New Concepts in Global Tectonics

NEWSLETTER

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and Gulf of Aden – Carlsberg Ridge. These ridges are underlain by plutonic and metamorphic rocks (Vp=6.0 km/sec) of Late
Proterozoic (Grenvillian) age at the 10 to 11 km depth. This fact implies that the three deep bays formed as rift valleys
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FROM THE EDITOR

Earthquakes and their prediction

Earthquakes are direct, lively expressions of Earth’s geodynamic processes. Because of this, we can use earthquakes to decipher the structures and processes of Earth’s interior. The study of earthquakes is all the more important because catastrophic earthquakes bring unimaginable devastation and tragedy on humans and society. It is an urgent task for us to correctly understand the dynamics of earthquakes and formulate a scientifically viable prediction method.

However, the world’s earthquake research institutions, most of which have adopted the plate-tectonic theory, have not yet successfully presented a tenable geodynamic model of what triggers earthquakes. Therefore, no reliable prediction method has yet been proposed: They are still talking about plate subduction as the main cause of earthquakes – because plate movements are unpredictable, earthquakes cannot be predicted. This is in stark contrast to our own studies, which have already provided a vast amount of convincing evidence for rejecting plate tectonics.

We have encouraged our readers to study earthquakes and the NCGT has published numerous papers on the subject: their tectonics and geologic significance in relation to the shallow and deep Earth structures as well as precursory signals (see the list of publications at the end). What have emerged from our studies can be summarized as follows:

1. Earthquakes mainly occur on structural highs, and at crustal block boundaries (Blot et al.; Suzuki; Suzuki et al.; Choi; Choi et al.).
2. Many phenomena precede major earthquakes: precursory deeper earthquakes (Blot), clouds/vapors (Shou), electromagnetic phenomena (Kolvankar; Bapat), and luminous phenomena (Straser). These papers commonly noted regularities between the occurrence of precursors and main shocks, and concluded that earthquake prediction was feasible.
3. Earthquake zones are concentrated in the circum-Pacific belts which are underlain by shallow slow mantle (Choi and Vasiliev), indicating the direct contribution of the slow mantle to volcanic and magmatic activities including earthquakes.
4. Deep earthquakes (over 300 km) show a linear distribution along major deep fracture zones which reach the core mainly in the western Pacific. Whereas shallow earthquakes are related to arc structures which have formed relatively recently (in the Cenozoic). The Wadati-Benioff zone is a thrust zone formed in relation to the subsidence of the Pacific basin (Choi).
5. Shallow earthquakes are generally compressional, but deep ones are tensional (Meyerhoff et al.; Suzuki; Tarakanov).
6. Energy flows from the core flows to the shallow Earth, and causes tectonic activities at the surface (Storetvedt; Scalera; Choi)
7. Global-scale massive horizontal energy flow in the shallow mantle along major tectonic belts, which is detected by studying the time delay in regional volcanic eruptions and seismic events (Tsunoda).

Thanks to much improved tomographic images, the above facts are now more coherently explainable by adopting the view that energy transmigration (which triggers earthquakes) proceeds subvertically from the core through global-scale deep fracture zones to the upper mantle, and subhorizontally in the upper mantle along major tectonic belts (geanticlinal trends and deep fracture zones). Recently Tsunoda (see p. 52-55 of this issue) proposed a model along these lines. It is a fully developed version of surge tectonics. The Tsunoda model assumes that electromagnetic energy originating from the core stimulates and reactivates the magma chambers and partial melts in the upper mantle, which expand to raise the overlying crustal blocks, finally triggering earthquakes.

It appears we are getting closer to a proper understanding of earthquake formation and occurrence. I believe we will be able to build a new, viable tectonic model for earthquakes, and on its basis, to formulate a scientifically tenable prediction method in the near future. I would encourage our readers to examine this new viewpoint from various angles. If we cannot establish a viable prediction method, we are not serving the global community.

Earthquake papers published in NCGT Newsletter
Bapat, A., 2007. Seismo-electro-magnetic and other precursory observations from recent earthquakes. No. 43.
Shou, J., 2006. Precursor of the largest earthquake in the last 40 years. No. 41.
Straser, V., 2007. Precursory luminous phenomena used for earthquake prediction – the Taro Valley, northwestern Apennines, Italy. No. 44.
Straser, V., 2008. 300-day seismic cycles in the southern segment of the San Andreas Fault, California. No. 49.
Tarakanov, R.Z., 2005. On the nature of seismic focal zone. No. 34.

Other publications

**LETTERS TO THE EDITOR**

**Facts about the Earth and the search for a functional global theory**

Zombie, an expression of West African origin, is referring to a dead body said to be revived by witchcraft. In the ongoing controversy over mantle plumes, two of the loudest speaking anti-plumatics – Don Anderson and Warren Hamilton – recently published an article entitled *Zombie Science and Geoscience* ([www.MantlePlumes.org](http://www.MantlePlumes.org)) in which they make the following statement:

“Editors, reviewers and funding agencies unwittingly perpetuate zombie science, which differs from simply bad science in that it is immune to evidence. As a result, zombie science becomes entrenched as conventional wisdom, and even mainstream science. Speculations that may have been reasonable when proposed become cemented by constant repetition of dogma, impervious to disproof and defended passionately by committed advocates”.

Later in the same article, after having listed a number of nails in the plume coffin, they add: “All of this signals a failed hypothesis—zombie science—but the conjecture is sustained outside the domain of science. A simple, elegant, satisfyingly neat, concise, falsifiable hypothesis has become a complicated, awkward, messy, unfalsifiable monster that refuses to lie down and die”.

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However, the authors (unwittingly?) fail to recognize that this is indeed a perfect description of the situation for present-day global geoscience activities, to the extent they are guided by plate tectonics ideology – one of the maxi-zombies of our time. Over more than 4 decades this phony theory has gradually vaccinated itself from contradictory facts – backed-up with ad hoc auxiliary hypotheses, strategic misrepresentations, and massive transfusions of funding. This sinister situation, to a large extent triggered by a combination of indoctrination, professional alienation, political pressure, self-interest and careerism – ‘opportunistic ignorance’ for short – must be exposed and opposed with all democratic means. The die-hard plate tectonics aficionados shall not be able to block the progress for long.

In your March 2009 editorial, summing up past achievements and future goals of the NCGT group, you listed 4 important pieces of hard evidence which must be integral in any realistic theory of the Earth. I fully agree with this core of basic facts, but would like to add the following comments:

**Continental rocks beneath basalts of the deep sea crust.** For decades, the evidence has been growing that continental rocks are widespread in the oceans, exposed on plateaus and aseismic ridges or covered by a variable layer of basalts. For example, rock sampling along central rifts of mid-ocean ridges has unveiled a great variety of metamorphics, of typical continental fold belt categories (cf. Kashintsev and Frikh-khar 1978; Udintsev et al., 1990; Pilot et al., 1998; many articles in the NCGT Newsletter, etc.). Furthermore, it has long been known that continental and oceanic crusts are not sharply defined surface entities. In geophysical terms both types of crust are relatively inhomogeneous – in thickness as well as in composition, and in many regions there is a gradual transition from the thick crust of the interior continents to the attenuated and more basalt-infiltrated crust of the deep oceans.

One gets a strong impression that an original thick pan-global crust has been variably assimilated by mantle processes – these crustal transformation processes were apparently in operation already during greenstone belt formation in the late Archaean. However, this progressive alteration of the outer planetary shell has evidently accelerated in late Phanerozoic times – paving the way for the development of the present-day deep oceanic depressions – a newcomer in Earth history. In segments of mid-ocean rifts, such as in the Molloy Deep of the northern North Atlantic (see Snow et al. 2001 and references therein) and in the Central Atlantic (cf. [www.sciencedaily.com/2007/03/07.0301112.htm](http://www.sciencedaily.com/2007/03/07.0301112.htm)), the inferred crustal elimination processes have seemingly gone to completion – in the latter region, over thousands of square kilometres of surface area, the mantle appears to be exposed on the seafloor. In terms of crustal evolution we are seemingly back to the thesis of Joseph Barrell (1927) and Vladimir Belousov (1962) that through geological time an original pan-global crust has gradually undergone variable degrees of attenuation and basification (‘oceanization’).

**Deep continental roots.** Modern seismic tomography unfolds a relatively clear difference between continental and oceanic mantles – relatively fast velocities for the upper continental mantle and correspondingly slow velocities for oceanic mantle sections, underlining the, by now, well-accepted concept of *continental roots*. These vertical subdivisions of the mantle, which may extend as deep as the core-mantle boundary, contradict lateral lithospheric motions of Wegenerian type, besides being exceedingly difficult to reconcile with the idea of mantle convection. And further, if sea floor spreading, or some sort of Earth expansion, had been in action, sheeted dykes would expectedly have been a characteristic feature of the oceanic basement. However, deep sea drilling has, so far, revealed that such dyke-in-dyke complexes are practically non-existent in the deep sea crust. Other pieces of evidence contradicting the spreading and swelling hypotheses are the surprisingly low heat flow of mid-ocean ridges (these ridges are basically cold – not hot!); apart from Iceland/Jan Mayen the ridge crests are practically without volcanic activity of any significance.

**Deep sea basins have only existed since the late Mesozoic; they seem to be products of long term progressive, but irregularly distributed, attenuation and basification processes of an early pan-global continental-type crust.** The generalized sea-level curve for the Phanerozoic – in which the more marked regressive inflexions, corresponding to principal geological time boundaries, may signify stages of escalating sub-crustal attenuation and isostatic subsidence of the evolving oceanic basement. Beginning in the Lower Mesozoic, a long-term transgression once more encroached on low-lying lands, culminating with the Cenomanian transgression in the Upper Cretaceous (ca. 100 Ma ago) and followed by a major regressive event at the end of the era. After this marked sea-level retreat the modern thin-crusted oceanic basins were largely in place. In concert with the pronounced mechanical weakening
associated with the major crustal-lithosphere thinning, the ensuing (inertia-based) geodynamic event – the Alpine revolution – pitched the Earth into a tectonic and environmental calamity.

**So what is our next step towards understanding of the geological history?** From evidence listed above I am led to believe that ever since the Earth settled as a terrestrial planet it has retained a relatively constant radius. However, in view of a rather messy build-up of the mantle, as currently unfolded by seismic tomography, it seems appropriate to infer that the Earth is still in a state of degassing. Internal mass reorganization, towards stable thermo-chemical equilibrium, has apparently been in action since early geological time, instigating jerky changes in its moments of inertia – dynamical changes that would give rise to the phenomenon of *true polar wandering* (spatial resetting of the globe relative to the axis of rotation) and variations in planetary spin rate, giving rise to surface tectonic processes. As I see it, this would neatly explain the irregular nature of the geological history – not least demonstrated by the catastrophic, and relatively short-lived, disturbances representing geological time boundaries. In other words, the episodic nature of the geological record may be driven by concurrent episodic changes in planetary rotation.

Deep continental drilling, in Kola and SE. Germany (KTB), has given many shots across the bows to conventional thinking, describing open fractures with free circulation of hydrous fluids (with gasses) at depths in the crust traditionally thought to be bone dry and without fracture porosity. In this regard, let us give the floor to science reporter Richard Kerr (1993), describing results from the KTB drilling:

“...after the drill bit had penetrated more than 3 kilometres of dry rock, it broke into water aplenty. Core samples retrieved from 3.4 kilometres were veined with open cracks more than a centimetre wide that had presumably carried fluids. That was only a hint of what was to come at 4 kilometres, where more than half a million litres of gas-rich, calcium-sodium-chloride brine twice as concentrated as sea-water poured into the well. Abundant fluids gushed from depths as great as 6 kilometres”.

All in all, growing evidence favours a relatively cold deep interior undergoing degassing – vertical transfer processes that keep the Earth dynamically active. The high gas/volatile pressures of the outer geosphere, the likely cause of observed porosity increase with depth, would provide effective mechanisms for sub-crustal attenuation – through processes of eclogitization/delamination and rock decomposition afforded by supercritical water. Palaeomagnetic and space geodetic data strongly favour some sort of relative continental motions, but lateral separations as required by Wegenerian drift/plate tectonics, or proposals of an expanding Earth, can be dismissed on a wide variety of geological and geophysical grounds. The tectonic alternative is inertia-driven *in situ* rotations of lithospheric blocks which readily satisfy the geophysical evidence for mobility.

In view of the currently bewildered state in global geology, it is obvious that a brand new theory is needed. As an attempt to get out of the present deadlock, I am proposing an alternative (degassing-based) global theory – Global Wrench Tectonics (Storetvedt, 1997 & 2003) – for consideration. Snippets of the new theory, with animations, can be found in my extended website: [http://www.storetvedt.com/karsten/index.htm](http://www.storetvedt.com/karsten/index.htm)

**References**


Intergovernmental. Oceanographic Comm.

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While on my recent (12 - 30 August 2009) cruise across the North Atlantic Ocean I was looking for certain things, such as a severe lack of snow and ice coupled with an active spreading margin in Iceland. Here is what I found:

We were in Seydisfjordur on the NE quadrant of Iceland and Reykjavik in the SW quadrant. Sailing on the southern route took us past the huge (8300 km²) ice field called Vatnajokull. It appeared to be alive and well. On our grand circle tour out of Reykjavik, we went to the region of the Thingvallir. This is the site of the Althing, held yearly by the Vikings as early as 1000 AD. It is also the site of the spreading center for the Mid-Atlantic Ridge, called the Reykjanes Ridge in this region.

We have been repeatedly told that the spreading rate here is on the order of 2.5 cm/yr. Giving a margin of error of a few meters, that should have been a rupture that has widened by about 20 meters in the last 1000 years. This is easy to measure, as the Vikings set up camp in the crack while airing their political and social differences. This crack has not widened even one centimeter since that time.

We asked the tour guide what he thought about global warming. He said “...is what people like Al Gore create to keep themselves in the news. We don’t believe in global warming in Iceland because our ice fields are growing.”

Our next passage was through Prinz Christian Sund at the southern extreme of Greenland. The loss of Greenland’s ice is by now legend according the Gore-ites. Because of the plethora of icebergs calving, and the growlers being spawned, we were the first ship to make it through this channel this summer. A ship following us had to turn around and go back out because they could not safely get past all the ice in the water. I counted seven tidewater glaciers on this passage. Five were advancing, and two were retreating. I'll give Gore that much. I looked at the ship’s satellite weather map and am also happy to report that, on 22 August, Greenland’s ice cap seemed pretty much intact. Looking up a 2005 report revealed that the ice cap was actually thickening for the duration of Gore’s reported ice melting and general public alarm caused by this “fact.” There seems to be no net ice loss at all for Greenland with the exception of that part lying over the active volcano.

Lastly, in crossing the Labrador Sea from Qaqortoq, Greenland, to St. Pierre and Miquelon, we heard a discussion by an emeritus professor of geology concerning the breakup of Laurasia, more specifically that of Greenland and Scotland. With both having base rock of 3,700 Ma, they are in position to agree with the reigning hypothesis of a 65 Ma Atlantic basin opening. However, at the last look, one is only able to find one spreading center for the North Atlantic, and Iceland sits on that. With both North America and Greenland lying to the west of that, the question naturally arises as to the location of the spreading center that split Greenland off North America at the proposed 65 Ma. The Labrador Sea is a basin whose low is the Mid-Ocean Channel. Additionally, the continental-in-origin Orphan Knoll lies in that basin.

So, based on personal observations, I have to say that what I expected was not what I got. Knee-jerk reactions are not a sound basis for what we call science these days. Ground-truthing seems to be the answer. Other than the climate implications, I would like to hear from all of the different mobilist people a reasonable explanation for what I have just seen, one based on fact and not a dream feature. Is this possible?

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In Newsletter no. 44 I tried to explain the relation existing between anomalous phenomena in the atmosphere (L) and the earthquakes in the seismic area referred to as Taro Line-North-western Apennines (Italy) and Lunigiana (Italy). The time interval between the appearance of lights in the atmosphere and the connected earthquake (ΔT= E-L) is, on average, 52 days in the Taro Line and about 48 days in the Lunigiana seismic area, with a ± 3-day margin for about 50 km round (Fig. 1).
Since the collection of data based on direct observation is quite difficult, I gathered the accounts of UFO sightings, often accompanied by photographs and videos, which have also been published online. Without getting to the heart of the matter, that is the sensation created by media coverage of the assumed existence of UFOs, I tried to check whether the time intervals ($\Delta T = E-L$) between the “lights” and the earthquakes were the same as the ones analysed in NCGT Newsletter no. 44. The attention devoted to sightings of luminous phenomena regarded as UFOs is certainly greater compared to technical surveys, therefore this might provide additional data useful for the research on seismic precursors. My research is therefore not meant to try and explain the existence of UFOs, but rather to examine the possibility of considering the sightings of unidentified objects (balls of light) as seismic precursors. The results were positive, as shown by the data reported in the tables below including (in my English translation):

1. Account of UFO sighting and the website where the news was published;
2. Related earthquake recorded by the INGV Network (www.ingv.it);
3. Time interval ($\Delta T = E-L$) between the appearance of the “lights” and the earthquakes.


