Jan Koziar

Tensional development of active continental margins

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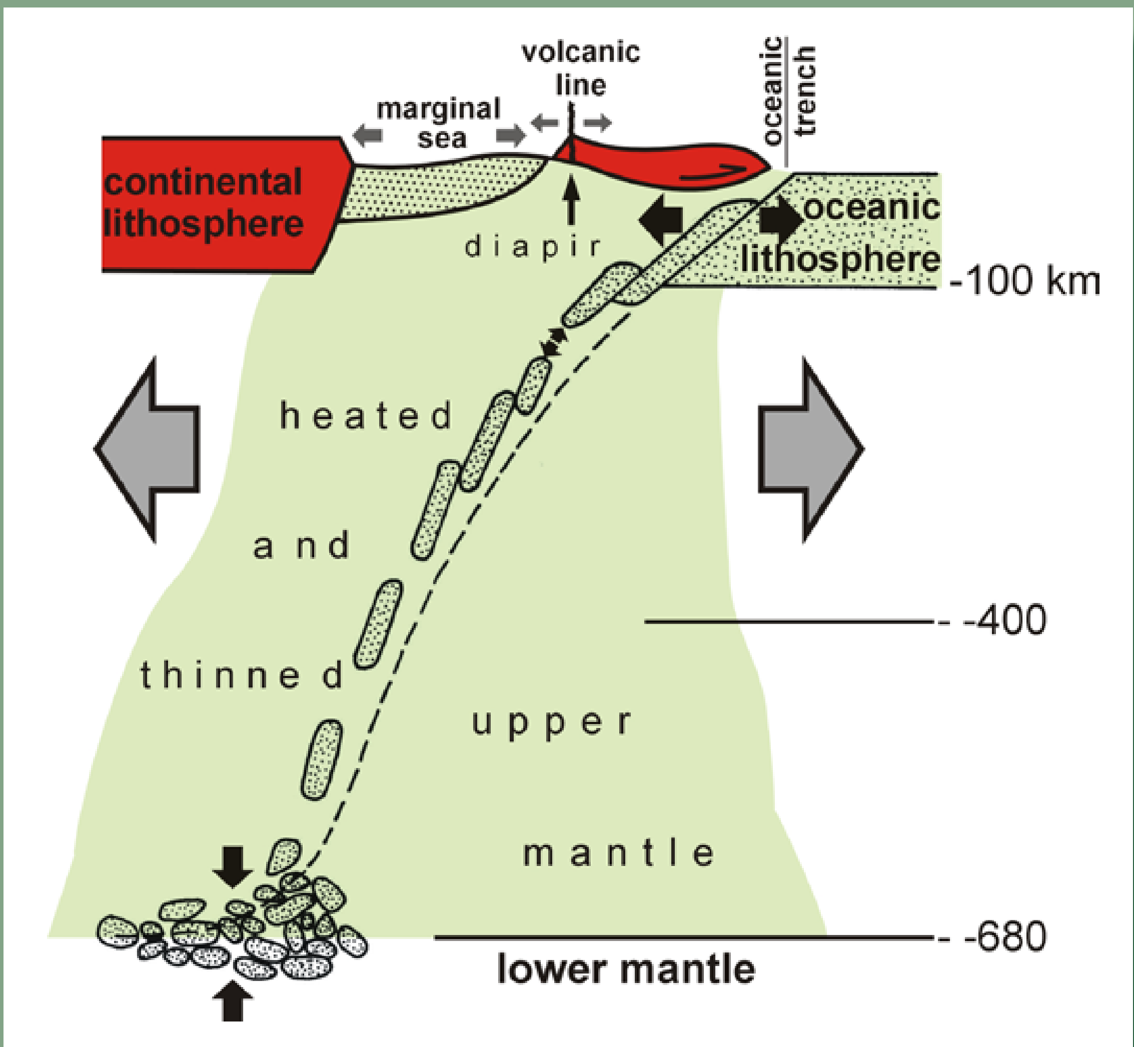

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TENSIONAL DEVELOPMENT OF ACTIVE CONTINENTAL MARGINS

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Abstract

Analysis of the deformations of oceanic plates in the upper part of Benioff's zone shows their gravitational destruction, typical for tensional tectonic grabens. The process, together with recorded warming up and diapirism of upper mantle and moving away of islands arcs from continents, prove divergent movement of the whole oceanic plate from the continental one, in active continental margins.

