4-12. - PLATE TECTONICS AND THE EVOLUTION OF TETHYS

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It is contended that the late Triassic to present day gross evolution of the Alpine System in the Mediterranean region has been the result of activity along an evolving network of accreting, transform, and subduction, plate boundaries between larger African and European Plates. A new fit of the continents around the North and Central Atlantic, for the late Triassic, is presented. Using geologic and paleomagnetic criteria, the smaller continental blocks within the Alpine System are restored to their proposed positions relative to this reconstruction.

The motion of Africa relative to Europe for the past 178 m.y. (Toarcian Stage, Lower Jurassic) has been determined by analysis of the sea-floor spreading history of the Atlantic Ocean, with the assumption that relative motion has occurred between rigid lithospheric plates. By fitting well-defined key pairs of magnetic anomalies back together by a series of rotations, the relative positions of North America, Europe, and Africa have been determined for the following times: 178 m.y. (Toarcian Stage, Lower Jurassic); 148 m.y. (Kimmeridgian Stage, Upper Jurassic); 80 m.y. (Santonian Stage, Upper Cretaceous); 63 m.y. (Danian Stage, Paleocene); 53 m.y. (Ypresian Stage, Eocene) and 9 m.y. (Tortonian Stage, Miocene). From these positions a series of rotation poles presumed to describe the motion of Africa relative to Europe were computed.

A series of plate tectonic interpretations are presented for the following times: late Triassic, 178 m.y., 165 m.y., 148 m.y., 110 m.y., 80 m.y., 63 m.y., 53 m.y. and 17 m.y. In addition, a plate tectonic scheme for the Upper Triassic is presented. A sequence of eight phases or chapters in Atlantic spreading history are recognized, based upon changes in direction and rate of relative motion between the continents bordering the Atlantic. Nine phases of Tethyan history are recognized on the basis of the age of ophiolite sequences representing sea-floor spreading at various times during the history of the Alpine System. All the models are tentative since at no time, apparently, was there a single plate margin between Europe and Africa. The sequence of plate tectonic interpretations involves a complex evolving and changing mosaic of accreting, transform, and subduction plate boundaries. Since 178 m.y. the ocean (Tethys 1) of the initial reconstruction has been mainly swallowed up, with small remnants remaining at present as the crust of the Black and South Caspian Seas. The other oceanic portions of the system (e.g., western Mediterranean Basins, the Ionian Sea and the Levantine Sea) were generated by sea-floor spreading mainly since 178 m.y. Several oceanic regions generated by sea-floor spreading prior to 178 m.y., and many generated since 178 m.y., have been destroyed by subduction and collision between continental blocks. These sutures are represented by ophiolite and/or blueschist zones within the Alpine System.

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Observations présentées à la suite de la communication de W. RYAN : 4-12.

Pr. L. GLANGEAUD - Il serait difficile de dire en quelques mots, et même en une heure tout ce qu'il y a de bien dans cette présentation et également les quelques erreurs importantes. Il y a aussi pour nous un problème de terminologie française qu'il faudra revoir et c'est le rôle de l'Académie des Sciences que je représente ici.

Au point de vue méthodologique, je voudrais savoir si vous prenez une hypothèse de base avec rayon constant de la Terre ou non ?

Réponse : Our interpretation is made without expansion of the Earth.

Pr. L. GLANGEAUD - Si nous partons de ce principe, une extension de l'Océan Atlantique devra s'accompagner de réduction d'autres océans. (En Français, il vaudrait mieux parler d'extension que d'expansion de l'Océan Atlantique). En ce qui concerne l'Europe et l'Afrique, vous tirez des conclusions sur les mouvements relatifs principalement NS c'est-à-dire orthogonaux à l'extension de l'Atlantique. Si je suis d'accord avec les rotations, je crois que les rapports de ces différents mouvements devraient être revus sous l'angle de leurs relations orthogonales en milieu sphérique.

Réponse (Ryan) -
Perhaps I have not been quite clear that these maps are computer drawn tracings on a Mercator projection but all the rotations were done in the spherical domain of the Earth. We were surprised ourselves. If you are extending Africa to the East from America you expect shear along the Tethys but if you carry it out rigourously about a pole that must satisfy the fracture zone trends, if there was interaction along a single plate boundary there will be compression in some places and extension in others.

Dr. CLOSS - It is a very interesting paper and a good attempt to bring together geologists, geophysicists and petrologists cooperate to use what we observe today in plate tectonics and project it in the past. I am impressed by the accuracy in which you have collected all the indications of such plate movements. This is what we need. I must thank this group for doing this pioneering work presented today.

MERCIER Jacques - Dans les schémas successifs qui ont été présentés concernant l'évolution de la Méditerranée, les positions successives des blocs d'Apulie et du Rhodope (qui jouent un rôle important dans l'interprétation du domaine de la Méditerranée orientale) ne rendent pas bien compte des phases tectoniques connues. Sur la bordure occidentale du bloc du Rhodope (dans la zone du Vardar) devraient nettement apparaître

les phases de déformation suivantes qui se placent : 1. au Jurassique supérieur - Crétacé inférieur (avec métamorphisme HP.-BT°, direction axiale N-S), au Crétacé supérieur - Eocène inférieur (avec métamorphisme H. P.-BT° direction axiale NE-SW), 3. à la fin de l'Eocène supérieur, 4. après l'Oligocène (direction axiale dinarique NW-SE).
Il ne s'agit pas là d'un détail mais du comportement du bloc du Rhodope et donc de l'évolution tectonique des zones internes (orientales) de l'ensemble des chaînes helléniques et dinariques.

Réponse - RYAN. If we refer to our text and figure 16, at the beginning of the Cretaceous there is a compression phase between the Rhodope massif and the Apulian plateau. We had great difficulty to know what to do with the Pindus trough, and whether the trails came out of Rhodope Syncline thrust to the west, over Auboin's internal ridge for that is what the Pindus trough is. Or is the Pindus trough an other extensional opening ? We definitely agree with a compressional phase and à great Upper Cretaceous uplift thrusting.

MERCIER - Il ne s'agit pas d'un soulèvement, mais de phases de compression syn-métamorphique ce qui est fondamentalement différent.

Réponse - RYAN. We have a compression without metamorphism by a process we call "ophiolite upduction". We think this is an existing process in the plate tectonic literature as a proved process.