“My husband got up because he couldn’t go off to sleep. He went to the window and his gaze rested on a ball of light motionless in the sky over the Setta valley mouth above Piccolo Paradiso. He was amazed by the fact that the light intensity of that ball increased and decreased within a few seconds, so he woke me up to have a look at that strange thing and help him find an explanation for that unusual phenomenon. It was about half past one a.m. when my husband saw the light. We looked at that flying object for about ten minutes.”

(http://notiziefabbriani.blogspot.com/2009/04/ufo.html)

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<th>Earthquake (E)</th>
<th>($\Delta T= E-L$)</th>
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<td>04.29.2009 Sasso Marconi</td>
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<td><strong>Place</strong></td>
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<td>06.18.2009 Reggio Emilia area</td>
<td>44.552°N 10.512°E</td>
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<td>3.6</td>
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<td>51 days</td>
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MASSA, May 13 2009. – “Many inhabitants of Massa have reported that they saw one or more UFOs over the coastline near Ronchi. The flying object was described almost in the same way by all the people who claimed they had seen it. They say it was like a big saucer. Other witnesses reported they saw the UFO appear suddenly, stay still for a few minutes and then suddenly disappear.”

http://evidenzialiena.wordpress.com/.../avvistamenti-ufo-a-massa-carrara/

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<td>44°02'00&quot;N 10°07'58&quot;E</td>
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<td>06.28.2009 Massa</td>
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<td>3.3</td>
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<td>48 days</td>
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PARMA, May 30 2009 - “Strange sightings in the sky over Fidenza. A few days ago some drivers reportedly saw an unidentified luminous, whirling object in the sky, which was visible for half an hour at least.”

(http://koroljov.splinder.com/post/20662877/Strani+avvistamenti+nel+cielo.
(http://www.centrostudifortiani.it/Documenti/News-Fortiane15.pdf)

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<th>Earthquake (E)</th>
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<td>05.30.2009 Fidenza Parma</td>
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<td></td>
<td><strong>Place</strong></td>
<td><strong>Coordinates</strong></td>
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<tr>
<td>07.18.2009 Neviano Arduini</td>
<td>44.559N 10.296°E</td>
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<td>2.7</td>
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<td>50 days</td>
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Fig. 1. Index map. • Place where the atmospheric luminous phenomenon was sighted
  • Epicentral area of the connected earthquake

Reference

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I was pleasantly surprised to stumble upon the NCGT website a month ago via a link from Wikipaedia (expanding earth page). I have since downloaded all of your past issues and am currently digesting them from start to finish. I am very heartened by the open minded and excellent papers that have been presented from the beginning. Much of the data that I really wanted to obtain seems readily available. Congratulations for providing the world with an alterative voice.

As an aside I also happen to have spent the last 12 years in the information technology industry so if you need a willing slave to assist with your website I will volunteer. For starters I think the site could be a bit more dynamic with things like an online discussion forum etc.

Gavin Vetten
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1 August, 2009

My boss cannot stop talking about the papers in NCGT Newsletter that he has already read. They are making a great impression on him and I am sure that he will contribute when he can. I have accessed your publications and printed out all the PDF files that I could.

Terry Heidemann
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26 June, 2009
Dear Editor,

Perhaps you have seen in the media some reports of small "earthquakes" in southern Victoria (Australia) (UTC 22 Sep. 2009, 08:20:32, M=2.7, H= 0 km, Lat. -38.280, Long. 145.250); two were reported only minutes apart on Tuesday evening. In fact there are vibrations going on constantly and my family and I are observing and discussing them. Apart from movement of our houses with accompanying creaks, there have been incidents of floorboards separating, wall cracks and plaster falling off walls. On an even smaller scale there is movement (settling) of particles in containers. When I buy porridge I buy rolled oats plus the finer Quick oats and mix them carefully in a large bowl before placing them in tins. When I open a tin I find the finer quick oats at the bottom and the coarser rolled oats at the top.

The same can be seen at Brighton Beach (south of Melbourne) where the vibrations plus wave movement cause the coarser sand to accumulate at the surface on the edge of the beach as the finer sand filters down, and can be observed compacting a couple of metres out from the waterline.

We have a family parable on this same principle: to organise your tasks consider them as rocks and into your jar of time, energy and money, place the largest and most important ones first. Then in go the next smaller size, and give the jar a little shake so these can fit comfortably inbetween the larger rocks, and so and so down to a handful of sand, the smallest tasks in your busy, happy, satisfying life.

So it would seem to be with our Earth which is now receiving the strongly vibrating influence of the combination of loosening attractions but increasing radiated energy from other bodies as our universe expands, combined with the increase in gravitational power as every particle in our Earth-sphere moves closer together and is energized. The small grains are "falling" inwards and compacting as we tremble, and this is changing the support structures on the surface.

The escaping of gases from the Earth as the more volatile elements are heated and expand and seep their way to the surface does happen wherever there are possible vents and I have photographed rocks with foaming surrounds that are not merely like the effects of waves breaking over them at Brighton Beach and the entrance to Andersons Inlet (both in Victoria), and at Coogee (just south of Sydney). At the first two I was able to observe coarser sand at the waterline and many limpet shells (they release their muscle foot attaching them to the rocks when there is a vibration, you can tap a spot on the rock beside them and observe this). At Brighton Beach we get "smelly gases", either sulphur or chlorine type smells, coming up from the beach from time to time and people attribute them to "those industries over the bay". At Coogee I spoke with a local lady who was walking along the beach and she said yes they get bad smells, as the Irish tourists pee on the steps down to the beach. I went and sniffed these steps and found no stale urine odour but just what one would expect of concrete constantly washed with wet sandy footsteps and moist sea air. While I was holidaying at Anderson Inslet, a local told me of the smelly air that comes in from the sea from time to time, and I also learned of the prolific dinosaur fossils now being found in the area.

It seems to me that there may well be twofold roles of rocks. They provide a stable surface, protecting living things from energy-sapping and fear generating vibrations. And they provide a conduit for a continuous and even transmission of heat from the inner areas of the Earth to the surface. So when there was high particulate in the atmosphere and protection of the Earth from sunlight necessary for photosynthesis production of oxygen, then living things moved to warmer places to seek survival, and thus the dinosaur fossils. I wonder if they appear around Coogee. Do you have anyone who might be interested to look?

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(Editor’s note: The southern Victoria and Port Phillip Bay are considered to be underlain by an active magma in the mantle which generates earthquakes and hot springs. Cretaceous basin develops in the region. A major NE-SW tectonic zone runs along the Port Phillip Bay to Melbourne. Margaret Levin’s observations are consistent with these geological/tectonic settings. Margaret is a distant relative of John Grover who passed away recently)
ARTICLES

GEOID TECTONICS

CHAPTER 6 SOME MAJOR GEOLOGICAL PROCESSES

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ABSTRACT: The geoid tectonics model of the previous chapter predicts that past geosynclines would have formed where paleoequators in the oceanic crust were aligned along the interface(s) with continental/shield boundaries. This implies that the present-day equator should exhibit geosynclinal characteristics under such conditions and confirmation comes from the Indonesian Archipelago. The Amazon basin and central Africa, both in shield regions, also provide evidence of recent/ongoing subsidence in the shield itself. The step from geosyncline to fold mountain is illustrated by the relatively simple examples of the Rocky Mountains and the Appalachians, while the complex Alpine-Himalayan systems also provide reasonable concordance with the model and an oscillating equator. The anomalous Madang outlier (PNG) can be explained by the equatorial/post-equatorial succession of the model, while an explanation for crustal shortening is available in repetitive orogeny.

Key words: present-day equator, fold mountain origins, Madang outlier, repetitive orogeny

The geoid tectonics model of the previous chapter (NCGT #51) might be summarised in the following way:

- Equatorial locations suffer stretching and, where the equatorial bulge is fortuitously aligned along an interface of shield and oceanic crust, stretching becomes exacerbated. At such locations, rifting and major subsidence occur, giving rise to geosynclines.
- The crust at this interface is also subject to tear faulting subparallel to the equator, giving rise to the crustal lineations mapped along all former geosynclines.
- Equatorial locations of the past are not those of the present. Therefore, geosynclines of the past must have undergone subsequent latitude changes and subsequent compression. This has produced folding and uplift of the deep sediments. Perhaps several cycles of subsidence and uplift need to be involved in most fold mountains.

Predictions made from this model are, firstly, that all fold mountains are equatorial in origin, a point that was also made by Professor Warren Carey, based on geological field work (Carey, pers. comm.) Secondly, it would be reasonable to expect that the present-day equator exhibits some of the characteristics attributed to past equators.

Let us first look at the present day equator.

6.1 Present day Equator

Much of the Indonesian Archipelago comprises oceanic crust, but granitic crust extends out from the Malayan Peninsula to mid Borneo and Australian continental shelf underlies Indonesia’s south western islands. The Indonesian Archipelago is thus located between two zones of submerged continental crust, making conditions ideal for the equatorial development of a geosyncline. Indeed, the southern periphery is regarded as such by most geologists. The island of Sulawesi exemplifies the “stretching” predictions of the model. The tectonic pattern of the island comprises both rifts and active tear faults, Figure 6.1. The shorter versions of these discontinuities run north-south across the island and occasional rifts contain elevated lakes (at 400 m or more) that do not bottom out until below sea level. The lakes are not associated with volcanic calderas and their unique morphology suggests that the crust is “split” under tensile stresses.
Longer discontinuities run east-west, as faults. Not only are these aligned sub-parallel to the equator but they also skirt the edge of continental crust, as predicted in the previous chapter. The largest of these, a left lateral fault, passes just to the north of the Bird’s Head of New Guinea and appears to terminate against the eastern coastline of Sulawesi. A second runs along the northern coastline of Ceram. During a large earthquake in 1896, large slabs of the north coast of Ceram disappeared into the sea.

Major Benioff zones bound either side of the Gulf of Tomini, which lies along the equatorial alignment of Sulawesi. The Benioff zones straddle the equator and dip inwards at inclinations of $55 - 60^\circ$. Their geometry is that of a large graben in the process of development, spanning the equator. Subsidence of this zone is recorded and is probably still ongoing.

![Figure 6.1](image)

**Figure 6.1.** Equatorial Indonesia exhibits many characteristics predicted by the model: rifts, subsidence, long tear faults along the crustal interface.

Dutch navigators of the Spice Islands, in the 17th C, produced a map of the Celebes (Sulawesi) which showed the Gulf of Tomini as dry land. If this map were correct, it would indicate a rate of subsidence of several metres per year, which is far greater than anything known elsewhere. A more likely explanation in this case is that the map itself is incorrect. Nonetheless, the gulf does show a remarkable degree of fairly recent subsidence being, itself, some 2 – 3 km deep and containing 4 km of young sediments within it. The topographical slope from the mountains on the north side of the gulf, to the sea floor, averages $10^\circ$: a slope probably exceeding that of any other major slope on Earth, except for individual mountain peaks and sea mounts.

Moving from Sulawesi westwards to the Mahakam delta, on the central east coast of Borneo (Kalimantan), there is further evidence of subsidence. Thick sequences of shallow water sediments have been recorded here by oil drilling, some sediments dating back to the Pliocene. These sediments were not, however, deposited by the Mahakam River in its present mode, but by westerly flowing rivers. It would appear that such rivers once flowed from the Sulawesi vicinity across an area that is now deep ocean.

In the Sunda Sea, between Borneo and Sumatra, there is a major submarine valley crossing the shelf at an almost flat gradient. The origin of the submarine valley here is not a problem, since the sea itself is quite shallow and could have been exposed as late as the last ice age. However, navigation charts reveal that, between $1^\circ$ S and $4^\circ$ N, the average gradient of the valley is only 1 in 30,000 – a gradient insufficient to form a valley by fluviatile processes on land – while a section just north of the equator shows no gradient whatsoever. This lack of gradient could be explained by equatorial subsidence that has taken place subsequent to the
formation of the valley. Assuming that the valley was originally carved out by normal fluvial processes during the last ice age, a rate of subsidence of 1 mm per year over 15,000 years would probably have been adequate. Also on the point of sea level changes in this region, it seems that Marco Polo, in the late 13th C, was unable to sail through the Straits of Singapore because they were not then open. If this were so, and even higher rate of subsidence (or sea level rise) is implied.

In the 19th C, Charles Darwin was told by the inhabitants of the Maldives Islands that their islands had been “sinking” for two hundred years. The Maldives comprise a string of atolls running from the equator to about 6° N. Those atolls nearest the equator have lagoon depths 20 – 40 m deeper than those in the north of the island chain. Lagoon depths in coral atolls are a traditional indicator of subsidence, since (vertical) growth rates of coral can cope with a subsidence rate (or sea level rise) of the order of 1 cm per year.

Almost on the opposite side of the globe from Indonesia is the Amazon, with a flow equal to the size of the next five largest rivers put together. It presumably carries a correspondingly large sediment load. Remarkably, there is no delta forming off the mouth, unlike off the mouths of other large river systems, such as the Nile or the Mississippi. Instead, the Amazon exhibits the superficial features of a drowned estuary. Moreover, the South American pre-Cambrian shield is depressed all along the Amazon basin, Figure 6.2. If the blame for this phenomenon could be laid at the feet of equatorial subsidence, then we might eventually witness sea incursions into the Amazon, reaching as far back as the Peru-Colombia borders. The Amazon vegetation – or what is left of it after logging - might then be preserved as a protolith of coal.
Figure 6.2. The Amazon Basin drains a wide depression in the South American pre-Cambrian shield. Despite its large sediment load, there is no delta forming at the estuary, possibly owing to subsidence.

The other large equatorial river, the Congo, does not discharge at the equator but some distance to the south, after cutting its way through a series of gorges. However, its central section lies in a depression in the pre-Cambrian shield, just as the Amazon, Figure 6.3. This feature, in itself, might not be diagnostic of equatorial subsidence. However, according to Arthur Holmes (1944), the crust to the east, in the vicinity of Lake Victoria, is sagging so much that the flows of some rivers have been reversed.

Figure 6.3. The equatorial mid-section of the Congo Basin drains a depression in the African shield. Equatorial Lake Victoria is a known area of subsidence in the shield.

It can be concluded from the above brief outline that the concept of equatorial subsidence is not without a reasonable degree of supporting evidence. On this basis, let us now move on to the history of some of the world’s fold mountain systems, using the palaeoequatorial locations defined in Chapter 2 (NCGT # 41).

6.2 North American Geosynlines

During the Lower Cambrian, palaeoclimatic evidence collated by Opdyke (1962) places an equatorial alignment running down what is now the western coastline of North America. The zone was then a sea way abutting against the edge of the Canadian Shield. As much as 20 km of subsidence has been recorded here and the sediments deposited in the deep troughs contain crystalline rock fragments derived from the adjacent shield.

Trend lines, or lineations, run parallel to this equatorial alignment, shown in Figure 5.9 of the previous Newsletter (NCGT # 51), and separate terrains exhibit slightly different paleomagnetic imprints. As already proposed, these trend lines are believed to be relics of the long troughs that developed as the thin oceanic crust was subject to tearing against the bulwark of the thick shield.

By late Cambrian times and into the Ordovician, equatorial conditions shifted slightly, with both palaeoclimatic factors and early paleomagnetic indicators placing the equator on an alignment running south
west to north east across the continent, Figure 2.2 (NCGT # 41). Paleomagnetic indicators are those obtained from McIlhinney (1973). There are obviously more up-to-date data, but the McIlhinney consensus was fundamental to the development of the hypothesis of plate tectonics. The equatorial shift looks quite substantial on a Mercator projection, but does not require a large degree of polar wander in reality, as might be checked on a desk globe. Some oscillation of the equatorial alignment is also implied by the various recordings. Thus in the late Cambrian, the central parts of the Canadian Shield lay under equatorial conditions but, as predicted by the model, now a geosyncline did not form. What did take place was, however, some sagging of the shield allowing marine transgressions to extend right across the central parts of the continent. Some minor rifting of the shield may have accompanied this stretching and sagging.

With this late Cambrian change, parts of the geosyncline down the western side of the shield would have come under compression and this should mark the initial stages in the complex development of the Rocky Mountain Cordillera.

From Ordovician to Silurian times, the paleomagnetic data suggest continuing oscillation of the pole and the equatorial alignment. A general equatorial movement to the east is suggested, allowing the palaeoequator(s) to run up the eastern seaboard of the Canadian Shield. Palaeoclimatic data from both the Silurian and Devonian support this trend, with Silurian salts being deposited in New York State, indicative of temperatures as high as 38 - 40º.

