Geotectonic hypotheses at the beginning of the 21st century

Carol Strutinski, Rodica Stan
Geological Institute of Romania, 3400 Cluj-Napoca 1, POB 181, Romania
Adrian Puşte
'Babeş-Bolyai' University, Dept. of Mineralogy, 3400 Cluj-Napoca, Romania

Introduction

In this short contribution in honour of Ott C. Hilgenberg it is not intended to give an extended state-of-the-art of geotectonic hypotheses at the beginning of the 21st century. Instead, in a more or less subjective manner, only those hypotheses better known to the authors will be reviewed.

The complexity of geological processes, their long duration and the impossibility to observe directly, let alone to reproduce in the laboratory, all those phenomena taking place in the interior of the Earth make it extremely difficult to state the physical-chemical laws ruling them and to work out sound geotectonic hypotheses. In this respect it is illustrative that we are still limited to literacy for describing the hypotheses, instead of using 'numeracy,' as Carey (1988) calls it. This clearly shows the peculiarity of geological science, that continues to be, even at the beginning of the 21st century and despite some geophysical modelling, rather qualitative than quantitative. Should it remain so in the future, asks Carey (1988)? And he answers:

> 'Of course not. Because of the wide spectrum of interdependent variables inherent in it, geology should profit more than most other sciences from vast computing capacity. But broad training across the board and thorough experience in observing real rocks in the field is even more necessary than before.'

Continental drift hypothesis

Irrespective of how multifarious the data, how complex the reasoning that forms the basis of a scientific hypothesis, almost always there is a primordial observation that acted as a crystallizing germ for it.

For the drift hypothesis of Wegener as well as for plate tectonics and the Earth expansion hypothesis this crystallizing germ was obviously the same: the similarity of shape of the opposing African and South American coasts, also known as the South Atlantic or the Bullard fit. Even so this is not a truly geologic fact, it has far-reaching geotectonic implications, arousing the imagination of numerous scientists of the past, beginning with Francis Bacon.

From Scalera, G. and Jacob, K.-H. (eds.), 2003:
Why expanding Earth? – A book in honour of Ott Christoph Hilgenberg. INGV, Rome, 259-273.

It was, however, Wegener who worked out the first well-founded hypothesis about this fit, published in his treatise *Die Entstehung der Kontinente* (1912). According to Wegener, the sialic continents float freely on their simatic ground, something like icebergs on the sea. The direction of their drift is chiefly ruled by the Earth rotation and the distribution of mass between the poles and the equator. Wegener started from the assumption of a unique landmass, Pangea, being surrounded by the primeval ocean, Panthalassa. By the end of the Paleozoic the precession forces, triggered by Earth rotation, succeeded to tear off the Americas from the supercontinent and make them drift west, through the ocean-like upper mantle. In their wake the Atlantic Ocean opened, whereas on their frontal side they suffered compression, giving birth to the folded chains of the Andes and Cordilleras. At about the same time, due to a force called *'Polflucht'* (pole-flight), Eurasia and Gondwanaland collided in the equatorial region, building up the Alpine-Himalayan chain.

This hypothesis, by which Wegener also tried to explain the opening of the Indian Ocean, failed to get general acceptance, his opponents objecting that the mechanism imagined by him was fictitious, bare of any sound physical basis. Besides, it has been argued that the fit across the Atlantic is by no means as perfect as it should be. In his latest refinement of the hypothesis, Wegener admitted, accordingly, that the separation between Afro-Eurasia and America was not clear-cut, some continental splinters being torn off and left behind the eastern side of the American continents during their westward drift. These splinters were then drowned by the ocean waters.

Plate tectonics

After decades of almost unanimous ridicule and rejection, the continental drift hypothesis was reconsidered by the end of the sixth decade of the last century and finally rehabilitated officially in 1964 on the occasion of the Continental Drift Symposium held at the Royal Society of London. The latest results of marine geology brought about the change over. A world-wide net of mid-oceanic ridges had been discovered and thereafter the hypothesis of ocean-floor spreading was launched (Dietz, 1961; Hess, 1962). This hypothesis became the cornerstone not only of plate tectonics, but also of the Earth expansion hypothesis. According to plate tectonics, continents are no longer drifting through their simatic basement, as imagined by Wegener, but take part in the build-up of lithospheric plates, some 70 to 100 kilometres thick, that are carried like rafts on the rear of horizontal currents, supposed to operate in the asthenosphere. These are thought to belong to a global system of convection currents that recycle the whole mantle. Ascending branches reach the asthenospheric level under the rifts of mid-oceanic ridges, partially penetrating to the surface, where they contribute essentially to the formation of new oceanic crust. The rift zone is considered to be the place where two adjacent lithospheric plates are actually growing being fed from below, and at the same time removed in opposite directions by the horizontally branching asthenospheric currents. From here it follows that the dominant stress in the rift zone should be tensional, and that the oceanic crust, including the sedimentary veneer, should continuously age away from the rifts. In order to prove this, an ambitious Deep Sea Drilling programme was carried out, particularly across the Mid-Atlantic Ridge. At a rough approximation, the results seemed to confirm the expectations. However, some remarkable anomalies occurred, that throw some doubts on the validity of the model. Thus, directly on the ridge crest or in its near vicinity significantly older rocks were recovered, a situation at variance with the sea-floor spreading hypothesis (Meyerhoff *et al.*, 1992; Storetvedt, 1997; Pratt, 2000). These facts have been explained away or underestimated by the different scientific crews that supervised and interpreted the drillings, and it is suspected that, at least in part, this happened in order to 'save' the programme from being abandoned. As a matter of fact, this is a policy often pursued by scientists to 'convince' their financiers that their expectations, on the ground of an 'established' theory, were right, in order to keep the funding open. Investors do not like to spend their money on unpredictable experiences, you know! Therefore it is fully understandable that, from the plate-tectonics standpoint, the evidence of very old rocks on both flanks of the Mid-Atlantic Ridge must be rather disturbing and that 'despite the crucial importance of further clarifying these findings no recent effort in this direction has apparently been attempted' (Storetvedt, 1997). Likewise, it is highly improbable that, under the present plate-tectonics auspices, additional (and not very little) money will be spent 'to drill the ocean floor to much greater depths to see whether there are more ancient sediments beneath the basalt layer that is currently – and conveniently labelled *basement*' (Pratt, 2001).

