination of heat flow and surface gravity data, velocity information from surface waves, and observations of artificial Earth satellites, presented the first tentative evidence of regional differences between continental and oceanic upper mantles. MacDonald concluded: "*The deep structure of continents places heavy restrictions on any theory of continental drift. A relative* [lateral] *motion of the continents must involve the mantle to depths of several hundred kilometres; it is no longer possible to imagine this continental blocks sailing over a fluid mantle*".

According to MacDonald, the idea of mantle convection, to most mobilistic geophysicists the only plausible cause of drift had run into problems. The continents were too thick and the mantle too rigid to permit lateral motions. The early suggestion that continents have deep roots into the upper mantle has later been amply demonstrated by modern mantle tomography. Taken at its face value, the presence of deep continental roots, and shallow oceanic anti-roots, put the very idea of mantle convection into doubt. The deep-rooted land masses could be interpreted in favour of being remains of an original pan-global continental crust while oceanic basins, with their corresponding mantle anti-roots, represented later crustal thinning and chemical transformation instigated by unevenly distributed mantle processes. The quasi-stationary continental arrangement arrived at by Spjeldnæs' palaeo-climatic evaluation would fit rather well with such an evolutionary scheme.

Fictitious supporting evidence

In the early 1960s, continental drift was much more acceptable in Britain than in the USA, and under the auspices of the Royal Society a *Symposium on Continental Drift* was held on 19-20 March 1964 – convened by P.M.S. Blackett (London), E. Bullard (Cambridge) and S.K. Runcorn (Newcastle). Perhaps the most conspicuous contribution at this meeting was the paper entitled *The fit of the continents around the Atlantic* – by Edward Bullard and associates. During Runcorn's NATO symposium in Newcastle a couple of weeks later, stubborn rumours would have it that the Cambridge group had "proven" that Wegener had been right by his pre-drift closure of the Atlantic. The fact that Wegener had considered the vast Azores Plateau as a barrier to a complete closure of the North Atlantic was not mentioned; in retrospect, this neglect is not difficult to understand for, as mentioned above, at that time hardly anyone had seen or bothered to study Wegener's book.

The contributions from the meeting of the Royal Society were published in book form a year later (*Phil. Trans. Roy. Soc.*, 258, 1965). The article of Bullard and associates attracted enormous attention; all of a sudden traditional geological counter arguments became overshadowed. The great interest was primarily because the 'least squares' fit of Bullard et al. gave the impression of being a solid scientific product. The study was based on objective arithmetic methods, Euler's theorem for motions on a sphere, in addition to using a digital computer which at that time was the latest thing. The legendary reconstruction of the Cambridge Group is shown in **Fig. 4**. However, if we take a critical look at the procedures of the Bullard-group, the physical meaning of their pre-drift Atlantic is effectively eliminated by two essential facts:

a) Land masses and topographic contours which fitted with the wishes of the drift sympathizers were retained, while topographic features that did not ‘fit in’ were excluded; in other words, they had removed what they ‘disliked’. For example, the major Iceland Plateau, the shallow Faeroe-Iceland-Greenland Ridge, Jan Mayen Ridge, Walvis Ridge etc. were disregarded because they were obstacles to the drift model. The large Rockall Plateau was however accepted because it could be adapted. In other words, the popular ‘mathematical configuration’ of Bullard et al. was based on a combination of an arbitrary data selection and wishful thinking.

b) For the ‘sake of clarity’, continental excrescences which stood in the way of any trans-Atlantic adaptation were disregarded. The vital question of what Wegener, and now also the Bullard group, had done with regions such as the larger part of Mexico, all of Central America, and the Caribbean was as unclear as before.

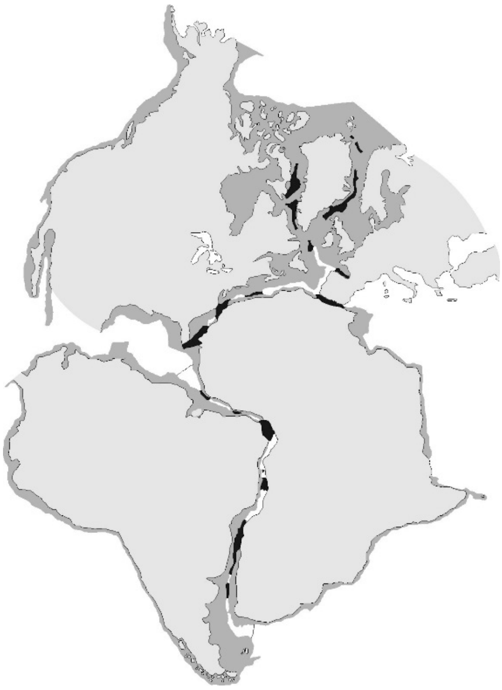

Fig. 4. The famous ‘computer fit’ of the adjoining Atlantic margins was based on questionable procedures and was completely without scientific value. The alleged continental fit is based on Bullard et al. (1965), for which black between-continent segments denote overlaps and gaps. See text for discussion.

Science historian Homer Le Grand writes that Bullard and co-workers “*had massaged the data and though the term ‘garbage in, garbage out’ had not been coined, charge could be made against their use of a computer*” (Le Grand, 1988, p. 204). What one had witnessed was nothing more than a game for the gallery. The attention surrounding new technology and a semblance of objectivity, using mathematical methods, had taken the concentration away from the real issues that remained unresolved just as before. However, the attacks on the work of the Cambridge group died away very quickly. The popularity of continental drift drew to ever greater heights, and because hardly anyone would take the chance of ending up on the outside, critics soon got self-imposed muzzle.

One may wonder why a prominent geophysicist like Edward Bullard could let himself enmesh in a survey that completely lacked sobriety with regard to the data base. Was it all staged to win easily acquired publicity? In any case, it was very easy to see that the investigation had absolutely no scientific value – in fact, it was a clear abuse of mathematics. In spite of this, the 'Bullard fit' became famous and for years it was one of the most frequently cited works in the geoscience literature. In his scientific autobiography, *The Ocean of Truth*, Henry Menard gives a few short recollections from his research stay at the institute in Cambridge (located on Madingley Rise) – just before Bullard’s sudden interest in continental drift. Menard

(1988, p. 208) writes: "*Everyone met and talked twice daily at tea and coffee, so anything noteworthy was known widely at once at Madingley. I do not remember anyone, let alone Teddy* [Edward Bullard] *making any interpretation in which continental drift was important"*.

According to Menard, neither Walter Munk, who at the time had close cooperation with Bullard, can remember that continental drift was featured. The question now arising is whether the continental drift epidemic – a mentality change that was about to conquer the collective imagination among British geophysicists – had turned Bullard to become a 'weathercock' scientist? Researchers will gain honour and power by defending and supporting popular intellectual fashions; this was probably the case with Edward Bullard's sudden attraction to continental drift. Often we become silent witnesses to how 'turning-the coat-for-the-wind' maneuvers can have a decisive influence on the general adherence to an idea – especially if people with professional standing are leading the way.

During the prosperity of the drift hypothesis in the early 60s, another prominent personality entered the arena: John Tuzo Wilson, professor of geophysics at the University of Toronto. With his early academic background and later work as a geologist in the Precambrian of Canada, he had got a fairly static view of global geology – totally in keeping with the traditional way of thinking among the majority of North American professionals: continental drift was not the answer to geological problems! As late as 1959 Tuzo Wilson supported the American version of the contraction theory (Wilson, 1959). He rejected mantle convection and continental drift as realistic mechanisms to account for the new structures which, during and after World War II, had been discovered on the seabed. With regard to the mid-ocean ridge system, he wrote (Wilson, 1959, p. 5): "*The lack of abandoned ridges and slow rate of the ridge's volcanism suggest that it has been in its present position for a very long time, perhaps most of the Earth's history*".

However, the continental drift epidemic pushed on, and just a year later Wilson (1960) sympathized with a mobilistic scheme: the theory of Earth expansion. Within a short time, he had abandoned the traditional continental fixity in favour of mobile land masses. Not only that, after another two years he had been 'influenced' by the theory of sea floor spreading (Wilson 1963), in addition to accepting Runcorn's convection model as the actual driving mechanism for drift/spreading. The mid-ocean ridges had now become young, not old as he had suggested a couple of years earlier. If the crust of these ridges were newly formed and therefore relatively warm, their topographic elevation was naturally a product of Archimedes' principle. It is a fact that Tuzo Wilson, at an age of more than 50, suddenly gave up his traditional scientific platform, and in just three years emerged with two new conceptual outfits. Would such a major shift of emphasis be a natural thing for a scientist of his age, or did he just turn towards the most promising wind direction?

Tuzo Wilson had a prominent position within the geological sciences. During the years 1957-63 he had been President and Past President of IUGG, received many awards and was also well-established as an international lecturer. With his prominent status and freedom of speech he had unusually large 'elbowroom'. In the first half of the 60s he published several interesting articles related to the model of sea floor spreading. As a young and inexperienced researcher I found Wilson's articles highly welcome contributions for my teaching. It was only many years later that I became aware that his conclusions might have been ruled by a combination of wishful thinking and the reinforcement syndrome.

One of Wilson's articles was about the age of volcanic islands versus the sea floor spreading model; their ages were supposed to increase with increasing distance from the crestal zone of mid-ocean ridges (Wilson, 1963). He concluded that his study had shown that this prediction was correct. He proclaimed: "*Convection [...] introduces horizontal motion. This would slowly move volcanoes away from their sources on the mid-ocean ridge, so that those volcanoes would cease to be active. The sources would remain fixed over the vertical currents and would produce fresh volcanoes. Thus, in time, each source on the mid-ocean ridge would produce a chain of progressively older extinct volcanoes, or perhaps two such chains, one on either side of the mid-ocean ridge*" (Wilson, 1963, p. 537). All of a sudden, he seems to have set aside both earlier and new objections against continental drift. Wilson had entered the mobilism train, and soon an ever growing number of Earth scientists jumped after him. For many years Wilson's mid-ocean ridge/islands article became one of the most cited in the geoscientific literature, but how many had really taken time to critically evaluate his paper?

Wilson’s conclusion was simple and elegant on paper, but the reality is totally different. His assertion that young volcanoes are a characteristic feature along the central axis of mid-ocean ridges was obviously wrong. With the exception of Iceland and Jan Mayen there are hardly active volcanic islands along these ridge axes; in the Pacific for example, active volcanism may occur anywhere within the deep sea basins. Furthermore, even since the time of Charles Darwin it has been known that St. Paul’s Rock, located on the Central Atlantic Ridge, is non-volcanic – consisting mostly of mantle rocks brought to the surface in sold state and driven by tectonic forces. Nevertheless, St. Paul's Rock was included in the selective data base – only because these mid-ocean cliffs *had to* be young, according to Wilson. Menard in his autobiography wrote that Wilson’s plea that “*the father an ocean island is from a mid-ocean ridge, the older it is likely to be*” was both vexatious and wrong. Menard further added that Wilson made a number of refutable errors, but despite of the many glaring problems he (Menard) admits of having been “*unprofitably distracted into publishing a refutation of the significance of his data*” (Menard 1986, p. 194).

Concluding perspective: Buying a pig in a poke

Since the late 1980s, I have argued that the continental drift/plate tectonic revolution in the late 1960s was little more than a quasi-scientific cultural invasion; to a large extent this relatively rapid unorthodox transition was driven by a combination of wishful thinking, the pressure to conform, the repetition principle, rubbing shoulders, and authoritarianism (cf. Storetvedt, 1997, 2003, 2010 and 2014). Critical evaluation of facts versus the hypothesis was in surprisingly short supply. In the late 50s, palaeomagnetism was in need of some kind of between-continent motion, in order to make sense of the discrepant polar wander paths. As Wegener’s lateral drift model was ready at hand, this long-held anarchic hypothesis was soon announced, by the leading British palaeomagnetists, as a major breakthrough for understanding Earth’s physiographic and structural development. By the early 60s, the drift idea drove forward like an epidemic; in this upturn, researchers persistently ignored observational inconsistencies and behaved as if the foundation of the new belief system was entirely secure – though hardly anybody had a reasonable professional grip on the state of the art. The 1929-book of Wegener’s was frequently referred to but, as it later turned out hardly anybody had seen the book. In order of getting firsthand information on the academic laziness with reading primary basic publications, I took a trip to Newcastle and Edinburgh, in late November 2003, to meet David Collinson and Ken Creer – both working under Keith Runcorn in the critical years of the 50s, first in Cambridge and then in Newcastle.

I first went to see David Collinson in Newcastle, and we spent a full day talking about the early history of palaeomagnetism and its connection with Wegener’s hypothesis. He told that he had not seen Wegener’s book, neither in Cambridge nor in Newcastle, before it was reprinted in 1966. He thought the same had been the case with Keith Runcorn. I further asked David to read Ernie Deutsch story about the Deccan study of the Imperial College group and their controversy with Cambridge/Newcastle team (summarized above). I was glad to hear that David had no objection to what Ernie had told me. The following day I went to see Ken Creer in Edinburgh to discuss the heroic 50s in palaeomagnetic research. Ken argued that he and Eduard Irving had accepted Wegener’s continental drift at least a couple of years before Keith Runcorn. But he admitted that it was first of all Keith who, with his ceaseless worldwide travelling, reopened the debate on drift in Europe and North America and practically singlehandedly managed to break down the traditional resistance to the hypothesis. To my question whether he had read Wegener’s book in the 50’s, Ken denied it and remarked: “*We did not have time chasing that old book in the library*”. Ken further stated that they had primarily been interested in Wegener’s classical figures which they had found in the books of Arthur Holmes and Alex du Toit. In other words, they had frequently referred to Wegener’s book but without having read it; in doing so they had in fact committed an academic lie – by having plagiarized Wegener’s hypothesis from the Holmes/du Toit books. In other words, the leading British palaeomagnetists had consulted only secondary literature written by careless drift sympathizers (notably with respect to the ignorance of the true palaeoclimate history of Antarctica) – and thereby having spread an ‘adorned’ but utterly false scientific message.

If one plagiarizes, but write in one’s own words, a claim that turns out to be completely lunatic, one gets not only a pig in a poke. But the lack of actual citations and consulted references implies that other readers will find seemingly independent texts which mutually confirm and reinforce each other. In that way, errors and fantasies may float around in academic publications building up tenacious urban legends. "*A good reason for avoiding the use of secondary sources in academia is that messages that pass through several links have the unfortunate tendency to become modified or altered along the way, as in the whisper game* […] *Hypothesis, assumptions, and suggestions can in such a way be transformed into knowledge and scientific facts*" (Rekdal 2014). The current state of affairs is probably worse than ever; publication pressure and competition for resources have clearly led to a careless and sloppy working culture (see Bauerlein et al. 2010). For example, today many Earth science publications are overloaded with references – sometimes filling up whole paragraphs of journal articles, but it often does not take much effort to unveil that the majority of the cited papers have not been read. Exaggerated references are actually a form of academic littering unless one, on the basis of these references, brings something new into the discussion.

Nevertheless, during the 1960s Wegener's undocumented continental drift, and then its successor plate tectonics, became a global tectonic pop-wave sweeping across the geosciences. Fairly soon it was meritorious only to claim support of the new model, and from the 1970s onwards critics were frequently sat aside and ridiculed. The PT bandwagon became the guarantor of geoscientific modernity and soon was so captivating that it became shielded from refutation by even the strongest counter evidence (cf. Storetvedt, 1997 and 2003). Testing the theory's explanatory capability and its capacity to link diverse geological phenomena did not turn out as expected, but even so the increasing load of disheartening complications was sidelined. Actually, when a new set of basic rules and mechanisms (a paradigm) achieves to become widely accepted, it will eventually become inextricably associated with the complicated network of socio-politics, pressure to conform, power, honour, and professional identity – integrated components in any intellectual activity. Numerous research careers may even get to stand and fall with the theory's validity.

For these reasons, even the worst of ruling theory get the cat's nine lives because few will have the courage to openly admit that they have backed the wrong horse – and thereupon having bought a pig in a poke. For that reason the geoscientific community at large has, for decades, been restrained by a kind of 'Frankenstein Monster' who refuses to give up its dominance. Therefore, it will be up to a new generation of scientists to clean up the mess that has accumulated by empirical data having been manipulated into contexts in which they do not belong. Such an utter confusion is readily demonstrated by the uncoordinated *ad hoc* situation characterizing present day PT-dominated research activity (**Fig. 5**). Despite the major geo-technological advances during the last few decades true phenomenological understanding has not been achieved; all prominent questions in global geology have remained incoherent and unsettled.

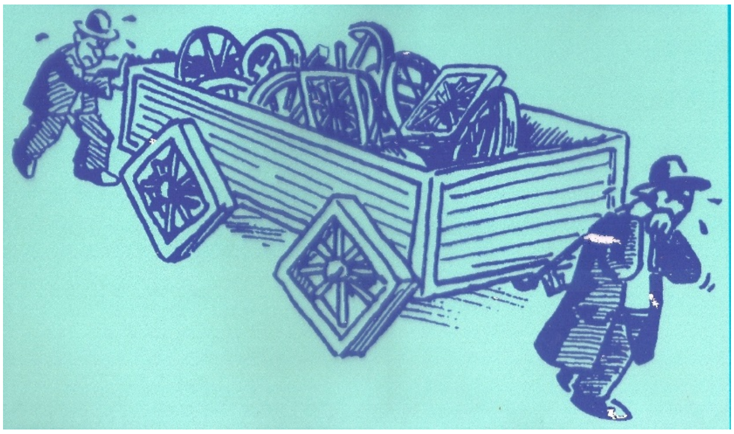

Fig. 5. Guided by a faulty maxi-theory, real scientific progress – in terms of coordinated phenomenological understanding – may come to a complete halt. Thus, during the reign of plate tectonics Earth science books and journals have been filled up with a confusing mix of true and theory-laden observations, from which interpretations and conclusions have given rise to a heavy load of non-contiguous and baffling *ad hoc* propositions.