The shallow earthquakes under the island arcs are related to gravitational gliding of the arc towards oceanic trench, not with the movement of the oceanic plate in opposite direction, assumed by plate tectonics.

The divergent movement of the oceanic plate from the continental one, does not compensate the spreading on oceanic ridges. So that is one of the proofs of the expansion of the Earth.

Key words: Active continental margins, expansion of the Earth

I. Introduction

Active continental margins are marked by oceanic trenches, volcanic lines and seismic (Benioff) zones. Their developed forms include islands arcs and marginal seas.

1. Wegener's model of the development of island arcs

Active continental margins were treated by the theory of contracting Earth as a result of collisions between continental and oceanic cratons. Alfred Wegener was the first (1915) who noticed that the island arcs have been torn from continents (fig. 1).

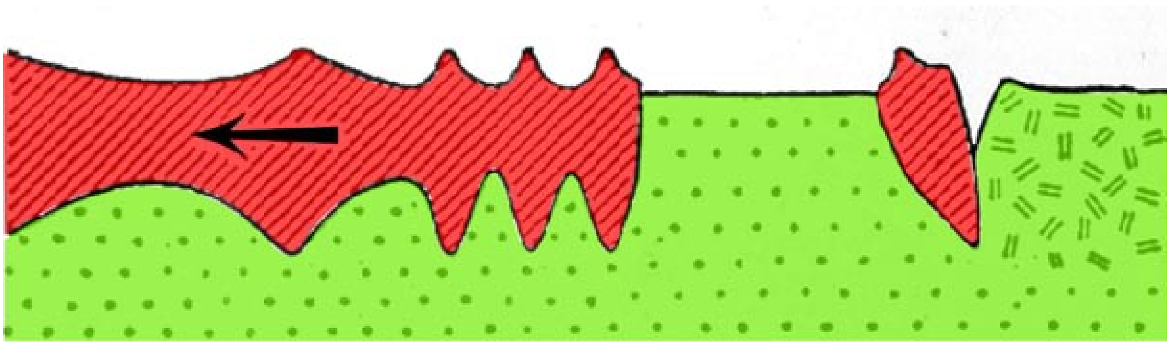


Fig. 1. Wegener's model of tensional development of island arcs

Wegener tried to explain the process by his concept of west drift of continents. Thus, the island arcs (island garlands) mostly situated off east coasts of the continents would be lost by them and placed in the "wake" of continental blocks drifting westward. However, the explanation was in contradiction to the existence of island arcs turned to the west (the western part of Malayan Archipelago).

2. Expanding Earth theory removes difficulties of Wegener's theory

There was already another theory at Wegener's time which was able to explain tearing away fragments of continental crust from, this time, freely oriented continental coasts. It was the theory of the expanding Earth. The first author who postulated expansion of the Earth was a Pole Jan Jarkowski (Yarkovski) –1888, 1889.

After the appearance of Wegener's theory two German scientists, Bruno Lindemann (1927) and Ott Hilgenberg (1933) came to the expanding Earth using consistently and at a global scale, the process of drawing aside continents, discovered and proved by Wegener. The last author removed the controversial land bridges from the Atlantic and Indian oceans pushing together the surrounding continents. He should do the same with the Pacific because the land bridges were postulated also in this ocean. It is easy to forget today that the data collected by the land bridges theory indicated non-existence of the Pacific in Paleozoic, just like Atlantic and Indian oceans.

Hilgenberg (1933) did what Wegener did not manage. He closed all the oceans and created continuous continental shell on a smaller Earth. Józef Oberc (1986) named the shell Hilgenberg's Pangea to distinguish it from the insular Pangea of Wegener, surrounded by huge hypothetical pre-Pacific (Panthalassa).

During the breaking up of the Hilgenberg's Pangea (resulting from the expansion of the Earth) the Pacific grows larger like the other oceans, contrary to its alleged decreasing during the breaking up of the Wegener's Pangea.

3. Carey's proofs of expansion of the Earth

The growth of the Pacific was proved in 1958 by Samuel Warren Carey. He was creating then, together with Bruce Heezen (1960), the foundation of the theory of the spreading of the oceanic lithosphere and the conception of lithospheric plates. Both authors combined their discoveries, fundamental for today geotectonics, with the expansion of the Earth.

Carey showed that the perimeter of the Pacific is growing larger because all the gaps between the continents, surrounding this ocean, are growing larger. It means, that all the continents araund the Pacific are moving away from the centre of this ocean (fig. 2)

The increase in the area of the Pacific, together with the increase in the area of the other oceans, proves unequivocally the expansion of the Earth.