Plate tectonics expectations regarding ocean-floor spreading were considered to have been verified also by the apparent stripe-like pattern of magnetic anomalies that run parallel to ocean ridges. The anomaly bands have been interpreted as being created due to paleomagnetic polarity reversals. Carey describes the inferred process:

'As basalt, newly injected into the axial rift zone of a spreading ocean ridge, cooled through the Curie point, it became magnetized by the prevailing field. During times of normal polarity, the new basalts would be normally magnetized, but when in due course the polarity reversed, the following new basalts would be reversely magnetized until the polarity flipped again, perhaps a million years or so later. Because the rift progressively widened with new basalt consistently taking the path of the least resistance, splitting the most recently preceding basalt, the spreading strips on opposite sides of the rift should be in mirror image. Vine (1966) proceeded to show that this was indeed so, in perhaps the most elegant geological demonstration I have ever seen (Carey, 1988).'

Anyhow, some others seemingly were not impressed as much by that demonstration (Storetvedt, 1997; Pratt, 2000, 2001). And Storetvedt stresses the tight correlation of magnetic stripes with topography, hinting to the possibility that the anomaly pattern may not be associated at all with geomagnetic polarity reversals.

'Instead there is a distinct possibility that the magnetic anomalies may be the consequence of a fault-controlled ridge-parallel topographic grain (Storetvedt, 1997).'

Another fact that should remind to caution is that in some cases the width of bands of magnetic anomalies is not proportional to the duration of the geomagnetic epochs. Pratt (2001) calculated that the length of the Brunhes, Matuyama and Gauss epochs have the ratio 1.0:2.4:1.6.

'However, on the Reykjanes Ridge, the distances between the anomalies closest to the axis have the ratio 1.0:0.5:0.4. An equally great breach of proportionality is observed on the East Pacific Rise (Pratt 2001).'

One feels also strange about plate-tectonics reasoning, by learning that the spreading rate of one of the most active ridges on Earth, namely that on and near Iceland, should be, according to the magnetostratigraphic time scale, only 1 cm/a, whereas a volcanically highly inactive ridge, like the East Pacific Rise, is credited with expansion rates of 10-12 cm/a. These spreading rates have been extrapolated for relatively long geologic periods and are not considered to be accidental.

That linear magnetic anomalies along the East Pacific Rise cause serious difficulties for interpretation has been remarked also by Milanovsky (1991). According to him, the great width of the East Pacific Rise may not be connected with the inferred high rate of Cenozoic spreading, but

'[... ...] with its diffuse nature, *i.e.* with the presence within this belt of several (up to three ...) spreading zones mutually parallel and partly diagonal and almost transversal to each other ..., [working] alternatively and sometimes nearly simultaneously.'

Another tenet of plate tectonics is the assumption that along the divergent plate boundaries tensional stresses prevail. However, as noted by Dickins and Choi (2001), who are relying on a compilation of earthquake data by Zoback *et al.* (1989), 'spreading' ridges are generally under compression, tensional earthquakes associated with them being rather rare. Compressive activity is associated also with the East African Rift system and the Rhine Graben, that are likewise considered in the plate-tectonics framework to represent zones where active extension occurs.

In order to maintain the Earth's radius constant, the hypothesis of plate tectonics assumes that the creation of new crust along mid-oceanic ridges must be compensated by the swallowing of old crust along the so-called subduction zones, that run parallel to continental margins or island arcs. This, however, implies that the asthenosphere, moving as part of the mantle convective system, should act as a conveyor belt, transporting the lithosphere from the place of its generation (oceanic rift zone) to that of its burial (oceanic trench). This simple model does not satisfactorily work even under wholly oceanic plates, not to mention mixed plates, consisting of oceanic and continental crust. This is because seismic tomographic studies have clearly demonstrated that the asthenosphere, *i.e.* the conveyor belt, is missing at least beneath continental shields. Moreover, sub-horizontal flow at asthenospheric levels in the predicted direction of plate motions should easily be revealed by regionally consistent seismic anisotropy patterns, which has not been observed (Silver, 1996). But the supporters of the hypothesis still defend their creed, interpreting seismic tomographic studies in their own way, trying to demonstrate – against verified physical principles – that diapirism may function upside down, *i.e.* that the lighter lithosphere ($\rho < 4$ g/cmc) is capable to penetrate through the heavier mantle ($\rho > 5$ g/cmc), right down to the mantle/core boundary, where the subducted plates finally come to rest, in what is called the 'graveyard of slabs' (Van der Voo *et al.*, 1999).