A functional (realistic) theory make the information flow manageable, meaning that it serve to create unity from a phenomenological diversity. Without such an operating thought construction the flow of new data may become impossible to handle, and the whole science in question may suffer serious setbacks. Regarding global geology, both space geodetic techniques and palaeomagnetism give strong evidence in favour of some kind of between-continent motion. But after decades of unsuccessful data adjustment, time is long overdue to conclude that the lateral drift system is not working. In fact, it was Wegener's wishful thinking about his preferred Gondwana continental assembly that eventually brought global tectonics astray; if he had taken the fossil and rock evidence for long-term tropical to subtropical climate in Antarctica at their face value, his southern hemisphere continental unification would have got a powerful shot across the bow. In that case, it is likely that the British geophysicists would have looked for an alternative mobilistic scheme, than lateral drift, to account for the observed discrepancies between polar wander curves of individual continents. And if so, global tectonics would most likely have got a completely different development. The moral is: honesty, directness and simplicity are the true way forward for science.

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SCIENCE

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To the Editor: I am worried that science, particularly university, is proceeding on the wrong path and using the peer review system to prevent the review of presentably accepted facts. This is particularly so in my branch of geology where any criticism of plate tectonic theory is prevented from being published by even *Nature* or by the *Australian Journal of Geology*. I attach a recent talk that I gave to a local audience. The article includes my CV.

When I was at High School I got a book out of the local library by A.W. Haslett called "Unsolved problems of science" which inspired me to study science. Further discoveries have been made since the book was published in 1935 but some of the supposed advances made have not always been correct such as in mountain building and there appears to be a reluctance in the university professors, who are the reviewers on all scientific publications, to allow theories which has caused their elevation to professorship to be criticised whereas all scientific theories must continue to be under ongoing criticism and review. I feel that even in modern physics the mathematical physicists have led scientific theory into a dead end.

I looked at how Einstein derived his formula $E=mc^2$, where E= mass x acceleration + half mass x velocity squared that is from two of Newton's laws of motion. Einstein's genius was to start from these formulae and making certain assumptions (just as Euclid in geometry started with a set of unprovable axioms). Following through with complex mathematics he finished up with the formula $E= mc^2$, where E= both kinetic and energy from an external force, mass is weight, and c is the speed of light in a vacuum. His assumptions were;

1] that the laws of physics were identical in all inertial systems
2] that the speed of light is the same between all inertial systems.

Even when I first studied physics I was concerned that the force due to gravity and the force due to inertia were possibly not equivalent and looked forward when they landed on the moon with its lower gravity where they would test this out but never did. Nor could I get any explanation how light, which is a wave, travels through a vacuum, though in quantum mechanics it is also a set of photons.

A consequence of Einstein's formula is that both time and length are different in different inertial systems. This was proved by keeping one of two identical clocks one stationary on the earth while the other was flown round the Earth. They finished up with different times. This means that none of the properties that we rely on mass, length and time apparently really exist. According to the modern mathematical physicists we are really sets of electrical particles whose movements are described by complex unsolvable differential equations.

A Christmas ago our eldest son, who is a physicist, then working for the Defence Department, gave me a book, "The Quantum Universe" by Brian Cox and Jeff Forshaw explaining quantum mechanics in simple layman's terms. I was also reading a book "Modern Physics"" by Kenneth Krane which starts off with a revision of Newton's physics including his laws of motion. Combined I found them and quantum mechanics completely incomprehensible particularly when they talk about particles with spin and colour.

In the same period as Einstein in the 1920's the Danish geophysicist Niels Bohr produced the model of the atomic structure of the 92 stable elements with positively charged protons and neutrally charged neutrons making up the nucleus of atoms surrounded by shells of negatively charged electrons. Ernest Rutherford, originally from New Zealand, had already deduced from his experiments of shooting beams of electrons at a thin gold film that the main mass of an element was concentrated in the centre. The mechanics of this is only explainable in quantum mechanics. The calculations are so complex that only the hydrogen atom with one proton and one electron has been fully explained by this method.

The Russian scientist Mendeleev in 1890 found that elements when plotted in the order of their atomic weights fall into groups with the same chemical characteristics. For instance, the noble gases Helium, Neon, Argon, Krypton, Xenon, Radon form no chemical compounds with other elements and fall into one column of the periodic table. From this Bohr and others deduced that these elements had complete electron shells and that vacancy in these shells of 2, 8, 8 provided the valencies that made chemical compounds of different elements possible but did not provide for any mechanical way for this to work other than by quantum mechanics which only works for the hydrogen atom.

Meantime no one seems to explain what protons, neutrons, and electrons are actually made of (quarks?), and how they have mass, and what gravity really is. Even today with the postulation of the Higgs boson and the inability of quantum mechanics to proceed beyond the mechanics of the hydrogen atom we have proceeded into a mystery. No one adequately explains how light moves through a vacuum what protons are really made of and what dark matter postulated to exist to account for the really additional mass in the universe really is. There is a great deal yet to be discovered, although the discovery of the Higgs boson and the Higgs field is starting to help. There is no adequate explanation how light travels through a vacuum unless the so-called vacuum is actually an unrecognised field of some kind.

In physics, mass is a property of a physical body which determines the body's resistance to being accelerated by a force and the strength of its mutual gravitational attraction with other bodies. The SI unit of mass is the kilogram (kg). As mass is difficult to measure directly, usually balances or scales are used to measure the weight of an object, and the weight is used to calculate the object's mass. For everyday objects and energies well-described by Newtonian physics, mass describes the amount of matter in an object. However, at very high speeds or for subatomic particles, special relativity shows that energy is an additional source of mass. Thus, any stationary body having mass has an equivalent amount of energy, and all forms of energy resist acceleration by a force and have gravitational attraction.

There are several distinct phenomena which can be used to measure mass. Although some theorists have speculated some of these phenomena could be independent of each other, current experiments have found no difference among any of the ways used to measure mass:

- Inertial mass measures an object's resistance to changes in velocity $m=F/a$. (the object's acceleration)
- Active gravitational mass measures the gravitational force exerted by an object.
- Passive gravitational mass measures the gravitational force experienced by an object in a known gravitational field.
- Mass-Energy measures the total amount of energy contained within a body, using $E=mc^2$.

The mass of an object determines its acceleration in the presence of an applied force. This phenomenon is called inertia. According to Newton's second law of motion, if a body of fixed mass m is subjected to a single force F, its acceleration a is given by F/m . A body's mass also determines the degree to which it generates or is affected by a gravitational field. If a first body of mass m_A is placed at a distance r (center of mass to center of mass) from a second body of mass m_B, each body experiences an attractive force $F_g = Gm_Am_B/r^2$, where $G = 6.67\times10^{-11}$ N kg^{-2} m^2 is the "universal gravitational constant". This is sometimes referred to as gravitational mass. Repeated experiments since the 17th century have demonstrated that inertial and gravitational mass are identical; since 1915, this observation has been entailed a priori in the equivalence principle of general relativity.

May be some future physicist will explain all this in words of one syllable without complex differential equations. As I once heard a respected senior geologist say to another geologist – "if you think there is a new discovery explain it in one sentence".

Another unsolved problem is whether there is life on other planets. I am not a biologist but I have just found out that all reproducible life on Earth is apparently based on one DNA molecule with a left handed spiral. Has this been proved? If it has it makes the chances of life originating much lower though the vast number of stars with planets still makes it likely. I heard a talk by Charley Lineweaver of the Institute of Planetary Science In Canberra who suggested that planets with surface water were likely to develop life but refused to agree with my suggestion that some of these other planets might develop more intelligent life than us.

The plate tectonic theory which has the continents floating around like rafts on the surface of the Earth is not true. The continents never floated around. There has never been any adequate driving mechanism proposed for them to do so. The theory is a bandwagon on which dozens of academic geologists have built their careers, publishing papers and textbooks without looking dispassionately at all the facts; and ignoring the completely inadequate basis of proof on which it rests. Yet it is being taught as fact in universities and has even penetrated popular science programs and textbooks as facts.

The basis of the problem is that geology is very largely a science of observation and opinion. Academic geologists have neither the time nor money to spend on examining large areas of rocks and rely on textbooks. To have become an academic geologist one must have successfully regurgitated to the examiners the opinions of numbers of eminent geologists, many of whom also learnt most of their geology from textbooks. If successful they then do research on a subject usually chosen by their lecturer. It is expected that the research will not dispute his views. Compounded with this, many geologists are also failed physicists or mathematicians and do not fully understand those sciences.

The theory predicts no `continental crust' in the ocean basins. Yet increasing areas of `continental crust' are being found (see **Figure 1** revised from Nur and Ben-Avraham, 1982). For a long time holes in the offshore deep ocean drilling program could only be drilled to the top of any Tertiary basalt. This was always presumed to be `oceanic crust'. Older rocks dredged of the bottom were assumed to be ice rafted fragments from melted icebergs from the Polar Regions. The extensive offshore work carried out by the Australian Geological Survey Organisation has found even more areas of `continental crust' in the Tasman Sea and south of Tasmania. Petroleum exploration companies can now re-enter holes drilled into basalts.

Figure 1. Distribution of continental crust in the ocean floors. Revised from Nur and Avraham, 1982.

Palaeomagnetics - Measurements on the present day magnetism of rocks is interpreted by plate tectonicists as showing the position of the geographic pole at the time the rocks were laid down. The assumption is made that the Earth can be treated as a perfectly magnetised sphere and that all anomalies will be ironed out by averaging observations over a sufficient time interval. This includes, the variation currently about 10 degrees between the magnetic and geographic poles. It also includes magnetic anomalies - the departure of the total magnetic intensity of an uniformly magnetised sphere because of variations in the susceptibility of the underlying rocks. Post deposition alteration of rock magnetism is dealt with by partial demagnetisation.

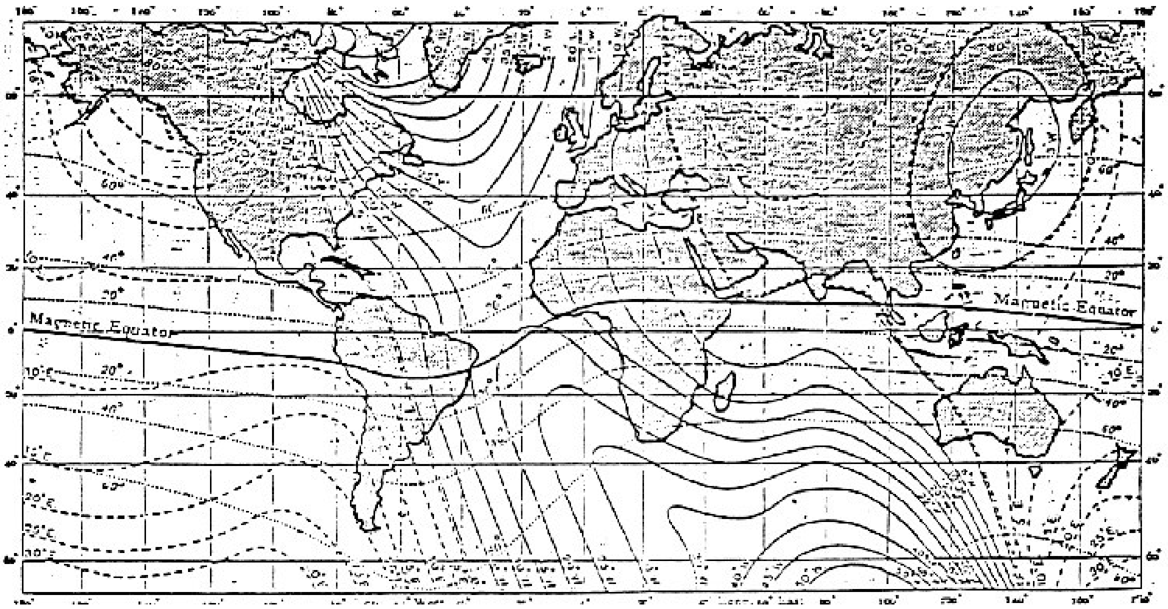

Figure 2. Map of the world showing the isogonals and isoclinals.

Figure 2 from Duncan and Starling (1950) shows the present magnetic field of the Earth. It would be impossible at the present to find one's latitude with a compass alone with any accuracy and longitude could never be found out.

In view of these facts results of paleomagnetic determinations must be looked at very sceptically and even more so when we see the latest summation of results in Australia applied to the movement of the "Australian plate" (see **Figure 3** from Li, Powell, Thrupp and Schmidt, 1990).

The result appears to show the "Australian plate" rotated 130 degrees clockwise between early Ordovician and mid Silurian then anticlockwise 30 degrees between mid Silurian and early Devonian then a further 30 degrees anticlockwise from early Devonian to mid Devonian and a further 15 degrees anticlockwise to late Devonian.

This scenario is so improbable and mechanically impossible as to confirm my suspicion that paleomagnetic results are worthless. Some workers in California trying to use paleomagnetics to interpret fault block movements have also come to the same conclusions.

The interpretations become even more ludicrous in the reassembly of the supposed Proterozoic continent Rodinia from parts of what is now Siberia, China, India, Australia (Li, Zhang and Powell, 1996). What we are now supposed to believe is that there was once a single continent on the Earth Rodinia in Proterozoic times; and that it broke up into two continents Gondwanaland and Laurasia situated in the southern and northern hemispheres respectively in the Paleozoic; and subsequently into the present configuration. This is the stuff of bad science fiction yet it was allowed to be published by the editors and reviewers of a reputable scientific publication, the Australian Journal of Earth Sciences which incidentally refuses to publish papers critical of the plate tectonic theory.

When we come to consider magnetic stripes and midocean ridges we are indebted to two recent papers in the Geological Society of Australia Journal (Veevers et al., 1991).

What they are assuming from plate tectonic theory is that is there is continuous injection of basalt at the mid oceanic ridges. This flows out on either side of the ridge and cools below the curie point being magnetised in the prevailing direction of the Earth's magnetic field, which they believe, reverses regularly.

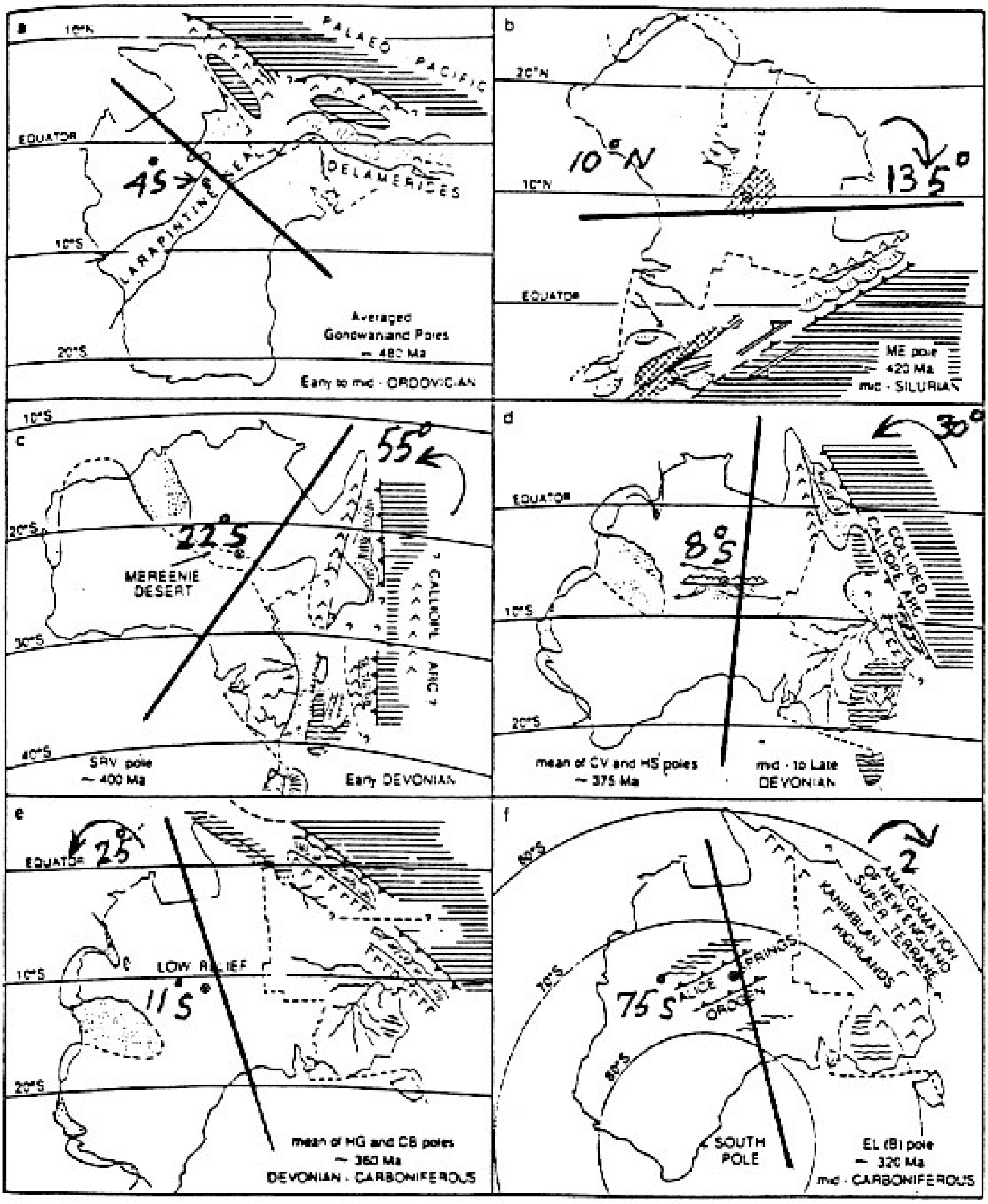

Figure 3. Rotation of Australian continent between Ordovician and Carboniferous, after Li et al. (1990) with the latitude of Alice Spring added. Also added is a reference line to determine the amount of supposed rotations of the continent.