Now we have conditions once more favourable to the development of a geosyncline, with equatorial stretching aligned along the eastern seaboard of the Canadian Shield. Once more, field evidence records geosynclinal troughs with sediment thicknesses of some 10 km, all marking the inception of that doyen of all fold mountain belts, the Appalachians. The sediments in this case were mostly shallow water sandstones, limestones and shales, suggesting that sedimentation accompanied the subsidence to a large degree. It is of interest to note that much of this sedimentation came from a land mass lying to the east and south east of the geosyncline. This source of sedimentation has led mobilists to argue for the juxtaposition of a large land mass abutting against the east coast of North America, that is, Europe. However, one wonders why this is deemed necessary. There is quite a large fringe of continental crust lying to the east of the Appalachians, running from Florida to New York. This may have been at a greater elevation in Ordovician times and been subject to erosion and equatorial subsidence since then. Evidence from Indonesia and Barbados shows that huge oscillations in sea level have taken place even in relatively recent geological time.

Trend lines along the Appalachian chain are once more aligned sub-parallel to the relevant palaeoequators. Thus it might be inferred that equatorial disruption of pristine crust leaves permanent disfigurement.

Post-equatorial compression of the Appalachian geosyncline(s) occurred incrementally. Uplift began at the northern end, a fact that is in accord with the equatorial migration pattern of the Devonian. The main uplift came in Permo-Carboniferous times, when equatorial conditions moved to the south for at least parts of that Period.

During the same time periods of the lower to mid-Palaeozoic, the western side of the continent was experiencing mid-latitude climates and post equatorial conditions producing, by the Silurian, uplift in what was to become the Rocky Mountain Cordillera.

* A point is worth raising here regarding contemporaneous conditions outside North America. If one glances at the relevant figures in Chapter 2 (NCGT # 41), it can be seen that equatorial trends from the Ordovician, Silurian and possibly later, not only ran along the pre-Appalachian zone but continued over the Atlantic to be aligned, even if transiently, across the top of the land mass that now forms the northern parts of the British Isles and Scandinavia. A similar situation developed in these regions, producing the Caledonian geosyncline(s). Large thicknesses of sedimentation were again involved and the relevant trend lines are still visible today, running south west to north east across the top of the British Isles and Scandinavia.
The similarity of trend lines between the Caledonian and Appalachian terrains has been another piece of evidence cited in support of continental drift: that is, that these contemporary trend lines indicate the two continents were once joined together. As already mentioned in the previous chapter, an alternative explanation is provided by the geoid tectonics model in that the trend lines represent no more than quasi-contemporaneous equatorial alignments.

This idea can be taken further. In the Cambrian, the (palaeoclimatic) equatorial alignment extended from North America ran NNE to SSW across the middle of Russia, on the eastern side of the Baltic Shield. Here, large rifts some 5 – 6 km deep are known to have formed at the time, marking the initiation of the Ural Mountains.

Returning to North America, there appears little to be said until the Triassic when marine transgressions once more occurred. These could correspond to some of the wildly fluctuating equatorial alignments of the Period. Fossils deposited in the Triassic troughs on the western side of the continent include Tethyan fusulinids, equatorial fossils similar to those found in contemporaneous strata in South East Asia. This correlation has again been seized on by mobilists to suggest that fragments of South East Asia detached themselves and then drifted across the Pacific to become welded on to North American terrains. That such a suggestion could be taken seriously reveals not only a faith-like acceptance of the ideals of mobilism but also an unwillingness to analyse the sorts of mechanisms that could allow this to occur.

By Jurassic times, the equator appears to have moved away from North America on a fairly permanent basis. This has produced compression of the Triassic sediments both in the Nevada orogeny and later in the Eocene Laramide orogeny. Uplift continues today in parts of the Rocky Mountain Cordillera, which is one pointer to the fact that the strength of the lithosphere exceeds the loadings imposed by this high mountain chain.

### 6.3 Alpine-Himalayan Events

The Alpine-Himalayan fold belt began life as a long, wide, and complex development known, at least in part, as the Tethys Sea, which appears to have existed, on and off, since the Carboniferous. In the Permo-Carboniferous, practically all the palaeoequators ran along this zone. Subsidence and embryo geosynclinal development is thus to be expected under the right set of crustal interface circumstances. Such conditions are depicted now by the broad bands of the Hercynian cycle(s). In the Jurassic, there appears to be a paucity of equatorial conditions but the equators return in the Cretaceous, a condition that probably existed until the Eocene. This was shown in an earlier Newsletter as Figure 2.12 (NCGT # 41). In accordance with this pattern, we find uplift of the Alps, at the western end of Tethys, in late Eocene times. The related Himalayas were formed from the geosyncline(s) confined between the bulwarks of India, to the south, and China to the north. Again, uplift took place when the equator moved away in Eocene times.

Trend lines along most of the Alpine-Himalayan belt, Figure 5.10 of the previous Newsletter (#51) run sub-parallel to the original equatorial alignments of Carboniferous times and also to the Cretaceous palaeoequator(s), with some curly appendages.

It would be convenient here to discuss a possible method for the cyclic deposition of Coal Measures in Europe, during the Permo-Carboniferous. From Chapter 2 (NCGT # 41) it can be inferred that much of Europe experienced transient equatorial conditions during the Permo-Carboniferous, leading to a complex system of contemporaneous subsidence zones from the British Isles down to North Africa. The cycles of the Coal Measures require such conditions.

Let us make the assumption that a wandering pole does not necessarily travel directly from one point to another, but tends to home in on its new location by circling in circles of decreasing diameter. The associated equatorial alignments would then travel up and down the surface of the Earth accordingly, Figure 4.4 of an earlier Newsletter (NCGT # 50). In this way, a series of tropical and mild climatic conditions would be imposed as the equator passed back and forth. During the growing tropical periods, lush vegetation would become established in fresh water swamps, as indicated by coal seams found resting on a “seat earth”, a clay formation riddled with their root systems. As equatorial subsidence continued, this allowed marine
transgressions to occur killing off, or swamping, the vegetation. Strata immediately overlying coal seams sometimes contain the casts of great trees, still in the position of growth.

The strata above the coal seams often comprise a sequence of shales, suggesting a deep marine environment. These are succeeded, in turn, by sandy shales and sandstones, indicative of a shallowing of water. In the model, this would be explained by deep water at the height of the equatorial situation, with seas gradually becoming shallower as the equator moved away. On emergence of the land in temperate climes, vegetation would once more become established. Then as the equator returned, it would become progressively tropical and eventually drowned by sea incursions.

This cycle of subtropical and tropical freshwater swamps, followed by rapid marine transgression and deep water that gradually gives way to shallower conditions, would be a logical result of the equatorial oscillation shown in Figure 4.4 (ibid).

6.4 Papua New Guinea

A further example of an equatorial geosyncline formed along the edge of a continental shelf is provided by the geological history of Papua New Guinea, with an ancillary feature militating against the mobilist view that the PNG Highlands are the result of the Australian plate collision. The geological regimes of the eastern half of the island of New Guinea are depicted on Figure 6.4. The northern part of the island is basically formed of oceanic crust. The spine is termed a “mobile belt” comprising geosynclinal sediments of late Jurassic or Cretaceous age, uplifted during the Oligocene to form the PNG Highlands. The southern part of the island rests on the northern edge of the Australian platform, which consists basically of crystalline rocks overlain by shallow marine and lacustrine sediments of Mesozoic age: typically flat lying and thinning northwards. Along the mobile belt, the shallow sedimentary conditions on the southern side change abruptly to deep geosynclinal sediments over a distance of little more than ten kilometres. The southern boundary between the Australian platform and the mobile belt is faulted; and a long tear fault is present along the northern boundary between the mobile belt and the oceanic crust.

There is a problem with interpreting this geology in terms of mobile plate tectonics.

On the northern side of the mobile belt, near Madang, there are two outliers of the Australian platform, comprising shallow, flat-lying, Mesozoic sediments. The age of these sediments pre-dates the geosyncline. According to the mobile plate tectonics history of this region, these sediments on the Australian continental platform, and on the northern side of the mobile belt, should have been deposited when Australia was at a distance of a thousand kilometres to the south. How, then, did these outliers get to be isolated on the far side of the mobile belt without severe distortion, unless they were located there prior to the development of the geosyncline?
Let us approach the problem using the model of stable continents and migrating poles as set out in the preceding pages.

Evidence from Papua New Guinea, and from global palaeoclimatic evidence, Figure 2.11 (NCGT # 41), reveals that in Cretaceous times an equatorial alignment ran pretty much along what is now the mobile belt. With stable continents, this would have coincided – at least in part - with the edge of the Australian continental platform. In other words, the equatorial alignment would have run along the interface between Australian continental platform and oceanic crust lying to the north. Conditions should thus have been suited to the development of a geosyncline. As can be judged from the fact that sedimentation conditions changed within a matter of kilometres, from shallow water deposits on a continental platform, to deep geosynclinals sediments at the oceanic interface, confirms the development of a geosyncline.

In order for the outliers to be where they are, one must postulate that the geosyncline did not form exactly at the outside edge of the Australian platform. At some points along its trace, there must have been a couple of projections of the Australian platform, perhaps where the platform was locally thinner. These projections were then left as the outliers on the far side of the geosynclinals trough. The possible mechanism is shown in section in Figure 6.5.

In the Oligocene, and again in the Pliocene, the region underwent post-equatorial compressions, uplifting the mobile zone (now the highlands) as a barrier between the Australian platform and the oceanic crust on the northern side. The post-equatorial compressions were restricted to the geosynclinal zone, where the crust was already weakened by disruption and already infilled by normally consolidated argillaceous sediments. The northern outliers on the remnant Australian platform were isolated and suffered only minor disruption. Whether, as shown in the figure, there are any remnants of the Australian platform present at depth below the mobile belt is a matter for speculation at this stage.

6.5 Repetitive Orogeny

There remains one thing to clear up with the present model, and that relates to the crustal shortening that accompanies orogeny. One of the attractions of plate tectonics model is that it can cope with any amount of crustal shortening using the fallacious subduction argument, but the geoid tectonics model runs into a problem.
of adequacy in this regard, since the absolute shortening for an element of crust involved in latitude migration is probably of the order of 10 – 15 km: substantially less than the 60 – 100 km of crustal shortening measured in the field for some systems such as the Rocky Mountain Cordillera or the Himalayas. The problem can, however, be overcome to a large degree by recourse to repeated orogeny.

When a sedimentary series in a geosynclinal belt is folded in the initial stages of compression, this causes a degree of slip between individual beds, particularly those of slightly different lithology. For instance, to accommodate the folding, weaker members such as the argillaceous rocks tend take up the bulk of the slippage at the interface with adjacent members. Termed flexural slip, this process causes the clay platelets of the argillaceous strata to be rotated, producing residual strengths at the interface. The affected zones might be no more than a few millimetres thick but the zones can be traceable laterally right throughout a formation.

Flexural slip planes are essentially planes of weakness in the formation and, as such, can be a frequent problem encountered in, say, dam foundations. Flexural slip seams have been much studied, are well understood in geotechnical engineering and although originally discovered in argillaceous rocks, they are not restricted to this lithology. The writer encountered flexural slip seams in hard pre-Cambrian gneiss, in a dam foundation in Sri Lanka, with strengths as low as c' = 0 and φ_r = 12º – a strength that one would expect in a weak sheared clay, not in a crystalline rock. The folding episode that gave rise to the flexural slip seams was Triassic in age, indicating that healing does not occur along these shears even over geological time.

The point about flexural slip is that they are present in virtually all folded rocks and hence they are inbuilt into the sediments of a geosyncline when the sediments are first compressed and folded. They then represent planes of weakness that can be exploited by any new set of similar compression events.

Repetitive orogeny develops where a migrating pole undergoes oscillation, with an initial geosynclinal trough thereby suffering repeated equatorial stretching followed by post-equatorial compression. Each new episode of equatorial stretching does not undo the effects of a previous compression, since deformation paths are not reversible. However, each cycle of compression would tend to be additive, in that, where possible, it is taken up first along the inbuilt flexural slip planes established during the initial compression.

Most fold mountains show evidence of at least several major episodes of geosynclinal trough development, followed by as many episodes of uplift. Under an oscillating pole, the direction of each compression would be similar in each case. Five or six pulses of compression, for example, could therefore produce the sort of crustal shortening that is measured in fold mountain chains.

Such a repetitive process could also be invoked to explain some of the large lateral displacements of well known faults such as the Great Glen Fault of Scotland and the San Andreas Fault. Faulting itself produces residual strengths along a fault plane, by dint of the large strains developed during the faulting. Thus, each new episode of equatorial stretching, or tear faulting, would tend to be concentrated on the pre-existing weakness in the crust, such as an already present transcurrent fault.

This completes the series on Geoid Tectonics. Most of the remaining topics have already been published in NGCT. For example, a subsequent chapter on “Earthquakes”, from a geoid tectonics point of view, is available in individual papers: Reservoir Induced seismicity, #17 (2000); Analysis of the earthquake patterns in #26 and #27 (2003) and deep earthquakes #37 (2005); the Sumatra earthquake patterns, #34 (2005); the equatorial mid-Atlantic ridge activity, #35 (2005). A Synthesis of Major Objections to Mobile Plate Tectonics was published in an early NGCT, possibly #2. A piece on the Origin of Fissure basalts was presented in #7 (1998).

References
ROCK ASSEMBLAGES FROM THE PACIFIC OCEAN BEDROCK IN THE CLARION-CLIPPERTON FAULT REGION

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Keywords: Clarion and Clipperton Fault Zones, Pacific Ocean, Precambrian granitic-metamorphic rocks, Cretaceous geosynclinal sediments, Pre-Eocene basalt, Eocene-Miocene basalt-andesite-rhyolite

Abstract: Petrographical study of 48 fragments and 204 pebbles of rocks dredged from volcanotectonic structures, horsts and normal fault scarps shows that the basement rocks of the study region consist of multiple-age/formational complexes. They are: 1) Precambrian (?) granite-metamorphic, 2) Cretaceous geosynclinal volcanogenic-siliceous-sedimentary, 3) pre-Eocene oceanic basaltic, and 4) Eocene-Miocene oceanic basalt-andesite-rhyolitic.

Until recently preference was given to the conception that the World Ocean bedrock floor is structurally and materially homogeneous (Yegaizarov and Litvinov, 1983; Hilde et al., 1977). The basaltic basement with various ages, which forms the upper part of the Earth’s oceanic crust, its second layer, was believed to be petrologically homogeneous and made up of mid-oceanic ridge basalts. The structure, composition and age of the third oceanic layer, specifically for regions of interrift spaces or plates (Staritsina et al., 1986; Tabunov et al., 1985) have not been finally specified, and its geologic nature is disputed.

The supply of rock material from dredging grounds made it possible to study the composition of deep horizons of giant basins in the World Ocean. The first results of the study of the dredged samples of “continental” rocks from some rises of the Pacific marginal-oceanic swells showed that they belonged to metamorphic and intrusive rock associations characteristic of geanticlinal continental and microcontinental zones. The fact that the geologic structures submerged along the eastern periphery of the Pacific Ocean, within which the dredged samples of “continental” rocks were taken, belonged to the Asian continent did not raise any particular doubts (Vasiliev, 1982; Korneev et al., 1982; Challes et al., 1982). However, rare finds of “continental” rocks both at the bottom of deep basins of the central Pacific Ocean (Korsakov, et al., 1983; Prokoptsev, 1975) and in the deep-sea trenches of the Eltanin (Kashintsev and Frikh-Khar, 1979) and Kurchatov (Kashintsev and Rudnik, 1984) faults did not find any satisfactory explanation from the position of the concept of the bedded-block structure of the Pacific thalassocraton.

Abundant and compositionally diverse bottom rock material (BRM) was first collected in the equatorial zone of the Pacific Ocean open spaces, in the central part of the Clarion-Clipperton fault region (Fig. 1). The attempt made to sort the BRM into lithologically and petrologically related groups and unite them into age-based assemblages expands our ideas of the geologic nature of this part of the Pacific thalassocraton.

The majority of the BRM samples were trawled. The extent of trawling was 0.5-4 km. One trawl sample weighing about 1 ton held 1-3 BRM-bearing samples, occasionally, 20. The sampling of the bottom with dredges also revealed rare single BRM specimens. Once, a weakly cemented conglomerate was brought up measuring 0.3 m (Station 8284). Compositionally, the most diverse BRM was dredged together with blocks of Oligocene-Miocene compact polygenic clays on the slopes of abyssal hills and low normal-fault scarps of the abyssal plain. There, according to continuous seismic profiling evidence, the thickness of the sedimentary cover decreases to zero (Fig. 2). Undersea photography shows a chaos of overturned blocks of sedimentary rocks on the base of some normal fault scarps and cliffs up to 15 m high (Moreal and Le Suave, 1986). On the other hand, some bottom parts of the flat abyssal plain with undisturbed Eocene-Miocene sedimentary cover...
150-175 m thick (Piper et al., 1979), overlapped by Late Miocene-Quaternary siliceous mudstone ooze up to 25 m thick, show no BRM.