A diversity of opinions exists among plate-tectonics opponents as to how Benioff zones should be interpreted. However, almost all of them admit that these features have nothing to do with swallowing of oceanic crust and that subduction is merely a myth (Carey, 1976; Meyerhoff and Meyerhoff, 1977; Pfeufer, 1981; Wezel, 1986; Strutinski, 1990; Milanovsky, 1991; Storetvedt, 1997; Choi, 2000; James, 2000; Pratt, 2001; and others).

Earth expansion hypothesis

The quintessence of the Earth expansion hypothesis is that newly created crust, particularly along mid-ocean ridges, is not compensated elsewhere by subduction, and that, as a consequence, the Earth is exponentially increasing its volume. As already mentioned, the starting point for this hypothesis was the striking similarity of shape between the African and South American coasts across the Atlantic. Hilgenberg, to whom this volume is dedicated, was apparently the first who assembled the continents, without intervening oceans, on a globe a little less than two thirds of the diameter of a reference globe (Carey, 1976). His book, *Vom wachsenden Erdball* (1933), which he dedicated to Wegener, met with meager approval under the then ruling Earth contraction hypothesis. Further developments of the hypothesis were due to Egyed (1956), to the 'globemakers' Brösske, Barnett, Creer and Vogel (Vogel, 1983), and particularly to Carey. His book, *The expanding Earth* (1976) became the reference work in the field, still largely ignored by the followers of the 'theory' of the day. For one of the present authors (C.S.) it was, however, a revelation, that decisively left its mark on the evolution of his geological thinking, though he gradually departed from what could now be termed as 'classical' expansionism. Yet, the work of the patriarch from Tasmania has, nevertheless, been continued through the contribution of an ever growing number of scientists, as for instance Luckert (1979, 1999), Scalera (1988, 1990, 1998), Maxlow (1998, 2000), Hoshino (1998). Some authors agree only partially with Earth expansion, admitting at the same time the reality of the subduction process (*e.g.*, Shields) or supposing that expansion phases are cyclically followed by contraction phases (*e.g.*, the 'pulsating Earth' hypothesis of Milanovsky, a.o.).

The expansion hypothesis is fundamentally a fixist hypothesis, assuming that the lithosphere is welded to its underlying mantle. From here it follows that under mid-oceanic ridges not only new lithosphere is created, but also its corresponding upper mantle tract, and that, essentially, the movement is not, like in the plate-tectonics model, horizontal, but radially outward, *i.e.*, vertical. Yet, according to Carey (1988), this is a process taking place on a global scale, being not restricted only to oceanic spreading zones. In his view, orogens are also expressions of Earth expansion, where

> '...[the motion] is upward at all stages... Orogenic zones, like oceanic spreading ridges, are fundamentally widening zones; indeed, where the rate of extension in the mantle below an orogen increases enough, it becomes an oceanic spreading zone.'

Continental arcs and island arcs bordering the Pacific are also regarded as zones of expansion. They are different from intra-continental (orogenic) and intra-oceanic (spreading) zones by their striking asymmetry, which is due to their peculiar position, along the boundary of two different types of lithosphere. Thus, in Carey's model of orogeny almost all structures, attributed by plate tectonics to compression, are originated by a forceful moving up of mantle diapirs, in combination with gravity spreading.

However, other expansionists do not share this view. Thus, Maxlow (1998) considers the 'radial expansion' concept to be rather unprofitable in attempting to explain orogenesis, as the opponents of the expansion hypothesis all agree that radial expansion would rather prevent than create tangential movements of the sort which build mighty orogenic belts. He emphasizes, on the contrary, the asymmetry of the expansion process, which gives rise to both tangential and radial vector components. For Maxlow, 'this process, in conjunction with relief of surface curvature, is considered to be the primary mechanism for continent to continent interaction during exponential expansion, resulting in orogenesis.' However, Maxlow does not insist on this topic.

Carey is also aware of the asymmetric expansion, which grossly divides the Earth into a land hemisphere and an oceanic hemisphere. He assumes that complex interaction of gravity, rotational inertia and asymmetric expansion are responsible for the generation of two global megashears, or 'torsions', crossing each other at right angles and acting simultaneously, particularly during the Late Cretaceous and the Paleogene. The sinistral 'Tethyan torsion' has been generated in a sub-equatorial position, while the complementary dextral torsion approximately corresponds to the Pacific perimeter. At their intersections they 'produce the contused areas of the East and West Indies' (Carey, 1988). These assumed megashears of the crust are, perhaps, the most mobilist elements within the Earth expansion hypothesis. However, according to Carey, they are not really involved in orogenesis, except for contorting and 'contusing' otherwise straight orogenic belts generated, or, at least, initiated tens of million years before.