The area south of Australia can be considered as an example. It has been used to try and prove separation taking place between Antarctica and Australia. Nine magnetic profiles over 850 km were taken and the ups and downs inevitable in any magnetic profile were correlated naming the ups as positive magnetic and downs as reversals. After processing everything through the computer an attractive series of coloured maps was produced. This paper was also published - with colour plates - by the *Australian Journal of Earth Sciences*.

To a working geologist who has carried out, supervised and interpreted numbers of magnetic surveys this data is completely inadequate and does not justify the sweeping conclusions drawn from it. In point of fact in the type mid-ocean ridge, the mid Atlantic ridge, Russian deep sea drilling has cored Palaeozoic sediments and analysis of seismic results has suggested north south rather than east west movement. Later work (Agoc et al., 1992) has shown the Mid Atlantic Ridge just south of Iceland consists largely of Palaeozoic and Proterozoic rocks. They also showed that the linear magnetic anomalies could be caused just as easily as by changes in the magnetic susceptibility of the Palaeozoic and Proterozoic rocks which outcrop in numerous places on the Ridge.

Ups and downs on magnetic profiles do not necessarily prove magnetic reversal. In the first ground magnetic survey I carried out I was warned that over basalts you got blocks separately magnetised with north and south poles. According to Tarling (1971) rock samples with exsolved FeTi oxides are liable to spontaneously reverse their magnetisation and many of the British basalts with reversed polarity have this mineralogy. It is also interesting that movements calculated from expansion of the ocean ridges and from paleomagnetic poles differ in magnitude and direction.

The latest supposed support for the plate tectonic theory is a series of measurements, which claim to obtain the accuracy of any position on the globe to 1 cm or less. Claims have been made that these measurements show measurable plate movement (Christodoulis et al., 1985), although their quoted conclusions only state that the methods used are still doubtful.

I studied surveying as well as geology and assisted at a number of astrofix determinations. One second of arc, which is difficult to measure, in Queensland represents about 30 metres on the ground. National Mapping surveyors were claiming an accuracy of 0.4 seconds, which would be about 12 metres. Modern satellite navigation claims an accuracy of about 5 metres. This is also the best the latest satellite navigation systems claim.

The interferometer methods being experimented with by Christodoulis et al. make all sorts of assumptions about refraction, clock accuracy, Earth tides, figure of the Earth, effect of solar gravitational field on light. It is far too early for those methods to claim the accuracy in positioning suggested for them and the observations have not gone on long enough to show reliable trends.

I have attempted to show that the modern information on which the plate tectonic theory rests is very doubtful.

We then come back to the earlier information, the fit of continents, and stratigraphic indications of different climates and distribution of fossils. These are equally doubtful.

There is currently one continent with three lobes, so why is it philosophically necessary to have two original continents, Gondwana and Laurasia. The fits are not that good even across the Atlantic and present day shorelines seem to be used rather than the Permian shelf edges.

I am assured that similarity of stratigraphy between South Africa and Australia is less than believed. Despite these facts the plate tectonic theory is still being taught as fact in universities and has even penetrated to popular science programs and textbooks as facts.

Another currently un-investigated problem is the question of ESP (extrasensory perception). This is ignored in courses in psychology in Australian universities although J.B. Rhine carried out extensive research in the subject at Duke University in USA. A friend who was a medical student gave a demonstration of hypnosis on a subject whom he brought to our house one evening. I wrote on a piece of paper to him an instruction for his subject to get up and go and pick up the phone. He did. While having dinner at Dunedin (in the South Island) when I felt strongly that I should phone home (in the North Island). My mother answered the phone and said that she had been trying to get hold of me as my father been thrown off one of my sister’s horses and badly hurt. You hear plenty of similar examples from the aborigines. My father had a long standing compact with me that when he died he would send me a message. He died in 1978 and I am still waiting. Any powers only relate to telepathy.

Extrasensory perception or ESP includes reception of information not gained through the recognised physical senses but sensed with the mind. The term was adopted by Duke University psychologist J. B. Rhine to denote psychic abilities such as telepathy, clairaudience, and clairvoyance, and their trans-temporal operation as precognition or retrocognition. ESP is also sometimes referred to as a sixth sense. The term implies acquisition of information by means external to the basic limiting assumptions of science, such as that organisms can only receive information from the past to the present.

Parapsychology is the study of paranormal psychic phenomena, including ESP. Parapsychologists generally regard such tests as the ganzfeld experiment as providing compelling evidence for the existence of ESP. The scientific community rejects ESP due to the absence of an evidence base, the lack of a theory which would explain ESP, the lack of experimental techniques which can provide reliably positive results, and thus considers ESP a pseudoscience.

In the 1930s, at Duke University in North Carolina J. B. Rhine and his wife Louisa tried to develop psychical research into an experimental science. To avoid the connotations of hauntings and the seance room, they renamed it "parapsychology". While Louisa Rhine concentrated on collecting accounts of spontaneous cases, J. B. Rhine worked largely in the laboratory, carefully defining terms such as ESP and psi and designing experiments to test them. A simple set of cards was developed, originally called Zener cards - now called ESP cards. They bear the symbols circle, square, wavy lines, cross, and star; there are five cards of each in a pack of 25.

In a telepathy experiment, the "sender" looks at a series of cards while the "receiver" guesses the symbols. To try to observe clairvoyance, the pack of cards is hidden from everyone while the receiver guesses. To try to observe precognition, the order of the cards is determined after the guesses are made.

In all such experiments order of the cards must be random so that hits are not obtained through systematic biases or prior knowledge. At first the cards were shuffled by hand, then by machine. Later, random number tables were used and nowadays with computers. An advantage of ESP cards is that statistics can easily be applied to determine whether the number of hits obtained is higher than would be expected by chance. Rhine used ordinary people as subjects and claimed that, on average, they did significantly better than chance expectation. Later he used dice to test for psychokinesis and also claimed results that were better than chance.

Finally on retiring from the Australasian Institute of Mining and Metallurgy Geoscience Committee. I was asked to provide for the next Geoscience newsletter a copy of my CV and answer certain questions.

This is attached below:

1] My CV with comments.

Colin (A.C.M. Laing) graduated B.Sc., A.O.S.M. (Associate Otago School of Mines) in 1950, later in 1963 completing M.Sc. at Victoria University of Wellington, New Zealand.

1951-1954 He worked in the N.Z. Geological Survey on geothermal, regional geology and NZ tectonics.

1954-1960 He worked in AAR (Minad) mainly on regional geology and gravity work geologically mapping large areas in Qld, NT, PNG, but also in reinterpretation of Roma area and Denison Trough that led to the 1959 and later gas discoveries.

1960-1962 He worked in NZ for BP Shell & Todd Petroleum Development mapping an area of the East Coast of the North Island.

1963-1973 He was Senior then Chief Geologist for Alliance Oil Development during their great period of operating and discovery of numbers of gas fields and one oilfield. During this period he carried out basin studies of nearly all Australian basins.

1973-1981 He was environmental geologist advising on the future use of crown land in Victoria, then was acting OIC Groundwater Section Victorian Geological Survey. Later 1982 he had to take over and write a report on the naturally carbonated waters of Daylesford Hepburn Springs in Victoria and became the Australian expert on mineral water.

1983-1996 Technical adviser finding mineral and spring water for Cottonwood Valley Pty Ltd, a major water exporter.

1985-1986 Consulting geologist Work included a major groundwater study of the Denison Trough for Denison

Resources.

1986-1990 He was Chief Petroleum Geologist and Chief Petroleum Inspector in charge of the Petroleum Division, PNG Dept. of Minerals and Energy.

1990-present Consulting geologist, A.C.M. Laing & Associates.

1996-2013 Tutor in Environmental Geology, Brisbane University of the Third Age.

2000-2006 Director Kokstad Mining Pty Limited planning to produce sodium bicarbonate from groundwater north of Roma in Queensland.

2006–2008 Chief Advisor to Clark Oil & Gas Pty Ltd forming a new oil exploration company

2009 –present Technical advisor to Pacific Enviromin now Australian Pacific Coal

2] I got most satisfaction from my success as an explorationist discovering deposits and being successful in my well prognoses knowing how to draw cross-sections.

3] The end of the small no liability companies which raised money from successive calls on the basis of their discoveries.

4] Get an extra qualification in hydrogeology. Groundwater is more stable. Make sure you get a legal contract. It would be a good idea for the AusIMM to draw one up for members.

5] I am worried about the state of academic geological scientific thinking. There seem to be lots of professors ignoring global warming. Lots who still believe continents float around like rafts and are prepared to prevent publication of different ideas in the main journals. Lots who cannot tell the difference between water laid conglomerates and glacial laid tillites. Lots who think the Jurassic beds in Gippsland are similar to the Jurassic in New Zealand without having seen both.

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OCEAN FLOOR FABRIC ASSISTS IN TECTONIC INTERPRETATIONS

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Controversies over scientific opinions are not uncommon in the evolution of the different branches of science. Creation versus evolution is one such prominent case that has raged for quite a while. Big bang versus steady state is another example. Currently the world is gripped in a hot debate between those who believe the science of cause-and-effect relationship between CO_2 and global warming is established and those who believe the jury is still out. Indeed, among the latter group there is a strong opinion that out rightly rejects this relationship. Because the subject has assumed open and direct political stage for reasons that are evidently going to impact future public welfare across the globe, it is not surprising that there is an unprecedented public involvement in the debate. Each piece of scientific data presented in favor or against the two opposing views is being subjected to intense scrutiny not just by opposing camps of scientists but also by interested citizenry. And media is not far behind; and sometimes even in the vanguard. No doubt this public scrutiny has exposed and smeared many a scientific careers. But, it is expected to impose strict scientific ethics at least in climatology.

We, the Earth scientists, know it first hand as for the current mainstream geodynamic concept, the plate tectonics, is concerned. Like the CO_2-induce global warming mantra, it caught the imagination of vast majority of Earth scientists although the fact remains that a small percentage of the ocean floor had been mapped to any degree of certainty, and vast tracks of continents remained unmapped by early 1960s when plate tectonics was formulated and accepted. However, from its inception plate tectonics continued to be contested by scientists based in different parts of the world, though miniscule in overall numbers. Data continued to be presented that underscored its unviability and plate tectonicists continued to provide explanations that opposite camps labeled 'ad hoc fixtures.' However, over the time the opposite camp, like the global warming "skeptics," even lost platforms (journals, conferences) to present their data though their numbers continued to increase.

Let us return to the early 1960s. The geophysicists were in a quandary, as they had amassed such items as seafloor spreading, continental drift, and earthquake bands underlying the world's trenches. What did it all mean? The geologists were happy with uniformitarianism and collecting rock information, being more concerned with the tectonic aspects than the geodynamics. A couple of academicians put together the magnetic stripes in the Gulf of Alaska and, lo and behold, it all made sense. Plate tectonics was born in 1966 at a GSA conference, and the rest is history (Smoot, 2001).

Or, is it? Those geologists and oceanographers were still out there doing their respective jobs. They were into exploration geology and mining engineering. They were into surveying the ocean bottoms and collecting rock samples. The US Geological Survey was still trying to make an effort at surveying the entire United States (which they have not finished to this day). And, this has been going on since 1966 when only about 0.0001% of the ocean floor had even been sampled. So, plate tectonics was formulated with little or no knowledge of about 71% of Earth's surface. In fact, not that much of the surface above sealevel had been surveyed either.

Essentially, we were presented with yet another concept much like that of global warming. Nobody really knew much about what was out there; they just felt like putting something together without collecting all the facts. The most recent example of that is the "findings" by NASA(?) of a warm body of water off eastern Greenland. Had they thought about the placement of a few earthquake seismometers and studied an ocean floor map, they might have discovered the presence of the Mid-Atlantic Ridge off the NE coast of Greenland. They might have even consulted a few oceanographer/geologists and discovered that MORs exude hot magma on occasion. They might even have discovered that such was the case, and that this magma extrusion was heating the water above and melting the ice pack.

And, they apparently had the ear of the "proper" authorities, just like Gore with global warming. They had fellows like Menard, Revelle, Heezen, and others. Who in his right mind was going to argue with these icons of the ocean world? Well, somebody did.

In the 1970s experts from Scripps, Lamont, and the World Chart Group (WCG) at the US Naval Oceanographic Office (NAVOCEANO) divided ocean floor sections and compiled contour maps to the best of their collective abilities. Huge cracks in the ocean floor were observed everywhere, all with some degree of linearity.

These were thought to be the result of the seafloor spreading, so that they would naturally show how the continents split apart. Conversely, they would also show how they originally fit back together. As a result of this, combined with Wegener's original idea of drift, a few fossils were thrown into the mix, and Gondwanaland and Laurasia were created, two supercontinents. Going back a little further in time, Pangaea was created from the fertile imaginations of the respective scientists so that, by now, plate tectonics was a *fait accompli.* Everyone jumped on board.

All Earth scientists ceased thinking at this point, just like what the Kyoto Protocol would have us do. But, there was a fly in the ointment. When the pundits who concocted the idea of "seafloor spreading" got together to compare maps, a near-riot occurred when some of them told the others that their ideas were all wet. The room was fraught with dissension (see Smoot, 2001), and this is why:

To begin with, we must understand the inner workings of the institutions which finance the field work. One such example is the US National Science Foundation (NSF). A field investigator visits those schools/professors the NSF has funded. They try to do this every two years. For the grant money, the investigator is required to publish his findings in a timely manner, take these findings to conference(s), and generally share the information.

Let's just say an investigator, a full-fledged professor, has reported that widgets are blue for the past 25 years. All of a sudden one of his/her students, or he/she himself/herself, discovers that widgets are red. Is the investigator going to tell the NSF representative that he/she has been reporting erroneous information for the past 25 years? The NSF would revoke his/her grant, and he/her would lose his/her tenure at the "respected" university. For that very reason it takes at least one full generation for any new ideas to creep into the reigning hypothesis, whatever that may be. This story was actually told to me by a head honcho of the M, G, and G Division of the NSF during my career.

Not to be dismayed, or dissuaded, these goodly Earth scientists went back to their universities and continued down the same primrose paths that had brought them to that point, whatever their "area of expertise" may have been. This, instead of nipping the problems in the bud. And, problems were abundant.

As noted before, the maps were limited in scope by the 1970s, so that the original premise was more or less based on "false hope." During that time frame, the Meyerhoffs, father and son, took the time to analyze the Pacific basin trends/fracture zones (1974) from these same maps. Overlooked in the discussions was the fact that the trends all converged on the western edge of the basin rather than parallel to each other. This was a physical impossibility within the emplaced constraints, as the fracture zones theoretically showed the direction of seafloor spreading, and a plate could not be spreading to the NW, W, and SW at the same time. Something was wrong, and the Pacific basin covers much of Earth's surface. Nothing was done.

Additionally, a red flag should have immediately been raised on the inspection of the first maps. The total length of the midocean ridges that is, the spreading centers, was 76,070-km. In order for the formula to work, twice that much take-up length needed to be recorded for the subduction zones and collision margins because the spreading occurs on both sides of the ridge. We will allow some deviation for shrinkage of the ocean floor due to cooling and subsidence. We also know that spreading is not a continuous event based on the most talked about spreading center around, that of Iceland. However, the global linear distance for the trenches is 35,610-km. When the collision margins are added to that figure, the total becomes 39,310-km. The math did not work then, nor does it now, and that has been repeatedly shown (Smoot, 1997 and 2015). Again, nothing was done.

Fast forward a few years. Rock samples are being collected; more and more fossils are being uncovered; larger areas are being added to the total areas surveyed; in short, the data bases are becoming more robust. As an example, by the 1990s NAVOCEANO had surveyed enough of the ocean floor by multibeam sonar to compile a different set of cracks/trends for that basin when added to the maps (Smoot, 1989b and 1999), and this gave the orthogonal intersections.

To establish the age, the article will use rock ages, not from the Deep Sea Drilling Project (DSDP) or its offshoot, the Ocean Drilling Program (ODP), but from worldwide ships-of-opportunity and analyses of the real age of the ocean floor and of the Indian/Eurasian collision margin. Years ago, papers started appearing in the literature refuting the idea of 180 million-year-old (Ma) ocean floor. This seems to have been ignored by the membership of the DSDP/ODP for whatever reason. Apparently, it never occurred to them that the drill holes were not reaching basement, even though almost every site description stated that basement was not reached.

To begin, younger rocks lie atop older ones all along the Mid-Atlantic Ridge and Iceland.
Choi and others (1992) provide the foundation, summarizing much previous work for the Pacific basin. Huge regions of Precambrian crust have been found, especially in the northwestern region (their Great Oyashio and Nankai Paleolands). The samples have kept growing over the years until it is no longer a question; it is a fact – the ocean floor is at least over one billion years old. In fact, initial findings of a 3.5 GA crust under the Pacific have been deciphered (Vasiliev and Yano, 2007; Vasiliev et al., 2012; Yano et al., 2009).

Of the more than 1277 bore-hole sites done by the combined DSDP/IPOD/ODP, at the time only 18 had reached “basement.” The descriptions in those volumes do not inspire a great deal of confidence in the accounts. The oldest age recorded, 157 Ma from Site 801 reads as interbedded with basalts with some pillow basalts (Smoot, 2015). This is not basement.

We will not list all of the conflicting data (see Meyerhoff et al., 1992), merely stating that a plethora of maps, dredge hauls, rock samples, etc. are available through a variety of outlets that show more scientific interpretations of ocean floor ages, beginning with Precambrian continental rocks and land bridges. For the Pacific region, Precambrian is the proper age of that basin, so we have longevity. Of course, Precambrian may cover back to Earth’s formation.