An independent evidence of the expansion of the Earth, given then by Carey, is the longitudinal growing of oceanic ridges that reveals in reflecting by them, on a larger scale, outlines of the neighbouring continents. The process is best seen around Africa.

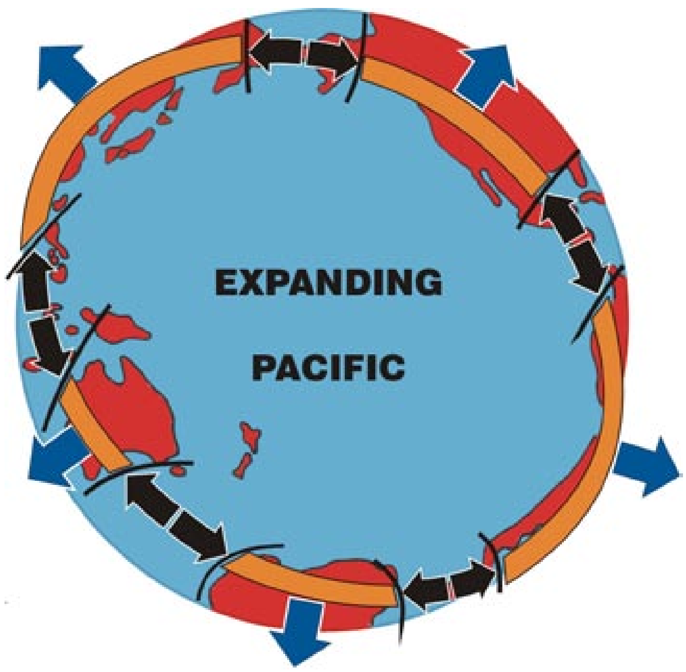


Fig. 2
Carey's test. Elongation of the perimeter of the Pacific proves increase in area of the ocean and thus the expansion of the Earth.

Proving the expansion of the Earth Carey proved simultaneously the existence of universal conditions for moving away of all island arcs from the continents. The process is common and refers also to recently inactive continental margins and fragments of continental crust torn away from them and not forming the islands arcs. Wegener pointed out the process too. The most spectacular examples of it are Madagascar and Greenland.

In particular, the increase in the length of the Pacific perimeter demonstrated by Carey means tension oriented perpendicular to circum-Pacific continental margins. The tension determines processes of formation of the margins there, in a way quite opposite to the one, assumed by the rejected contracting Earth theory and, almost generaly accepted today, plate tectonics theory.

4. Plate tectonics model of convergent active continental margins

The plate tectonics comes to the model of convergent movement of lithospheric plates in the active continental margins, starting from the proved spreading of oceanic lithosphere and the unproved assumption of constant Earth radius. It is seen in the statement by one of the founders of the plate tectonics, Xavier Le Pichon (1968):

If the earth is not expanding, there should be other boundaries of crustal blocks along which surface crust is shortened or destroyed.

The model of convergent movement of the plates and subduction of one plate under another, suggested by plate tectonics, built on the above a priori assumption, is in contradiction with:

1. thinned upper upper mantle and its diapirs found under the active continental margins and
2. moving away of island arcs from the continents.

Besides of it, the plate tectonics ignores not only the Carey's proofs of the expansion of the Earth presented above but also newer proofs such as mutual moving away of hot spots (Stewart, 1976) and the mantle roots of the plates pointed out by Kremp (1990).

5. Models of divergent movement of lithospheric plates in active continental margins

Understanding of the geotectonics through real processes, not by dogmas, leads to several models of tensional development of the active continental margins. The first was the Wegener's model presented above. Let us mention, that the model applied to the non-expanding Earth did not face a problem of expanding lithosphere of the Pacific. The process was unknown at Wegener's time.