Apart from an all in all unconvincing interpretation of orogenesis, the Earth expansion hypothesis faces the same problem, which plate tectonics is confronted with, *i.e.* the existence of older than assumed sedimentary, magmatic and even metamorphic rocks in different parts of the oceans, which are questioning 'traditional' views of sea-floor spreading.

Surge tectonics

What kind of observation might have been the crystallizing germ for surge tectonics is unclear. Anyhow, the above mentioned existence of old rocks in the oceans, wherein hypotheses discussed in the previous sections require a systematically decreasing age of the ocean floor from the margins (where the age should not exceed 200 Ma) to the mid-oceanic ridges (0 Ma), largely contributed to create this alternative model to plate tectonics. However, it is not only adverse to plate tectonics, but also to expansion tectonics, as it disagrees with both subduction and ocean spreading. Another important keystone of the evolving new hypothesis was the statement that the asthenosphere *surges* (1) from beneath the Asian continent, (2) between North and South America, and (3) between South America and Antarctica, to produce the eastward-facing island arcs in those three regions (Meyerhoff and Meyerhoff, 1977). The hypothesis was finally worked out by a number of scientists grouped around the Meyerhoffs, father and son (Meyerhoff *et al.*, 1992; Meyerhoff *et al.*, 1996). In a way, it may be viewed as the resurrection of the contraction hypothesis because its fundamental principle is Earth contraction, due to cooling.

This cooling maintains the mesosphere (called by the adherents of the hypothesis strictosphere or stereosphere) in a state of tension and the lithosphere in a state of equiplanar, tangential compression. These oppositely stressed 'spheres' are separated by a 'level of no strain,' the asthenosphere. The motor of all Earth dynamics is seen in the interaction between these 'spheres.'

Very important in the substantiation of the hypothesis were the findings that in all active tectonic belts, whether compressive or tensile, (1) long linear fault and fissure systems, (2) bands of elevated heat flow, and (3) corresponding bands of microearthquakes occur, all of them running rigorously parallel to the belts. These features, along with some others, all suggest, according to the proponents of the hypothesis, that 'something is moving horizontally at fairly shallow depths' beneath such linear zones. This 'something' is believed to be channeled fluid or semifluid magma. From here it is concluded that the whole lithosphere is penetrated by a network of horizontal magma conduits, termed *surge channels*, which are periodically fed up by the underlying asthenosphere. These channels are arranged hierarchically, the most important of which being the trunk- and feeder-channels, respectively. Within this network the general tendency of the magma is to migrate from west to east. The flow creates all the linear structures observed on the surface, which are interpreted to be traces of the streamlines of such a flow. At times of surge channel collapse, due to disequilibrium between a continuously shrinking mantle and its lithospheric roof that is forced to sustain steadily growing stresses, magma is poured up and outward, while foundering lithospheric segments undergo distortion (crumpling, folding), thrusting and rifting. This is how tectogenesis (including orogenesis) works, according to surge tectonics.

The surge tectonics hypothesis seems not very well ripened, in spite of the frequently invoked physical laws, which the model is said to obey. Linear structures on the surface, even accompanied by bands of high heat flow, do not necessarily witness channeled horizontal flow in the basement, particularly if this involves fluid magma. Also, the generation of an Earth-encircling interconnected network of magma channels is highly problematic, the more so as, according to the model, this network is almost totally destroyed during a tectogenetic climax and has to be, cycle by cycle, re-created. Although subduction is rejected as a process of lithospheric swallowing, Ampferer's *Verschluckung*, *i.e.* engulfment of hundreds of kilometers of crust, is, nevertheless, admitted. Large-scale lateral displacements along strike-slip faults or megashears are considered 'unlikely;' crustal sectors supposed to be missing along such alignments are interpreted as *verschluckt*.

An obvious paradox of this hypothesis is the fact that, notwithstanding the great amount of lateral movement implied by the magma surges, no such movement is transmitted to the upper crust. This rests practically at the same place, being only 'crumpled' downward, in accord with the contraction assumption. From this point of view, the model is diametrically opposed to the expansion model, in which movement is almost exclusively up. Yet, both models are truly fixistic. The analogy goes even further, both hypotheses trying to explain evidently different features like mid-oceanic ridges, island-arc environments and orogenic belts by a unique process, be it lithosphere collapse or, on the contrary, mantle diapirism.

However, the explanations, although unconvincing, do not invalidate the observations, among which some are remarkable. Beside those already mentioned, of special interest is the observation of contorted or whirl-like structures, as, for instance, the Pannonian (Carpathian) and Aegean arcs, or the North Fiji vortex. These features could not be satisfactorily explained by plate tectonics, except for resorting to an already well-established trick: to nibble at a plate's margin in order to give birth to some more platelets. This way geological science seems to advance 'piece by piece!'

