

Geodynamic evolution of the Aegean Region

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ABSTRACT — *The synchronous uprising of magma in the north Aegean and the gravitational compression due to spreading in the Atlantic, Indian and Pacific Oceans, as well as the sinistral Tethyan megashear, determine the geodynamic evolution of Tethys and of the Aegean region.*

In the south Aegean the well defined Benioff zone is due to the underthrusting of the African continental lithosphere, while the weak north Benioff zone is due to the uprising mantle.

RIASSUNTO — [Evoluzione geodinamica della regione egea] — *La contemporanea ascesa del magma nella zona del Mare Egeo del nord e la compressione causata dalla gravità, dovuta alla fuoriuscita di magma nell'Oceano Atlantico, Indiano ed in grado minore nell'Oceano Pacifico, come pure la faglia sinistrosa della Tetide, determinano l'evoluzione geodinamica della Tetide e della regione egea.*

Nel Mare Egeo del sud è ben determinata la zona di Benioff, collegata alla subduzione della placca litosferica continentale Africana; invece la zona di Benioff del Mare Egeo del nord non è ben determinata ed è collegata all'ascesa del mantello.

INTRODUCTION

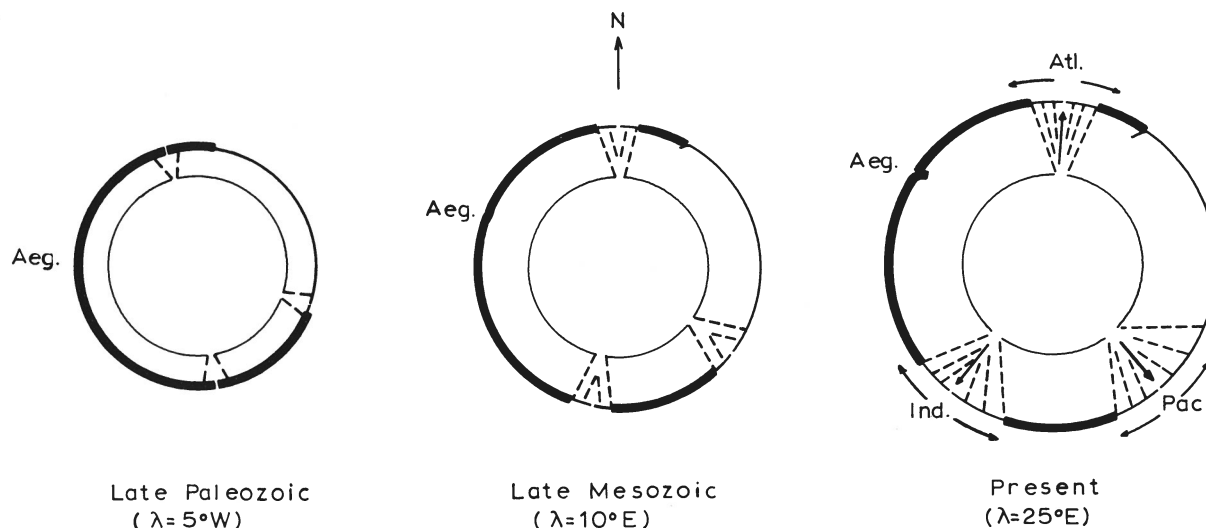
The plate-tectonics theory and the predominance of horizontal movements have been proposed in an effort to explain in a rather simple way the observed geodynamic phenomena. As a working hypothesis though, is very complex because it assumes a state of symmetry and equilibrium for a very long period of time, even in geological terms. On the other hand the acceptance of asymmetry, through expansion, is simple in principle, but its expression in geodynamic phenomena is complex, in the sense that the quantification of all major dependent variables is required.

Within that framework tectonism is a result of internal processes that involve three dimensional movements, and any regional model should take that into serious account especially in an area as complex as the present Mediterranean and old Tethys. Therefore horizontal movements can only be viewed as part of this three dimensional system, and the goal should be to define as accurately as possible the evolution of the system in time and space.