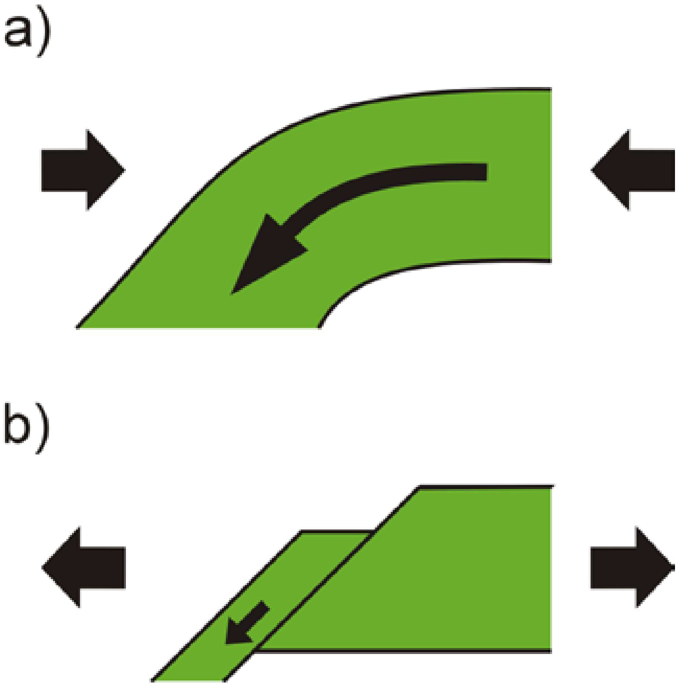
The next trial of making a tensional model was undertaken by Carey (1976). Several publications by Yuri Chudinov were concerned with the problem (1981, 1985, 1998). The subject was also analyzed by Giancarlo Scalera (1994). The scheme presented below, elaborated in Wrocław, belongs to the same category of solutions.

II. Tension – gravitational development of active continental margins

The tension-gravitational development of active continental margins was worked out by the present author. It was first presented in 1980 at the seminar of the Institute of Geological Sciences of University Wrocław. In time of the martial law the author could not appear publicly, so it was presented in a co-authorship by the second co-author Leszek Jamrozik. After that it was published in co-authorship too (Koziar and Jamrozik, 1991, 1994 – www.wrocgeolab.pl/margins1.pdf).

1. Oceanic trench as a fragment of tensional tectonic half-graben

The basic element of the new approach is a new explanation of the process of sinking of oceanic lithosphere along Benioff's zone. Plate tectonics, following methodological approach of Le Pichon, postulates bending and sinking of the whole oceanic plate during its movement towards a continent (fig. 3a).



However, seismic profiles of oceanic trenches demonstrate stepwise descent of the oceanic lithosphere along gravitational faults (e.g. Moore and Shipley, 1988). Exactly the same situation is under the frontal parts of intracontinental fold belts. The double structure of the Benioff's zone (Hasegawa et al., 1978) indicated that the fragments of the oceanic lithosphere (but not the whole oceanic plate) shifts downwards between the inclined planes being separated by the distance of only 30 – 40 km. So, the oceanic plate is under destruction, typical for gravitational grabens, and creates the so called gravitational (tensional) "half-graben" (fig. 3b).

Fig. 3
(a). Pushing and bending of the oceanic plate according to plate tectonics model.
(b) The real tension-gravitational destruction of the oceanic plate marking the opposite tectonic regime.

The movement of the oceanic plate relative to a continent, resulting from that, is quite opposite to the one assumed by the plate tectonics (fig. 3a).

2. Sinking of oceanic lithosphere along Benioff's zone

Further falling of the products of the gravitational destruction of the oceanic plate is simply their sinking (fig. 4) in the lighter material of the thinned upper mantle. The recorded existence of the thinned mantle and its diapirs under the active continental margins proves independently the general tensional regime and excludes the existence there of any descending branch of a hypothetical convection current.

Such kind of destruction of the oceanic lithosphere and its sinking in the thinned upper mantle were noticed already by plate tectonists (e.g. Spence, 1977). There is only lack of proper understanding of the regional tectonic regime, which it is still seen as in fig. 3a.