Wrench tectonics

An interesting and very stimulating new hypothesis was launched some years ago by Storetvedt (1997). It is much better founded than the surge tectonics hypothesis, notwithstanding that it also seems to admit Earth contraction, at least in the far geological past. Moreover, the author considers that 'it is not unrealistic to think that the Earth as a whole is still in a state of cooling.' No need to say that Storetvedt also rejects quite definitely subduction and ocean spreading. Thus, for him the similarity of shape of the coasts across the Atlantic is purely accidental. He began his scientific work as a plate-tectonics adherent, but then gradually became aware of the inconsistencies of the model, mainly on grounds of paleomagnetic data. Storetvedt's model presents a closer relationship to the oceanization hypothesis of Beloussov than to the surge hypothesis. Like Beloussov, he admits that in its early history the Earth had a pan-global granitic-granulitic crust that became chemically unstable during subsequent cooling. As a consequence, major parts of the original sialic cover have been replaced during crustal evolution by a thin basaltic layer, now mainly occurring under the oceans. Yet, 'undigested' remains of continental material have been preserved in most of them.

Another important assumption of Storetvedt's is that Earth tectonics is strongly linked to planetary rotation and to polar wander and that foldbelts have developed mainly in two paleo-geographical settings, either along or perpendicular to the time-equivalent equators. This idea is unequivocally related to Carey's idea of global torsions. However, according to Storetvedt, Benioff zones – that accompany the Pacific rim, which more or less coincides with Carey's Tethyan counter-torsion – 'apparently formed in response to Earth contraction in Archean time.'

Regarding oceanization, it is not very clear how Storetvedt interprets the unequal distribution of oceanic crust in the northern and southern hemispheres, considering that mantle pluming, which he holds to be the main mode of driving this process, is seen to be active particularly along equatorial belts during stages of decelerating Earth rotation. He writes:

> 'In a rotating planet, within which mantle pluming takes place, pulses of outward flow would be assumed to be modified by the centrifugal force that has its maximum effect along the equatorial belt. Therefore, a global pulse of rising fluid material would have had a certain concentration around the corresponding paleo-equator, expectedly giving rise to an overall more effective crustal attenuation in such paleo-geographical settings (Storetvedt, 1997).'

In fact, by this statement Storetvedt defends the concept of geosynclinal evolution, together with implied subsidence and basic volcanism during the first stages. At the same time he places the ancient geosynclines in an equatorial position. Under these circumstances one has the feeling that mantle plumes are overtasked, being expected to hold for both (asymmetric) oceanization and preferential distribution along equatorial zones.

As to the generation of orogenic belts, Storetvedt considers that these are evolving out of geosynclines during stages of accelerating Earth rotation. The process is due to a combined effect of rotation and other inertia forces, among them the Coriolis force, which trigger a global lithospheric shift towards the equator. This equator-ward shift is accompanied by twisting (or *wrenching*) into a general westerly swing. Thereby a transpressive tectonic regime develops in the equatorial (geosynclinal) zone, bringing about all those phenomena that make up orogenesis.

One may say, according to Storetvedt, that a geotectonic cycle consists of two main stages, the first characterized by decelerating, and the second by accelerating velocity of the Earth's rotation. No great horizontal displacements are required. We are dealing once more with a fixistic hypothesis. In Storetvedt's model there are not even surge channels to conduct magma horizontally through the lithosphere. Therefore, regrettably, no emphasis is given on linear elements that are conspicuous in many continental and oceanic domains. Mid-ocean ridges, which are regarded as a relatively new crustal element, represent, according to Storetvedt, equivalents of continental mountains, being located along oceanic shear zones. It should be noted that the author makes a clear distinction between orogens and mountain chains.

Seed for a new hypothesis?

The contribution of one of the present authors (C.S.) to the field of geotectonics consists in his assumption that orogens are megashears of the lithosphere (Strutinski, 1990, 1994). What does this mean?

Looking at a geological globe, one has the impression that some abstract artist has produced the combination of structures and colors by thoroughly kneading together different sets of variously colored plasticine sticks and then pasted them over the globe. However, the general aspect suggests that there must be some sense beyond the muddle. Grossly, one may distinguish areal and linear structures and learn that in general the areal structures are older than the adjoining linear ones. The former may indeed be composed of several older, more or less contorted, linear structures. Why are we so stubbornly dealing with rigid plates, slabs, blocks, fragments, pieces, slivers, splinters, active as well as passive margins, edges, borders when discussing geotectonics, in front of this image of plasticine amalgamation and distortion?

Field work in provinces of continental basement and theoretical considerations on metamorphic rocks lead to the conclusion that only a few kilometers beneath the surface rocks flow like water. Not as fast, naturally, but they have plenty of time to do so. Why then are we so reluctant to tackle geotectonics from the point of view of fluid dynamics? Imagine that, instead of using all the terms listed above, we would speak about currents, streamlines, channels, fronts, eddies, vortices, whirlpools, flow direction, laminar flow, turbulence, meandering, erosion and others of the kind. What if *sub*duction and *under*plating do not exist, but instead *sub*-erosion and *under*mining? Do we really have the right terms in order to step forward in geological thinking? From the hypotheses discussed above, only surge tectonics seems to be really involved with fluid dynamics.