In another world entirely Ismail Bhat and A.K. Dubey went to work for the Wadia Institute of Himalayan Geology. Their job entailed tromping around all over where the Tethys Sea used to be, the Himalayan Mountains of India and Tibet. This would be the region between the Gondwanaland and Laurasia of the plate tectonics scheme. The field hands at WIHG found that the Himalayan Range had been in place for at least 2.5 Ga, and that precluded the idea of a Tethys Sea of any magnitude. The higher range contained ocean floor fossils, showing that the mountains had arisen above sealevel at that time. It also showed that India had always been in place (Dubey and Bhat, 1990; Bhat, 1998).

With no Tethys Sea as such ever in existence, we are allowed to remove about 4000-km of the Indus Yarlung-Zangbo suture zone from the collision margins with a minimum of trepidation, leaving the take-up margin linear distance at about 39,500-km (Smoot, 2007), a little over one-half the linear production distance. But, that is on the surface. This information must be combined with the earthquake data. What this does is to allow tectonic interpretations using ocean floor trends not to be interfered with a sub-continent plowing across the floor and disrupting actual facts.

It must be noted, though, that latest papers simply ignore the work of WIHG and still have India plowing through the ocean floor. Why? Your guess is as good as mine. The ghost of Alexander du Toit must be guiding their hypotheses mindset.

Similarly, prior work has removed the idea of the subduction zones from the plate tectonic hypothesis, thus creating a null hypothesis. With that, we have created a more stable environment for Mother Earth. With no subduction, we must assume that whatever the crust is now, it also was then, possibly even moving it closer to the age of the continental crust. At this stage the idea of oceanization may come into play, but not here.

Certainly all of this magma pouring forth from the "spreading centers" has not increased the diameter by that much over the years, or has it? The playing field is now more level for the direction this article is headed, that of across-boundary matching of oceanic/continental lineaments. Thus, the continents are free to roam/twist as Storetvedt and Hall have proposed.

Finally, the *piece de resistance*: The article will use the multibeam bathymetry collected by NAVOCEANO to establish ocean floor structural trends. In places of scarce bathymetric coverage, the structural trends have been enhanced by the addition of the high-pass filtered results of the GEOSAT surveys done in the late 1980s. For this, total coverage bathymetry of the North Atlantic Basin was used. I drew the "stick figure" based on the structural trends; that is, the transform fault/fracture zones (Smoot, 1989b). At the time, this was a revolution in itself. The Bullard fit was negated by the simple fact that the Hayes/Oceanographer FZ did not connect Boston Mass to the west coast of Africa as called for by the "fit." It connected Boston to Portugal. The Bullard fit figures prominently in most tectonic interpretations, so that is a null hypothesis.

I began to notice interesting things about the ocean basin cracks, such as the presence of linear seamount chains (Lowrie et al., 1986). Along the way it became more difficult for me to get papers accepted because what we were seeing on the ocean floor did not agree with the original premises for the foundation of plate tectonics. I became a maverick, just like what happened to field hands like Art Meyerhoff and Karsten Storetvedt. Some of the academic investigators even wrote into journals that the OSP data were no good. They said it was misrepresented. I said that the only misrepresentation was that I was not allowed to use seconds in my geographic tick marks on the diagrams. Therefore, everything I ever published was less that one nautical mile (nmi) off in geography. Considering that these features were mostly over 50-75 nmi wide and up to basin wide, this is negligible, not even the width of the pen nib used to draw the diagrams. Especially, this was, and is, true based on the worldwide bathymetric data bases.

In the late 1980s a classified satellite was launched to collect gravity data over the world's oceans, a satellite called GEOSAT. This satellite would collect information on the sea surface wave heights, which show a correlation to ocean floor structure. This is especially true for seamounts and fracture zones, which are not isostatically compensated. When enough orbits had been completed, NAVOCEANO produced a classified 5-minute grid using 8000 of the orbits. The data were manipulated to remove obvious spikes and noise, misadjusted tracks, and tracks over polar ice. The collector measured the marine geoid height to determine the gravity geoid because undulations in the geoid are caused by changes in the local gravity field.

Baylor University produced an algorithm that applied a two-dimensional high-pass filter to the gridded GEOSAT data file, thus creating a filtered data set that was presented at a 5-cm contour interval. The filter extremes were set to pass data over 125 nautical miles (nmi) and less than 70 nmi.

Where the trends were lost in the bathymetry by overprinting in the abyssal plains, the GEOSAT data carried the trends through (Leybourne and Smoot, 1997). Carrying out a similar exercise of the structural trends in the North Atlantic to the bathymetric trends of the same region showed NO DIFFERENCE between the two. What he did was to allow regional interpretation worldwide between 72^{o} N and 72^{o} S whether bathymetry existed or not (Smoot and Meyerhoff, 1995). This was a huge breakthrough for anyone interested in global-wide tectonics.

The plate *ad hoc* committee, whoever that may be, has given us two directions of plate motion a stated before. Absolute motion of the lithosphere, relative to the surface is defined by linear features such as seamount chains (Smoot, 2005). Relative motion of the lithosphere (plate) is relative to the upper mantle, and this is shown by the fracture zone azimuths. Thus, two sets of imprints are possible on the same piece of crust. I have the feeling this was in order to give yet another *ad hoc* explanation as to why the Emperor Seamounts do not align with anything else.

The addition of the GEOSAT data set to the bathymetry greatly enhanced the ability of scientists to interpret ocean floor structure once that correlation was made. When the North Atlantic basin trends agreed in both the bathymetry and gravity data sets (Smoot and Meyerhoff, 1995), the door was opened for world-wide ocean floor structural interpretation.

A relevant exercise shows that the Mid-Atlantic Ridge in the northern Atlantic basin is spreading both east and west as it separates the Corner Rise from the Cruiser/Hyeres edifice (Tucholke and Smoot, 1990). So, we know that some force involving ocean floor spreading is occurring. The fly in the plate tectonic hypothesis ointment is that no convergent margin exists in the eastern United States, so the newly created ocean floor still keeps moving west, being a proposed 165 Ma at the ocean/continent boundary. However, by plate definition, it keeps moving west to the Pacific basin, still the same plate. No spreading center appears in the eastern Pacific between the East Pacific Rise and the Gorda Ridge, essentially the length of the west coast of the United States. No convergent margin appears either, so the ocean floor produced some 165 Ma at the Mid-Atlantic Ridge is still moving west. The nearest convergent margin is the western Pacific trenches, where it is still only 165 Ma, so this is all one entity. Never mind the Cascade Mountains or the Rocky Mountains. No divergent margin ever existed in the eastern Pacific basin to cause this monumental collision. However, by magnetic anomalies, both the Mid-Atlantic Ridge and the west coast continental margin are “0” age!

How is this possible? One could go with the San Andreas Fault scenario whereby it is classified as a transform fault. That just makes it yet another orthogonal intersection with the Mendocino and Murray megatrends.

Therefore, the ocean floor lineaments have been largely ignored. Had the continents been moving about by either twisting/wrenching or tectonic movement to conform to those ideas, then one would expect to see offsets between the continental and oceanic lineaments/megatrends. If the reader will look very closely at the figures, he/she will not be able to find any offsets. This has been repeatedly shown by Choi, Dickins, and myself. It has also been repeatedly ignored by the landlubbers. And, the fracture zone swarms, called megatrends, cross the entire Pacific basin (Smoot, 1989a, 1997 and 1998; Smoot and Leybourne, 2001; Smoot and Choi, 2003).

Additionally, the ocean floor fabric is an excellent indicator, especially the cross-fracture imprint. That is precisely what we will study to help put an end to the idle speculation brought on by the different hypotheses. The fabric, called tectonic spreading fabric (TSF), can do one of three things. It can leave extensional features such as stretch marks if Earth is expanding. It can maintain the status quo. Or, it can leave a compressional alternating ridge-valley-ridge topography if contraction is occurring. If twisting is occurring, then the fabric on the outside of the fracture will show extensional features, such a mini-cracks, or fractures. Conversely, on the inside of the twist, compressional features such as the ridge-valley-ridge configuration will be present.

A “normal” fracture zone, such as the Murray Fracture Zone (MFZ), Surveyor Fracture Zone (SFZ), or Clipperton Fracture Zone (CFZ) in the northern Pacific Ocean basin, is a good example. The SFZ and MFZ are perpendicular to the San Andreas Fault. No spreading center exists anywhere near the eastern end of these fractures. Nor, does one exist anywhere along the track, nor at the western end, which is the western Pacific trenches. The ridge-valley-ridge features vary up to 400-m from top to bottom.

Excluded the across-trench depth differences, the topography on both sides of the SFZ is exactly the same; that is, alternating ridges and valleys for the length of the fracture with the exception of some regions of sediment overprinting. Therefore, one would not be remiss in making the statement that, for the region of the SFZ, the entire region is in compression. That is exactly what one would expect in a contracting Earth. Differential horizontal and vertical movement may occur, but contraction seems to be the only force acting upon the SFZ.

The same can be said of the NNW—SSE-trending Kashima, the Krusenstern, and the Emperor Fracture Zones in the NW Pacific basin.

Interestingly, the bathymetric depth of the SFZ in some spots is up to 6000-m, which is commensurate to that of many of the trenches. The CFZ ranges from 7000—8400-m at the deepest points. The Emperor Fracture Zone has depths of 7500—7686-m. The equatorial mid-Atlantic Romanche Fracture Zone shows depths of 7760-m for over 300-km. Comparing, the Middle America Trench, for instance, generally ranges from 5400-m deep on the north and 6400—6600-m on the south. The Peru-Chile Trench has a maximum depth of 8065-m in one spot, but generally ranges from 5400—6300-m deep. The Java Trench has the deepest point in the Indian Ocean basin at 7725-m. The Bonin Trench has a mean depth of 6950-m. The Philippine and Mariana Trenches are much deeper, but they are exceptions to the general rule (Smoot, 2015).

Naturally, we do not know the ages of any of the fractures or trenches, so this line of questioning becomes a moot point. Until such time as rocks are collected from a variety of the inner walls of the megatrends, it shall remain a moot point, and we are just whistling in the wind.

We know now that the ocean floor is at least Precambrian in age. We know that none of it has disappeared in the trenches because subduction has not occurred. And, we have beautiful sets of oceanic megatrends. What can we do with them? If we could establish an age for them, that would be helpful. However, this has not been done for any with the exception of the equatorial Romanche Fracture Zone and southern portion of the Vema FZ in the Atlantic basin when continental rocks of “anomalous” ages; i.e., older than zero age for a spreading center, were recovered (many papers by Enrico Bonatti). These fractures are just to the south of the Hayes/Oceanographer megatrend. From a quote: “alkali gabbros are of special interest, particularly because rocks with modal nepheline have not been reported in the past from oceanic ridges.” (Honnorez and Bonatti, 1970)

We can conclude with this thought, though: If the geology, geometry, geography, and GEOSAT all refute most of the current models of global tectonics, why should the geomagnetics be the only science that “proves” any form of global tectonics? This includes Earth expansion as well as wrench/twist tectonics and oceanization. Rather than to keep pummeling the readership by tooting our own horns about the never-to-meet multi-variant hypotheses, we need to bring all of the known, hard-core, accurate data together. After 20 years of the Newsletter/Journal, we are no closer to an actual model than we were at the beginning. Talk about whistling in the wind…..

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GLOBAL CLIMATE CORNER

ANTHROPIC GLOBAL WARMING

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Declaration *– I have no affiliation, no support, no sponsor, no direct or indirect relationship to any kind of business, and no economic or carrier interest related to climatic items. Since November 2005 I retired from every professional job. The present short note - which relies on 52 years of studies of issues related to climate carried out mostly during my stay at CNR in Rome - deals only, and strictly only, with a mere scientific discussion, according to the usual standards of science, based on observational matters of facts and on an unbiased and unselfish objective discussion, upon clearly emphasizing, whenever needed, the eventual uncertainties of arguments and/or evidences.*

Abstract – The global climate change (or global warming, GW) is in progress, closely analogously to several other - eventually also much more violent – documented occurrences reported during the long history of the Earth. At present, the demographic expansion - altogether with the ever increasing energy demand - make humankind to be an unprecedented driving factor in the "climate" system. The consequent pollution has certainly to be suitably taken into account as an important aspect in climatology. However, contrary to a well-known and often strongly claimed warning, no objective evidence seems to support the hypothesis of any leading role of CO_2. Other drivers, which are essentially independent of the humans, certainly play a paramount and most relevant role. The very recent maps of the CO_2 planetary distribution provided by the NASA satellite OCO2 give an unexpected clear support for the inferences derived from my volume published in 2002 (Gregori, 2002).[1]

Keywords*: AGW, CO_2, palaeoclimate, natural catastrophes, environmental ethics, science makers, sciences communicators, ethical organizations, decision makers*

Introduction – This note was born following a threefold invitation.[2]

- Marco Ferrazzoli, Director of the Press Agency of CNR (Consiglio Nazionale delle Ricerche) invited me to provide him with material for an interview that was included in the *Almanacco della Scienza* of CNR (www.almanacco.cnr.it, N. 11, 18 Nov 2015).
- Niels-Axel Mørner and Václav Němec invited me to give a contribution on geoethics, on the occasion of a recent meeting in Prague, where the ICG (Independent Committee on Geoethics) (http://geoethic.com) has been established; this explains my emphasis on ethical issues.[3]
- Dong Choi invited me to contribute the present note to NCGT by a suitable adaptation of this previous material.

In the present note I maintained the style of an extended interview, by adding a few figures, some new comments, and some essential references. Therefore, this note is unavoidably very different compared to a standard paper. However, all statements which are here made are supported by extensive references that cannot be here quoted in detail. An extensive complete discussion required an 8-volume set in preparation.[4]

The questions that are considered in the present "interview" begin by dealing with some basic ethical issues. Then, the emphasis is on the role of CO_2 and CH_4 (and in general of carbon) in "climate", both at present and during the geological history of the Earth. Finally, the evidence is briefly discussed that is provided by the NASA satellite OCO2 launched in 2014.

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[1] For some very brief account see Gregori (2006, 2006a or 2009).

[2] I sincerely thank them for their respective invitation.

[3] See also Gregori (2015).

[4] At present, this is fully completed. Altogether it is over 9,000 pages long. Its final editing is in progress. A preliminary progress report is given in Gregori (2014).

A premise *must* be *clearly emphasized*. The debate is often very harsh, with insults etc. that are incompatible with "science" and therefore are unacceptable for every true "scientist". Science can be only made of calm, tolerant and good-humored though eventually strong competition, upon distinguishing hypotheses, speculations, "generally agreed" beliefs, compared to observational evidence. Indeed, all debates are the "engine" for the progress of science (William of Ockham).

In contrast, people who like insults, also like to get the amplification by mass media, thus becoming an obvious and easy prey of some Big Brother …. They always want to identify somebody who is "guilty" for being against their opinion (this is "hunting for the greaser", see below).

In this respect, it *must be stressed* that it is total *nonsense* to blame ***anybody*** among the large amount of bona fide people who clearly appear to be convinced by the "greaser" campaign: he has the only fault to rely on the "certainty" propagated by self-claiming pseudo-scientists.

The great responsibility is rather of these "pseudo-scientists" - and this is very serious upon considering the unfortunate influence on the consequent delay on the development of science, and thus on the huge number of victims of natural catastrophes that cannot be suitably prevented or managed.

1) Global warming is the object of a great concern and of controversies. What about the present state of the art?

- I want to emphasize a few preliminary fundamental items dealing with a merely ethical standpoint.
- We must clearly distinguish between working hypotheses and observations. We must debate on sound matters of facts with no paradigms and no harsh standpoints. *Humility* in front of Mother Nature is fundamental. Only Nature can decide what can be wrong or correct.
- That is, I should stress that everybody should strictly avoid:
  – ***Servility*** – that is relying on items only because others claim something
  – ***Messianism*** – that is feeling that we are depositary of "truth"
  – ***Insults*** – that is claiming that the feeling of others is determined by interests etc.
  – ***Sectarianism*** – that is believing that one must necessarily choose and partake with either pro or con something or somebody
  – ***Incompetence*** – that is dealing with anything which is not closely and strictly related to science and only to it.
- Rather, everybody should consider that:
  – We are all involved in ***decoding*** the "book written by Nature", and no "final" code will ever be attained
  – We must ***always accept*** and discuss scientifically about *every possible* hypothesis, explanation and model
  – Science is ***not democracy***, rather it is a tight dictatorship, where the very severe dictator is Mother Nature
  – Every time that we accept - or believe in - an incorrect explanation or model or that we make a mistake, we are potentially co-responsible and ***guilty for the death*** of several people, much like a medical doctor who makes a mistake is responsible for the eventual death of his patient.
- The deontological obligation has to be very clearly distinguished of three different kinds of communities:
  - *Science makers*
  - *Science communicators*
  - *Ethical organizations (such as religious or humanitarian institutions, etc.)*
- These are to be considered as being three very distinct and independent entities. Every community should inform the others about its internal controversial items, but it should never interfere with the debate inside the others. This derives from the deontological need to avoid a ***conflict of interest***, because every community judges the controversies of others with no

adequate competence and from the standpoint of its respective biased "feeling". By this, it can contribute no objective argument. Rather, it can be only misleading or even dangerous.

