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Paleogeographical reconstructions compatible with Earth dilatation

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Abstract
The present research concerns the study of the possibility of an increase in the size of the Earth because of a still unknown process. After a previous recognition of the existence in the Pacific of shape conformities in a number of pairs of continental and oceanic boundaries (Scalera, 1991, 1993a), a search for compatibility of these results with independent data sets, paleomagnetic and geological and paleontological was undertaken. The conclusion is that the Earth's dilatation is compatible with the used data, while nothing can be affirmed with certainty about the dilatation process or its continuity or discontinuity through geological time. A tentative model of the evolution of the trench-arc-backarc systems has been provided, tuning it in agreement with a dilatational planet.

Key words *paleogeography – global tectonics – Earth expansion*

1. Introduction

Digitization was performed for all the ocean floor fragments of the same age and continental shields from the map «Bedrock Geology of the World» (Larson *et al.*, 1985), and for all the magnetic anomalies from the map «Identified magnetic sea-floor spreading anomalies» of Roeser and Rilat (1982) and the paper of Nakanishi *et al.* (1992). Software was created to extract and use the data from the updated version of the Global Paleomagnetic Database (McElhinny and Lock, 1990a,b), filtering the paleopoles on the basis of their quality (Scalera *et al.*, 1993; Florindo *et al.*, 1994; Sagnotti *et al.*, 1994). Variable radius precise computized cartography has been used, and the non-Pacific ocean floor fragments were considered connected to the adjacent continent to constitute an entire plate.

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2. The paleogeographic reconstruction

The Jurassic plates were matched on a globe with a radius less than the modern one (R = 3800 km) to seek a solution to the simultaneously imposed boundary conditions. An impressive result in the paleo-Indian ocean is the matching between the Jurassic nucleus of the Pacific and the Jurassic of Wharton basin, Northwest of modern Australia. The Wharton basin becomes simply a split fragment of the Pacific. The second impressive fact is the matching of the Jurassic band adjacent to Somalia and the Southern Arabian peninsula with the Jurassic band adjacent to Antarctica from the Weddel sea to the Maud Queen land.

In the Cretaceous reconstruction (R = 4800 km) India is virtually in contact with Eurasia and only a shallow sea with interposed islands was traced south of Tibet, in agreement with geologic and paleontologic data. The area surrounding the Eurasian cratons is now larger and can be the seat of the Alpine orogeny and of the Ob sphenochasm. A suitable space is found for the Bering sea and the Artic sea Cretaceous fragments. Antarctica is now largely at intermediate latitudes, in agreement with the paleon-