One of the main arguments between plate-tectonists and expansionists is the existence of a compres-

sional field. In my opinion such a field can be justified in both theories. When expansion and spreading take place in opposing directions the result could be compression, especially when continental plates are involved, because there is an elastic inertia of crustal response to mantle expansion. With the acceptance of compression, subduction can be locally justified as an expression of the asymmetry between expansion rates, and sedimentary loading. This kind of subduction can be identified by the lack of decoupling between the crust and the mantle, the limited depth of crustal penetration, and the lack of repetition in time and space. It is a unique phenomenon within the framework of non-uniformitarianism.

For the Aegean Region two basic models have been proposed. The one accepts the existence of a well defined south Benioff zone (Papazachos *et al.* 1966, Papazachos and Comninakis 1969, 1971, 1977, 1978, Ritzema 1969, Mackenzie 1972, Papazachos 1974, 1977, Papazachos and Papadopoulos 1977, Comninakis and Papazachos 1980), while the other accepts the predominance of vertical tectonics and the lack of a well defined south Benioff zone (Makris 1973, 1977, Makris and Todt 1977).



Text-fig. 1 - Size evolution of the earth and major areas of spreading and underthrusting. Other locations of rising mantle such as the African triple junction and possibly the north Aegean are not shown, because the attempt is to indicate the major sites of uprising associated with a clear surface manifestation and the resulting stress pattern.

Tassos (1983a, 1983b) proposed a third model which is a combination of the other two. This work is on that line, and offers an alternative model, in an effort to explain reported and well documented data.

GENERAL SETTING

Text-fig. 1 shows the proposed general mechanism and the evolution of spreading and subduction around the present 25°E meridian. Mantle material rises from the outer core in a conical form. The younger material intrudes in the core of the older one, thus introducing a global tensional field. In the areas where oceanic crust meets with continental crust subduction might take place as a result of compression and gravitational drag due to density differences resulting from stress heating. The phase change of basalt into eclogite could be responsible for a negative buoyancy. Underthrusting of continental crust can take place when a continental plate is surrounded by spreading centers and consequently, due to its elasticity, is under compression. Phase changes due to stress heating can also introduce a downward gravitational drag. Similarly continents might collide when they passively drift in opposing directions, the centers of rotation being in the interior of the earth, and not on its surface as plate-tectonists want, thus limiting horizontal displacement.

Fast spreading within the framework of expansion is proposed to have started by the end of Palaeozoic. Therefore compression and subduction, to the degree it takes place, is proposed to have started

about 250 m.y. B.P.. The crustal material, if any, which goes down the trench is a very small fraction of the material added on the surface, and represents the asymmetry between the rate of addition of new material and the rate that the rigid surface of the earth responds to this addition.

EVOLUTION OF THE AEGEAN AREA

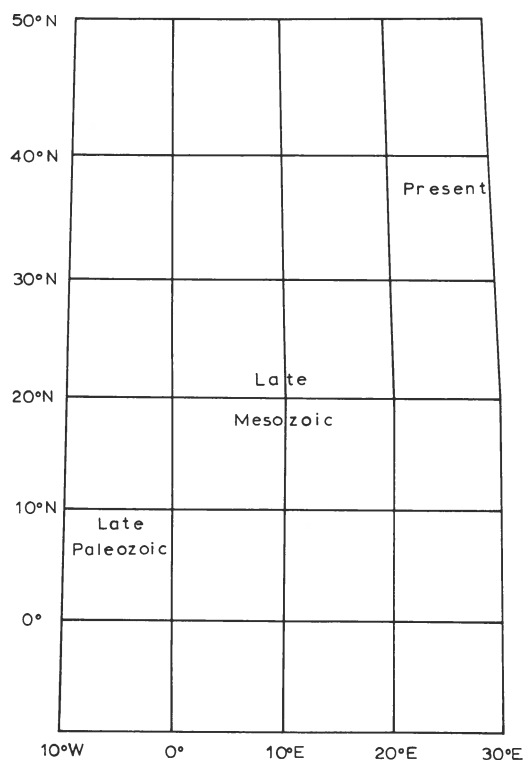
By the end of Paleozoic Pangea, after its initial split, through the formation of the Eo-Pacific, was fragment into smaller continents, and spreading started in the newly formed Atlantic and Indian Oceans, as well as in the preexisting Pacific (Carey, 1976).