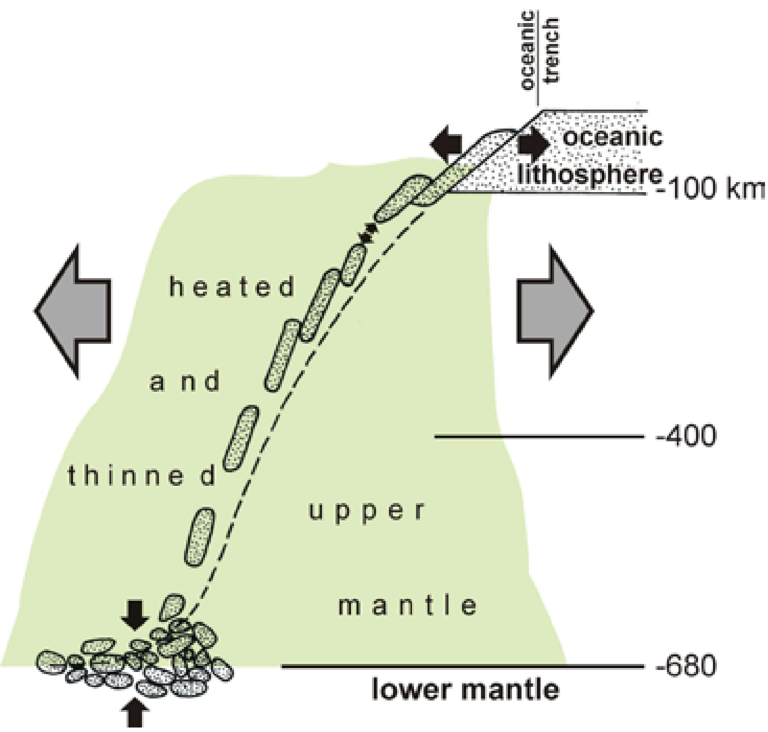
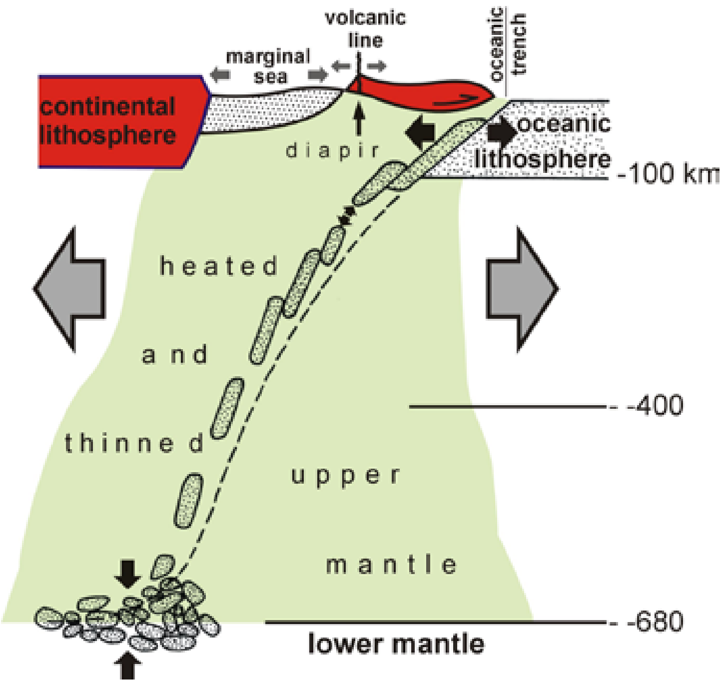


Fig. 4
Sinking, along the Benioff's zone, the fragments of the oceanic lithosphere that is destroyed by tension-gravitational mechanism



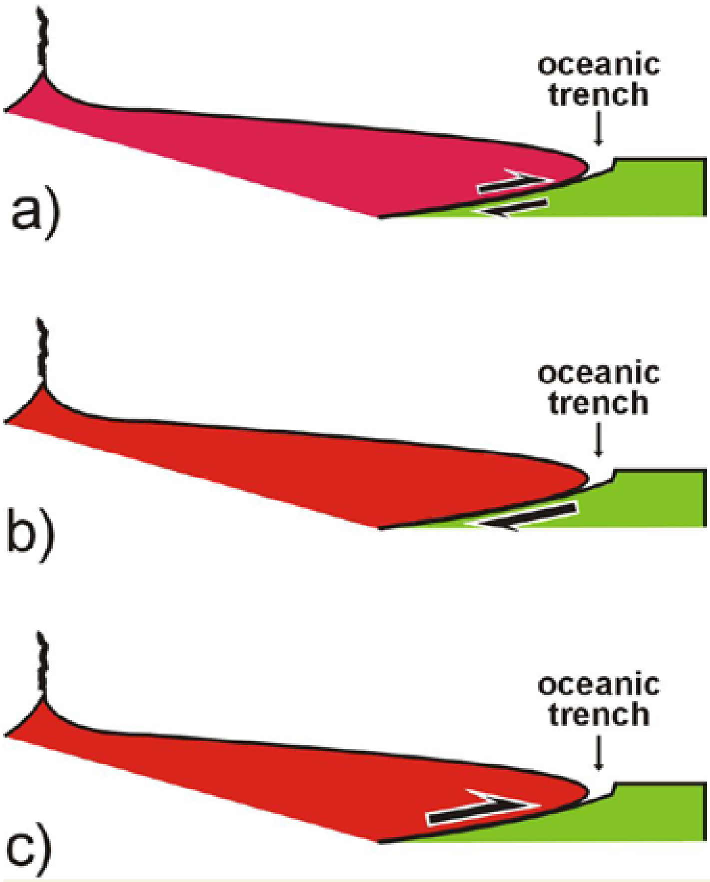
3. Processes documenting the divergent movement of plates in active continental margins

The mechanism of destruction of the oceanic plate demonstrated above, diapirism of the thinned upper mantle and extensional development of the marginal see, document unequivocally moving away of the oceanic plate from the continental one (fig. 5).