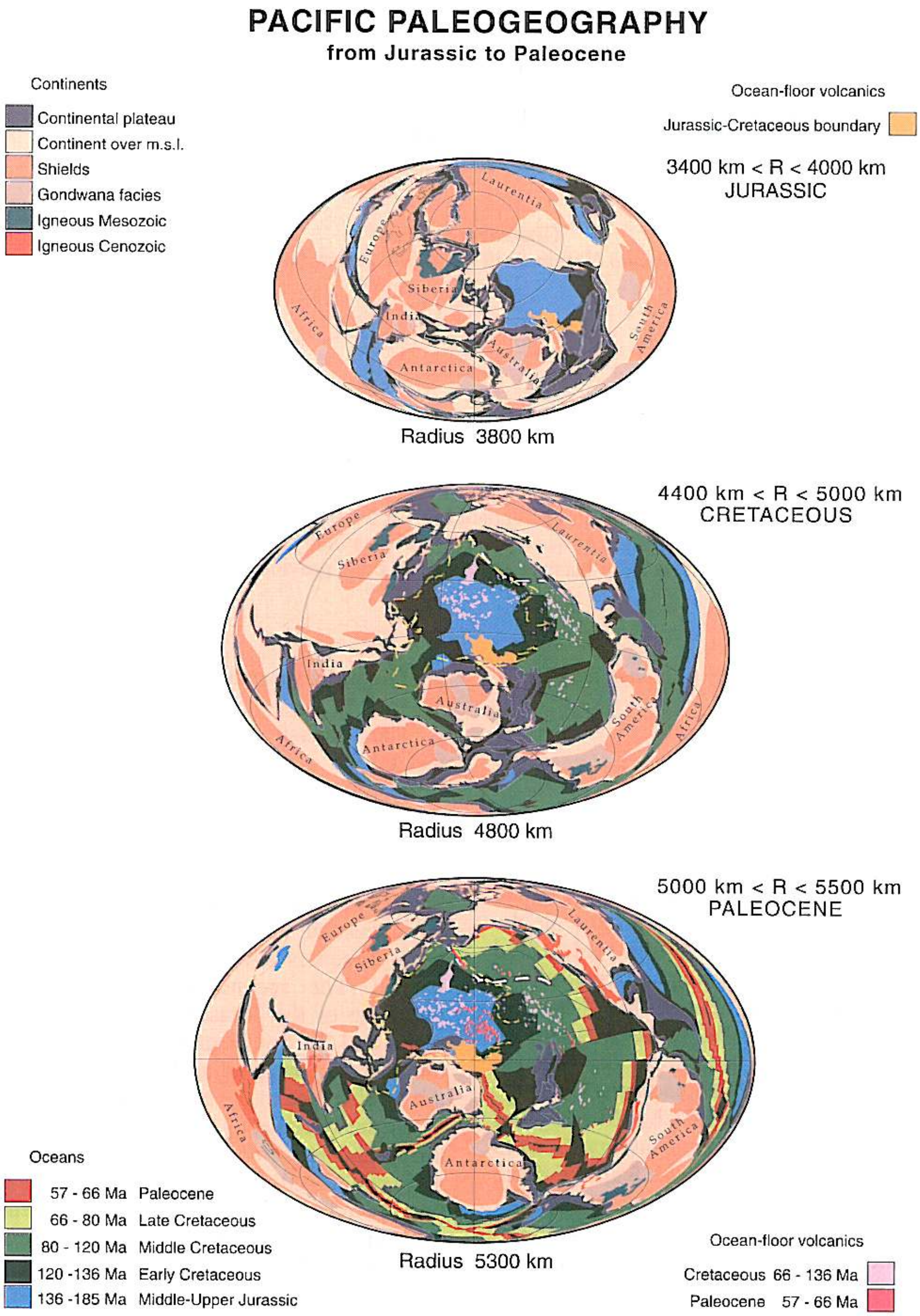

Fig. 1. The pacific paleogeography in three geological times. The reconstructions were made using the constrains of several databases: geographic, paleomagnetic, geological and paleontological. The white broken line represents the Emperor-Hawaii lineament; the yellow broken line is the conformity ruler.

tologic data of vegetation (Truswell, 1991). The limited extension of the Pacific is in agreement with the non existence of the «Pacific Barrier» in this period (Grigg and Hey, 1992).

The Paleocene reconstruction is also provided (R = 5300 km), which, together with the other reconstructions, gives a diachronic view of the kinematics of the plates of the Pacific region, and discloses the main counter-clockwise rotation of the Pacific basin (Maslov and Romanovsky, 1990), Australia and Antarctica.

From Jurassic to Paleocene a constant link exists between the northern boundary of Australia-New Guinea and the evolution of the Ontong Java oceanic basaltic plateau (Jurassic Cretaceous boundary in fig. 1).

To roughly reconstruct the ancient shapes of the Asiatic margins, the current existence of strong conformities among continents and ocean basins (Scalera, 1988, 1991, 1993a), and their geologic outgrowth, was used. Due to the use of the conformities «ruler», the Siberian shield, and its huge Mesozoic basaltic emission, has been recognised to have connection, and a possible Jurassic contact, both with the Kolyma basaltic emission and that of the Chinese Pacific coast.

3. The model

Starting from the Carey's model (1975, 1976), a non-subductive model of the evolution of Trench-Arc-Backarc (TAB) zones was developed using as key points the tensional state of stress of trenches and the presence of a volcanic zone on the arc and the backarc, which exert a rear push on the orogenic arc. The two cooperate with gravity and with high frequency tidal movements (Kosygin and Maslov, 1986) to favour gravitational spreading of the arc toward the trench. The spreading is accompanied by the folding and thrusting of oceanic crust beneath the accretion complex. Once the trench is filled in by the advancing edge of the arc, the consequent subsidence of the zone produces the disruption of the oceanic margin and a new tensional zone starts seaward from the old, creating a new trench. Both old vanishing and newborn zones of tensional weakness are traced by earthquake foci explaining the possible presence of the double Benioff surface. The TABs initiate their evolution with uplift of a new orogen on the continental edge, subsequent subsidence of the orogen and open of backarc. Covering of the subsided orogen by pillow lavas and a cyclic sequence of uplift and exumation of deep crust could explain several typical features of the TABs, namely the «obduction» of ophiolitic fields, the high backarc heat flow, the special characteristics of the metamorphism.

