Boundary conditions and kinematic parameters for palinspastic restorations of the Central Mediterranean region during Neogene

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Around the end of the sixties and the beginning of the seventies, scientific results of innumerable oceanographic cruises allowed researchers of the Lamont-Doherty Observatory of Columbia University to identify and date the principal magnetic lineations of the Central and Northern Atlantic and to propose a quite reliable reconstruction of the ocean spreading (Pitman & Talwani 1972). Once the parameters of the relative motion between Europe and America and between Africa and America had been determined, it was possible to calculate virtual poles and finite rotation angles representative of the Africa-Europe interaction through discrete time intervals (Dewey *et al.* 1973). In an approach of global tectonics, the Atlantic Ocean was regarded as a first-order kinematic system entirely controlling the Alpine tectonic evolution of the Mediterranean region. Through the whole time span ranging from the late early Jurassic to the Oligocene, the fit between computed and observed data resulted excellent. Starting from the Oligocene/Miocene boundary, however, a dominant misfit was found over most of the Central and Western Mediterranean region, with the exception of the Alps where predictions were not contradicted by regional geology. The misfit regarded both the directions and the magnitudes of the slip vectors, with angular deviations as great as 90° and slip rates in excess of 500 per cent. After the basic work of Pitman & Talwani (1972) new data on the Atlantic have been produced and new kinematic models have been proposed on the post-Oligocene evolution of the Mediterranean region (see, among many others, Biju-Duval *et al.* 1977; Livermore & Smith 1985; Dercourt *et al.* 1986; Savostin *et al.* 1986; Dewey *et al.* 1989; Mazzoli & Helman 1994) but a lot of misfit between prediction and observed data still persisted. Starting from the second half of the seventies, the introduction of the rollback mechanism (Malinverno & Ryan 1986) provided new conceptual tools for solving the discrepancy between predictions derived from global tectonics and facts observed in regional geology (e.g. Patacca & Scandone 1989; Gueguen *et al.* 1989; Rosenbaum & Lister 2004). Global tectonics defines boundary conditions and provides thus important constraints for any palinspastic restoration, but cannot predict the role of the flexure retreat of the lower plate. Rollback mechanisms, on the other side, control the flexure-hinge retreat in the lower plate and the related kinematic parameters (extension in backarc basins, shortening and consequent forward migration of the compression front in thrust belts). In the case of passive lithosphere sinking, high-rate flexure-hinge retreat may be responsible for remarkable extension in backarc regions and severe shortening in the mountain chain, with a forward migration of the thrust belt-foredeep system at rates several times greater than the plate-convergence rate.

In this presentation we will describe the geological evolution of the peri-Tyrrhenian region starting from middle/late Oligocene times, when two orogenic belts having opposite sense of subduction were developed east of Corsica-Sardinia and in the Alps, separated by a transform fault zone in correspondence to the Tertiary Piedmont-Liguria basin. During the Oligocene, both systems behaved as neutral arc, with plate convergence compensated by flexure-hinge retreat and with opposite forward migration of the thrust belt-foredeep-foreland systems. Starting from the Oligocene/Miocene boundary, the high-rate flexure-hinge retreat of the

Africa plate not compensated by plate convergence brought to the opening of the Western Mediterranean and Tyrrhenian basins. We have used four principal parameters:

- Vectors describing the Africa-Europe interaction deduced from the spreading history of the Atlantic, derived from the geological literature;
- Velocity of the flexure-hinge retreat estimated from original data on the forward migration of the Apennine foredeep basins across restored balanced sections;
- Velocity of shortening, estimated from original data on the times of incorporation in the thrust belt of foreland domains across the same restored balanced sections;
- Velocity of extension of the Western Mediterranean and Tyrrhenian post-collisional basins deduced from the available literature.

Flexure-hinge retreat, reaching rates 5-6 times higher than the Africa-Europe convergence, was the dominant parameter in the tectonic evolution of the study area.

Keywords: Neogene, Mediterranean, Adria, palinspastic restorations, kinematic evolution

References:

Biju-Duval B., Dercourt J. & Le Pichon, X., 1977. From the Tethys Ocean to the Mediterranean Seas: a plate tectonic model of the evolution of the Western Alpine system. In: Biju-Duval B. & Montadert L. (eds.)-International Symposium on the Structural History of the Mediterranean Basins (Split, 1976). *Editions Technip, Paris*: 143– 164.

Dercourt J., Zonenshain L.P., Ricou L.-E., Kazmin V.G., Le Pichon X., Knipper A.L., Grandjacquet C., Sbortshikov I.M., Geyssant J., Lepvrier C., Pechersky D.H., Boulin J., Sibuet J.-C., Savostin L.A., Sorokhtin O., Westphal M., Bazhenov M.L., Lauer J.P. & Biju Duval B., 1986. Geological evolution of the Tethys belt from the Atlantic to the Pamirs since the Lias. *Tectonophysics*, 123 : 241-315.

Dewey J.F., Helman M.L., Turco E., Hutton D.H.W. & Knott S.D., 1989. Kinematics of the western Mediterranean. In: Coward M.P., Dietrich D. & Park R.G. (eds.)-Alpine Tectonics, Geol. Soc. of London, Spec. Publ., 45: 265-283.

Dewey J.F., Pitman W.C., Ryan W.B.F. & Bonnin J., 1973. Plate Tectonics and the evolution of the Alpine System. *Bull. Geol. Soc. Amer.*, 84: 3137-3180.

Gueguen E., Doglioni C. & Fernandez M., 1998. On the post-25 MA geodynamic evolution of the western Mediterranean. *Tectonophysics*, 298: 259-269.

Livermore R.A. & Smith A.G., 1985. Some boundary conditions for the evolution of the Mediterranean region. In: Stanley D.J. & Wezel F.C. (eds.)-Geological Evolution of the Mediterranean Basin. *Raimondo Selli Commemorative Volume:* 83-98. Springer-Verlag, New York.

Malinverno A. & Ryan W.B.F., 1986. Extension in the Tyrrhenian Sea and shortening in the Apennines as a result of arc migration driven by sinking of the lithosphere. *Tectonics,* 5: 227-245.

Mazzoli S. & Helman M., 1994. Neogene patterns of relative plate motions for Africa-Europe: some implications for recent central Mediterranean tectonics. *Geol. Rundschau*, 83: 464-468.

Patacca E. & Scandone P., 1989. Post-Tortonian mountain building in the Apennines. The role of the passive sinking of a relic lithospheric slab. In: BORIANI A., BONAFEDE M., PICCARDO G.B. & VAI G.B. (eds.)-The lithosphere in Italy. Advances in Earth Science Research. Italian National Comm. Intern. Lithosph. Program, Mid-term Conference (Rome, 5-6 May 1987), *Atti Conv. Lincei*, 80: 157-176.

Pitman W.C. & Talwani M., 1972. Seafloor spreading in the North Atlantic. *Bull. Geol. Soc. Amer.,* 83: 619-646.

Rosenbaum G. & Lister G.S., 2004. Neogene and Quaternary rollback evolution of the Tyrrhenian Sea, the Apennines and the Sicilian Maghrebides. *Tectonics,* 23, TC1013, doi:10.1029/2003TC001518.

Savostin, L.A., Sibuet, J.C., Zonenshain, L.P., Le Pichon, X. & Roulet, M.J., 1986. Kinematic evolution of the Tethys belt from the Atlantic Ocean to the Pamirs since the Triassic. *Tectonophysics*, 123: 1-35.