Fig. 5
Full scheme of the tension-gravitational structure of developed active continental margin. All tensional elements of the structure confirm themselves mutually, proving the drawing apart of lithospheric plates.

4. Gravitational gliding of island arc

The island arc is situated between the culmination of the diapir, marked by the volcanic line, and the depression of the oceanic trench (fig. 5). Such close vicinity of the elevation and depression must cause the gravitational gliding of the island arc towards the oceanic trench. Then, the gravitational gliding must generate compression at frontal part of the island arc. However, the compression has nothing to do with hypothetical convergence of the plates, as it is demanded by plate tectonics.



The shallow earthquakes under the islands arcs record the shear movement shown in fig. 6a. Plate tectonics maintains arbitrarily (according to its a priory assumption) that the arrows mean subduction of the oceanic plate under the island arcs (fig. 6b). However, the arrows can also mean an overthrusting of the island arc over the oceanic plate (fig. 6c, compare with fig. 5). Plate tectonics does not take into account the latter possibility at all. However, the shape of the shear surface marked by the shallow earthquakes

Fig. 6
(a) The shear movement marked by shallow earthquakes under the island arcs. It may mean either
(b) underthrusting of oceanic plate under island arc or
(c) overthrusting of island arc over oceanic plate

manifests it. And so, the surface does not extend to the Benioff's zone but makes its way sloppy towards the volcanic line (Plafker, 1965). The results of the analysis of the deformation of the island arcs related to the shallow earthquakes are decisive to solving the problem, since the deformations of the island arc correspond exactly to the ones in landslides. It proves that the island arc (or big part of it) changes itself into a gigantic landslide during the shallow earthquake. It is indicated by both, horizontal and vertical displacements of rock masses.

The horizontal displacements are like the ones in fig. 7a (Parkin, 1969, Plafker and Savage, 1970, Fitch and Scholz, 1971, Campos et al. 1996, McNeil et al. 1997). They correspond exactly to the horizontal displacements in landslides (fig. 7b), while according to the plate tectonics they should be like those in fig. 7c.

The vertical displacements (fig. 8a) described by many authors (Plafker, 1965, Fitch and Scholz 1971, Plafker and Savage, 1970) correspond also to the typical ones in landslides (fig. 8b).

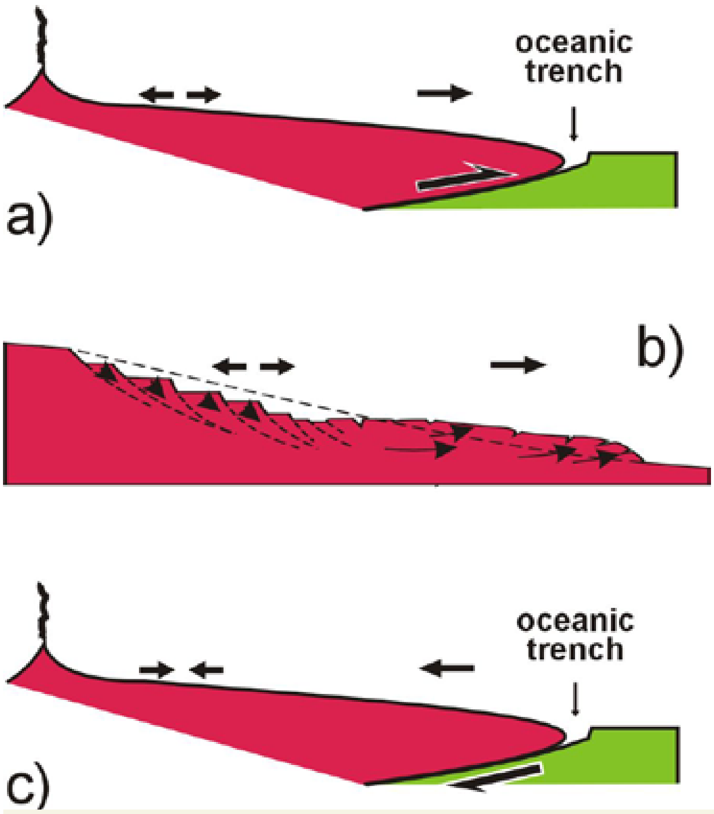


Fig. 7
(a) Recorded horizontal displacement in the active continental margins related to shallow earthquakes.
(b) Handbook scheme of landslide.
(c) Horizontal displacement implied by the model of plate tectonics