It seems further that Meyerhoff and Meyerhoff (1977) were right supposing that there is something like an asthenospheric current under the Caribbean 'plate' and beneath the Scotia Sea. But, on the other hand, how could one dismiss the fit of the continents across the Atlantic? Is there really no alternative to integrate both groups of observations into a unifying hypothesis? Considering the lithosphere as the time- and stress-adapted plasticine of the Earth, how relevant is the expansionists' globe modeling making use of continents with immovable contours? And yet, it seems that the Earth has really expanded! Particularly during the Cretaceous. At a time when probably the greatest part of Alpine metamorphics almost suddenly rose and cooled under the blocking temperatures for argon retention. Could this be mere haphazard?

It is quite clear that not all 'plasticine' suffered displacement and deformation at one time. And not to the same degree. However, it can be taken for granted that orogens are those global linear structures that concentrated most of the displacement and deformation that took place during the time of their generation. The most important orogenic belts on Earth are considered to have been initiated and evolved along their time-equivalent equator (Carey, 1983; James, 1994; Storetvedt, 1997). If this is really so, then a connection between orogenesis and Earth rotation seems unavoidable. What lies nearer as the supposition that something beneath the nascent orogens is moving relatively fast, due to this Earth rotation, and drags the lithosphere on its back? The lithosphere deforms in a corridor above the flowing asthenocurrent and is sheared off from the neighboring regions – possibly cratonic zones – along a pair of megashears. In accordance with the observations on Sun, Jupiter and Saturn, the movement takes place from west to east and is known as zonal rotation (Jardetzky, 1954: Gilliland, 1964, 1973). Thus, on Earth a sinistral shear system should delimit the orogen to the north and a dextral one to the south. These are the findings that have been published in previous papers (Strutinski, 1994; Strutinski and Puşte, 2001).

However, a critical test of this shear-belt hypothesis failed to be passed until now: if orogens have been generated according to this model, why is there no indication along the actual equator that a new orogenic cycle is on the way? Surely, there is the already mentioned Caribbean zone, but it seems trifling as compared to the forces apparently involved, let alone that it lies about 15° much too far to the north. And what about the Scotia arc, at 60°S latitude?

A tentative solution of this riddle is herewith presented for the first time and dedicated to the memory of Hilgenberg. It depends on the following assumptions:

a) Earth expansion is real, but does not evolve exponentially; an expansion phase of catastrophic dimensions took place during the Middle- Upper Cretaceous (Larson and Pitman III, 1972; Rihm, 1996).

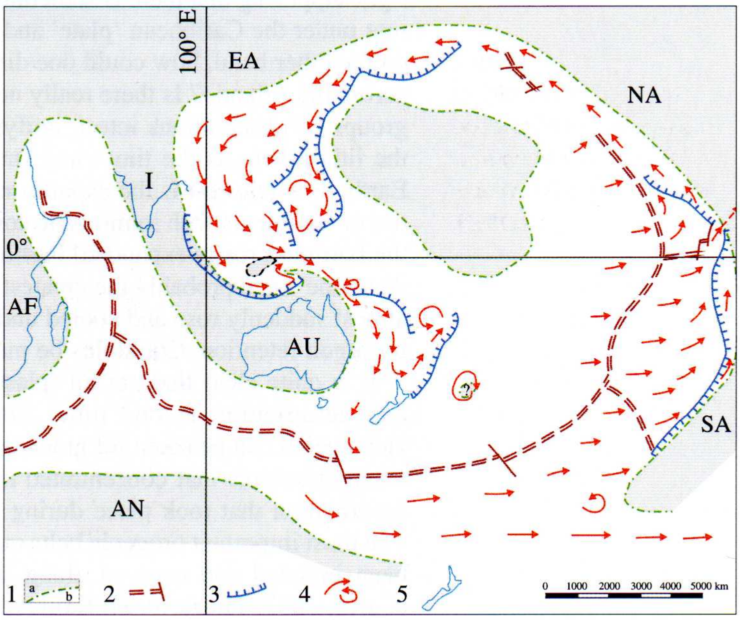

Fig. 1
The Pacific Basin a 'Great Blue Spot?'

1. Approximate limit between lithosphere with (b), and respectively, without (a) underlying 'asthenosphere.'

2. Oceanic ridges, simplified. Only some transforms are shown.

3. Oceanic trenches.

4. Supposed direction of asthenospheric flow within the Pacific perimeter; vortices ('Tectonic tornadoes').

5. Contours of continents have been greatly omitted. Those shown are for the purpose of orientation. AF-Africa; AN-Antarctica; AU-Australia, EA-Eurasia; I-India; NA-North America; SA-South America.

b) Before then a more or less uniformly thick lithosphere of continental type covered the Earth and was underlain by an asthenosphere in which zonal rotation could take place.

c) Due to the catastrophic Cretaceous expansion phase a mass disequilibrium occurred: the remaining continental areas were uplifted and developed deep roots, while the newly created, thin oceanic crust 'drained' a great volume of water from above the continents and of the warm asthenosphere from beneath them.

Under such circumstances a zonal rotation is no more possible, except for those restricted regions where the continental blocks are interrupted along the meridian (the Caribbean and Scotia arcs).