All the dredged BRM was subdivided by macroscopic description into angular fragments and well-rounded pebbles. The petrographical composition of BRM is shown in Tables 1 and 2. The BRM fragments are represented by angular chip stones and rock samples measuring ≤ 20 cm across. The surface of most fragments is partly or completely covered with thin ferromanganese crusts. Some fragments are crust-free and show fresh chips, which may indirectly indicate their local origin. BRM pebble has a spherical form and is more often well-rounded. Its surface is smooth, polished and lacks either stokes or scratches, which is typical of beach marine deposits. The surface of the majority of the pebbles is partly, less often completely, covered with a thin ferromanganese crust or coating. Judging by the conglomerate dredged at Station 8884 (see Fig. 1), ferromanganese coatings are developed at the places on the pebble surface that, when exposed, came in contact with water, while the part of the surface that was enclosed in the zeolite-clay cement has a clean surface. The pebbles range in size from 1 to 5 cm across, reaching 10 cm in rare cases. Among the 252 studied BRM samples, fragments account for a quarter, and ≤ 20 of these specimens display fresh chips. A small part of the samples showing fresh chips and lacking ferromanganese crusts and coatings is characteristic of many dredging sites of the World Ocean (Allen and Tucholke, 1981).

![Figure 1](image.jpg)

**Figure 1.** Distribution of sampling stations where BRM fragments were dredged. 1 – trawl samples and their numbers; 2 – samples taken by bottom sampler, and their numbers; 3 – "intermediate" fault zone (Sclater et al., 1971), from a hydromagnetic survey; 4 – faults in the oceanic sedimentary cover, from continuous seismic profiling evidence; 5 – volcanic seamounts and volcanotectonic uplifts, from bathymetry evidence; 6 – location of profile 84-30 (Fig. 2).

The absence of direct observations from descent modules does not make it possible to establish a rigid geologic reference for the samples. Therefore, we now discuss three hypotheses of BRM origin at the oceanic floor surface.

The first hypothesis supports the local origin of BRM: angular fragmental material, especially with fresh chips, is the underwater alluvium of bedrock (edaphogenic material). In this case, bedrock from the deep horizons has been carried along fault zones and is exposed in horsts and normal-fault scarps among loose Upper Miocene-Quaternary sediments of low thickness (0-25 m). Pebble material is alluvium of conglomerates. The conglomerates from Station 8884 (see Fig. 1) are part of the Eocene-Miocene sedimentary cover, which forms the first oceanic layer. The conglomerate alluvium is exposed on the oceanic floor in the same way as rock outcrops of the bedrock floor, within fault zones in the uplifted horsts, pop-outs of the acoustic basement, and normal-fault scarps.
Figure 2. Geologic-geophysical section along seismic-acoustic profile 84-30.

Table 1
Composition of rocks from fragments of the bottom rock material dredged as trawl samples in the central part of the Clarion-Clipperton fault region (Pacific Ocean); their groups and age complexes

<table>
<thead>
<tr>
<th>Rock complexes of structural elements of the oceanic bedrock floor</th>
<th>Rock groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Eocene ocean basalt complex of the second oceanic layer</td>
<td>Effusive basic rocks: basalts (18384-1, 18384-2), plagiophyre basalts (X46-4, 3A-170-2, 3A-170-6, 3A-170-7, 3A-170-8, 3A-170-11, 3A-170-12), volcanic glass (3A-170-1).</td>
</tr>
<tr>
<td>Cretaceous geosynclinal volcanogenic-siliceous-sedimentary rock complex of the third oceanic layer</td>
<td>Pyroclastic rocks: crystallolithoclastic tuff (X31-3). Sedimentary rocks: polymictic sandstone (X27-1, 1A-161), quartz sandstone (2076-2, 2155), siltstone (2162-2, 2137), silicified siltstone (1A-19-1), siltstone pelites (2128), siliceous mudstone (3A-176), siliceous rocks (17984-1, 18184-3, 3A-176), radiolarian siliceous rocks (X29-6, X29-8, 3A-170-16). Weakly metamorphosed foliated sedimentary rocks: clay shale (1A-19-2), foliated siltstone (12984-1). Metamorphosed igneous rocks: granodiorite (11284-1), quartz diorite (3A-133-1).</td>
</tr>
<tr>
<td>Precambrian (?) granite metamorphic rock complex of the third oceanic layer</td>
<td>Metamorphic rocks: granulite-facies – garnet gneisses (3A-170-14, 3A-170-15), bipyroxene-plagioclase crystalline schists (enderbites) (3A-170-17, amphibolized garnet-pyroxene-plagioclase crystalline schists (3A-170-17); amphibolite-facies – biotite-muscovite gneisses (17484-1), amphibole-plagioclase crystalline schists (3A-170-13). Ultrametamorphic rocks: cataclastic granite gneisses (1A-</td>
</tr>
</tbody>
</table>
The second hypothesis claims that the whole BRM sampled by trawling is the disconnected material transported by icebergs in the Pacific Ocean equatorial zone. Rock material and typical iceberg sediments have been recognized and studied in columns on the seamounts of the northeastern Pacific, north of the Mendocino fault. It is presumed that in Quaternary time icebergs together with the California Current could penetrate into the Tropics (Lisitsyn, 1978). At present it is believed that the boundary of distribution of iceberg rock material in the Northern Hemisphere corresponds to the extreme southern boundary of ice distribution as far as 30°N (Lisitsyn, 1978). Despite the fact that the boundaries of paleogeographic belts during the maximal temperature drop in the Pleistocene shifted toward the equator, when the general temperature of the ocean surface waters fell by 3°C (Nikolaev et al., 1984), it seems impossible to suggest iceberg influence on oceanic sediment genesis in the equatorial zone. If further investigations prove that at least part of BRM from the Clarion-Clipperton region is incidental cryogenic material of the superdistant transport by icebergs, then the extreme southern paleogeographic boundary of ice distribution in the tropics in Pliocene and Pleistocene time should be revised.

The third hypothesis suggests transport of rock material by roots of floating trees or by sea animals; however, this assumption also lacks proof.

The results of our investigations provide evidence in favor of the local origin of BRM. This is also indicated, in the first place, by fragment samples taken at trawling sites, where, according to continuous seismic profiling, bedrock was brought up to the surface of the oceanic floor devoid of sedimentary cover. Such sites were registered at Stations X21, X29, X45, X51, 1A-19, 3A-170, 3A-197, and 2162 (see Fig. 1). Part of the sampled fragments displayed fresh chips. They were most evident on the garnet gneiss samples from Stations 3A-170-14 and 3A-170-15.

The following observations can serve as an indirect proof that the fragments originated from bedrock alluvium:

1. Doubling of numerous specimens of identical composition in one trawl sample from areas of rocky ground, for example, angular chip stone of radiolarian siliceous rocks (X29-6 and X29-8)*, aphyric basalt fragments (18384-1 and 18384-2; 3A-170-2, 3A-170-6, 3A-170-7, 3A-170-8, and 3A-170-11), and garnet gneisses fragments (3A-170-14 and 3A-170-15).

Table 2

Composition of rocks from pebble brought up in the trawl samples, central part of the Clarion-Clipperton fault region (Pacific Ocean); their groups and complexes

<table>
<thead>
<tr>
<th>Rock complexes</th>
<th>Rock groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volcanic complex of acid, intermediate and basic rocks</td>
<td>Effusive acid rocks: rhyolite porphyries (X21-2, 1A-72-1, 1A-86-2, 2097, 2117-5), quartz porphyries (M46, 21484-1), felsites (2102-2, 2122-4), felsite-porphyries (M06, X13-1, 17284-1), albitophyres (X13-2, X26-1, X41-2, X54-1, 1A-77-3, 21584-3, 3A-171-1, 3A-171-2), obsidians (3A-169, 3A-176), lava breccia of rhyolite porphyry (12484-1, 14684-1), dacites (M08-2, 12784-5, 21584-2), dacite porphyries (7284-1), lava breccia of dacites (13084-1); pyroclastic rocks: tuffs of acid rocks (1A-78-2, 2162-17, 3A-170-3, 3A-170-5, 3A-196), intrusive rocks: granophyres (18084-3, 1A-48-2, 1A-77-2), granite porphyries (10284-2). Effusive intermediate rocks: andesites, andesite basalts (X29-1, X29-4, X29-7, X45-4, X55-2, 0484-1, 0484-2, 11684-3/1, 13384-1, 14684-3/1, 14684-3/2, 14684-4, 15384-1, 18584-1, 18584-3, 18584-4,</td>
</tr>
</tbody>
</table>

* Herein, sample numbers are bracketed
Basalt complex

Effusive basic rocks: basalts (M20, M45, X16-1, X21-3, X26-4, X27-3, X29-2, X29-3, X45-1, X45-3, X51-1, 8884-2, 9184-2, 18084-1, 18384-2, 1A-23, 1A-45-1, 1A-48-1, 1A-69-1, 1A-69-2, 1A-82, 1A-86, 1A-97, 2042, 2060, 2074-2, 2078-2, 2079-1, 2095, 2112-A, 2115, 2122-3, 2133, 2140-4, 2143, 2162-4, 3A-197-3); intrusive rocks: metadolerites (18184-1, 19784-3, 2058-2, 2138-2, 3A-167-1, 3A-167-2).

Complex of sedimentary rocks

Sedimentary rocks: fine-pebble conglomerates of siliceous rocks (10284-3), polymictic sandstone (0284-1, 6884-1, 13784-1, 13784-5), quartz sandstone (12784-2, 16584-1, 2075, 2134, 2162-1), tuff sandstone (3A-170-10), silty sandstone (2112-4), siltstone with radiolarians (8884-1, 8884-4), siltstone (2077), silty pelites (2154-1), siliceous mudstone (X26-3, 8884-3, 3A-168, 3A-170-9), siliceous rocks (8884-3, 13481-1, 2145-3), radiolarian siliceous rocks (18184-1, 18384-3, 19784-4). Pyroclastic rocks: crystallolithoclastic tuffs with chert, siltstone, microquartzite and quartzite fragments (X21-1, 2162-7, 2162-10). Weakly metamorphosed sedimentary rocks: quartzite sandstone (2072, 2076-2, 2105-2, 2136-2, 2162-1, 3A-191).

Granite metamorphic rock complex


2. Patterns of sample distribution of sedimentary rocks of similar composition and structure in the trawl samples from stations located near the latitudinal fault (see Fig. 1). These are fragments of quartz (2155) and polymictic (X27-1) rocks, sandstones and siltstones (2128, 2137, 2162-2), radiolarian siliceous rocks (3A-170-
16, X29-6, X29-8). Moreover, the sandstone cement in sample X27-1 and the siliceous rock in sample 3A-170-16 showed radiolarian remains of one Cretaceous species, Holocryptocanium (Late Aptian-Cenomanian).

3. Xenogenic material in the fragments of polymictic sandstones gives additional information on the material composition of the deep subsided horizons of the thalassocraton. Judging by the age of radiolarians of sanstone X21-1, these sandstones formed at the turn of the Cenomanian at the expense of erosion of granitoid, metamorphic siliceous rocks and siliceous mudstone. In addition, metamorphic quartzites are present in the sandstones of sample 1A-16-1 among xenogenic material. Thus, the xenogenic material of Cretaceous polymictic sandstones exhibits continuity of composition of the rocks of the Precambrian (?) granite-metamorphic complex.

4. The whole amount of the dredged BRM is noted for a considerable portion of aphyric basalts: 24% for fragments, and 21% for pebbles. The latter indicates basalt distribution among rocks of the bedrock floor; the rocks are part of the second oceanic layer. Similar basalts were penetrated by deep-sea drilling holes 161 and 162. They belong to the pre-Eocene covers forming the second oceanic layer and underlying the sedimentary cover of Middle Eocene-Quaternary age. They are ocean-typical aphyric, poorly crystallized basalts, devoid of bubbles and pores.

The petrographical study of 48 angular fragments of BRM made it possible to unite them into lithologically and petrologically related groups and different-age complexes corresponding to the known continental geologic formations. Four different-age rock complexes have been distinguished: conventionally, Precambrian (?) granite-metamorphic, Cretaceous geosynclinal volcanogenic-siliceous-sedimentary, pre-Eocene oceanic basaltic, and Eocene-Miocene oceanic-basalt-andesite-rhyolitic. The age of these complexes can be tentatively substantiated by Cretaceous radiolarian remains in the sedimentary rocks (samples X27-1, X29-6, X29-8 and 3A-170-16), Eocene-Quaternary sedimentary cover, and by the pre-Eocene (pre-Early Eocene, to be more precise) age of basalts penetrated by deep-sea drilling holes 161 and 162 by the Glomar Challenger SRV, and also by analogy with similar formational rock complexes on the continents.

In terms of composition, metamorphic grade and age, the rocks of the four distinguished different-age complexes correspond to the four structural-and-material complexes of the bedrock floor, respectively, and are part of all the three layers of the Earth’s oceanic crust. We’ll dwell on the characteristics of these complexes below (see Table 1).

The recognition of the Precambrian (?) granite-metamorphic complex in the deep structure of the World Ocean is disputable so far. However, finds of fragments of metamorphic and ultrametamorphic rocks in the trawl samples from the western part of the region (see Fig. 1) cannot be ignored. Granulite- and amphibolite-facies, and also ultrametamorphic and cataclastic rocks of granite composition were detected among them. Granulite-facies rocks are represented by garnet gneisses, bipyroxene-plagioclase crystalline schists and amphibolized garnet-pyroxene crystalline schists. Macroscopically, the garnet gneiss of sample 3A-170-14 is banded-spotty due to irregular quartz distribution. Large (up to 1-2 cm) porphyroblasts of K-feldspar are distinguished against this background. The part of the rock with average quartz content has a heterogranoblast structure and the following composition: quartz 35%, K-feldspar 40%, acid plagioclase 20%, and garnet 2%. The rock is characterized by reaction-metasomatic relations of K-feldspar and plagioclase: either plagioclase relics are hosted inside the K-feldspar crystals or irregular grains of thin twinned albite corrode and substitute K-feldspar. Such relations are the result of impact of ultrametamorphic processes on the rock. The rock bears distinct traces of cataclasis and recrystallization, which is evidenced in the formation of bands of fine-grained material composed of a granoblast quartz and albite aggregate with rare muscovite flakes.

The garnet gneiss of sample 3A-170-16, dredged in the same trawl sample, is also characterized by a heterogranoblast structure with grains measuring 0.1 to 1 mm, and consists of thin twinned acid plagioclase (55%), mosaically-dimming quartz (30%), and garnet (5%). The rock is cross-cut by cataclasite subparallel bands, within which secondary muscovite is developed (10%) with subordinate quartz and plagioclase.

Garnet gneisses are exclusively fresh rocks, while sample 3A-170-17 of bipyroxene-plagioclase crystalline schist is represented by a flat plate measuring 1 x 6 x 6 cm covered on all sides with a film of hydrous Fe and Mn oxides. The latter penetrate into the sample for 1-3 mm forming a dark-gray zone on its periphery. The
central part of the sample is made up of a fresh fine-grained light-gray rock. The structure of the rock is heterogranoblast with grains measuring 0.2 to 2 mm. The directional distribution of plagioclase grains conditions foliation of the rock. The rock is made up of thin twinned plagioclase (70%), greenish monocline pyroxene (15%), rhombic pyroxene (10%) and magnetite (5%), and corresponds to the composition of basic enderite. All the minerals are fresh; only at the edges of clinopyroxene grains is greenish amphibole developed in places. The amphibolized garnet-pyroxene crystalline schist of sample 3A-173 is represented by an angular plate measuring 1 x 2 x 5 cm covered from all sides with a film of hydrous Fe and Mn oxides. The rocks are characterized by a granoblast structure. The main rock-forming mineral is greenish monocline pyroxene. Green amphibole is developed on it. Occasionally clinopyroxene relics in amphibole are observed. More often the latter replaces pyroxene to form pseudomorphs. Pyroxene together with amphibole replacing the former account for 70% of the rock volume. Garnet (almandine) does not exceed 20%. Solitary muscovite flakes and sphene and apatite grains are noted. Quartz (5%) as lenticular segregations is recognized in the rock as a consequence of the latest processes of silicification.

Amphibolite-facies rocks are represented by three lamellas of amphibole-plagioclase crystalline schist (3A-170-13) from one and the same trawl sample, and muscovite-biotite gneiss (17484-1). The gneiss is characterized by a lepidogranoblast structure and is composed of quartz (35%), K-feldspar (20%), plagioclase (10%), muscovite (20%), and biotite (5%). Leucocratic mineral grains are isometric in shape measuring 0.5-2 mm. Secondary processes of silicification, muscovitization and albitization were evidenced in the rock. Thin twinned albite replaces K-feldspar. Quartz and muscovite develop intensively on K-feldspar replacing it not only at the crystal edges but also penetrating into them. Besides, muscovite partly replaces biotite.

Among ultrametamorphic rocks two angular fragments are represented by cataclastic granite gneisses (1A-75-2, 2117-2). Their structure is heterogranoblast. Quartz is the dominant mineral (80%). K-feldspar (20%) shows spherulites; the accessory mineral is zircon. The rock displays thin bands of cataclasite which are subparallel and consist of finely crushed and recrystallized minerals – quartz and kalsilite. They are associated with new growths – flakes of greenish chlorite and colorless mica, and also with hydrous Fe oxides holding rare magnetite grains.