- More in detail:
  - ***Science makers***, i.e. scientists, must rely on observational evidence alone, they must refrain from relying on paradigms, they must debate although by allowing *full freedom* of thought for every interpretation, they must refrain from every argument other than what relies on strictly scientific topics (such as refrain from insulting each other about any kind of presumed bad faith), they must avoid to communicate "certainties" to non-scientists, they must rather stress that *there are many more items that we cannot understand compared to what we can really explain*.
  - ***Science communicators***, i.e. mass media, must avoid every kind of irresponsible sensationalism, of alarmism, of simple-minded "explanation" of scientific items. They must refrain from "*hunting for the greaser*" (see below for explanation) which is a devastating present "*psychological catastrophe*" being only the ***excuse*** or ***alibi*** for decision makers in order to avoid taking decisions. Communicators must refrain from confusing scientific and economic items. They must inform public opinion and decision makers, but always on the basis of documented matters of fact. They must avoid propagating unproven guesses about either scandals or presumed bad faith by anybody. Indeed, owing to the present unprecedented amplification by social networks, an irresponsible use of information results into a devastating weapon for every Big Brother.

    [The term "*hunting for the greaser*" is well known in the Italian culture, being expressed by a famous classic of the Italian literature, the novel "The betrothed" ("I promessi sposi") written in 1840 by Alessandro Manzoni, being ranked among the masterpieces of world literature. This novel is set during the XVII century. It includes the description of a severe bubonic plague that hit during that century. Manzoni vividly describes a real historical fact, i.e. the belief that - according to the generally agreed feeling of the XVII century – somebody propagated the plague. They speculated about the existence of guys, generally called "untori", literally "greasers" or infectors, who were believed to propagate the contagion through some kind of infected "grease". In reality, the sewer rats were responsible for the contagion. But, at that time people were recommended to avoid to bath, in order to avoid that the skin pores opened and thus permitted an easier contagion.

    At present, "*hunting for the greaser*" denotes somebody who searches for some non-existent culprit of some bad action of any kind. Very often, as a standard, all mass media and people immediately look for a culprit. Thus, everybody, including the decision makers, feels free from any responsibility. Everybody forgets about the hazard of concern, and nobody minds about the actions that ought to be strictly needed in order to prevent the occurrence of future similar "catastrophes". That is, this is a true and frequent present "*psychological catastrophe*".]
  - ***An ethical organization*** of any kind, such as e.g. an important either religious or humanitarian organization - or anybody who has a great influence on the behavior of people - should ***never*** forget that an ethical organization is ***not*** institutionally devoted to science. It has to rely unavoidably on information borrowed after some "self-claiming" scientists. These ethical organizations *must refrain* from supporting either one controversial viewpoint or another among scientists. Indeed, every *true* scientist *must* be expected to respect his *primary deontological obligation to avoid exploiting* ethical organizations to support his point.
- It should be stressed that it is a ***real insult*** for every true scientist to classify him either as "climatic catastrophist" or "climatic non-alarmist". Every *true* scientist is never a *partisan* of either one interpretation or another. Rather, he *must* always humbly rely on Nature. Every true scientist ***must*** always remain at the understating level of an objective and realistic, honest judge between eventual partisans.
- Summarizing,

– ethical organization must refrain from ***entering into scientific debates***

– scientists must avoid to ***confuse a scientific discussion with ethical or religious items***

– mass media must refrain from ***searching for scoops or sensationalism*** if they want not to be guilty for the death and sufferance of huge amounts of people in the next future.

In addition, for subsequent reference I have to clarify a few preliminary key scientific breaking issues:

a) I call "*climate*" the domain in space and time where the biosphere can develop and survive. Note that "environment" is a term that applies everywhere, even in interstellar space, while *"climate"* refers to a tiny portion of "environment", and it is identified with some thin layer around the Earth's surface and during the time lag when life was present on the Earth. That is, it is meaningless to identify "climate" with a statistics of temperature, or other meteorological parameters, much like it is nonsensical for a medical doctor to define the health of his patient only by means of a mean of his body temperature etc.

b) The *Earth is a battery* that stores and releases endogenous energy at different times and by different amounts in time and at different locations at Earth's surface. The *Earth is not a hot ball* cooling in space. The tide acting on the whole Earth's body is the primary energy supply to the battery. Enormous variations of the energy balance of the battery occurred in both space and time. This is extensively observationally documented e.g. by the magma emplacement rate of the Hawaii volcanism during the last ~70 Ma (million years). This is also the clear reasonable explanation of the several observed palaeoclimatic changes, including all great extinction events, and this is also the very likely explanation of the present ongoing climate change. Refer to the very extensive discussion given in Gregori (2002).[5]

c) The *encounters of the Solar System* with interstellar clouds of matter determine changes of the solar wind flow, and also a refill of comets and meteoroids. The most violent events sometimes determine a geomagnetic field reversal (FR), and in any case originate a violent generation of endogenous energy. The amount of Earth's atmosphere at every given epoch resulted from the balance between the amount of gas exhalation from soil (controlled by endogenous heat availability), and the atmospheric depletion by direct interaction with the solar wind on the occasion of a FR, when the Earth missed the protecting shield represented by the magnetosphere.

d) The endogenous energy is generated, as mentioned above, through a *tide-driven (TD) dynamo* inside the whole Earth's body. Energy propagation occurs according to the standard classical laws of electromagnetism. In particular, the propagation through the outer core of the Earth occurs through MHD (magneto-hydro-dynamics). Let me just explain the concept by means of **Figure 1**.

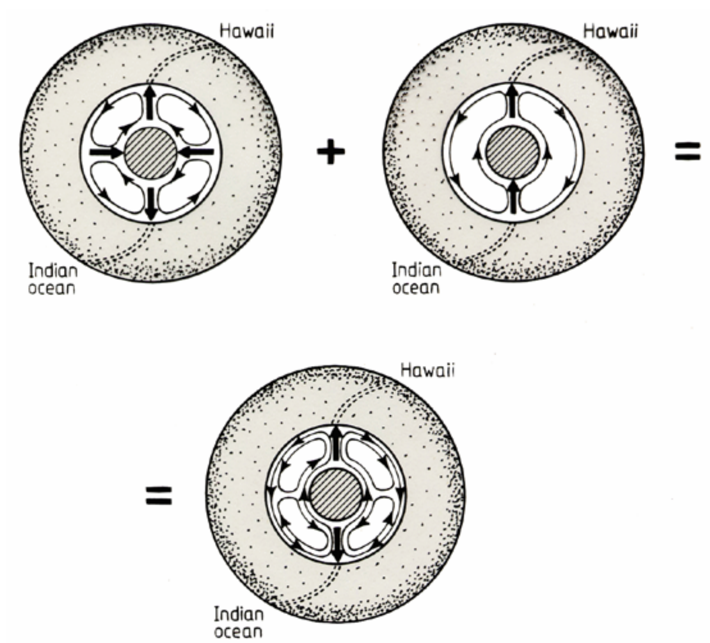

Figure 1. Patterns of endogenous energy propagation through the Earth's outer core. The two leading mechanisms correspond to spherical harmonic patterns of degree 1 and 2. The resulting picture envisages one leading region of comparably more intense release of endogenous energy that is very likely to be associated with the Hawaii hotspot. A second region, characterized by a comparably slightly smaller endogenous heat release, is roughly antipodal to Hawaii, i.e. in Botswana involving mainly the southwestern large fraction of the Indian Ocean. After Gregori (2002).

[5] A short summary is given in Gregori (2006), or see also Gregori (2006a or 2009) for a simpler illustration of this innovative idea.

This is a well-known pattern in fluid dynamics, and it is said that it represents "convection cells". In the MHD case, however, the leading role is played by electromagnetic rather than by thermodynamic forces. However, when heat transport is treated by means of formal mathematics, it is very convenient since the Gauss' time to use a standard well known tool (spherical harmonics) by which it is possible to define some hierarchy of different patterns of heat transport (note that this energy transport occurs through electric currents, even with negligible or no transport at all of matter). In **Figure 1** it is thus shown that two areas are expected to be characterized by a large amount of endogenous heat release, one roughly around the Hawaii, and the other, which is slightly less intense and antipodal to it, roughly around Botswana.

e) A very common *misapprehension* is the standard way to consider "climate" as being mainly a matter of *physics* and *chemistry*, while an undeclared belief is that the *biosphere* can - or cannot - be "onboard" the planet Earth, much like a passenger eventually books a seat on a flight, and then he can board on it or not. This feeling is *completely wrong*, as "climate" is *mostly controlled by the biosphere*, while every physical and chemical effect is just a lesser detail of the mechanisms that drive "climate".

In this respect, according to a simplifying although expressive conceptual scheme, "climate" can be illustrated as being basically mainly controlled by *three "engines"*. Every engine has its typical time-pace and space-distribution (**Figure 2**). In addition, as a subsidiary control factor, solar irradiance affects mostly the *biological* engine, and it plays a complementary although relevant role, being responsible for the seasonal variation and for all Milanković's periodicities.

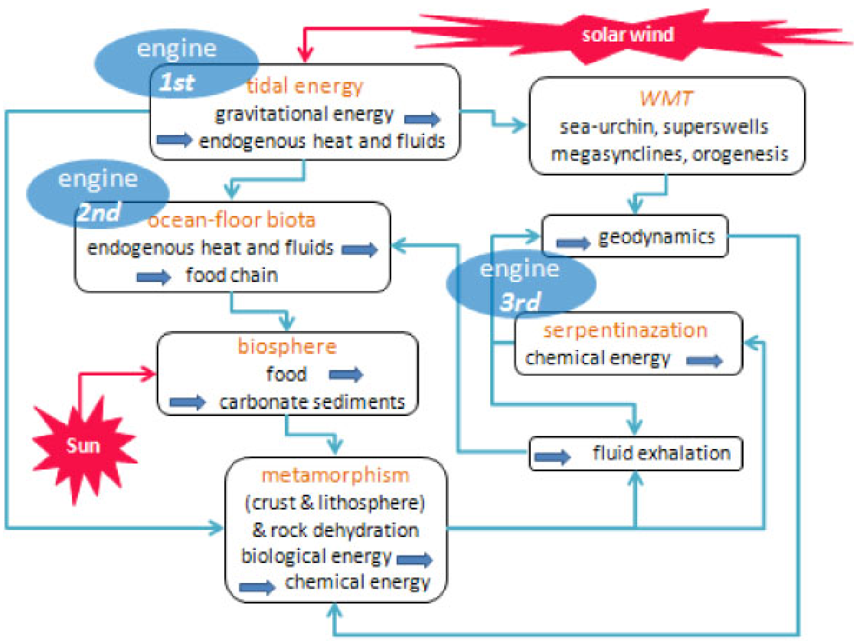

Figure 2. The drivers of "climate" are three engines. The Sun modulates the *physical* engine by means of the solar wind (i.e. the TD geodynamo, mainly supplied by the Moon). Then, solar irradiance amplifies the role of the food chain in the conversion into biomass of the fluids and energy exhaled from soil. Biomass finally returns into ground in the form of organic sediments. The *chemical* engine is serpentinization: it re-hydrates rocks, previously de-hydrated by endogenous heat. See text.

The respective different roles of the three engines can be better appreciated upon considering long-term climatic variations.

The first engine is *physical*, as it is the aforementioned TD geodynamo. A second engine is *biological* and it transforms endogenous energy (heat plus soil exhalation of CO_2, CH_4 and other) into food being the start and primary supply for the food chain. Thus, the biosphere transforms into biomass the carbon exhaled from soil, and the biomass is finally deposited into carbonate sediments on the ocean floors. Endogenous heat from the physical engine supplies metamorphism in the crust and lithosphere. It causes water exhalation and de-hydration of rocks and of other crustal materials. The third engine is *chemical*, i.e. it transforms (through hydration and the so-called "serpentinization") chemical energy into gas exhalation, which is a supply for the biosphere, and, in addition, it also causes substantial and intense geodynamic phenomena.

f) For brevity purpose, I can only mention two additional fundamental key items that definitely ought to deserve a very long discussion, i.e. the *carbon cycle* and the *water cycle*. Owing to the huge number of concurrent processes and phenomena, they are basically almost non-understood, and a long hard thinking and measurements are required before getting rid of their mysteries. It is therefore just nonsensical and irresponsible to make any forecast on the basis of the available present understanding. Let me just only remind about the well-known impossibility to define any kind of “mean temperature” of the planet Earth, or also the well-known unreliability of any information related to sea level change. Indeed, in this respect consider e.g. the Mediterranean basin. Owing to a tectonic tilt due to geodynamic phenomena, The Mediterranean floor is uplifting in its western side and sinking in its eastern side. Therefore, it is practically impossible to make any realistic estimate of the true variation of the total mass of water contained in it. Similar tectonic phenomena certainly occur also everywhere, although they are basically almost unknown.

Concerning specifically the Global Warming (GW), very briefly the present state of the art is as follows:

a) At present GW is in progress.
b) Somebody wants to claim - and to insist, although this is vigorously controversial for others - that GW is *certainly* originated by anthropic[6] action, hence the name “anthropic global warming” (AGW).
c) Until a short time ago it was not possible to prove that CO_2 is very dangerous for human kind, but it was also impossible to prove the opposite.
d) Today - after the records monitored by the OCO2 satellite (see below) - we almost got a “smoking gun” proof: CO_2 appears to be the result of an overwhelming soil exhalation (consistently with the aforementioned mechanisms extensively discussed in Gregori, 2002), while the anthropic contribution in general is only a lesser component.

2) Why has the anthropic CO_2 hazard been controversial?

Due to several reasons:

a) Several observational data series have been shown to have been modified *ad hoc* in order to support the AGW hypothesis.
b) Mathematical models (improperly called numerical models) resulted to be reckless, unreliable, misleading.
c) Recent observational data very clearly appear to disagree with the AGW hypothesis. In contrast, they seem to confirm a definitely overwhelming role of natural drivers, consistently with analogous – or even more violent – events that happened during the geological past history of the Earth, including all great extinction events.
d) In particular, different substantial evidences envisage that in the past, on different occasions, the Earth’s atmosphere experienced periods with a density 5-10 times larger than the present value, also having enormous concentrations of CO_2.
e) According to present experiments carried on inside greenhouses, all plants that grow in air that has been enriched in CO_2 experience a much larger growth.
f) According to the "principle of preservation of life" (Ronov, 1982), the primary carbon cycle has a major source (volcanism and soil exhalation) and a major sink (life). Hence, with no carbon source, no life could survive on the Earth, as life would finally transform into oceanic sediments the whole available atmospheric carbon (CO_2 and CH_4).
g) Unquestionable evidence (Judd and Hovland, 2007 and references therein) shows that microorganisms are steadily generated in very deep ocean floors, where no sunlight can be available. Rather, the unique available energy-source is the soil exhalation of warm CH_4. These microorganisms are the beginning of the food-chain, while more developed life-forms progressively occupy shallower ocean layers being finally supplied by solar radiation. This is the aforementioned biological engine. That is, life is a steady permanent regeneration process, which is *always* ongoing on the ocean floors, with consequent slow genetic mutation related to every eventual “climate” change. Note that this phenomenon also implies the possible existence of life on other planetary objects, although limited to their subsoil, due to the absence

[6] Concerning the use of the term “anthropic” or “anthropogenic”, etymologically “anthropic” is an adjective that indicates something related in some way to humankind, while “anthropogenic” refers to something related to the *generation* of human kind. Hence, the frequent use of “anthropogenic” is improper. I use the term “anthropic”.

either of an atmosphere, or of a sufficient amount of solar radiation suited for its emergence at and above surface.

h) Differently stated, soil exhalation of CO_2 and CH_4 has been essential – both in the past and at present - for the evolution, development and survival of life on the Earth. In addition the amount of exhalation has experienced several huge temporal and spatial variations thus explaining palaeoclimatic changes and life evolution.

i) As far as the greenhouse effect is concerned which is caused by CO_2, since a long time it is well known that the greenhouse effect which is originated by atmospheric water has been estimated to be comparably much stronger. In any case, the exhalation of water, of CO_2, of CH_4 and of "geogas" is largely controlled by the release of endogenous heat.

j) As mentioned above the Earth is *not* a hot ball cooling in space. Rather it is a *battery* that is recharged, and also discharged at different times by different and non-homogeneous amounts all over the globe.

k) The assessment of all these observational matters of fact primarily implies *enormous moral responsibilities* for the scientific community, as these are not a matter of academic disquisition, rather they can be relevant for our concrete capability to *manage and mitigate dramatic natural catastrophes*, in terms of *causalities, sufferance, and damages.*

3) Can you give some better detail about a few items?

- I cannot specify items dealing with *ad hoc* modification of observational data series, because this implies a technical discussion. Similar more specific statements are often reported, although one should refrain from taking for granted every statement with no personal direct check of the associated observational evidence and of the way it was analyzed.
  I only recall a very authoritative, exhaustive, documented, and unbiased study (Quinn, 2010) where it is shown that every variation of solar radiation - i.e. including both solar electromagnetic irradiance and solar corpuscular radiation (i.e. solar wind) – is first manifested as an impact on geomagnetic-related phenomena, and only after some relevant time delay also on other climatic parameters. Indeed, geomagnetic phenomena are the direct indicator of endogenous heat production. In any case, it is shown that several claimed "observational evidences" of GW have often been incorrectly reported and changed in order to support the AGW hypothesis. This item is harshly debated, and owing to brevity purpose I cannot enter into this very vivid and often unfair controversy.
  A huge literature exists. For instance, Epstein (2014) is a documented report against AGW, and it is focused mostly on economic issues. As far as the AGW supporters are concerned, let me recall Massonnet (2015) and Weart (2015) where they complain that the AGW community seems to be focused only on polemics rather than on a search for new scientific evidence.
  I also recall that - on the occasion of the COP21 meeting in Paris - 12 Italian scientific associations, including the very authoritative SIF (Società Italiana di Fisica), strongly disapproved the AGW hypothesis and stressed that every statement is unscientific of the kind: "it is likely that with 95% probability the cause of GW is anthropic". Indeed, such a statement ought to imply, in true science, that "95%" is associated with a precise estimate of a statistical confidence limit that in the case of climate studies is certainly missing. In particular the SIF contends the conclusive declaration of the Science Symposium on Climate recently held at FAO in Rome.
  That is - whatever is everybody's feeling - there is lack of any concrete and clear data analysis of any given sound and uncontroversial observational database.
- As far as the "numerical models" are concerned, they are computed by applied mathematicians with very great skill and expertise. However, their main concern is the search for a confirmation of the interpretation scheme that had been proposed to them by some Earth's scientist. A mathematician really exploits his greatest skill while attempting to confirm what his customer wants. A mathematician wants to show that he is "clever". However, knowing how to solve a difficult equation is different from understanding the physics of problems.
- In any case, all computed climate numerical models gave – as it is unanimously acknowledged – a forecast that, according to the present check, *a posteriori* resulted incorrect in excess. This difficulty caused a well-known concern for AGW supporters.