The equatorial asthenospheric current initiated, nevertheless, but only in the largest (Pacific) oceanic basin, and only to be shortly after deflected along the western margin of the American lithosphere, in a northerly direction. It is surmised that this current migrates along the whole perimeter of the Pacific (Fig.1), its flow representing the main cause of the tectonic movements that are unfolding here. On its course the current may have 'eroded' the 'stiff' roots of the adjacent continents (incipient basification/oceanization?), particularly undermining the Asian continent, as is obvious by the presence of warm asthenosphere under the Japan arc, the Japan Sea and all along Eastern China and Korea. Further to the south the current may loose its power and disintegrate through a number of vortices, the most important of them being situated in the Philippine, Bismarck and Fiji Basins. Such vortices are seemingly a characteristic feature of dying-out currents, as is illustrated by the northern tract of the Gulf Stream (Fig.2).

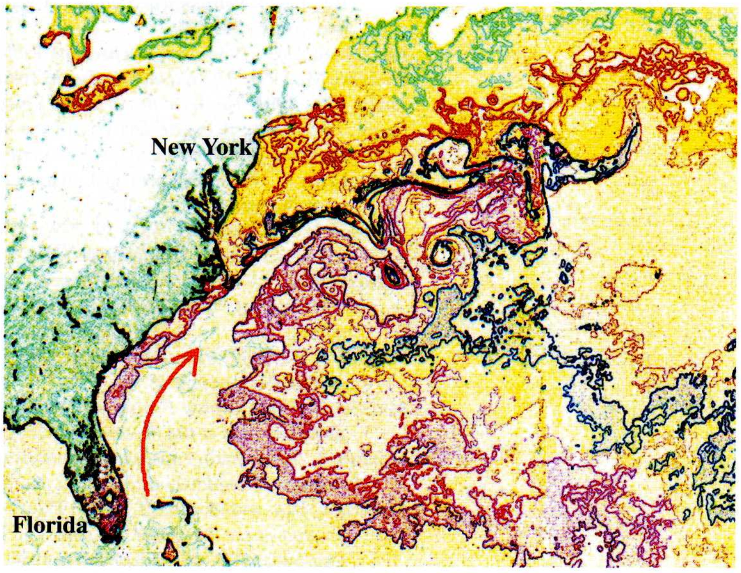

Fig. 2
The Gulf Stream with its characteristic vortices along the northern tract (reprocessed from Geo, nr.8/1993).

If the above assumptions are correct – and they are in agreement with a lot of geological and geophysical data which shall be discussed in detail elsewhere – then one may face under the Pacific a structure much alike the Great Red Spot on Jupiter, which therefore should be termed as the Great Blue Spot of the Earth. Moreover, a confirmation of the above sketched model would give another clear evidence against uniformitarianism and make the controversy between fixism and mobilism look obsolete.

The best conclusion to this paper is to quote J.J.H.Teall:

> 'Controversy as to the truth or falsity of a theory often seems to me beside the mark, for if a given theory coordinates more facts than any other it is at least worthy of respect, and may be tentatively held as a working hypothesis, along with the conviction that it is not true, or only partially true.'

References

Carey, S.W., 1976: *The Expanding Earth.* Elsevier, Amsterdam, pp.488.

Carey, S.W., 1983: Tethys and her forebears. In: Carey, S.W. (ed.): *Expanding Earth Symposium.* Sydney, 1981, University of Tasmania, 169-187.

Carey, S.W., 1988: *Theories of the Earth and Universe.* Stanford University Press, Stanford, pp.413.

Choi, D.R., 2000: Subduction does not exist – from seismic data interpretation. *New Concepts in Global Tectonics Newsletter,* 15, 9-14.

Dickins, J.M. and Choi, D.R., 2001: Neogene events and the modern world. *Himalayan Geology,* 22 (1), 199-206.

Dietz, R.S., 1961: Continent and ocean basin evolution by spreading of the sea floor. *Nature,* 190 (4779), 854-857.

Egyed, L., 1956: The change in the Earth's dimensions determined from palaeogeographical data. *Geofisica pura e applicata,* 33, 42-48.

Gilliland, W.N., 1964: Extension of the theory of zonal rotation to explain global fracturing. *Nature,* 202, 1276-1278.

Gilliland, W.N., 1973: Zonal rotation and global tectonics. *American Assoc. Petroleum Geologists Bull.,* 57, 210-214.

Hess, H.H., 1962: History of ocean basins. In: Engel, A.E.J., James, H.L. and Leonard, B.L. (eds.): *Petrological Studies – A Volume to Honour A.F. Buddington.* Geol. Soc. Amer., 599-620.

Hilgenberg, O.C., 1933: *Vom wachsenden Erdball.* Selbstverlag, Berlin, pp.56.

Hoshino, M., 1998: *The Expanding Earth.* Tokai University Press, Tokyo, pp.295.

James, P.M., 1994: *The Tectonics of Geoid Change.* Polar Publishing, Calgary, pp.176.

James, P.M., 2000: A coarse analysis of the alleged processes of subduction. *New Concepts in Global Tectonics Newsletter,* 16, 5-7.

Jardetzky, W.S., 1954: The principal characteristics of the formation of the Earth's crust. *Science,* 119, 361-365.