In detail from fig. 2:

a) The final state in the plate tectonics interpretation. This figure shows the classic interpretation of the trench-arc-backarc zones in the plate tectonics framework (redrawn from Bally *et al.*, 1985, modified). A lithospheric oceanic slab is underthrusted for hundreds of km in the mantle. The accretional complex contains fragments of oceanic crust delaminated from the subducting plate. The lT/lP metamorphism is produced by this low temperature oceanic crust delaminated and metamorphosed at shallow depth. The high heat flow in the arc-backarc region is a consequence of a convective flow driven by the subducting slab and by overheating due to the friction. Water is underthrusted with the sediments of the subducing slabs and creates the conditions for andesitic melts emplacements in the arc.

b) Initial state in the proposed new interpretation. In the new interpretation the trench-arc-backarc zone develops mainly under the influence of a general tensional state of the lithosphere. Contributions to the process by transtensional movements, along the arc-trench direction, are probably present. The idealized undisturbed state is strongly asymmetrical because two different kinds of lithospheres, continental and oceanic, are coupled.

c) The start of trench opening and rising of a marginal orogenesis. Tensionally induced upwelling of the mantle starts, which produces an upwelling of the continental margin, constituting a tabular orogen (Ollier, 1990). This is necessary to the emplacement of the ophiolitic complexes on the future arc, because typically they are obducted on a slightly older orogen. Decompression and first traces of a line of