The Tethyan region which at the beginning of Mesozoic was equatorial slowly drifted to its present position, due to tilting by something like 30° to the north, and by about the same thirty degrees to the east (Text-fig. 2). Faster expansion in the southern hemisphere is responsible for the northeastward drift.

Due to spreading and the gravitational gliding and tilting that takes place mainly in the Atlantic and Indian Oceans, but also in the Pacific, the Tethyan zone is under compression, both in the N-S and E-W directions. At the same time is experiencing an anticlockwise rotation and forms sinistral transcurrent faults.

The proposed geodynamic evolution of the Aegean region is shown in Text-fig. 3.

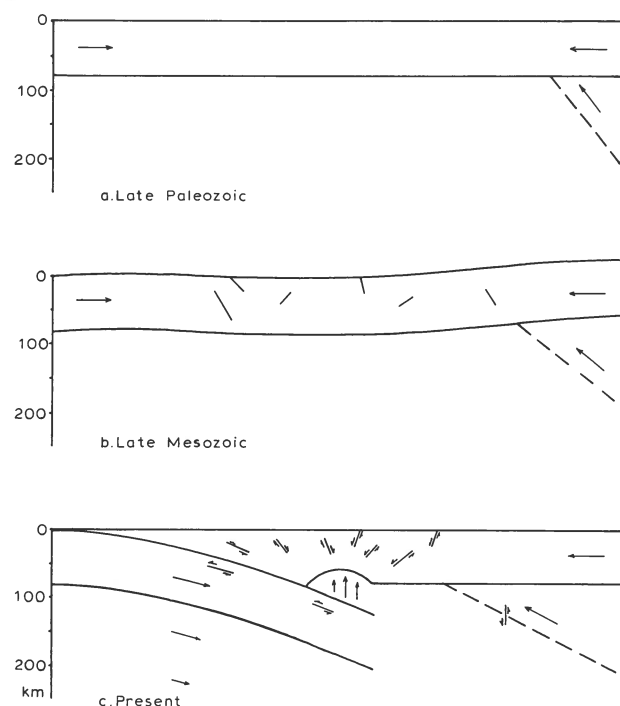
During late Paleozoic the rising mantle in the northern Aegean started to exert a substantial upward stress on the overlying crust, while spreading



Text-fig. 2 - Change with time of the position of the Aegean Region relative to the present geographic coordinates.

was starting in the Atlantic and Indian Oceans and as a result of that the Tethyan zone was under compression. In upper Mesozoic vertical and horizontal forces continued to act with a greater intensity and the formation of Tethys, could be attributed to the isostatic movements that took place due to those forces. Within that framework, Tethys should be viewed as a shallow epicontinental sea, something which is supported by the continental character of its crust. Some wedge shaped intrusions of oceanic crust in the deeper parts of the basins, represent the fragmentation and splitting of the Alpine zone that most likely took place in Middle-Upper Miocene (Calcagnile *et al.*, 1981). The underthrusting of the African continental lithosphere, seems to have taken place during Upper-Miocene as a result of the synthetic faulting in the Alpine chain that took place during that time. The formation of a well defined south Benioff zone is a consequence of the underthrusting, while the weak north Benioff zone represents the stress field created by the uprising mantle.

Anticlockwise rotation which is a result of the sinistral Tethyan megashear, gave the present shape to the area, and to a great degree prescribes its future evolution.



Text-fig. 3 - Geodynamic Evolution of the Aegean Region.

CONCLUSION

The evolution and the present morphology and tectonic features of the Aegean region, such as the Hellenic arc, earthquake activity and mechanism, volcanism and plutonism are interpreted within the framework of expansion, as a result of mantle uprising, gravitational compression, and sinistral shearing in the Tethyan zone.

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