- In this same respect, a curious event occurred in April 1974 (Sartini, 2014). The very authoritative State Secretary of USA, Henry Kissinger, gave an official speech at UN. He strongly warned every head of state – independent of every political controversy – about the hazard of a 1°C change by 2015 of the ocean temperature. He relied on the best known models computed by the most prestigious universities and scientists of that time.
  But, as a most curious fact, the forecast was for a 1°C ***decrease*** of water temperature by 2015. Somebody even proposed to construct a dam through the Bering Straits in order to prevent cold Arctic water to enter ocean circulation.
  Should we believe that present climatic models can be better reliable?
  Note that the investigation of climate is even much more intricate than the study of the human body. *Suppose that somebody has a cancer, and that an oncologist invites his patient to wait while he computes the numerical model of his body in order to define a therapy …….*
- Differently stated, the skilful mathematician should make his job, the oncologist his job, the meteorologist his job, and the geophysicist his job.

4) Why do you distinguish a meteorologist and a geophysicist?

- A meteorologist applies wonderful numerical models that (in contrast to climate models) are very well tested and certainly reliable (at present) on the time scale of, say, up to one week. However, their spatial resolution is characterized by grid points at the order of one point every few kilometers.
- In contrast, a flash flood or a tornado or a hail storm ought to request a resolution of one grid point every few ten meters. Thus the mechanisms that originate this kind of phenomena will never be forecasted by means of the present methods and computational tools available in meteorology.
- In any case, also on the much larger scale, the meteorological methods are well known to be incapable to predict the birth, evolution and track of a hurricane (consider e.g. Katrina, or the recent hazard for the western Mexico coast).
- A popular explanation - which is often recalled by mass media - is the so-called "butterfly effect" (which is a well-known possible effect triggered by a mathematical instability).[7] However, where does the energy-supply come from? For instance, one should explain why Katrina had its tremendous energy supply originated by a very rapid, very intense, abrupt and violent increase of sea-surface temperature through the Gulf of Mexico, unquestionably and clearly monitored by satellites …… Is this ocean energy input a "butterfly effect"?
- Consider that the distinction between different disciplines of solid Earth, ocean, atmosphere, biosphere, etc. is an artificial superstructure invented by scientists. Rather, the Earth is a unique natural system. What is the significance of a study limited to the atmosphere alone?
- *Never forget*, however, about the deontological obligation imposed by the dramatic, *tragic consequences of natural catastrophes* …. We *must* always be humble and realistic.

5) Why AGW supporters feel distressed? Due to the difficulties of their models?

- Not at all. Several observational data are now available. But, owing to brevity purpose, I shall recall only the very last evidence. Maybe this is the most shocking result, a real ''smoking gun'' proof.
- Only very recently (after 2014) the records have become available of the satellite OCO2, specifically launched by NASA in order to exploit a survey and planetary maps of the CO_2 concentration in the atmosphere at ground.
- The expected result was to find a clear proof of a relative maximum CO_2 concentration in areas of greater anthropic territory occupation, in terms of inhabitants and/or of industrial settlement.
- The comments, describing the first maps released by NASA, appear embarrassed. This can be well understood, as their evidence appears to be opposite to the AGW hypothesis, which is declaredly supported by President Obama.

[7] "Exotic" explanations are always appealing to mass media. This reminds about ancient Babylonians who considered mathematics like an exotic matter for illusionists, and identified astronomy with astrology. The correct feeling about "science" was born in the Ionic Miletus.

- But NASA has to be sincerely and very gratefully appreciated and acknowledged for having generously put data and maps available on the web. Thus, other researcher can study the observed CO_2 distribution. Social networks rapidly recorded a conspicuous number of comments.
- The first tentative proposed interpretation by means of numerical models - based on the assumption of anthropic origin - certainly cannot explain observations.
- I shall show here only two figures that I borrowed after the web. Note their very recent date. I shall briefly comment only some of their most evident evidences. My basis is my aforementioned book Gregori (2002) that is now getting an increasing consideration by other investigators.
- **Figure 3** displays a few maxima that unquestionably do not correspond to the regions of major CO_2 production of anthropic origin. I comment here very briefly on these maxima:

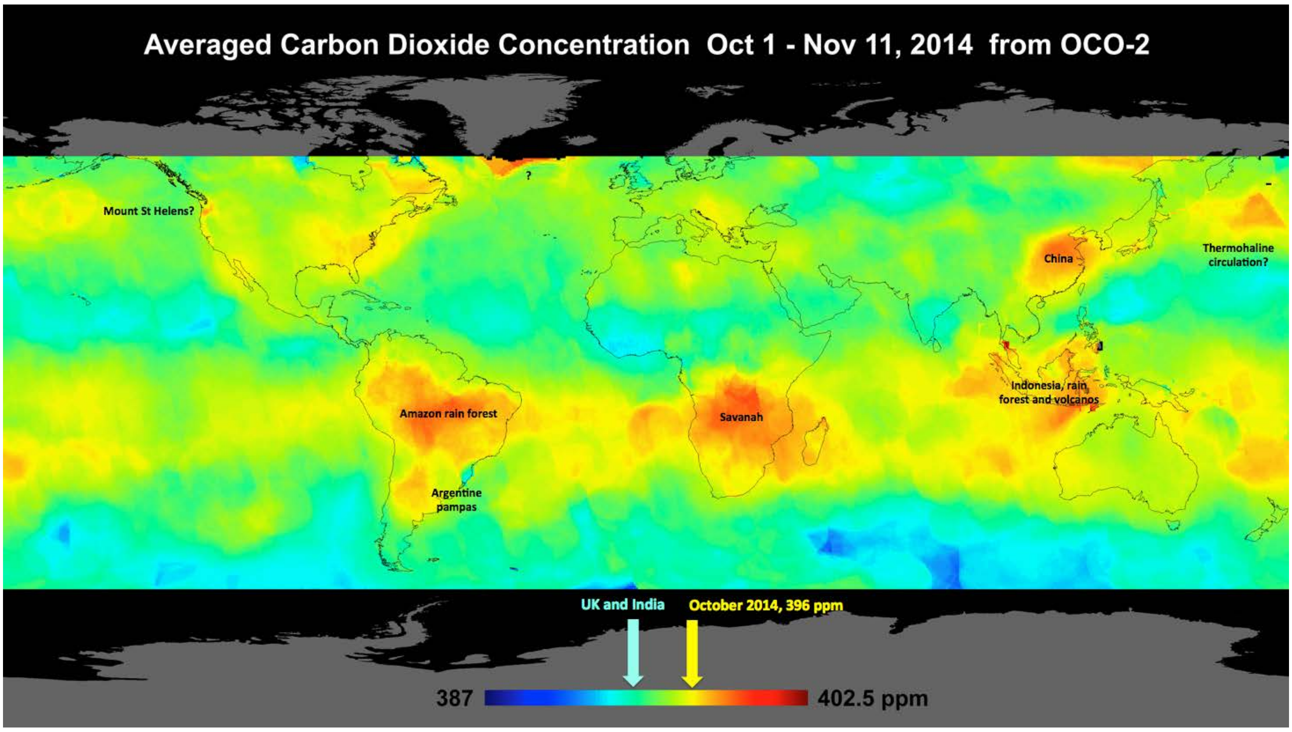

Figure 3. Global map of the recorded atmospheric CO_2 concentration. See text. Credit: NASA. After Mearns (2015).

a) Owing to several reasons that support the pattern of **Figure 1**, two huge maxima of soil exhalation are to be certainly expected to be located in two large approximately antipodal regions, one roughly centered in Hawaii, and the other in Botswana. It would be excessively long to list the several related supporting evidences, dealing with morphological features observed either at the Earth's surface or by seismic tomography of the deep Earth's structure, etc.

b) The Hawaii maximum, however, cannot be observed due to the cover by ocean water. Ocean circulation is the likely cause of heat transport from the Hawaii's region to the large observed CO_2 maximum south of Alaska.

c) The huge Botswana maximum is very clearly shown. In addition, it is confirmed by several other observational evidences, both at the Earth's surface and in the deep Earth's structure. Just recall e.g. the chemistry of oceanic basalts (the so-called "Dupal" anomaly), or also the fact that Botswana is the greatest producer of diamonds on the Earth. But this list really ought to be very long.

d) The Amazon Basin maximum is correlated with a well-known large and strong geomagnetic anomaly (the so-called SAA, or South American Anomaly), and it can be reasonably presumed to be the likely site of a large exhalation of endogenous heat and geogas.

e) By the way, note that, if the observed CO_2 concentration is rather the consequence of the Amazon vegetation cover, one should explain why in Africa the maximum is not observed in Congo and Cameroun, rather than in the savannah of Botswana ….

f) The Indonesian maximum is associated with a region that experiences one of the well-known largest soil exhalation of hot fluids all over the world. In this respect, the Banda Sea is suspected to be the site of the trigger of El Niño (Leybourne et al., 2008). This Banda Sea feature seems also to explain some curious pattern of wildfires, according to satellite monitoring that is provided since several years by NASA.[8] That is, an increased endogenous heat release implies micro-fracturing of the crust, hence an increased exhalation of CH_4, which supplies wildfires … But, I cannot enter into these details.

g) Only the maximum that appears slightly north of Beijing could be associated with anthropic origin. However, the concern is why it appears displaced northward with respect to the well-known huge dust-cloud caused by anthropic pollution that presently stands over a large fraction of southeastern Asia, being a most serious concern reported by mass media. Consider, rather, that this region north of Beijing is the likely location of a conspicuous source of endogenous friction heat. Indeed, it is well known to be characterized by a tremendous geodynamic activity and to be the source of devastating historical earthquakes.

h) As far as the Mediterranean region is concerned, maybe the gentle maximum over the Balkans could be associated with atmospheric circulation that transports gas exhalation from the Aeolian Islands area. In any case, the absence has been emphasized of any maximum in Europe, even though this is one of the most inhabited and industrialized regions of the world.

i) The two maxima – one in eastern Siberia and one south of Greenland - appear more mysterious. See below the discussion of **Figure 4**. Better data and investigations are needed.

j) **Figure 4** deals with consideration of the seasonal variation of CO_2 distribution. It gives an almost incredibly clear evidence of an enormous and surprising, “revolutionary”, anomalous CO_2 exhalation from a large region on the whole northern polar cap.[9] Some effects are associated with atmospheric circulation. But - according to a large number of other evidences - it is evident that an increase is in progress of endogenous heat-release underneath the whole Arctic cap.

k) By the way, it can be shown that a greater release of endogenous energy implies a global increase also of geodynamic and seismic activity.[10]

l) In any case, just owing to this reason, ice is melting in the Arctic Ocean.

m) In general, greater water evaporation is in progress over a large fraction of the Earth.

n) Consequently, somewhere an increase must occur also of atmospheric precipitation.

o) Indeed, precipitations are increasing over the largest part of Antarctica (the so-called eastern Antarctica), where the mass of ice-cover is observed to increase. Hence, the glacier at high elevation slide down, and press over the ice sheet at lower altitude, thus favoring a large release of icebergs.

p) Note that claiming – as it is often stated – that atmospheric warming causes the detachment of icebergs, is one of the greatest stupidities, a real way to shoot nonsense by some ignorant people with no logical basis.

q) Note, however, that ice-sheets are retreating also on a small fraction of Antarctica, due to the large release of friction-heat associated with the increased geodynamic activity. Nothing happens by chance ….

r) As far as all other glaciers are concerned all over the world, their more or less irregular observed general retreat depends on their respective local very complicated balance related to complicated mechanisms including meteorological phenomena and local endogenous heat release.

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[8] See http://earthobservatory.nasa.gov/GlobalMaps/.

[9] This feature is already clearly stated in Gregori (2002), although a much more extensive and systematic discussion is given in my aforementioned 8-volume set in reparation.

[10] Due to the so-called “warm-mud-tectonics” (WMT). See Gregori (2002) or also Gregori (2006, 2006a or 2009).

In particular, concerning the OCO2 seasonal data, compare the maps for spring and autumn. They ought to be symmetrical between northern and southern hemisphere. But, they are substantially different …. because during springtime the frozen soil melts through the entire Eurasia, thus permitting exhalation of endogenous fluids.

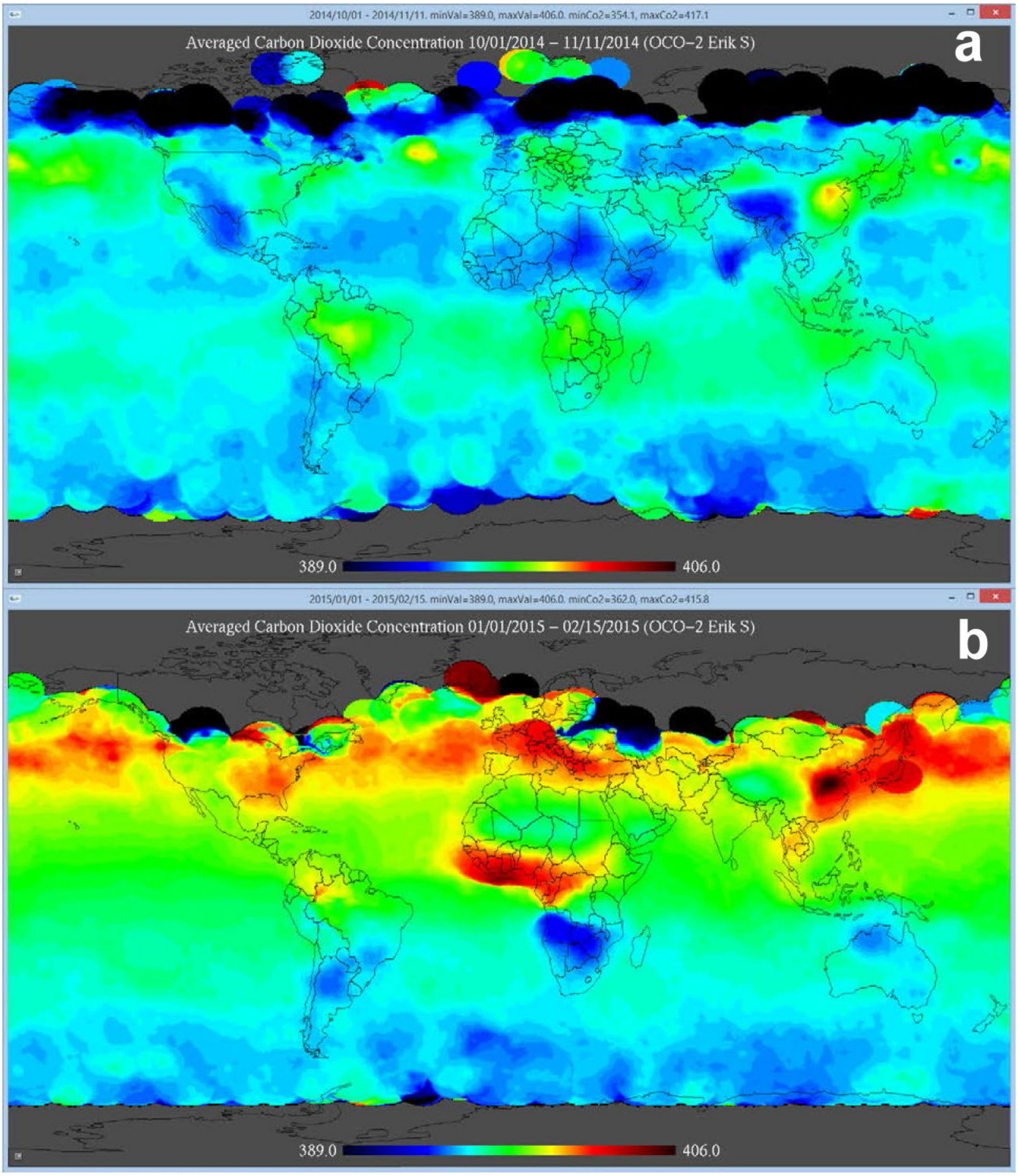

Figure 4. For captions, see next page.

s) This cannot occur in the southern hemisphere, and the autumn map displays the lowest CO_2 concentration of all seasons. Indeed, this envisages a likely crucial (although still poorly understood) role of vegetation in the final disposal of atmospheric CO_2 during summer time.

t) Only the summer map shows a comparatively larger CO_2 concentration in the southern hemisphere. The reason is not clear. Consider, however, that the land/ocean distribution is very different in both hemispheres, and the seasonal impact on land - through vegetation - plays therefore a substantially different role in the overall balance of soil exhalation phenomena.

u) Note also the winter map. Only in winter, when soil exhalation from frost soil is absent through the whole Eurasia – and vegetation seems to have cleaned the previous CO_2.