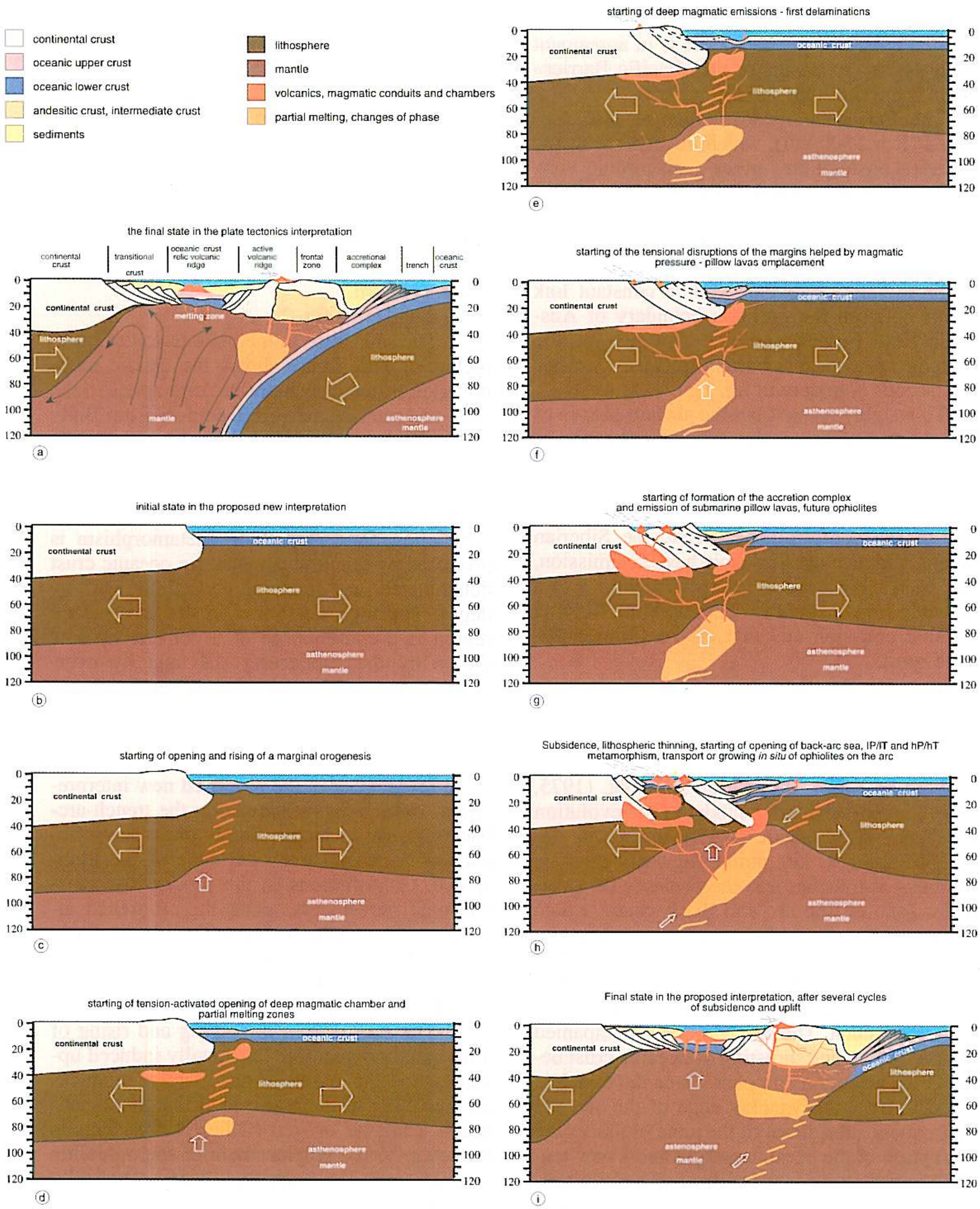

Fig. 2. A non subductive interpretation of the trench-arc-backarc zones. For details see text.

lithospheric instability in which partial melting appears is possible. A graben-like depression constitutes the first developing stage of the trench seawards.

d) Tension-activated opening of a deep magmatic chamber and partial melting zones. The decompression activates the opening of a deep magmatic chamber under the continental and oceanic crust. Major partial melting zone appears in the lithosphere along an instability line.

e) Starting of deep magmatic emissions – first delaminations. The progressive fracturation of the continental margin is triggered essentially by the instability created by the growth of the magmatic chambers. Magmatic pipes intrude into the continental and oceanic crust along favoured paths, weakness zones and fault planes. First emission of continental lavas appears. The first emission of pillow lavas in the trench zone will constitute the future ophiolites of the accretional complex. Compressional stress and tensional stress characterize now the frontal zone and the continental volcanic belt respectively.

f) Tensional disruptions of the margins helped by magmatic pressure. Pillow lava emplacement goes on. The tensional disruption and the collapse of the continental margins start with listric faults. The disruption is helped by magmatic pressure, gravitational spreading, low frequency secular variation of the lithospheric tensional state, high frequency variation of the stress linked to solid earth tides. Pillow lavas are emitted on the proto-backarc basin. First overthrusts of oceanic fragments due to the rear push of the proto-arc.

g) Formation of the accretion complex and emission of submarine pillow lavas, future ophiolites. The rear push of the proto-arc produces repeated overthrusts of oceanic slabs which constitute the accretion complex. Sediments are included in the accretion complex. The filling of the trench is complete. Further pillow lavas are emitted. Lithospheric thinning goes on.

h) Subsidence, lithospheric thinning, opening of backarc sea, lP/lT and hP/hT metamorphism, transport or growing *in situ* of ophiolites on the arc. Lithospheric thinning is now in an advanced state. The backarc sea is fully opened, and fragments of the continental margin are detached from the continent and undergo strong subsidence along with portions of the accretional complex. The subsidence creates the conditions for a low temperature and low pressure metamorphism. The volcanic spreading of the backarc and the magmatic activity on the arc cooperate in the obduction or *in situ* emplacement of ophiolites, and create the conditions for a high temperature and high pressure metamorphism. A deep mix of continental and oceanic crust, and of water both from the mantle and underthrusted oceanic crust gives place to an intermediate crust. The tensional collapse of the zone also involves the oceanic margins and a new instability line develops, at the edge of which a new trench evolves.

i) Final state in the proposed interpretation, after several cycles of subsidence and uplift. Repeated cycles of backarc spreading, filling of the trench, subsidence and upwelling of the arc and of the accretion complex lead to a mature trench-arc-backarc zone which has the same geological characteristics as the actual zones.

4. The Benioff zone

The deep seismic Benioff zone can be explained by sudden changes in phase in a ductile environment, as suggested in literature. The focal mechanisms on the Benioff zone can be put in agreement with the data adopting a flow model different from the plate tectonics one. In fig. 3a,b the classical interpretation of Isacks *et al.* (1968) is shown in comparison with the new possible interpretation. The proposed interpretation of the mantle flow and crustal evolution can fit with the observed state of stress and focal mechanisms. A near steady rising of hotter and lighter mantle material in the deep backarc region, and a subsidence of the frontal zone could put the focal mechanisms on the Benioff zone in agreement with the data. The shallow more complicated flow under the arc could explain the different kinds of focal mechanisms.