So, it is possible to prove directly the gravitational gliding of the island arc presented in fig. 5, anticipated by us earlier, only on the basis of the existence of favourable tectonic conditions for it.

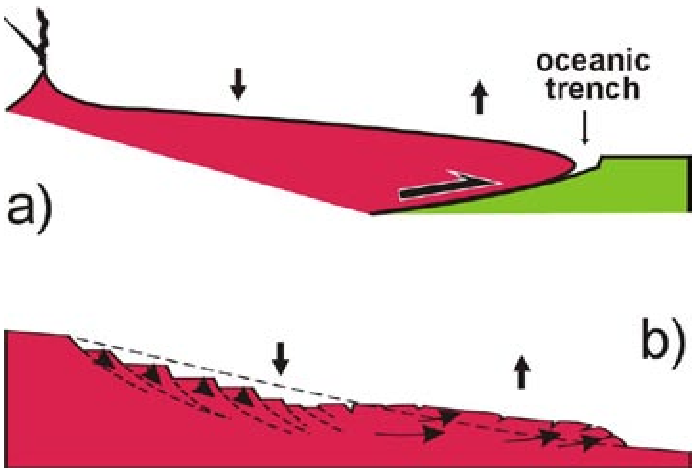


Fig. 8
(a) Vertical displacements related to shallow earthquakes under the island arcs.
(b) Handbook scheme of landslide.

5. Development of active continental margins confirms Haarmann's gravitational tectonics

A German tectonist Erich Haarmann introduced (1930) right and very important ideas of the primary tectogenesis (formation of the differences in height) and the secondary tectogenesis (gravitational levelling of the differences in height). The conditions of origin and character of the primary tectogenesis were however enigmatic in his gravitational model of the formation of fold belts. It turns out now, that the conditions appear during the tensional breaking of the lithosphere. The breaking causes the gravitational destruction of the edge of the plate (structural depression) and the diapirism (elevation) placed close one to another. All that, give the primary tectogenesis resulting in the gravitational gliding of the island arc towards an oceanic trench (the secondary tectogenesis).

6. Analogy between active continental margins and intra-continental fold belts

The development of the active continental margins should be similar to the development of intra-continental fold belts. It has been long ago noticed that both kind of structures are analogous. So:
1. an oceanic trench corresponds to a fold belt's foredeep
2. an island arc corresponds to a fold belt itself
3. a volcanic line corresponds to volcanism of internides
4. a marginal sea corresponds to an intramontane depression.

Thus the intra-continental fold belts should also originate as a result of the tension-gravitational mechanism. It happens in reality. The analysis of the mechanism of the origin of the belts made without any global a priory assumptions gives an analogous result as for the active continental margins (Koziar and Jamrozik 1985 ab; www.wrocgeolab.pl/Carpathians.pdf).

7. Tension-gravitational development of active continental margins as the next proof of the expansion of the Earth

The Le Pichon's reasoning has been quoted earlier to present the way of origin of the models of plate tectonics. So the models can not be taken as proofs of the basic assumption of the theory, claiming that the radius of the Earth is constant. If we do it, we are falling into a vicious circle of reasoning. In particular it concerns the plate tectonics model of active continental margin, i.e. the model of underthrusting (subduction) of one plate under another one.

The opposite situation is in the case of reconstruction of the tension-gravitational mechanism of the structures described above. We have proved the moving away of the oceanic plate from the continental one, not using any global assumptions. Using the correct procedure of proving, we only now may come to global questions and consider the relation between the active continental margins and the spreading of the oceanic lithosphere on the oceanic ridges. It turns out, that the spreading is not compensated in the described zones, thus the Earth is expanding. The present statement is a conclusion, not an assumption. Beside of that, it is the next independent proof of the expansion of the Earth in relation to the proofs mentioned above.