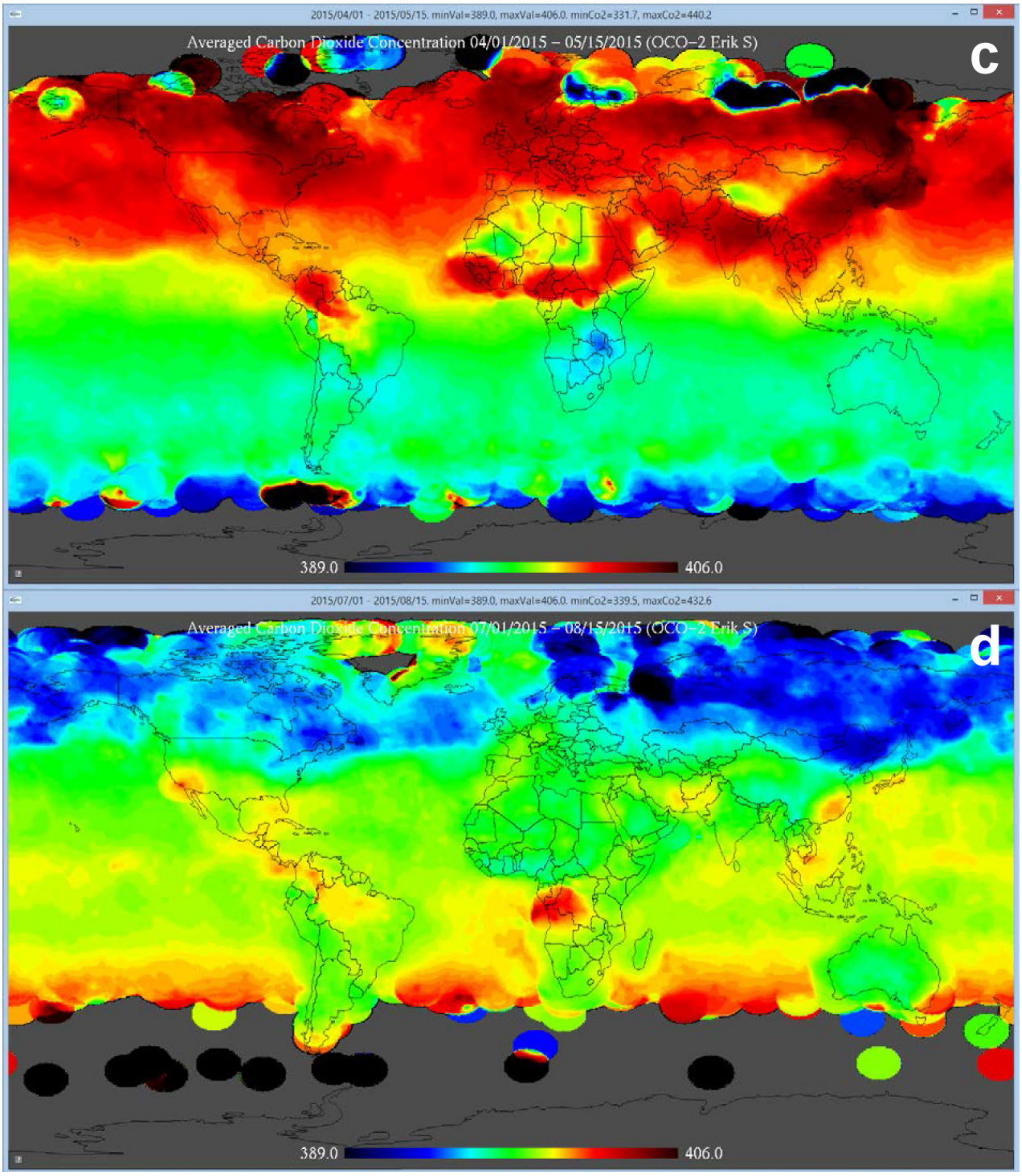

Figure 4 (continued from the previous page). Seasonal global maps of the recorded atmospheric CO_2 concentration. Top to bottom: (a) 1 October to 11 November = NH Autumn; (b) 1 January to 15 February = NH Winter, (c) 1 April to 15 May = NH Spring; and (d) 1 July to 15 August = NH Summer. Credit: NASA. After Mearns (2015a).

disposal - the CO_2 distribution envisages a credible, and even likely, anthropic origin, inside regions of intense human occupation of territory and activity.

v) Summarizing, the anthropic CO_2 is actually detected in winter, although, compared to natural exhalation, in general it appears to be certainly a lesser effect.

w) But, in general, an almost endless list of other evidences ought to be mentioned ….

6) But, why several people appear therefore obstinate in the defence of the AGW hypothesis?

- I do not want even to mention items dealing with economic implications. I am not an expert. Hence, I ought to report only statements by others, and I could not be reliable.
- In addition, I stress that I want to avoid reporting insults, such as suspects of bad faith ….. This style has often been used (e.g. by several AGW supporters, mainly when they lacked arguments to reply to scientific objections). The insult is violence, and it is just an index of weakness.
- Indeed, as stressed also by Machiavelli, insults and deceitfulness are well known to be typical of every more or less declared dictatorial regime, of every Big Brother …… tell, tell lies …. something always remains …..
- Therefore, I will rather only and simply stick to easily understandable psychological issues.
- Somebody got a Nobel Prize for AGW. If now he admits having been wrong, this amounts to disclaim all his activity during a few decades. By this, he loses power, honours, funding, important positions, public office, etc.
- For instance, remind about the ozone hole. It has been “ballyhooed” almost obsessively by mass media. It has been the object even of a Nobel Prize. Recent evidences have now proven that its main controller is represented by the flux of charged particles inside the radiation belts that are obviously controlled by the Sun. Therefore, at present the ozone concern is no more the object of great attention, it appears just forgotten, it seems politically incorrect ….
- The evidence provided by OCO2 are likely to have, on the AGW hypothesis and presumably very soon, the same resizing and deleting effect that on the ozone hole debate was produced by measurements of particle flux inside the radiation belts. Hence, it will be hard for AGW supporters to accept this evidence.
- That is, at present the key problem is to find a way-out with dignity, for all people who recklessly followed the prevailing fashion. Nobody should be pitiless with these people. Their present concern deserves our sincere human understanding.
- In any case, the “furious” reaction by several people who are involved in this concern denotes the typical behavior of people who feel to be weak and unprotected.

7) You refer to some kind of harsh reactions originated by this controversy ….

- Indeed, the dispute recently became very embittered.
- Some advisers – somebody reports some authoritative “scientist” related to IPCC – influenced the absolutely bona fide Pope (i.e. the Machiavelli process resulted very effective). His encyclical seems to be perhaps even less prudent compared to the more cautious position of President Obama.
- Certain prominent senators and lawmakers of the [Democratic] Party in USA appear to be in favor of a law to prosecute everybody who is against the AGW hypothesis.
- Remind about the fact that - unlike in any other country of the world - only in some USA States the Creationism is taught in primary schools (it would be like teaching astronomy by means of the “crystal sphere” of Eudoxus of Cnidus).
- Maybe, somebody would like to open a new case of Salem witch trials, with the blessing of the Pope ….
- I could recall several case histories, dealing with past historical very harsh debates in Earth’s sciences (and also in other disciplines). But, in any case, I guess that no comparable sourness ever occurred as at present. The present comparatively much greater efficiency of mass media also implies a corresponding amplification of these issues.

- In contrast, the debate ought to be only, and strictly only, scientific. But, at present, it appears to be just out of "science". It often has the character of a fight between lobbies, getting advantage from mass media, globalization, etc. All this is much harsher than in the past.
- Sometimes the debate seems to be even inspired by religious sectarianism, thus awakening unhappy ancient historical nightmares.
- The recent Paris COP21 meeting has been widely celebrated by mass media, according to a "perfect" scoop style. Let me realistically assume that some important participants were already well aware of the OCO2 evidence, which in reality is devastating (for AGW supporters).[11] However, the meeting – that, according to the press was supposed to involve the direct or indirect participation in Paris of about 40,000 people – had already been previously (and expensively) organized. For the government of every participating country this was a real great and very carefully organized event, excellently suited to claim, in front of its nation and voters, that their government is among the true "savers of the planet". The final "unanimous accord" was a way to show that all governments are correct and far-looking for the safety of their respective country ….
- Consider that politicians - on several occasions and all over the world - always showed that they are very clever and skilful masters in making promises that they know they will never abide, and mass media are an excellent sounding board …..

8) Therefore, what actions are presently in progress? What perspective can be concretely envisaged?

- The GW is now in progress. Consider that, around 55 Ma ago (at the time of the intense event that occurred two Earth's "heartbeats" ago)[12] and at least for a few million years, the Arctic Ocean had subtropical vegetation, which originated the coal, oil, and CH_4 that is presently exploited. Temperatures on the order of ~15 – 20°C occurred until ~ 46 Ma ago. Some ~49 Ma ago the Arctic Ocean was a large fresh water lake. Today the trend of temperature looks similar, although it has been guessed that, unlike at present, 55 Ma ago the different location of continents amplified the phenomenon.
- The often debated need[13] to search for a clean, non-fossil, energy source always seems to forget about the reservoir of electrostatic energy in the Earth's atmosphere. Its total amount is very large, certainly expressed by astronomical figures. Its evaluation and exploitation, however, requires measurements that were never carried out in order to assess the operative know how, and the concrete cost/income ratio. This is extensively discussed in my aforementioned 8-volume set. Note that it is not a matter of investment, rather only of decision to carry out experiments. However, the scientific institutions are normally generally inspired by conservatism and "servility", by worshipping "generally agreed" paradigms, by the impact factor, by "publish or perish", etc. The consequence is that every self-claimed discipline and thought school is thus usually self-referencing in an obsessive repetition of the same concepts, while, as a standard, every really new idea is normally contrasted, rejected as an "enemy" of the establishment that should be aborted before being born and discussed …
- Several different other kinds of anthropic pollution ought to be considered to be a real objective serious possible hazard. The list is almost endless. Owing to brevity purpose, I want to recall only a few most important and crucial issues, basically related to "cultural pollution".
    - I already mentioned "hunting for the greaser". For instance, while CO_2 is inauspiciously presented like the "greaser" that is the culprit for GW, decision makers from all over the world - sometimes even bona fide - feel free of any responsibility to search for other more concrete and real pollution hazards.
    - The lack of legislation for catastrophe management is a concern since at least almost 50 years (e.g. inside UNESCO), but no actions occur in any country. Science (e.g. Gregori, 2015) knows very well what must be done in order to manage floods and landslides.

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[11] It was even stated *"we shall stop GW!"* This sounds like stating *"we shall stop the season cycle!"*

[12] See Gregori (2002) or also Gregori (2006, 2006a or 2009).

[13] "*To achieve the grand ambitions set out in the Paris climate accord will require huge changes in the energy sources*…." (New York Financial Times, Dec 14th, 2015).

Shortly in the future it is likely that also earthquakes can be indicatively "predicted", although unavoidably with some uncertainty about epicenter location, time, and magnitude, and in any case with some possibility of a false alert. Similarly, also volcanic explosive eruptions can be even more easily "forecasted". Vesuvius - being the historically best documented volcano of the world - is a particularly disquieting concern (Gregori, 1993, 1996, 1996a).[14] But, in every country the decision makers seem to agree on the fact that the best way to solve a problem is to ignore its existence. Legislators continue in their political rituals, about econometrics, believing in the utopia of the existence of a top "expert" who certainly is capable to avoid every scientific uncertainty and error-bar. Thus, he can issue a "certain" forecast of a catastrophe, otherwise he is an "irresponsible criminal" to be prosecuted. The deliberate blindness of legislators is rather the criminal irresponsibility.

- But, a most important "cultural pollution" is represented by *(i)* corruption, and *(ii)* by the disputable, unnecessary and improvident proliferation of weapons (from simple pistols through nuclear weapons). Weapons seem to be easily available to everybody (from every single person through large governmental institutions). One wonders whether somebody ever considered the feedback on the planetary "climate" of an intensive bombing by means of the present very powerful tools. These two items are certainly the primary concrete causes that increase - rather than mitigate - the gap between poor and rich, development and underdevelopment, learned and untrained people, with consequent generation of terrorism, of huge migrations just for survival, of regional wars and underdevelopment, etc. Is this a really wise and far-looking behavior?
- Another basic "cultural pollution" is a very serious lack of consciousness in the self-claiming most developed societies. Everybody knows that one cannot leave free use of powerful weapons to a child, and this is for the security both of the child and also of others. Children require a long preliminary training before achieving a responsible decision capability. Also animals require a period of training for their pets …. Concerning society, laws are necessary in order to avoid anarchy. No law would be necessary if all people would know the real meaning of "freedom" and "democracy". The consciousness of "freedom" and "democracy" is a spiritual conquest of nations and peoples that requires a long training. It is very dangerous to leave "free" the use of powerful weapons to a child and also to unprepared people … This is not a matter of philosophical or academic speculation, rather it is an essential practical item for the good and the same survival of people and nations …. Starvation is not the main hazard for committing genocide …. If a person is left in the ocean and he cannot swim, he unavoidably drowns …

- Concerning the Pope, the encyclical certainly is a *very high and noble* statement. It seems to be the unique document – and this is a great merit – that was proposed and concretely emphasizes some hazard of "cultural pollution". It is fully shareable, and it holds particularly today. All good-will people *can and must* support it. But, unfortunately this encyclical has been "polluted" by fakes, by self-claiming pseudo-scientific arguments ……..
- Scientifically we can - and we must - discuss about everything, with full freedom. This is obligatory for everybody, as the life and security of huge amount of people depend on natural catastrophes!
- Therefore scientists *cannot* persist in partisan debates by means of methods that are even worse than several disgraceful episodes that we read in history books.
- In any case, scientists must avoid to provide government and decision makers with "greasers" (such as e.g. CO_2) suited to hide much more serious, both scientific and non-scientific, hazards.
- Every religious authority must openly dissociate from every attempt of exploitation for any partisan and "pseudo-scientific" purpose. If this dissociation will happen, the image of every moral institution - which can have no institutional responsibility in scientific research - will result much stronger and limpid, much above every partisan debate.

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[14] According to its historical recurrence, the evidence is reasonably suggestive of a possible sub-Plinian explosive eruption sometimes during 2015-2029. The hazard has been officially reported to involve almost one million people.

- We mostly need for *humility*, in its profound literal sense, the same humility of Saint Francis of Assisi. By the way, the very first verse of a famous and stupendous poem of Saint Francis, a poem that is one of the highest expressions of poetry and also of prayer (of any religion) …. improvidently (although undoubtedly bona fide) became the title of an authoritative statement in favor of AGW. But, Saint Francis of Assisi had certainly fully shared and very strongly supported the concern about “cultural pollution”. Hence, he had liked the use of his verse …
- As far as true scientists are concerned, they are generally quiet and peaceful scholars. Hence, often at present they appear to be frightened to express their sincere feeling … In fact, for a long time the skepticism about the AGW hypothesis has been presented as being politically incorrect, and the harshness of the present debate is certainly not reassuring.
- Several ethical committees have now been established, although everyone claims his viewpoint, and emphasizes that it is the real depositary of morality etc.
- In addition, true scientists don’t like infertile polemics, and quietly continue their investigations, they write papers and books … But, in the final analysis, we are all in the God's hands, and everybody, calmly and honestly, ought to perform with his job, by means of his real objective competence and skill, and mostly he should avoid every fashion **-** that very often almost always hides the dictates of some "Big Brother" of the moment.