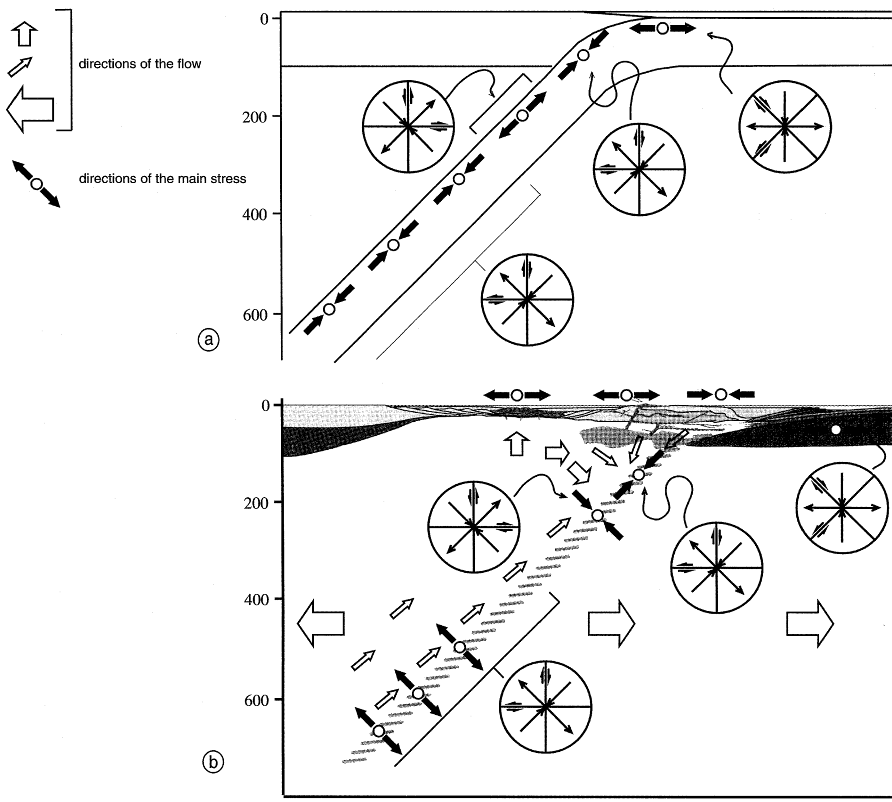

Fig. 3a,b. Comparison between (a) the classical subductive and compressional model of plate tectonics and (b) a tensional model without subduction. The focal mechanisms can be the same in the two models. See text.

5. Conclusions

The proposed model is substantiated by both experimental works on analogical scale model (Merle and Vendeville, 1992) and by observational evidence on different scale structures like thrust fault on glacial moraines (Lehmann, 1992), spreading of volcanic cones (Borgia *et al.*, 1992; Borgia and Treves, 1992; Delaney, 1992) and the role of melt in the uplift of orogenic belts (Hollister, 1993). The model needs further tuning to be adapted to other regional cases. With no pretence to be a solution for all the complex problems at the TABs, the main advantage of the proposed model is to fit observation with simple mechanisms.

The presence of large undisturbed detrital fans along the Aleutine arc, the existence of astonishing conformities between the members of pairs basin-continent in the Pacific, and the consequent non-random emplacement of the trench-arc zones (Scalera, 1991, 1993a), the many palaeontological clues (Scalera, 1994; see references in this paper), some paradox from synthetic paleogeography (Scalera, 1990), and the consistency of the proposed series of paleogeographical reconstruction, all witness a limited amount of underthrust of oceanic crust at the Pacific edges, raising doubts about the effectiveness of large scale subduction and suggesting the actual validity of an expanding Earth. This possibility is also supported by a recent analysis of space tracking data (Gerasimenko, 1993) in searching for change in Earth dimensions, which, using LAGEOS and VLBI data for stable non-orogenic continental regions, has indicated an increase in the Earth's radius of + 4.15 ± .27 mm/yr. This result has to be compared with the amount of global uplift and variation of J_2 which today is assigned to post-glacial uplift.

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