Granitoid and metamorphic rocks are assigned to the Precambrian complex, which being a relic-continental structural-material complex is preserved in the intrarift spaces (plates) of the Pacific thalassocraton. This complex is part of the third oceanic layer of thalassoplains (submerged plates) and bears a similarity to continental granite metamorphic assemblages of ancient platforms (Staritsina et al., 1986; Tabunov et al., 1985).

Metamorphic rock finds in the ocean are indicative of the structural similarity between the destructive submerged platforms (plates) and continental ancient platforms.

Recognition of the Cretaceous geosynclinal volcanogenic-siliceous-sedimentary complex is based on the age and composition of 17 angular fragments. They are, probably, part of the third (subbasalt) oceanic layer. Their finds are associated with one of the latitudinal faults (see Fig. 1) of the “intermediate” fault zone (Sclater et al., 1971). Compositionally, they are, evidently, quartz (12155) and polymictic (X27-1, 1A-16-1) sandstones, crinoidal tuffs (X31-3), numerous siltstones (1A-19-1, 2128, 2137, 2162-2), siliceous (17984-1, 18184-3) and radiolarian siliceous (X29-6, X29-8, 3A-170-16) rocks. According to L.I. Kadintseva’s identification (All-Russian Geologic Institute), radiolarians from sample 3A-170-16 refer to the genera *Spongostrochus* sp., *Holocryptocanium* sp., and *Sphaeroidea* gen. sp. indet. Their presumed age is Upper Cretaceous. The radiolarian siliceous rocks of samples X29-6 and X29-8 show radiolarian skeletons of the order Spumellaria. Radiolarian skeletons of the species *Holocryptocanium barbui Dumitrica* were detected in the cementing mass of polymictic sandstone (X27-1). L.I. Kadintseva inferred that this species was characteristic of Late Albian-Cenomanian age.

Siliceous rocks (17984-1, 18184-3) are characterized by a cryptocrystalline structure and are composed of an aggregate of fine quartz grains and chalcedony segregations. Against the background of the cryptocrystalline mass the radiolarian siliceous rocks of samples X29-6, X29-8 and 3A-170-16 contain remains of rounded
radiolarian skeletons as solitary forms or small colonies of three or fours skeletons growing on one another. Radiolarians measuring 0.1-0.2 mm account for 10% of the rock volume. The peripheral wall of the radiolarians is made up of pole-shaped radial quartz; and the central part, of fine-grained quartz.

The siltstone (2128, 2162-2, 2137, 1A-19-1) in the clastic part contains quartz and subordinate cericitized plagioclase, 0.05-0.1 of grain size. Solitary siliceous rock fragments are noted. The siltstone cement is micaceous-clay with insignificant siliceous material. Micaceous material replaces clay. The siltstone of samples 2128 and 2137 is characterized by fine lamination, occasionally grading into vortex lamination.

Fine-grained quartz sandstone, dredged as a large (16x18x20 cm) angular block (2155), has a homogeneous composition of the clastic part: 75% of quartz grains, 10% of siliceous rocks and siliceous mudstone, and 2% of acid plagioclase rains. The fragments are angular-shaped, and they measure 0.1-0.4 mm. The cement of quartz sandstone is porous siliceous mudstone-micaceous (13%).

On the other hand, polymictic sandstones (X27-1, 1A-16-1) are of variegated composition in the clastic part: quartz (30-50%), K-feldspar and plagioclase (10-20%), and fragments of siliceous rocks and siliceous mudstone (20-30%). The thin section of sample 1A-16-1 exhibits fragments of metamorphic quartzites (15%), and acid and intermediate effusive rocks (1%). All the fragments are angular measuring 0.1-0.5 mm. The cement of polymictic sandstones is siliceous mudstone-micaceous; contiguity is occasionally observed.

The composition of the clastic part of crystallolithoclastic tuff (X31-3) is pretty variegated. These are fragments of siliceous rocks and siliceous mudstone (25%), siltstone (15%), acid and intermediate effusive rocks (15%), granites (3%), plagioclase and quartz grains (7% and 5%, respectively), and also solitary fragments of silicified quartz sandstone. The fragments measure 0.2-1.0 mm. The cementing mass of tuff is chloritized ash material.

In the extreme western part of the region fragments of weakly metamorphosed sedimentary rocks are noted. These are clay shales (1A-19-2), foliated siltstone (12984-1), and siliceous rock with unclear foliation (17984-1). Clay shale is composed of siliceous mudstone material enriched in fine flakes of colorless mica distributed subparallel, which conditions the foliated structure of the rock. In addition, a spotty structure is noted caused by accumulation of clay material as irregular spots. The appearance of such structures is the result of initial stages metamorphism. The foliated siltstone exhibits its intercalation with thinner stringers of clay material. In the clay-micaceous siltstone intercalations quartz grains measure ≤ 0.1 mm; however, clay shale intercalations are devoid of clastic material. Some samples of sedimentary and pyroclastic rocks show stringers filled with quartz (2155), quartz and epidote (1A-16-1), and epidote (X31-3).

Tuff, sandstone, siltstone, siliceous rocks and radiolarian cherts of Cretaceous age, and also weakly metamorphosed siltstone and clay shale are rocks characteristic of volcanogenic-siliceous-sedimentary assemblages of geosynclines. The compositions of clastic material of sandstone and tuff are very similar, though the clastic material ratios in these rocks are different. The terrigenous and volcanogenic rocks are characterized by clastic material represented by siliceous rocks and siliceous mudstone. Fragments of siltstone, quartzite and other rocks are sporadic in them. This indicates that the formation environment of these rocks was similar to the accumulation conditions of volcanogenic-terrigenous early geosynclinal formations and was governed by repeated denudational reworking and rewashing of the subjacent rock sequences.

Fragments of intermediate metamorphosed intrusive rocks are conventionally assigned to the Cretaceous geosynclinal complex. Unlike granitoid rocks of the Precambrian (?) complex, quartz diorite (3A-133-1) and granodiorite (11284-1) are characterized by a hypidiomorphic-granular structure. The granoblast structure is noted in them only in places. Quartz diorite consists of acid thin twinned plagioclase (70%), quartz (15%), and hornblende (15%). Plagioclase is poorly zoned, sometimes containing antiperthite ingrowths of K-spar. Hornblende is secondary. It contains monocline pyroxene relics. Granodiorite is composed of plagioclase (55%), K-feldspar (25%), and a dark-colored mineral completely replaced by chlorite (5%). Albite develops on K-feldspar replacing it. Quartz diorite and granodiorite are characterized by the apatite-sphene-ilmenite association of accessory minerals (as distinct from the zircon association in granitoids). Fragments of quartz
diorite and granodiorite compositionally and structurally correspond to intrusive assemblages of geosynclinal belts and are, possibly, rocks of the Cretaceous geosynclinal complex.

Recognition of the pre-Eocene oceanic basaltic complex does not give rise to doubts. The fragments and chip stone of compositionally and structurally fairly uniform basalts are most frequent in the trawl samples. They are ubiquitously distributed; however, they are most frequent near the latitudinal fault (see Fig. 1). Compositonally, aphyric (18384-1, 18384-2) and polyphyric (X46-4) basalts, basic volcanic glass (3A-170-1), and plagiophyric hyalobasalts (3A-84, 3A-170-2, 3A-170-6, 3A-170-7, 3A170-8, and 3A-170-11) have been distinguished among the fragments. The fragments of these rocks are commonly represented by angular irregular pieces, often with a shelly fracture. Volcanic glass, judging by the oval form of the sample and its concentric-shell structure, is a “bud” on the glassy crust of the lava flow. All the rocks are bubble-free, which suggests their outflow at great depths. These are typical oceanic basalts with a specific aphyric structure or a small amount of microimpregnations. Besides, their common feature is the presence of panicleate, sheaf-like and skeleton structures of groundmass. A similar type of basalts is characteristic of the second oceanic layer (Staritsina et al., 1986). Compositonally and structurally, the basalts dredged in trawl fragments are identical with the basalts outstripped by deep drilling holes 161 and 162. The age of the latter was determined as Early Eocene. Numerous basalt fragments correspond to the pre-Eocene oceanic basalts of the second oceanic layer and belong to the pre-Eocene basaltic complex, which overlies two subjacent complexes – Cretaceous geosynclinal volcanogenic-siliceous-sedimentary and Precambrian (?) granite-metamorphic.

Recognition of the Eocene-Miocene oceanic basalt-andesite-rhyolite complex is based on the finds of fragments of rhyolite (2066 and 2162-3), rhyolite porphyry (X2-1), albitophyre (X58-1, 0884-1), acid tuff lava (19284-2), andesite (1A-19-5), andesite basalt (X13-3, 3A-197-5), and polyphyric basalt (X46-3). They are relatively regularly distributed within the region (see Fig. 1). At station 3A-197, andesite fragments were found in the trawl sample taken from the base of a seamount, where sedimentary cover is nearly absent. According to continuous seismic profiling evidence and photos of the sea floor (Morel and Le Suave, 1986), outcrops of magmatic rocks forming abyssal hills and seamounts 50-500 m high and ≤ 10 km wide at the base was ascertained. The chains of abyssal hills are most often confined to the “intermediate” fault zone of latitudinal strike located between the Clarion and the Clipperton fault zone (Sclater et al., 1971), and are traced toward the east as far as the Orozco fault zone (Anonymous, 1986). The relations between acid and intermediate effusive rocks in the seamounts are unclear.

Rhyolites and rhyolite porphyries are characterized by a porphyric structure with phenocrysts of acid plagioclase, pelitized K-spar and quartz. Impregnations amount to 10% and measure 0.2-0.8 mm. Feldspars are prism-shaped, and their edges are often broken off. Quartz phenocrysts are characterized by bay-shaped hollows. The groundmass is quartz-feldspathic microfelsic. Quartz recrystallization is observed occasionally.

Albitophyre is also characterized by a porphyric structure. Phenocrysts are represented by acid plagioclase (15%) and quartz (7%), and they measure 0.3-1.0 mm. Inside some zonal crystals of plagioclase K-feldspar relics are observed. The groundmass has a micropoikilitic or microgranite structure. Thin section 0884-1 displays quartz recrystallization. Quartz partially corrodes plagioclase impregnations. The accessory mineral is apatite. The rocks are cross-cut by quartz stringers. Epidote and chlorite are observed as isolated small lenses.

In the andesite of sample 1A-19-5 phenocrysts are represented by prism crystals of plagioclase (2%), and the groundmass is cryptocrystalline, fluidal-banded. The porphyric structure of andesite basalt (X13-3, 3A-197-5) is conditioned by the presence of phenocrysts of tabular plagioclase (15%), monocline pyroxene (3%), and rhombic pyroxene (2%). The groundmass has an andesite structure, and it is made up of plagioclase microlites. In the spaces between the latter there is colorless acid volcanic glass with insignificant amounts of fine grains of clinopyroxene and loose ore. Compositonally and structurally, polyphyric basalt with a glomeroporphyric structure (X46-3) is closer rather to andesite basalts than to common basalts of the second oceanic layer. It is characterized by numerous impregnations of prism plagioclase (15%), clinopyroxene (10%) and olivine keg-shaped crystals (5%). The groundmass is microdolerite, holocrystalline with an equal ratio of clinopyroxene and plagioclase, and substantial admixture of ore material (3%).
Rhyolites, andesites and andesite basalts are, apparently, volcanic assemblages of the youngest volcanic complex of epiplatform orogenic magmatism in the ocean. This magmatism became apparent at the final stage of development of oceanic basalt volcanism in the form of volcanotectonic structures, which form positive relief forms and pierce into the low-thickness (150-175 m) Eocene-Miocene sedimentary cover of the first oceanic layer (see Fig. 2). The low-temperature hydrothermal activity related to this complex conditioned the formation of Fe-Mn crusts and concretions, widespread in the region.

To conclude, we shall dwell on the comparison between the composition of the BRM fragments and pebbles. The amount of pebbles exceeds that of fragments. The latter are characterized by a wider range of composition. This information is necessary for elucidating the problem of the local or erratic origin of pebbles sampled on the oceanic floor. The petrographical study of 204 pebbles (see Table 2) was the basis for recognition among them of rock groups and complexes of corresponding origin. By and large, the pebbles and fragments have similar compositions. A nearly identical composition of pebbles and fragments is noted for sedimentary and effusive rocks, which argues in favor of their local origin. The identical composition and structure are noted for rocks of pebble and fragments of sandstone, siltstone, siliceous mudstone, and cherts (including Cretaceous radiolarian cherts). However, no quartzite sandstone and fine pebble siliceous conglomerates were detected among the BRM fragments. Nor were any weakly metamorphosed rocks – clay shale and siltstone – found among the BRM pebbles. Quantitatively, both the fragments and pebbles of BRM are represented by rocks of the Cretaceous geosynclinal complex (see Tables 1 and 2).

The compositions of pebbles and fragments of effusive rocks are also similar, though the composition of pebbles varies more widely. Obsidians and dacites appear there in the effusive facies. In addition, pebbles are characterized by rocks of the vein facies – granophyres and granite porphyries – while fragments show none of these rocks. Large amounts of andesites and andesite basalts among the BRM pebbles are noticeable. Rocks of the granulite and amphibolite facies were detected among the fragments, whereas pebbles held rocks of the amphibolite and greenschist metamorphic facies, and also numerous finds of ultrametamorphic rocks of granitoid composition.

The area of distribution of pebbles of metamorphic and ultrametamorphic rocks is wider than that of fragments, which were detected only in the western part of the region (see Fig. 1).

CONCLUSIONS

1. In terms of composition, the BRM angular fragments dredged in the central part of the Clarion-Clipperton fault region are united into lithologically and petrologically related groups corresponding, apparently, to different-age rock complexes: Precambrian (?) granite metamorphic, Cretaceous geosynclinal volcanogenic-siliceous-sedimentary, pre-Eocene oceanic basaltic, and Eocene-Miocene oceanic basalt-andesite-rhyolite complexes.

2. By and large, the composition of BRM pebbles is similar to that of angular fragments, though the range of pebble composition is somewhat wider.

3. In contrast to the existing conceptions of a rather simple geologic structure of the bedrock floor of the World Ocean, the study of BRM composition points to the heterogeneous structure of the third (subbasaltic) oceanic layer. The complex geologic history of the development of the Earth’s oceanic crust, formed by rock complexes more ancient than the age of the overlying basalts of the second oceanic layer, suggests a complex geologic history of this part of the Pacific Ocean which is generally similar to the geologic history of the North America western part.

4. The role of rupture dislocations in the Earth’s oceanic crust with the low-thickness sedimentary cover is more substantial than on the continents. This should be taken into account when studying the deep geologic structure of the bedrock floor: bedrock of the second and third oceanic layers “shows through” ruptures of the sedimentary cover. Such areas should be investigated in the first place by manned submersibles to determine the unequivocal relations of the geologic objects under study.
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ORIGIN OF THE WORLD’S DEEPEST BAYS

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ABSTRACT: The three deepest bays in the world are: Suruga Bay in Japan (2,500 m at the mouth), the Gulf of California off Mexico (3,700 m) and the Gulf of Aden in the Indian Ocean (5,360 m). All of these bays are commonly situated on the extension of submarine ridges: Suruga Bay – Izu-Bonin Arc, Gulf of California – Mid-Pacific Ridge, and Gulf of Aden – Carlsberg Ridge. These ridges are underlain by plutonic and metamorphic rocks (Vp=6.0 km/sec) of Late Proterozoic (Grenvillian) age at the 10 to 11 km depth. This fact implies that the three deep bays formed as rift valleys developed on the basement ridges which were solidified through multiple disturbances during the Proterozoic Era, as is the case for the Mid-Atlantic Ridge and its axial valleys.

Keywords: Suruga Bay, Fossa Magna, Gulf of California, Gulf of Aden, submarine ridges

1. Introduction

Most of the bays on the Earth were formed by the submersion of the seaward ends of river valleys during Quaternary ice ages due to the rise of the postglacial sea level and the water depth at the bay mouth is often about 100 m. However, a number of deep bays are found with a depth at the mouth of more than 2,000 m. In this paper we examine the geological/tectonic significance and origin of the world’s three deepest bays – Suruga Bay in Japan, the Gulf of California and the Gulf of Aden in the Indian Ocean from a viewpoint different from the widely accepted plate tectonics.

2. Geology of deep bays

2-1 Suruga Bay

Suruga Bay is the deepest bay in Japan with a depth of 2,500 m at the mouth, a width at the mouth of 50 km and a length of 60 km (Fig. 1).

Green tuff strata are distributed widely on the Izu Peninsula situated on the eastern side of the bay as a result of submarine volcanoes in the Miocene epoch, and Miocene and post-Miocene marine strata are distributed on the western side of the bay. These strata are thickly accumulated along the Itoigawa-Shizuoka Tectonic Line that extends as far as the Sea of Japan from Suruga Bay. Benthic foraminifera included in this Early Miocene epoch are marine species distributed at the CCD and deeper (Nakamori et al., 1991).