Let us mention, that the plate tectonics does not demonstrate convincing proofs of its basic assumption of the stability of the Earth's radius confining itself to the creation of the models based on the assumption. Comparison of the foundations of the two theories is presented in a separate paper (Koziar and Zagożdżon, 2003).

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Tensional development of active continental margins

(short version)

The key to understanding of general development of active continental margins is right interpretation of the processes under oceanic trenches and in the Benioff's zone. The plate tectonics assumes, that an oceanic plate moves towards the active continental margin. Then the plate is bended under the oceanic trench and conveyed down along the Benioff's zone. The starting point of the model is an assumption that the Earth is not expanding and so there must be zones in which compensation of the spreading of the lithosphere on the oceanic ridges takes place (Le Pichon, 1968). However, seismic data indicate that the oceanic plate forms a huge tectonic half graben under the active continental margins. In other words, the oceanic plate is terminated there by an edge being destroyed by the tension-gravitational mechanism. Fragments of the plate being destroyed in such a way, sink then in the thinned upper mantle which forms diapirs under the active continental margins. The sinking fragments create the Benioff's zone generating earthquakes and increasing the seismic conductivity by their presence and by producing a laminar structure (wave guide) in the upper mantle.

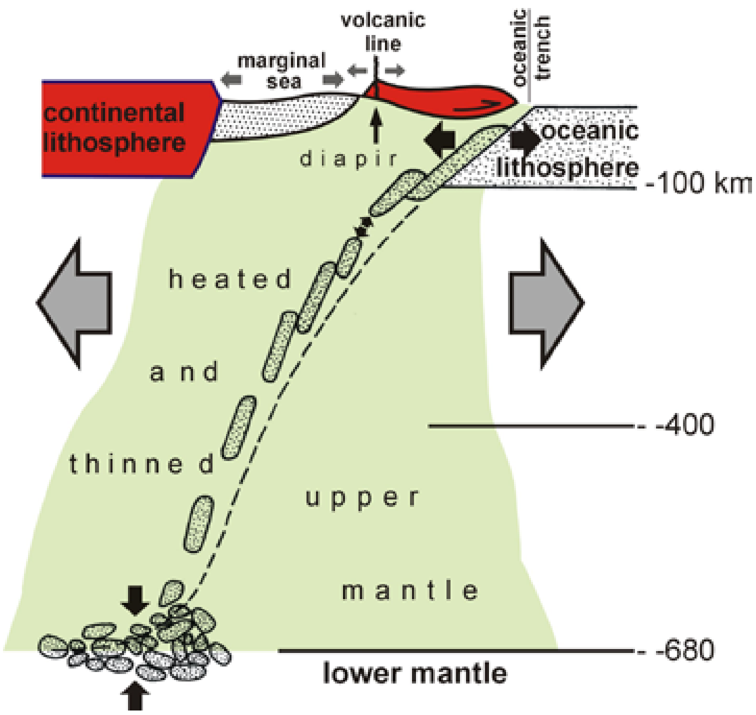
The tension-gravitational half-graben terminating the oceanic plate, the presence of thinned upper mantle and diapir (both indicators of tension) and the proved moving away of island arcs from the continents, all these indicate unequivocally the drawing away of the oceanic plate from the continent. That is quite opposite to the process assumed by the plate tectonics.

Another key problem is right interpretation of relative movement recorded by shallow earthquakes under the island arcs. They can mean either underthrusting of oceanic plate under the island arc or overthrusting of the island arc over the oceanic plate. The plate tectonics chose arbitrarily the first solution. However, the horizontal displacements of island arc as well as the vertical ones indicate that the upper part of the island arc creates a huge landslide during the shallow earthquakes, directed towards the oceanic trench. Compression that occurs at the front of the landslide has a local and superficial character and has nothing to do with hypothetical convergent plates movement assumed by plate tectonics.

The tension-gravitational development of active continental margins, presented above, is equivalent to tension-gravitational development of intracontinental fold belts (Koziar, Jamrozik, 1985). It is also a confirmation of gravitational tectonics of Erich Haarmann and his conception of primary tectogenesis (formation differences in height) and secondary tectogenesis (gravitational levelling of the differences in height).

We did not use any global assumption at recognizing of the tensional development of discussed zones. In contrary, we come now to the global problems in a form of a conclusion. Namely - in active continental margins is no compensation of spreading of oceanic lithosphere on oceanic ridges. So the Earth is expanding.

Full scheme of the tension-gravitational structure of developed active continental margin. All tensional elements of the structure confirm themselves mutually, proving the drawing apart of lithospheric plates.



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