Larson, R.L. and Pitman III, W.C., 1972: World-wide correlation of Mesozoic magnetic anomalies, and its implications. *Geol. Soc. America Bull.,* 83, 3645-3662.

Luckert, K.W., 1979: *Mother Earth once was a Girl: A Scientific Theory on the Expansion of Planet Earth.* The Museum of Northern Arizona Press, Flagstaff, pp.16.

Luckert, K.W., 1999: *Planet Earth Expanding and the Eocene Tectonic Event.* Lufa Studio, Portland, pp.78.

Maxlow, J., 1998: *Global Expansion Tectonics: Exponential Earth Expansion from Early Jurassic to the Present.* Terrella Consultants, CD-ROM.

Maxlow, J., 2001: Earth expansion: Quantification using oceanic magnetic isochron mapping. *Himalayan Geology,* 22 (1), 103-116.

Meyerhoff, H.A. and Meyerhoff, A.A., 1977: Genesis of island arcs. In: *Géodynamique du sud-ouest Pacifique.* Symposion internationale, Noumea – Nouvelle Calédonie, 27 Août – 2 Septembre 1976, Editions Technip, Paris, 357-370.

Meyerhoff, A.A., Taner, I., Morris, A.E.L., Martin, B.D., Agocs, W.B. and Meyerhoff, H.A., 1992: Surge Tectonics: A new hypothesis of Earth dynamics. In S. Chatterjee, N.Hotton III (eds.): *New Concepts in Global Tectonics.* Texas Tech University Press, Lubbock, 309-409.

Meyerhoff, A.A., Taner, I., Morris, A.E.L., Agocs, W.B., Kamen-Kaye, M., Bhat, M.I., Smoot, N.C. and Choi, D.R., 1996: *Surge Tectonics: A New Hypothesis of Global Geodynamics.* Kluwer Academic Publishers, Dordrecht, pp.323.

Milanovsky, E.E., 1991: Rifting and its role in tectonic structure and Meso-Cenozoic Geodynamics of the Earth. *HGI Report*, 1, 37-55.

Pfeufer, J., 1981: *Die Gebirgsbildungsprozesse als Folge der Expansion der Erde.* Verlag Glückauf GmbH, Essen, pp.125.

Pratt, D., 2000: Plate tectonics: A paradigm under threat. *J. Scient. Exploration*, 14 (3), 307-352.

Pratt, D., 2001: Problems with plate tectonics. Reply to Paul Lowman review. *New Concepts in Global Tectonics Newsletter*, 21, 10-24.

Rihm, R., 1996: Die mittelozeanischen Rücken – das größte Vulkansystem der Erde. *Meer und Museum*, 61-68.

Scalera, G., 1988: Nonconventional Pangea reconstructions: new evidence for an expanding Earth. *Tectonophysics*, 146, 365-383.

Scalera, G., 1990: General clues favouring expanding Earth theory. In: Augustithis *et al.* (eds): *Critical Aspects of the Plate Tectonics Theory.* Vol.II. Theophrastus Publications, Athens, 65-93.

Scalera, G., 1998: Paleogeographical reconstructions compatible with Earth dilatation. *Annali di Geofisica*, 41 (5-6), 819-825.

Silver, P.G., 1996: Seismic anisotropy beneath the continents: Probing the depth of Geology. *Annu. Rev. Earth Planet. Sci.*, 24, 385-432.

Storetvedt, K.M., 1997: *Our Evolving Planet. Earth History in a New Perspective.* Alma Mater, Bergen, pp.456.

Strutinski, C., 1990: The importance of transcurrence phenomena in mountain building. In: Augustithis *et al.* (eds): *Critical Aspects of the Plate Tectonics Theory.* Vol.II. Theophrastus Publications, Athens, 141-166.

Strutinski, C., 1994: An orogenic model consistent with Earth expansion. In: Barone, M. and Selleri, F. (eds.): *Frontiers of Fundamental Physics.* Plenum Press, New York, 287-294.

Strutinski, C. and Puşte, A., 2001: Along-strike shearing instead of orthogonal compression: A different viewpoint on orogeny and regional metamorphism. *Himalayan Geology*, 22 (1), 191-198.

Van der Voo, R., Spakman, W. and Bijwaard, H., 1999: Mesozoic subducted slabs under Siberia. *Nature*, 397, 246-249.

Vine, F.J., 1966: Spreading of the ocean floor: new evidence. *Science*, 154 (3755), 1405-1415.

Vogel, K., 1983: Global models and Earth expansion. In: Carey, S.W. (ed.): *Expanding Earth Symposium*, Sydney 1981, University of Tasmania, 17-27.

Wegener, A., 1912: Die Entstehung der Kontinente. *Petermanns Geogr. Mitt.*, 58, 185-195, 235-256, 305-309.

Wezel, F.C., 1986: The Pacific island-arcs: produced by post-orogenic vertical tectonics? In: Wezel, F.-C. (ed.): *The Origin of Arcs.* Developments in Geotectonics 21, Elsevier, Amsterdam, 529-567.

Zoback, M.L., Zoback, M.D. and Compilation Working Group, 1989: Global patterns of tectonic stress. *Nature*, 341, 291-298.