According to crustal cross-sections based on explosion seismics in the Tertiary areas in the northern part of Suruga Bay, the base of the surface-covering stratum (~ 5.5 km/sec) reaches a depth of 10 km and 6.0 km/sec granite strata are distributed in the lower part (Fig. 2).

On the Izu Peninsula, the surface-covering stratum is 2 km in thickness and the 6.0 km/sec strata are distributed in the lower part. The crustal cross-sectional diagram of the northern Izu-Bonin Arc region, which extends to the south of Suruga Bay, indicates a 6.0 km/sec stratum with a thickness of about 6 km in the center of the ridge. On the apex of this lens-shaped body is a pair of uplifts separated by about 30 km and with a relative elevation of about 1 km (Fig. 3). These uplifts are found at the bottom of an active rift belt developing on the western side of the volcanic front of the present Izu-Bonin Ridge.
Figure 1. Bottom topography of Suruga Bay and the northern Izu-Bonin Ridge.

Figure 2. Crustal cross-section of the northern part of Suruga Bay (Suzuki, 1987). For locality of the profile, see Fig. 1. The boundary between the cover layer (~5.5 km/sec) and the granitic basement (6.0 km/sec) lies at 10 km depth. STL: Sasayama Tectonic Line, ISTL: Itoigawa-Shizuoka Tectonic Line, KWN: Kawane, ODW: Odawara, HRT: Hiratsuka, OKZ: Okazaku, HOS: Higashiogishima, YMS: Yumenoshima. Position of Section shown in Fig. 1.
2-2 Gulf of California
The Gulf of California stretches for a distance of more than 1,000 km in a NNW-SSE direction between the Mexico mainland and Baja California. The mouth of the bay has a depth of 3,700 m and a width of 200 km (Fig. 4).
The Grenville geosynclinal strata (Late Proterozoic) are distributed here and the structural direction of the bedrock is parallel to the long axis of the bay. Baja California is a mountain range consisting of Cenozoic volcanic rock on the east side and Mesozoic rock on the western side. Mountain range uplifts are Middle Miocene and later (Hoshino, 1998, 2007), and the uplift movement is part of a global uplift movement.

What is interesting about the crustal cross-section of the bay are the 2.90 g/cm$^3$ rock uplifts distributed on the bay axis. The peak of the uplifts is about 5 km below the sea surface. The western side of this rock body is surrounded by the 2.73 g/cm$^3$ geological formation and the base of the 2.73 g/cm$^3$ rock body is 10 km below the sea surface and is horizontal (Fig. 5).

![Figure 5. Structural section across the mouth of the Gulf of California (after Harrison and Mathur, 1964). Density values (2.67, 2.73, 2.90, 3.30 and 3.20) in g/cm$^3$. Position of section shown in Fig. 4.](image)

2-3 Gulf of Aden
The Gulf of Aden has a depth of 5,300 m, a width of 420 km at the mouth and is about 800 km in length (Fig. 6).

Jurassic-Paleogene geological formations with a Precambrian basement are distributed widely on the Arabian Peninsula and in Somalia in the vicinity of the gulf, and Jurassic - Cretaceous formations are distributed along the gulf coast forming rugged mountains with an elevation of 2,000 m. Extensive Paleocene-Miocene flood basalts are distributed on both the north and south sides spanning the gulf. The activity period of this flood basalt coincides with the activity period of the flood basalt in Iceland (Belousov and Milanovsky, 1977), which will be treated next below, and overlaps the period of activity of green tuff distributed in the vicinity of Suruga Bay. It also coincides with the period of volcanic activity in northwestern Mexico.

The crustal cross-section of the Gulf of Aden is similar to that of the Gulf of California. Specifically, abnormal mantle uplift indicating 7.06-7.14 km/sec can be observed at the bottom of the seabed uplift zone on the central axis of the gulf and the 6.15-6.96 km/sec strata indicating the third layer of the crust are distributed on both sides of the uplift, and the bottom of this layer spreads out horizontally 10km below the present sea surface (Fig. 7). This depth is equivalent to the depth of the bedrock in Suruga Bay and to the rock stratum boundary line in the Gulf of California.
2-4 Iceland

Although there are no deep bays around Iceland, old valley topography exists in the flood basalt to a depth of about 10 km extending from the rift belt of the Mid-Atlantic Ridge (Fig. 8). Belousov and Milanovsky (1977) considered this thick accumulation of basalt layers to be the result of the downwarping of the crust and, since the basalt layers are distributed on both sides, the depression was uplifted at the end of the Miocene epoch, thus these basalt layers probably filled in a pre-existing valley. The 10 km depth of the valley is interesting (Fig. 9).
Two assertions have been made regarding the crust in Iceland. Belousov and Milanovsky (1977) contend that the crust in Iceland is thick and that it represents continental crust, while Bott (1983) states that the crust under Iceland is thicker than ordinary oceanic crust but that the component rock and its structure suggest oceanic crust.

Much granite-rhyolite and andesite are distributed in Iceland as xenoliths and intrusive rock. Petrologists, however, consider the origin of this acidic rock to be the product of crystal differentiation (Bott, 1983).

3. Origin of deep-sea bays
3-1 Deep-sea bays, island arcs and oceanic ridges
Deep-sea bays are extensions of island arcs and oceanic ridges and plate theorists consider the origin of the Gulf of California and Gulf of Aden to be the same as the formation of rift valleys due to the separation of two plates at the central ridge. In the case of Suruga Bay, however, no notable rift valley corresponding to the bay exists on the Izu-Bonin Ridge and Suruga Bay is thought to be a submarine trench caused by the subduction of the Izu-Bonin Ridge, which is migrating northward along with the Philippine plate (e.g., Niitsuma, 1987). Since there is a Neogene sedimentary basin with a thickness of about 10 km extending from the Pacific Ocean side to the Japan Sea side along the Fossa Magna tectonic zone in central Honshu with Suruga Bay at its southern extremity, it is not possible to explain the genesis of the Suraga Bay-Fossa Magna sedimentary basin as the result of a collision of the Izu-Bonin Ridge with the southern extremity of Honshu in the Miocene epoch. The current coastal slope in both the Gulf of California and the Gulf of Aden was formed by vertical faults (Normark and Curray, 1968; Cochran, 1981).
Figure 9. Seismic cross-sections across the western flank and the axial zone of the Reykjanes Langlökull zones in SW Iceland. The horizontal and vertical scales are approximately the same. Legend: 1, 2 and 3 – reflectors; 4 – refractors; 5 – refractors probably connected with geological horizons; 6 – inactive fracture zones; 7 – active fracture zone; 8 – body with homogeneous seismic property, probably a region of melting temperature (Bjomsson, 1983).

3-2 Island arcs and oceanic ridges originating in geosynclinal orogenic belts
Meyerhoff et al. (1992) introduced the contention of Haug, Kober and others that the Mid-Atlantic Ridge is a geosynclinal orogenic belt and that samples of old rock have been collected from various locations in the northern part of the Mid-Atlantic Ridge. It is also not possible to explain why St. Paul’s Rock in the central part of the Mid-Atlantic Ridge dates the end of the Precambrian period (835 Ma; Melson et al., 1973) using the plate theory. Hoshino (1991 & 2007) states that the Mid-Atlantic Ridge, Izu-Bonin Ridge and other oceanic
ridges and island arcs on the earth are probably geosynclinal orogenic belts of the Grenville period and, as an example, introduces the fact that Ediacara fauna are distributed in a fault trough in northeastern China (Yang, 1986) extending from the Kyushu-Palau Ridge.

Belousov (1968) divided island arcs into two types with alpine fold belts as the first type (e.g., Japanese archipelago, New Zealand) and current volcanic island arcs as the second type, though what he defines as the second type are, instead, probably fold belts of the Grenville period.

3-3 Oceanic ridge rift belts and orogenic central depressions

Contending that, though rift valleys do not necessarily develop in all uplift belts, rift valleys accompany all uplift areas including oceanic ridges, Holmes (1965) introduced the experimental results of Cloos (1939) demonstrating that orogenic rift valleys are formed by crustal thinning due to the rise of magma diapirism and tearing due to strain. Bhattacharji and Koide (1978; Fig. 10) report similar results of numerical experiments.

The evolution of rift valleys is the result of multiple activities from the Precambrian to the Cenozoic eras (Ramberg and Neuman, 1978). Salop (1983) states that important rift activity started in the Grenville period and, at that time, granitic rock emplacement was active especially in orogenic belts. Bertland (1988) reports that it is repeated igneous activity in the central axis of orogenic belts and that the oldest among them is often granitic rock. In other words, mantle diapirism that forms rift belts is probably plutonic magma originating in geosynclinal orogenic belts. High-velocity seismic wave and high-density rock bodies in the Gulf of California and Gulf of Aden and the 6 km/sec lens-shaped body on the Izu-Bonin Ridge are probably diapiric rock of such rift valleys in late Proterozoic time.

![Figure 10](image.jpg)

Figure 10. A: Elastic displacement vectors (lines) showing the development of a central basin on the valley bounded by normal faults. B: diagrammatic sketch showing various structures that may develop in the brittle and brittle-ductile lithosphere due to progressive mantle upwelling and intrusion of magma (Bhattacharji and Koide, 1987).
Figure 11. Geologic sketch map and schematic columns of the Precambrian outcrop area near Caborca, Sonora, Mexico (de Cserna, 1971).

One of the possible equivalents of the 6.0 km/sec layer beneath the oceanic rift valleys (which is considered to show the erosion phase of “kobergen”) can be found in the northeastern part of the Gulf of California in the vicinity of Caborca, Sonora, Mexico, reported by de Cserna (1975; Fig. 11). The Proterozoic rock strata have been eroded here, covered by sedimentary layers marked by an unconformity dating from the late Proterozoic to the Paleozoic eras. The pebbles that make up this conglomerate at the unconformity were supplied from a location to the west not far from this region and these shallow marine sedimentary layers and lower strata with an unconformity extending from eugeosynclinal belts in central Mexico are pre-1700 Ma quartz monzonite subject to metamorphism by pre-1400 Ma granodiorites, crystalline schist subject to intrusion by pre-700 Ma granite, quartzite and metavolcanic rocks. This bedrock is probably partially uplifted high-velocity rock on the central axis of the Gulf of California discovered through gravity surveys.

Just as the East African rift belt developed in the Pan-African Orogenic Belt and other continental rift belts are developed in orogenic belts subject to numerous fluctuations (Hoshino, 1998), it is thought that, with rift belts on oceanic ridges as well, both sides of the basin were uplifted during the Phanerozoic era when the central axial belt solidified as the result of numerous fluctuations in the Proterozoic era as remnant basins, forming present-day rift valleys.

4. Conclusions
Deep-sea bays are the relicts of mountain summit depressions formed on the central axis of orogenic belts during the Proterozoic era (Grenville period). These summit depressions were created due to the rise of granitic magma diapirism. Repeated granitic magma activity hardened the crust of summit depression belts, forming stable belts by the time of the Phanerozoic era.

Deep-sea bays are extensions of the summit rift belts of orogenic belts of the Grenville period and correspond to the penetrative aulacogens of Milanovsky (1982). The history of deep-sea bays is old and their formation is
not as recent as the Paleogene period or later as asserted by many plate theorists. It goes back to the Late Proterozoic.

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REFERENCES
“GEOTRANS” – A PLANETARY GEODYNAMIC SYSTEM OF TRANSCONTINENTAL ORE-CONCENTRATING ACTIVATION MEGAZONES

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Abstract: This article discusses the planetary geodynamic system – long-active transregional fracture lineaments or megazones which control the position of the largest ore- and oil-gas-bearing regions in the East European platform, the Carpathian-Balkan and Black Sea-Caspian regions. One of the energy sources for periodic tectonic and magmatic activation is the stress produced by changes in the Earth’s rotation. The study of transregional fracture megazones opens up new prospects for the evaluation of mineral potential, the evolution of large deposits and their localization at the dynamic junctions of the fracture megazones. Data comparison with other regions of the world shows the presence of such structures in all large continents. This fact provides the basis for defining the planetary system “Geotrans”, or transregional ore-concentrating activation megazones. Further studies will open up new prospects for finding large and unique deposits. In addition, the high seismicity and exodynamic activity in these areas needs to be taken into account in constructing large objects and preventing catastrophes.

Keywords: activation megazones, ore concentration, East European Platform, new planetary geodynamic system “Geotrans”

INTRODUCTION

In the East European Platform (EEP) of the Carpathian-Balkan and Black Sea-Caspian regions, a planetary geodynamic system, with long-active transregional lineaments or activation megazones, controls the position of the largest ore- and oil-gas-bearing regions (Fig. 1). The region is defined by anomalous geophysical, geochemical and geoelectric, gravity and thermal fields, high exogenous and endogenous activities as well as active seismicity. One of the energy sources for periodic tectonic-magmatic activation is the tensional force created by changes in the rotational regime of the planet (Stovas, 1959). As a result, in these areas, especially when they coincide with “critical parallels”, there is high-gradient tensional field, the presence of which is the necessary condition for the self-organization and functioning of the ore-forming systems. Further exploration of transregional activation megazones, especially in sublatitudinal directions, opens up new prospects for estimating mineral potential, mainly in regard to the strike of large deposits and their localization in the dynamic nodes of activation megazones. The high seismicity and exogeodynamic activity confined in these areas must be taken into account in building large objects and preventing catastrophes. This system is named “Geotrans” – the planetary geodynamic system of transcontinental lineaments (Galetskiy and Shevchenko, 1998).

Mega linear structures extend throughout the continents and the oceans with a length of thousands of kilometers and a width of 100-150 km accompanied by high endogenous and exogeodynamic activity, high and unique ore-richness and a long-lasting history of development – from early Archean to the present.

They exhibit anomalous, high-gradient, geodynamic, geochemical and geoelectric, gravity and thermal fields and are characterized by a concentration of subparallel fractures in narrow zones, key horst-graben structures and deep geological formations: mafic-ultramafic, alkaline and subalkaline, leucogranitic and also various metasomatic masses. The most productive ore- and oil-gas-bearing regions are located on their margins, along with large and unique deposits of various minerals, especially all ores of the nonferrous, rare and noble metals.

Both the diagonal and orthogonal systems are components of the “Geotrans” system, but orthogonal systems, and especially latitudinal zones are mostly exposed.
In the East European platform and structures in the surrounding area, more than 20 similar structures are selected. The main ones are Novgorod-Perm, Northern-Central and Southern Ukrainian, Pechenga-Ladoga, Khibinian, Northern Kola and others.

In this paper we will discuss the system of latitudinal megazones manifested in the south-western margin of the East European Platform, Carpathian-Balkan and Black Sea-Caspian regions and further traced in the whole of the Euro-Asiatic supercontinent in more detail.

MEGAZONES IN UKRAINE

1. Northern and central Ukraine

In the Ukraine territory the phenomenal geodynamic system is selected from three latitudinal transcontinental megastructures (Fig. 2) in the area where most large ore deposits are concentrated (Galetskiy and Shevchenko, 1998). Megazones develop in both the basement and its sedimentary cover, implying continuous tectono-magmatic activation from the early Proterozoic up to Quaternary time. They are characterized by active tectonic faults (fracturing, schistosity of rocks, cataclase, milonitization), endogenous processes and their related ore deposits. They are characterized by a complex, polychronic, and polycyclic character with widely ranging ages and geological structures. The areas where the activation of the mantle is marked are characterized by the irregular behavior of Mohorovičić discontinuity and by the manifestation of deep magmatism with a distinctive alkaline composition.

The Northern Ukrainian megazone is selected initially southward of the 52°N parallel in the north of Ukraine. Further eastward it is traced in the territory of the Voronezh massif, whereas its westward extension reaches Belorussia and Poland. It is an area of faults with an increasing frequency of sublatitudinal strike, about 80 km wide, where gravity and magnetic anomalies extend in a latitudinal direction and the thin crust of 35 km in thickness (as compared to the average thickness of the crust of the Ukrainian shield—45-50 km) is present. On the map of modern motions the zone is expressed by high-gradient areas with high speeds of block motions.

Within the limits of this zone there is the structure bend of the Dnipro-Donets depression in a sublatitudinal direction and further it connects with the Prypiat flexure, whose formation is related to the transcontinental deep sublatitudinal structure development, which took place in the Riphean as a rift. In the said flexures which are filled with Phanerozoic sediments, there are ledges of Precambrian basement (Bragyn ledge, Mykashevychy and Ratne horsts), which testifies to intensive differential motions of a “key type” (like the up and down motion of piano keys) in the Phanerozoic.

The indicated megazone controls the localization of the well-known Perha rare metal field at the junction with the Goryn-Perha zone of the northeast strike (Ukrainian shield); to the east in the Voronezh massif lies the Dubravino apatite deposit in the carbonatites and gold deposit, which are related to the ferrous-siliceous formations (at the node where the northwestern Alekseevka-Voronets and Kursk-Mikhailovka zones cross), and also gold-nickel mineralization, at the junction with the Kalach-Ertyl zone.