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PUBLICATIONS

The Approaching New Grand Solar Minimum and Little Ice Age Climate Conditions

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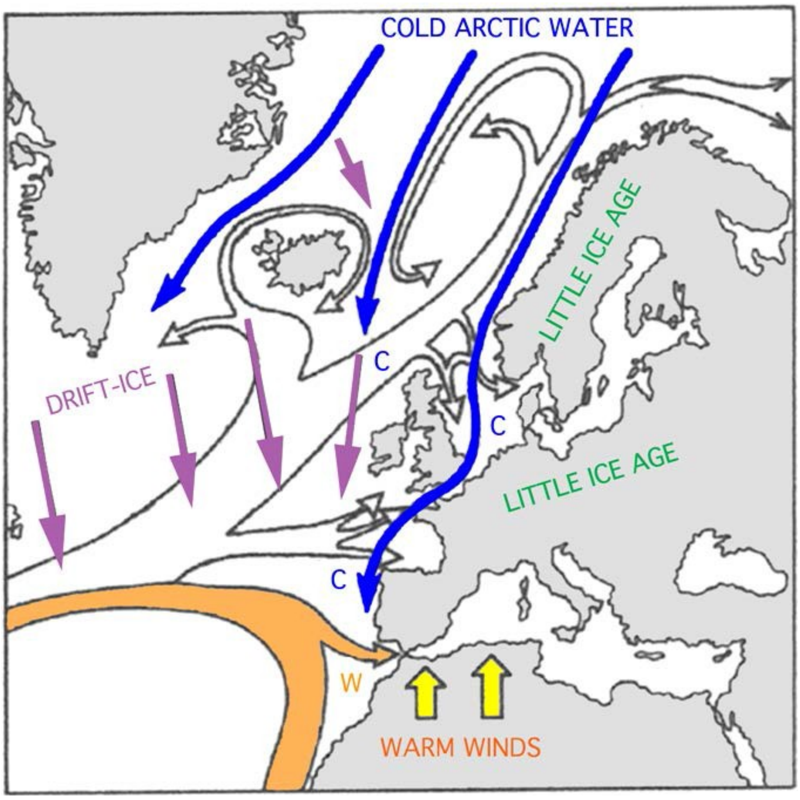
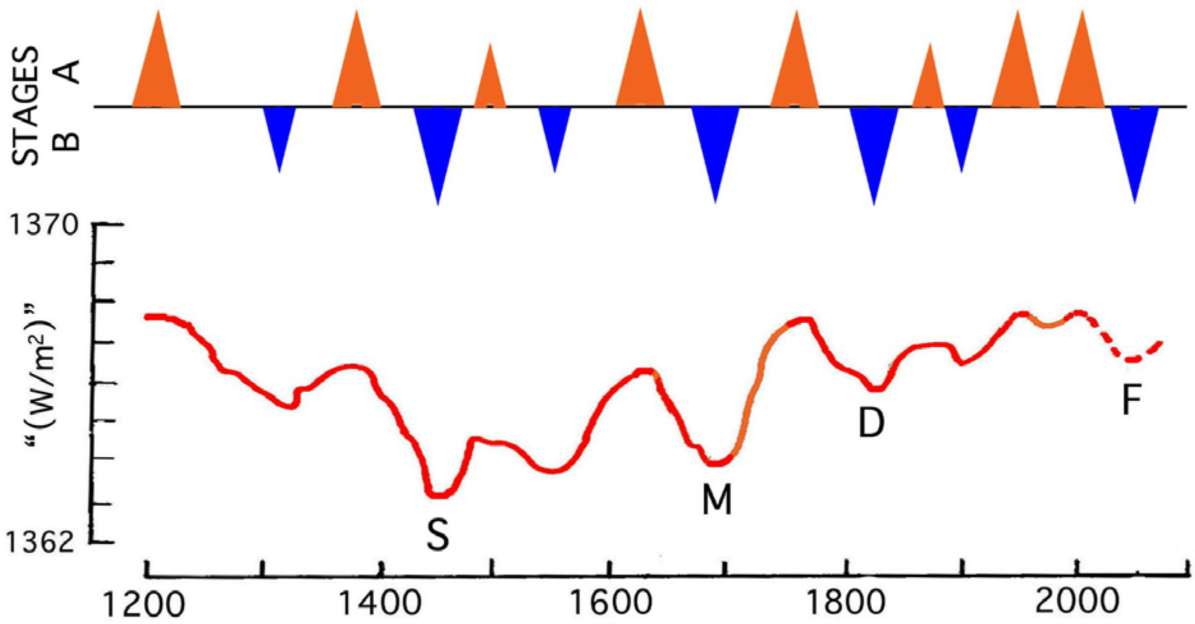
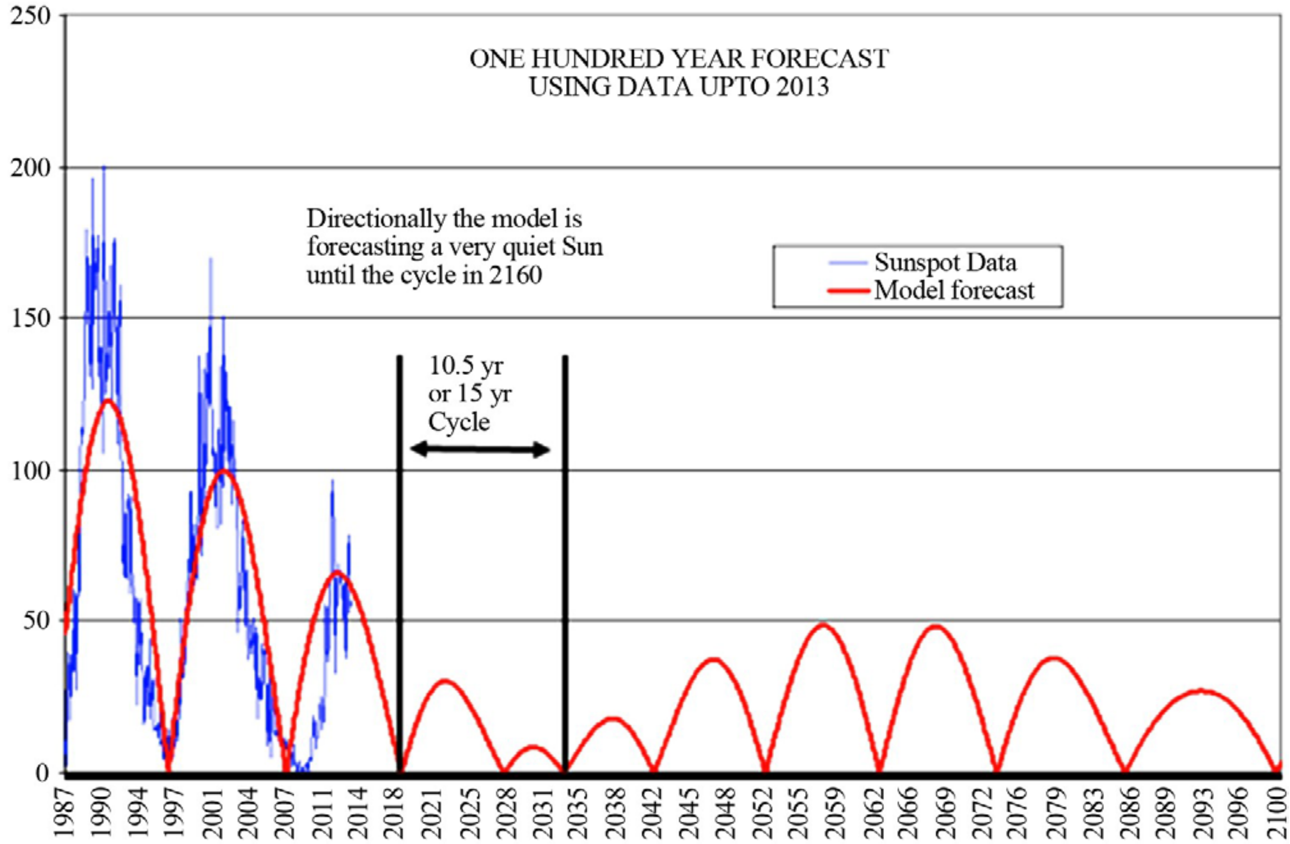
Abstract: By about 2030-2040, the Sun will experience a new grand solar minimum. This is evident from multiple studies of quite different characteristics: the phasing of sunspot cycles, the cyclic observations of North Atlantic behaviour over the past millennium, the cyclic pattern of cosmogenic radionuclides in natural terrestrial archives, the motions of the Sun with respect to the center of mass, the planetary spin-orbit coupling, the planetary conjunction history and the general planetary-solar-terrestrial interaction. During the previous grand solar minima—*i.e.* the Spörer Minimum (ca 1440-1460), the Maunder Minimum (ca 1687-1703) and the Dalton Minimum (ca 1809-1821) — the climatic conditions deteriorated into Little Ice Age periods.



During the Spörer, Maunder and Dalton Minima, Earth's rate of rotation speeded-up, the main Gulf Stream flow was directed SE:wards and Arctic water penetrated far down into the North Atlantic. At the New Grand Solar Minimum similar conditions are likely to re-occur. (Cited from fig. 2).



Atlantic warm (A) and cold (B) periods (above), and solar variability (below) with the Spörer (S), Maunder (M), Dalton (D) and Future (F) grand solar minima (character marked). The "solar irradiance" curve records the changes in Solar Wind, not irradiance, and must hence be relabeled "a curve of the changes in Solar Wind activity" (therefore their vertical scale of irradiance is put in brackets and quotation marks). (Cited from fig. 4).



A comparison of monthly sunspot numbers from 1987 to 2013 (in blue) with the absolute value of the correlation model (in red), derived using data up to 2013 and the extended forecast to 2100. (Cited from fig. 5).

Earth as a stellar transformer – Climate change revealed

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(**Editor's note:** The following note is an excerpt from the *IASCC Newsletter*, Issue 1, December 2015.)

The story of our inception "Earth as a Stellar Transformer: Climate Change Revealed" started last year – 2014. After a regular poker game, during a round of stogies and beer, I met Mick Davis for the first time and discussion started about the climate research I'd been looking into over the years. I mentioned the possibility that the space plasma rings around the Earth's poles responsible for the auroras were likely coupled to the mid-ocean ridge encircling Antarctica as well as Earths core creating natural ring to ring energy exchanges similar to electrical processes of a transformer, Fig. 1. Mick says, "You mean like a Stellar Transformer?" Well that's pretty much how the Institute for Advanced Studies in Climate Change began. We filed for non-profit status in Nov. 2014, and received our Charter this year in March 2015.

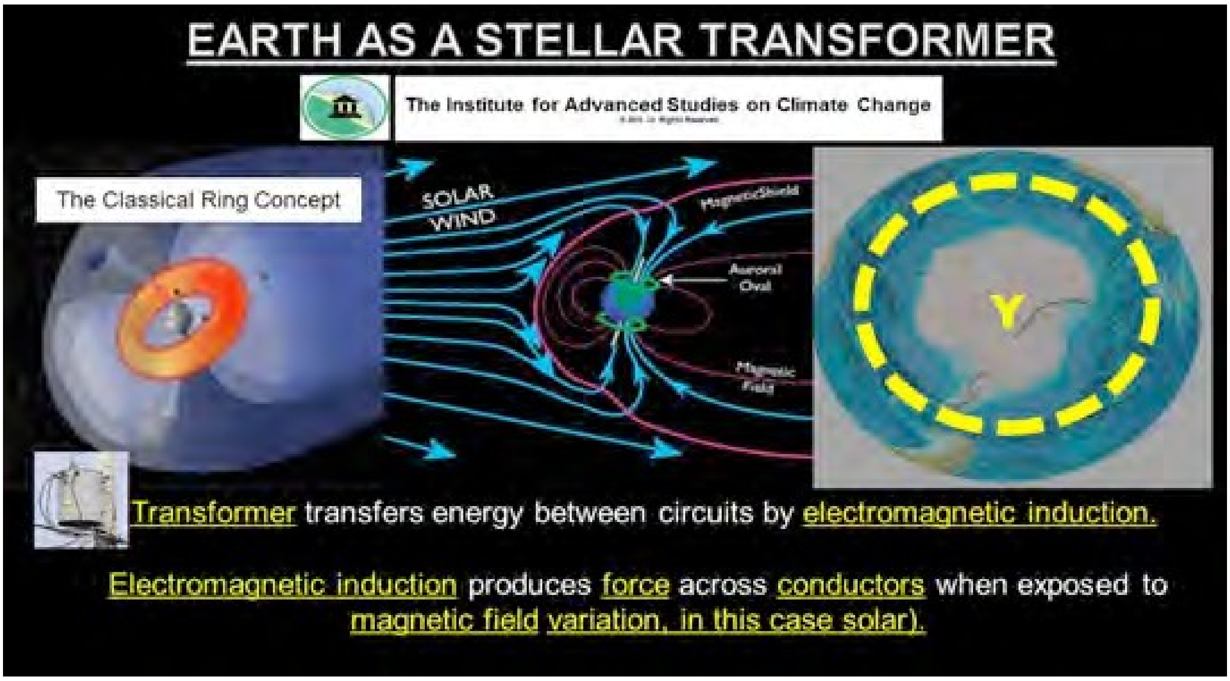

Fig. 1. Natural ring to ring energy exchanges similar to electrical processes of a transformer via Solar Y circuits.

IASCC introduces Earth as a Stellar Transformer and begins using an Electrical Universe model to interpret interactions of intense solar outbursts of plasma impinging upon Earth. Net electron flow is inward at Earth's south polar axis and hypervelocity proton impacts are around the north polar axis. During intense solar winds Earth experiences electro-magnetic (e.m.) induction charging, mostly from southern plasma ring-currents coupled to telluric currents in the ridge encircling Antarctica. This transformer effect from the south-pole exerts climate control over the planet via aligned tectonic vortex structures along the Western Pacific Rim, electrically connected to the core (Leybourne and Giovanni, 2014). This is consistent with the "Earth Endogenous Energy" theory (Gregori, 2002 - Earth as a rechargeable battery/capacitor). Differential solar rotation relative to latitude has been carefully observed on the Sun for many decades. These observations correlate an increase in Solar spin rates to increased magnetic activity. Increasing global lightning and telluric current generation. As Earth's magnetosphere experiences variations of the Interplanetary Magnetic Field and solar wind conditions this alters the global distribution of Field-Aligned Currents within the high latitude ionosphere. This in turn alters induced telluric currents, especially along the

Southeast Indian Ridge, Western Pacific Rim, and East Pacific Rise. Creating a modulating affect to atmospheric pressure, global Jetstream patterns, global warming and cooling cycles. These changes are directly linked to charging and discharging phases of the Earth and result in fluctuations of Earth's magnetic field cycles in rhythm with the climate. The Southern Ocean is bounded by plate-tectonic spreading ridges, or surge-tectonic trunk channels as the case may be: the Southwest Indian Ridge (SWIR), the Southeast Indian Ridge (SEIR), the Australia-Antarctic Discordance (AAD), the East Pacific Rise (EPR), and the Mid-Atlantic Ridge (MAR) to name a few of the larger ones (Fig. 2). The bathymetry is analogous to a huge overlapping spreading center. A structural diagram from 60°S to the South Pole reveals the whorl pattern imprinted on the ocean floor by the various transform fault/fracture zones dissecting the ridges. With the slight exception of the Scotia Arc along plate boundaries of the Southern Ocean, no other plate tectonic subduction zones exist anywhere along this "plate." Therefore, spreading predicts that newly intruded and extruded seafloor grows Earth as an oblate spheroid to the south. Likewise considering the geostream concept spinning around Antarctica like a traffic roundabout, creating a transformer coupling induction mechanism to south magnetic pole space plasma ring currents… and may also explain the oblate spheroid to the south.

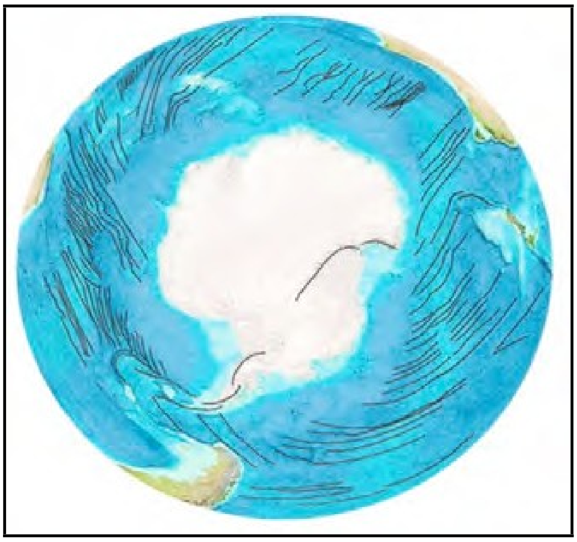

Fig. 2. Polar stereographic projection of the Southern Ocean region with structural features, such as fracture zones and mountain ranges, outlining Mid-Ocean Ridges in black.

Relevant youtube video. Electric Universe presentation. https://www.youtube.com/watch?v=QiM_gLRIuGc

Published on Dec 10, 2015.

In this presentation, Bruce Leybourne will present climate as the interplay between Field Aligned Currents in the ionosphere and Induction Currents charging Earth's core. He will show that climate change is driven by a transformer effect between plasma ring currents coupled to solar winds, which induce telluric currents in upper mantle structures grounded to the core. This transformer effect is strongest at the south-pole where the polar plasma jet is more strongly coupled to an upper mantle ridge structure encircling Antarctica. This effect exerts climate control over the planet via aligned tectonic vortex structures along the Western Pacific rim, electrically connected to the core. This is consistent with the "Earth Endogenous Energy" theory (Gregori, 2002 – Earth as a rechargeable battery/capacitor). Intense solar outbursts result in intense plasma impinging upon Earth, creating a modulating effect to atmospheric pressure, global Jet Stream patterns, global warming and cooling cycles. These changes are directly linked to charging and discharging phases of the Earth and result in fluctuations of Earth's magnetic field cycles in rhythm with the climate.

Multi-parametric analysis of earthquake precursors

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Abstract: Many scientists around the world have reported the occurrence of atmospheric anomalies prior to earthquakes. According to the Lithosphere-Atmosphere-Ionosphere Coupling (LAIC) model, the thermal flux results in temperature rising, humidity and pressure drop, and finally, changes in the velocity line when jet-stream passes through the region over the future epicenter. Using satellite observation, we tried to find out the possible atmospheric disturbances in the surface latent heat flux (SHLF), meteorological features, and jet-stream velocity change before the powerful M=7.8 Nepal Earthquake on 25 April 2015 and M=6.6 Taiwan Earthquake on 20 April 2015. To reinforce these observations, a numerical modeling of seismology regime dynamics is also performed.

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The synergy of earthquake precursors

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Earth Science, v. 24, p. 535-548, 2011. doi:10.1007/s11589-011-0815-1.

Abstract: The system of geophysical shells (lithosphere, atmosphere, ionosphere) is considered as an open complex nonlinear system with dissipation where earthquake preparation could be regarded as a self-organizing process leading to the critical state of the system. The processes in atmosphere and ionosphere are considered from the point of view of non-equilibrium thermodynamics. The intensive ionization of boundary layer of atmosphere (probably provided by radon in occasion of earthquake preparation) gives start to the synergetic sequence of coupling processes where the ionosphere and even magnetosphere are the last links in the chain of interactions. Every anomaly observed in different geophysical fields (surface temperature, latent heat flux, electromagnetic emissions, variations in ionosphere, particle precipitation, etc.) is not considered as an individual process but the part of the self-organizing process, the final goal of which is the reaching of the point of the maximum entropy. Radon anomaly before the Kobe earthquake is considered as a perfect example to satisfy the formal seismological determination of the earthquake precursor. What is genetically connected with radon through the ionization process can also be regarded as a precursor. The problem of co-seismic variations of the discussed parameters of atmosphere and ionosphere is considered as well.

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Aims include:

1. Forming an organizational focus for creative ideas not fitting readily within the scope of Plate Tectonics.
2. Forming the basis for the reproduction and publication of such work, especially where there has been censorship or discrimination.
3. Forum for discussion of such ideas and work which has been inhibited in existing channels. This should cover a very wide scope from such aspects as the effect of the rotation of the Earth and planetary and galactic effects, major theories of development of the Earth, lineaments, interpretation and prediction of earthquakes, major times of tectonic and biological change, and so on.
4. Organization of symposia, meetings and conferences.
5. Tabulation and support in case of censorship, discrimination or victimization.