To the west of the megazone lies a Lukiv-Ratne horst ore-bearing zone; it has native copper in Volynian traps. Further westward in the territory of Poland, Silesia silver-complex ore fields are located — they have been know and exploited since the early days. In Western Sudeten in the territory of Czechia, a few deposits of rare metals are located, among them the tin-tungsten-lithium Cinovec and the fluorine-lead Harrachov deposit; hydrothermal copper and complex ore-vein-type occurrences with iron, zinc, lead, antimony and arsenic are associated with the granite intrusive massif Karkonosze. Within the limits of the megazone the gold deposits (Jilové and other deposits) of the Czech massif, and also the silver-zinc-lead deposits of Příbram, Kutná Hora and others, are located.

It is notable that oil-gas-bearing occurrences of the Prypiat flexure and Volyn bed are also related to the sublatitudinal structures (Galetskiy and Shevchenko, 1998).

The Central Ukrainian activation megazone is the most considerable and extensive, traced along the 48°N parallel; it is well expressed in aerospace data. It crosses the entire Ukrainian shield and extends westward to the region of the Bohemia massif and joins the ancient core of the Alps; whereas, on the east — to Dzhezkazgan in Kazakhstan (Dzhezkazgan-Balkhash zone) and further to Baikal Lake — lies the Uspensk zone, while in southern Primorye there is the Transbaikalian - Upper Amur zone.
Practically all gold-ore objects in Ukraine (Donbass\(^1\), Carpathians, Ukrainian shield), and also of the Bohemia massif, Prague basin are in the area of influence of the Central Ukrainian transcontinental activation megazone.

At the intersections of the deep fault zones with those in other directions, deposits of iron, manganese, uranium, non-ferrous and rare metals, fluorite and others are concentrated.

Many researchers have noted the connection of ore deposits with these sublatitudinal zones. Belevtsev and Grechishnikov (1975) noted a “sub-latitudinal uranium-bearing metallogenic belt which passes through the uranium-ores province of Czechia” along the 48°N parallel. In the Atabaska Lake district of the Canadian shield, the sublatitudinal Proterozoic zone (250 km wide) is traced; endogenous uranium deposits and the deposits of Beaverlodge Lake as well are confined there.

In 1988 Galetskiy et al. and in 1996 Galetskiy and Nechaev showed the clear structural-tectonic control of gold-ore mineralization by a latitudinal zone not only on the territory of Ukraine but also on the east (Kazakhstan) and the west (region of the Bohemia massif).

The megazone is well manifested in the physical fields, characterized by the anomalous structure of the Earth’s crust and unique occurrence of ores. As a whole all megazones are represented by the increasing frequency of sublatitudinal faults; some of them are traced throughout the Earth's crust. From data on integral conductivity and electric resistances of the lithosphere, the Central Ukrainian megazone acts as a deep structural barrier (which is traced by magnetotelluric sounding up to 80 km depth) dividing the Volyn anomaly of geolectric heterogeneities in the south and the Dnipro anomaly in the north. The area also stands out for its active seismicity; shallow earthquake foci, related to contrasting heterogeneities in the Earth's crust, which are mainly boundaries of sections with different density and high stratification.

Megazones have significant manifestations of mafic, alkaline and subalkaline formations, a variety of dykes and metasomatic masses. The development of dykes of multiple ages distributed in a sublatitudinal direction is of special significance. For example, the Subotiv-Moshoryne zone of the Kyrovohrad block of the Ukrainian shield is saturated by mafic dykes of two age groups: 1) 1700 Ma and 2) 1100-1255 Ma. The Devladiv zone in the Dnieper block is saturated by dykes of mafic and ultramafic Archaean and Proterozoic rocks. In the Ukrainian shield basement the megazone stands out for the morphological stripe of the raised blocks, which are divided by the orographic network of the linear depressions. On the west of the Central Ukrainian zone are the Danube-Czech-Chernivtsi stripe, Bukovyna rise and Bohemia massif. In the Carpathians region the transcontinental megazone is traced through the east Carpathians, uniting with the Balaton deep fracture and dividing the Western Carpathians and the Apuseny massif. The zone bounds the region of Hercynian consolidation from the north, where Mesozoic superimposed depressions are developed. Recently new information about the anomalous structure of the Earth’s crust and influence of the transcontinental Central Ukrainian megazone on the development of such segments in the Prypyat-Dnipro-Donets aulacogen such as Donbass appeared (Kutas and Pashkevich, 2000). The thickness of the Earth’s crust increases here (to more than 60 km), the latitudinal zone with high values of thermal flow was proved, the presence of alkaline-ultramafic intrusives was assumed, and a lens of crust-mantle admixture was confirmed by deep seismic sounding. Kutas and Pashkevich (2000) concluded that a latitudinal zone cut through the structure of the Sarmatia segment of the East European platform and acted as a determining force in forming the paleo-rift and “a region within the crust of Late Proterozoic magmatic activation” (p. 33). It is necessary to add that supposed intrusions here are also located in a latitudinal direction. In the same district, based on Azarov et al.’s (1999) data, in the crust under the main anticline of Donbass, there are permeable electroconductive channels with

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\(^1\) Donbass is Donets Basin, it is a historical, economic and cultural region located on the territory of present-day Ukraine. The name of the region originates from the coal-field discovered in late 19th century, which was named after the Donets River flowing across the region. Donbass is a large synclinorium which is situated between the Voronezh anticlinorium and the Ukrainian shield.
integral conductivity $5000 \, \text{S}^2$. The deposits of mercury, gold, silver and complex ores are located in this anomalous sector – Mykytivka, Bobrykiv, Hostryi Buhor, Zhuravs’ke, and Biliaivka domes (Zemskov and Alexandrov, 1997).

The megazones have a brightly expressed metallogenic look and are notable for their unique ore saturation due to the high endogenous activity and high permeability for ore-bearing solutions. The majority of the largest deposits of the non-ferrous, rare and noble metals, uranium, mercury, and fluorite are concentrated in the megazones. In the Ukrainian shield, deposits of gold in particular are concentrated: Serhiivka, Balka Zolota, Balka Shyroka in connection with granite-greenstone complexes, Klynty, Yurivka in tectonic-metasomatic zones, and Mais’k in diaphoressed metamorphic complexes. The deposits of uranium (Kyrovohrad block) and rare metals are combined with the gold-ore fields (Stankuvatka, Polokhvika, and Shevchenko lithium deposits). Fluorite shows up in regional parts of the shield and surrounding depressions (Volnovakha, Bakhtyn deposits). In the Donbass the zone controls the mineralization of mercury (Mykytivka deposit), gold, silver and complex ores (Bobrykiv deposits, and Hostryi Buhor, Zhuravs’ke and Biliaivka domes) are present; and in the Carpathian-Balkan region mercury (Large Shayan), gold and complex ores (Muzhiievo, Berehovo, Sauliak) occur. In the district of the Bohemia massif we have the gold-ore deposit of High Tauern, a row of deposits in the Kašperské mountains, and the gold-ore field of the Čelina - Mokrsko in the Prague basin.

The Central Ukrainian zone is also oil-gas-bearing. Thus, the saturation by hydrocarbons of the crushed basement is a characteristic feature. On the west, in the territory of Hungary, a group of deposits of North Alföld is located. The presence of oil and gas is connected with a structural high of the Paleogene basement broken on blocks. East of the selected sublatitudinal structure lie the oil-and-gas-bearing areas of Azov and Volga (Astrakhan and others.).

![Figure 2. Transcontinental megazones of activation in Ukraine. Deposits and ore-occurrences: 1 – gold, 2 – uranium, 3 – polymetallic (Cu, Pb, Zn), 4 – hydrocarbons, 5 – rare metals, 6 – fluorite; 7 – boundaries of the Ukrainian shield; 8 – activation megazone: I – Northern Ukrainian, II – Central Ukrainian, III – Southern Ukrainian.](image)

2. Southern Ukraine
We have recently given the same rank to the sublatitudinal transregional zone running along the southern border EEP – **Southern Ukrainian**. The development of this zone is related to the formation of a basement structure and sedimentary cover of the Azov-Black Sea region, Northern Dobruja, foremost Southern Carpathian and Indolo-Kuban flexures, and the latitudinal turn of the South Carpathians. The anomalous...

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2 The **siemens** (symbol: S) is the SI derived unit of electric conductance. It is equal to inverse ohm.
structure of the Earth's crust and the upper mantle, and geothermal anomalies in the region testify to the deep character of the megazone. Throughout the Caspian Sea the oil-and-gas-bearing structural traps line up in a latitudinal direction.

In the Black and Azov Seas oil- and gas-bearing structures are controlled by the sublatitudinal deep fractures (Fig. 2): Sula-Tarkhankut, Holitsyn-Azov, Tendrovsk and others. Oil and gas fields on the shelf of the Black Sea (Holitsyn field), Sea of Azov and Kerch Peninsula (Signalnoye, Kanevskoe, Pryberezhne and other fields) line up by chainlets in a sublatitudinal direction. Further to the east in a sublatitudinal direction the deposits of the Stavropol and Caspian regions lie in the same zone.

In the western territories of Romania, zones of oil and gas accumulation in the foremost Southern Carpathian flexure bending are controlled by the sublatitudinal fracture and folding structures (Bîlteni, Zatreni, and Northern Pitești).

In the south of Hungary, in the selected sublatitudinal zone the deposits of hydrocarbons, related to the ledges of the crushed crystalline foundation, are located (Nagylengyel, Biharnagybajom and others).

The epicentres of modern intensive earthquakes are located at its intersection with the area of the structure bend of Carpathians (Vrancea district).

DISCUSSION
The main purpose of this work is to describe ore concentration in the transcontinental sublatitudinal zones of Ukraine. Therefore, using the published metallogenic maps on the territory of Ukraine and its neighboring territories, in a strip 600 km wide, 12° - 40° meridian, the distribution of the large number of ore occurrences and deposits of gold, uranium and rare metals (altogether 1012 points) was analyzed, and a graph of their distribution by latitude was made (Fig. 3). The latitudinal zone of 49° to 47° 30’ contains 79.8% of all large ore occurrences and deposits. The width of the ore-concentrating structure in this case is about 180 km. Thus, statistical information testifies to the presence of latitudinal belts of concentration of ore elements.

Figure 3. Histogram of occurrence of large gold, uranium, non-ferrous and rare metal deposits by latitude. The maximum ore concentration is shown in red.

Yet Noble (1980) wrote: "The features of placing of ore deposits of North America are in connection with linear zones having deep crust or under-crust location and crossing latitudinal belts of anomalous concentration of metals, arising up to formation of the Earth's crust. I do not have explanation for those processes which form transversal features of latitudinal belts. These belts are hidden, and many deny
their existence. This vagueness must not, however, be used for denying their existence: it only hinders the development of metallogenic science. A correlation with similar researches in other continents is extraordinarily desirable" (Noble, 1980, p. 595).

It appears that latitudinal belts with anomalous metal concentrations as selected by Noble (op. cit) coincide with Favorskaya and Tomson’s (1974) latitudinal and sublatitudinal transcontinental zones controlling mineralization of different types and ages in the North American continent. The latter authors named such zones "through" which are characterized by a transcontinental planetary extension; usually crossing from the continent-ocean border to the bottom of adjoining waters, where they are expressed by the chains of submarine ridges, frames of deep-water depressions, and transform fractures. Traced as fragmentary structures of different ages, they are characterized by high tectonic dislocations and the repeated revival of motions and tectono-magmatic activations.

A series of specific magmatic signs is characteristic for these structures. Among the intrusives and effusives magmatic manifestations of mafic and ultramafic composition prevail, usually of high alkalinity. It is not uncommon for typical alkaline varieties, subvolcanic bodies, suites of dykes and volcanic necks to be developed.

The node pattern of the most active tectonic and endogenous processes within systems is the main feature of the transcontinental systems of dislocations that determine the discrete placing of centers of high endogenous activity and of large ore deposits related to them. It is usually the local nodes of the high permeability, formed by the intersection of faults with different orientations, activated inside the transcontinental systems.

The structural features of the transcontinental systems are determined by geophysical signs: such as the fragments of high gravity and positive magnetic band-pass anomalies, local anomalies, which form the chainlets on strike, linear gradient zones, high thermal flow; the lenses of mantle within the limits of the systems are observed as fragments; on their continuation the epicentres of earthquakes are often located, especially those with deep foci. The transcontinental systems show up in the modern relief and are clearly traced by mophostructure analysis and decoding of space images.

As compared to a regional background the nodes of endogenous activity are marked by contrasting geochemical anomalies.

Favorskaya et al. (1974 & 1985) analyzed the structural positions of large deposits worldwide and concluded that the role of transregional planetary rectilinear zones in ore concentration is multi-event tectono-magmatic activation. These structures were classified into: 1) the first order, represented by the systems of large blocks, thousands of kilometers long; 2) the second order with structures 500 km wide, coinciding with the structures of the first class on strike; 3) the third order with structures 100-200 km wide, and 4) the fourth order, smaller ore-concentrating systems 20-40 km wide.

In terms of classification and geological-geophysical signs, each of three selected and studied sublatitudinal zones of Ukraine belongs to the structures of the second order, and all systems from the three sublatitudinal zones may compose the lineaments of the first-order transcontinental superzone (or superbelt) coinciding with "critical parallels" (Stovas, 1959). It should be noted that trans-sublatitudinal zones of vast extent – tens of thousands of kilometers – are quite common for planet Earth. It suffices to say that the superzones identified in Ukraine proceed through the Atlantic along the Gibbs transform fracture, which displaces the Mid-Atlantic ridge with a latitudinal ultramafic magmatism zone, and finally connect with the systems of latitudinal faults in Canada along the 48°-50° parallel.

In the oceanic area, the deep fractures thousands of kilometers long (in the northern hemisphere – Mendocino, Pioneer, Murray) are traced; in the southern hemisphere a sublatitudinal planetary shear zone is formed by fractures of deep-water ocean hollows: Easter Island, Academician Kurchatov, Sala-y-Gomez, Austral, Agassiz, Valdivia, Diamantina, Amsterdam and others (Kotov and Poletaev, 2000).
In general, the nature of "critical latitudes" remains obscure. It is known that superficial shell of the Earth tends to move in a latitudinal direction, especially the atmosphere and hydrosphere, along with blocks of the Earth's crust (Kotov and Pletaev, 2000). The mechanism of these motions is connected with the rotational regime of the planet and the gravitational influence of the Sun and Moon. The formation of latitudinal planetary flexures is connected with the anomalous state of the physical fields along the critical 46°-48° parallels and the change of geoid form (Zaroslov et al., 2000; James, 2009).

But the planetary sublatitudinal zones are particularly interesting as regards the formation of the highly concentrated ore elements. Metallogenic specialization in activation megazones came to light as a result of statistical analysis. For instance, the Northern Ukrainian megazone is mainly associated with rare metals and copper, the Central Ukrainian with rare metals, uranium and gold, and the Southern Ukrainian with hydrocarbons. It is interesting that the same associations along those latitudes was noted also by Noble (1980).

Such a surprising coincidence can not to be accidental. Consequently, the deep latitudinal (in this case) belts of anomalous metal concentrations can be the source of metals at the surface. This interpretation well explains a variety of geological structures with concentrations of certain minerals, and also polycyclicity in time and narrow localization of ore formation in space.

Modern scientific researches prove the existence of deep belts with high metal concentrations. Based on data from Nalivkina (2000), the evolution of mineralization in the Earth's crust in early Precambrian time saw a growth in its variety, with the change of its inlaid distribution in zones and even more in its localization. Abramovich (2000) writes that the origin of gigantic deposits takes place under the influence of many factors, but the "efficiency of primary concentration of ore component in the asthenosphere channel under influence of lateral gradients of temperature and overlithostatic pressure" is of primary significance. “Thus there is the redistribution of chemical elements and their compounds on the mechanism of ‘mantle separator’ reacting variously to the drop of temperature and pressure, that results in the formation of the high-gradient zones of the enriched areas with one or another geochemical specialization" (Abramovich, 2000, p. 10). The protracted dynamic influence creates considerable volumes of specialized mantle fluids which are transported to the surface along high-permeable zones during the following impulsive activation of the deep crust. The next stage of ore genesis is realized in narrow local space during synchronization of favorable dynamic, physical and chemical, structural and many other factors.

But if there are deep belts with anomalous metal concentrations, such a phenomenon is identified by geophysical methods. In this connection we cite the data from one of Azarov et al.'s (1999) works for gold-ore prospecting which established geoelectric models of gold-ore deposits: In all metallogenic zones considered in their work, ore-forming thermal flows are considered to correspond to permeable conducting channels in the crust, which are elongate and many tens of kilometers in length. Their integral conductivity reaches under the main anticline of Donbass 5000 S; in the Sursk greenstone structure under the Serhiivka ore field the subhorizontal crust conductor (S= 1000S) at a depth of 10-12 km was revealed. The Kyrovohrad zone of the deep fracture on the eastern side of the Klyntsii ore field is located to the west of the known Kyrovohrad anomaly with a conductivity of 3000 S. The Savran ore field is in the most permeable and conducting central part of the Golovanevsk block, where integral conductivity of crustal layers reaches up to 5000 S (Abramovich, 2000, p. 155). The vast majority of these anomalies are located at 10-12 km depth and have a sublatitudinal orientation.

What is the reason for the deep migration of metals and the formation of latitudinal belts with anomalous metal concentrations? One of our models assumes that in the spherical layer of the Earth as a result of rotation an ellipsoid of tension exists, the semi-axis of which is a function of the latitude and depth of the layer, but tensions raised by the changes in rotational regime of the planet are concentrated in the latitudinal belts (called "critical parallels" by Stovas, 1959). The Earth's crust has maximal adaptation to the changes in the figure of the Earth, provided by changes in rotational speed, the tilt of its rotation axis and other factors in a region between the 20° and 50° parallels (48° parallel – critical). It is credible therefore
that, as a result of permanent oscillation (precession etc.) in the position of the axis and a change of rotational speed in the zones, there is a high-gradient dynamic environment which (in accordance with the fluid-dynamic concept of ore and oil formation of Sokolov and Starostin, 1997) sends and concentrates the fluid streams, and possibly, also a deep migration of ore elements in the zones. That is one of factors determining the origin and formation of the fluid systems. A oscillation factor (vibration tectonics – Galetskiy and Shevchenko, 1998), presumably, is not unimportant for the formation of high concentrations of ore elements.

Structural traps are created at higher level, by deformations of different directions and in combination with other factors: by geochemical barriers, by the zones of active cataclase, by screening planes, \[ p-t \] conditions etc.

The conditions for ore formation are created by the cooperative influence of numerous factors – structural, dynamic, geochemical, determined largely by the physical state of matter. External and internal factors exert an influence based on the principle of mutual complementarity, resulting in self-organization of the ore-forming systems. The external factor here is cosmogeneous, whereas the internal is periodic tectonic-magmatic activation of deep shells of the Earth.

Non-linearity of development of geological and ore-forming systems which can be studied from the position of synenergetics is a consequence of the multifactoral nature of the process. A synenergetic model must include the aggregate of factors or processes leading to the formation of ore deposits, including the source of ore-bearing fluids, ore-forming materials, their transportation in the zones of ore accumulation and conditions of ore concentration. Note that the enumerated factors can have independent power mechanisms, but may work together closely. Cosmic factors, resulting in tensions caused by the rotation of the Earth, the presence of primordial heterogeneity in the planet’s shells, the regularity of the evolution of the Earth’s planetary shells in connection with endogenous energies, account for the regularities in the manifestation of impulsive activation of the deep crust, and planetary metallogenic impulses must be taken into account in any model.

Krats and Sokolov (1980) presented for the first time the concept of metallogenic impulses in the endogenous activity of the lithosphere: Its main essence is that the activation of structural-material complexes is a function of a very narrow time interval, by comparison with the protracted epochs of tectogenesis in the early Precambrian, and independently includes all rows of ore-bearing structures. Metallogenic impulses are correlated synchronously with the short time impulses of deep petrogenesis. Thus, from geochronologic data the concrete periods of high endogenous global and local activation of the deep crust can be known.

One of the intensive maxima of tectono-magmatic activation was in the period 1.9 – 1.7 billion years ago. These data were confirmed by research carried out by Ukrainian geologists, who selected the same time interval (1.8 – 1.6 billion years) of the metallogenic epoch related to activation and rift genesis (Gurskii et al., 2000; Scherbak and Grinchenko, 2000), the process of which is illustrated as follows: Planetary alteration of deep crustal structures and the appearance of a new spectrum of magmatic structures from mafic, acid, subalkaline and typical alkaline, which, cooperating with the deep planetary belts of metallic concentration, became the sources of ore-bearing fluids and mineralized solutions.

Thus, three main factors which have different origins but interact closely form the basis for the synenergetic model of the ore-forming system of activation epochs:
- pulsating tectonic-magmatic activation of the deep Earth crust;
- presence of deep planetary belts of metallic concentration (possibly with other deep sources in which activation takes place);
- presence of a high-gradient dynamic environment and structural-tectonic conditions for ore concentration.
CONCLUSIONS

It seems to us that the appearance of the examined planetary system of transcontinental fractures is a result mainly of rotational tectonics (Stovas, 1959; Galetskiy and Shevchenko, 1998). Relief of the accumulated tensions eventually results in the formation of a regmatic planetary network of fractures, each becoming active periodically. This appears to be an irreversible deformation process, which is especially peculiar to latitudinal zones — the so-called critical parallels.

Because of permanently oscillating tectonics there is periodic activation of these zones and there is a long-lived high-gradient dynamic environment; that is one of the determinatives for functioning of hydrotherms and fluid systems, which in the turn allows rich deposits to form.

The high-gradient tectonic field of tensions directs and focuses mineralized streams and creates geodynamic, geoelectric and geochemical barriers for ore and oil and gas accumulation, as ore formation is a multifactor process, the presence of a long-active high-gradient dynamic environment is the necessary condition for the self-organization and steady functioning of the ore-forming systems.

Thus, the “Geotrans” geodynamic system of transregional lineaments is of multifunctional importance:

• represents a new unique type of geological structure of general planetary importance, protracted development (from Precambrian to Cenozoic), penetrable in the most varied formations – from Precambrian shields to the Alpine fold belts and even modern deposits;
• produces the largest, unique deposits of minerals, both ore and nonmetals, oil and gas;
• possesses high stratification of the Earth’s crust and seismic activity;
• increase in exogeodynamic activity resulting in development of landslides, karst, suffosion;
• high speeds and gradients of modern tectonic motions;
• anomalous thermal fields of the Earth’s crust;
• anomalous streams and compositions of underground waters and processes of impoundment by the ground waters;
• development of geopathogenic zones.

Further study of these new types of structures is undoubtedly required. They should be taken into account when searching for new deposits, when planning and building large industrial-agricultural projects, when securing the water-supply, when choosing disposal sites for radioactive and toxic wastes, in preventing natural and technogenic catastrophes, and in providing safe vital functions and ensuring human health. Comparison of data from other regions of the world shows the presence of structures of the same type in all large components. It provides the basis for defining the “Geotrans” general planetary geodynamic system of transregional ore-concentrating activation megazones.

The study of the regularity of development of synenergetic geological processes in time and space will result in new discoveries and new explanations for many paradoxical phenomena.

References

Rotational tectonics is the relaxation of stresses which occur in the Earth’s crust as the result of changes in the Earth’s axial tilt and speed of rotation.
Regmatic planetary network of fractures is the system of faults the formation of which is connected with stresses or with rotation of the Earth or local redistribution of stresses through tectonic motions. It is the result of the passive or constrained lithosphere’s reaction to the influence of external (rotation parameters) or internal forces and processes occasionally of different age and orientation (Nagahama, 1997).
COMMMENTS AND REPLIES


COMMENT:
There have been quite a few "lights" (called Min Min Lights) in the Boulia area of Queensland, Australia (as I might have mentioned previously), but no earthquakes are registered there in the last few decades. The Qld Geol. Survey radiometric map of Queensland does show something strange ending up in the Boulia area. (I can't interpret it, however.) Perhaps it is worth watching there for further Min Min lights, etc. On ground temperature rises, I got a response from a farmer at Beacon, Western Australia, who said that he was the closest land owner to where the swarm of 60+ earthquakes took place in two days, at the end of January this year (2009). He said he did not have any rise in ground temperatures. So? Maybe the events were too small?

Peter James

REPLY:
Your query is really stimulating. Before we actually manage to formulate a well-defined pattern for the forecast of earthquakes, I think it is important to detect the different signals sent by the Earth, even though not just geophysical, useful for the forecast of seismic hazard. The local temperature increase in the would-be epicentral area during the days preceding the earthquake is one such signal.

For a few years now I have also been focusing my investigation on possible relations existing between the local temperature increase owing to tectonic stress and the vegetation. On 25 June last, at an International Conference about the Soil held in Imola (Italy) and organised by the Universities of Bologna, Athens and Lyon, I had the opportunity of speaking about the possible relation between temperature accumulation in the soil (which is also responsible for microclimates) caused by tectonic strain and the energy released by minerals under stress, the electromagnetic fields and local vegetation. In the course of the discussion I was given the chance of reminding two strange phenomena I had recorded photographically in the heart of the seismic area of the Apennines in the province of Parma referred to as the River Taro Line, in Fall 2006 and Winter 2007, respectively. The former was the blossoming of a pear tree (which generally occurs in March and April) at an altitude of 500 metres asl, and the latter was a field of ripe corn under the snow at over 750 metres of altitude: the pear tree in blossom out of season, the corn under the snow (see picture below) and gathered by a farmer. Such an investigation might also be applied to the farm you mentioned in your letter, to check if such relations could exist.

As far as the time lag between the appearance of lights and the seismicities is concerned, in NCGT Newsletter no. 44, I suggested that the interpretation pattern could be the so-called “Heel & Point” mechanism which, for the North-western Apennines of Italy corresponds to about fifty days. This datum could be checked for Queensland too, and the time lag between the two events might be to some extent explained.

With reference to the genesis of lights in the atmosphere I found an unpublished report which clearly explains the relation between weather changes and the appearance of balls of light. At least as far as the Italian Apennines and the Norwegian Hessdalen Valley are concerned, the mechanism should be linked to soil lifting phenomena. To answer your question, I think that whatever the earthquake triggering mechanism (and focal depth) could be, the evolution of crustal stress must have been very rapid, so as to impair the accumulation of thermal energy in the soil, to be recorded on the surface, as can be inferred by the relevant sequence of seismic swarm that followed the main shock.

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**BOOK REVIEW**

**HABITS OF EARTHQUAKES**
– When and where do they form and where do they transmigrate?
   Why can plate tectonics not predict earthquakes? –

*Fumio TSUNODA*: Prof. Emer. Saitama University, Japan. tsunochan@sky.email.ne.jp

This small book, published in Japan in late August 2009, proposes a new interpretation of earthquakes, totally different from the plate-subduction earthquake stories taught hitherto. It targets both the general public and specialists as well as those living in constant fear in the earthquake-prone Japanese islands. Therefore it is written in simple language.

The book presents exciting, well-founded accounts of earthquakes in terms of their formation, thermal energy migration and occurrence based on geological structures and mantle tomography – many of them are already familiar to readers of *NCGT Newsletter*. The ramifications of his ideas are far reaching, and I believe they will lead to the establishment of a viable scientific method of earthquake prediction. That is why I am introducing this book to NCGT readers, focusing on the first three chapters: Habits of occurrence, structures of the Earth, and energy transmigration paths in East Asia.

The book starts with the question, “Why are earthquakes not forecastable while weather is?” The cover asks: Why can plate theory not forecast earthquakes? He questions why the plate-subduction earthquake, known as the Tokai-oki (offshore Tokai) earthquake, long predicted by authoritative Japanese earthquake researchers (who have spent hundreds of millions of dollars of taxpayers’ money on its “prediction”) has not occurred, and asks how plate subduction can trigger the catastrophic Sichuan earthquake in May 2008, several thousand km from the alleged plate subduction site. He then describes the process of quietly abandoning a plate-tectonic earthquake model for south Kanto, central Japan, by the Japan Earthquake Forecasting Committee in 2004; these days the NHK, a national Japanese television station, does not present plate-tectonic explanations after earthquakes any more. The plate-tectonic earthquake model has already been discredited in Japan.

His earthquake model can be summarized by the following two figures (Figs. 2-3):
Fig. 2. Thermal structure model under the Pacific.

Fig. 3. Gigantic volcanic eruptions and earthquakes in the western Pacific margins. High-temperature zones (thermal energy transmigration routes) are indicated.

As seen in these figures, he contends that thermal and electromagnetic energies originating in the core transmigrate upward into the lower to middle mantle and move horizontally in the upper mantle along fractures. He calls this gigantic mushroom-shaped energy flow channel a “superplume”. This heat causes the expansion of the mantle under the crust, which results in the movement of overlying block-faulted crust. Thus earthquakes tend to occur along the boundaries of crustal blocks.

Tsunoda points out the close relationship between volcanic eruptions and earthquake occurrences (his VE process), because both are derived from the same source – energy originating in the core and carried through the “superplume”. Therefore the activity of the superplume is directly related to that of the VE process. He suggests that the electromagnetic microwaves discharged from the outer core through the
superplume stimulate the magma chambers and activate partial melts in the mantle; this triggers volcanic eruption and earthquakes. The scenario can be likened to a microwave oven used in our homes (Fig. 4).

Fig. 4. Earth as a microwave oven. Electromagnetic waves stimulate and activate the partial melts and magma chambers in the mantle.

His earthquake model is consistent with the Earth’s history since its birth as shown below (Fig. 5), which I consider is well supported by mounting hard data.

Fig. 5. The 4.5 Ga history of the Earth.
The second half of the book describes the three VE migration paths, Mariana-Japan (MJ), Philippine-Japan (PJ) and Sumatra-China (SC) routes (Figs. 1 & 3), and the movement of VE processes with convincing earthquake and volcanic data analysis. One of the examples demonstrated in the book is shown below (Fig. 6).

Tsunoda’s grand scheme has been developed from his own meticulous field work in the Japanese islands, and earthquake and tectonic studies by himself and other NCGT members (many of which have appeared in NCGT Newsletter), supported by mantle tomographic images. It builds on Meyerhoff et al.’s (1992) surge tectonics and Blot and Grover’s thermal energy transmigration (ET) concept (Grover, 1998). The book shows the right direction for future earthquake studies. He repeats the importance of understanding unique local earthquake characteristics in occurrence and ground vibration pattern (which he calls habits), an emphasis made by his mentor, the late Prof. Yukinori Fujita.

Tsunoda is one of the key members of the NCGT Japan group. The book is the culmination of his life-long work on tectonics supported by our past 12 years’ struggle for establishing a new global geodynamic paradigm. Certainly a change in tectonic paradigm is unmistakably occurring. I would like to congratulate Prof. Tsunoda on publishing this monumental book. I hope that the entire book will be translated into English so that it will reach a global audience.

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References
Reduction of the radius and heat losses within the Earth and other planets in light of recent data


Abstract—A reduction in the radius and considerable variations in the volume, surface area, mass, and average density of the earth were calculated from amplitudes of the Precambrian and present-day surface relief. Over a period of 4 Ga, the overall reduction in the Earth’s radius from heat and mass losses was determined to be 52 km or $1.30 \times 10^{-3}$ cm/year. At the same time, the gravitational contraction of the radius was estimated to be 52.0 km or $1.30 \times 10^{-3}$ cm/year as well. A good correlation between the epochs of global cratonization of the Earth’s crust and the reduction in the sphere volume was established. The inverse problem of calculating the heat flow from the gravitational contraction of planets was solved. The theoretical value for heat flow on the Moon’s surface ($1.7 \times 10^{18}$ J/year) is comparable to that measured by American astronauts ($1.9 \times 10^{18}$ J/year).

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On the ring-like arrangement of faults accompanied by shallow and deep earthquakes in central Honshu, Japan (Part 1)


Abstract. The faults accompanied by shallow and deep earthquakes are deduced from P-wave radiation pattern of the earthquakes occurred in central Honshu, Japan. The strikes of faults accompanied by earthquakes are defined definitely when the strikes of two nodal planes run parallel each other, and the faults are normal or reverse without strike-slip component. When two nodal planes are composed of steep and gentle ones, the steep nodal plane might be the fault plane as it runs parallel to the strike of faults of dip-slip type in the neighboring areas.

The ring-like arrangements of faults for both shallow and deep earthquake are shown in the area composed of the south part of Tohoku district and the north part of Kanto district. The area is about 200 to 300km in width.

The ring-like arrangements of faults for both shallow and deep earthquakes are observed in the area composed of the south part of Kanto district, Chubu district and Kinki district. The area is about 200 km in the north-south direction and 450 km in the east-west direction. The rectangular arrangement of faults accompanied by shallow earthquakes is observed in the Kii Peninsula. It is about 100 km in width.

The parallel arrangements of faults for both shallow and deep earthquakes seem to suggest the vertically deep roots of those fault patterns. It might suggest the control of deep faults along which the shallow earthquakes tend to occur near the epicenter of deep earthquakes at the same active period. The aseismic area between shallow and deep seismicity might be due to its ductile physical property.
General trend of faults deduced from P-wave radiation pattern of shallow earthquakes in relation to topography in central Honshu.

General trend of faults deduced from P-wave radiation pattern of deep earthquakes in relation to topography in central Honshu.

Successive occurrence of shallow and deep earthquakes in the Echigo and Ashio Mountains including their surrounding areas in northeast Honshu from 1926 to 1971.

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**ABOUT THE NCGT NEWSLETTER**

This newsletter was initiated on the basis of discussion at the symposium “Alternative Theories to Plate Tectonics” held at the 30th International Geological Congress in Beijing in August 1996. The name is taken from an earlier symposium held in association with 28th International Geological Congress in Washington, D. C. in 1989.

**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 of earthquake data, 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.