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GPS CONSTRAINS ON CURRENT TECTONICS OF ALBANIA

Përmbledhje: Tektonika e sotme e Shqipërisë është dokumentuar sipas treguesve të neotektonikës dhe sipas një numri të madh të tektonikave të mesme. Mekanizmat depërtuese sugjerojnë egzistencën e prerjeve tërthore të ditëve të sotme të Albanideve të jashtme, ndërkohë që Albanidet e brendëshme janë prekur nga tërheqjet me drejtim L-P drejt V-J. Në këtë artikull ne paraqesim një vlerësim sasior të e zhvendosjeve aktuale nga GPS me dy grupe të dhënash: stacionet e përkohëshme GPS që lejojnë një vlerësim sasior të saktë të zhvendosjeve dhe një rrjet i dendur GPS që lejon lokalizimin e ndryshimeve kryesore në fushën e zhvendosjeve. Ky studim ka mundësuar dallimin e territorit të Shqipërisë Perëndimore të prekur nga zhvendosja në drejtim të perëndimit relative me pllakën e Eurazisë dhe mikropllakën e Adrias Jugore, ndërsa shtrirja lokale në shumë drejtime preku grabenet aktive në Ohër dhe Korçë te Albanidet e brendshme. Të dhënat e GPS gjithashtu identifikojnë shkarjet e rajonit Shkodër-Pejë midis Dinarideve dhe Albanideve, sikurse dhe limiti i zonës Shqipëri-Greqi Perëndimore i prekur nga një rrotullim sipas akrepave të orës relative për Euroazinë. Zona tjetër e rrëshqitjeve të tërthorta Dibër-Elbasan duket e prekur nga një shtrirje e moderuar. Përpilimi i të dhënave të publikuara të GPS me të dhënat tona mundëson identifikimin e kufirit të Albanideve të brendshme dhe të jashtme si kufi perëndimor të fushës (territori i brendshëm i Shqipërisë, Greqisë veriore, Maqedonisë dhe Bullgarisë) të prekur nga zhvendosjet në drejtim të jugut relative për rajonin e qëndrueshëm të Euroazisë, ndërsa rrëshqitjet në rajonin Shkodër-Pejë mund të formojnë kufirin perëndimor të tij.

Fjalë kyçe: *Stacionet e përkohëshme GPS, rrjetet e dendura GPS, Albanidet, Dinaridet, rrëshqitjet në zonën Shkodër-Pejë, rrëshqitjet në zonën Vlorë-Elbasan-Dibër, mikropllakë e Adrias*

Abstract: Current Tectonics of Albania is documented by neotectonics indices and by a large number of medium size earthquakes. Focal mechanisms suggest the existence of

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current shortening across the external Albanides whereas internal Albanides are affected by E-W to N-S extension. In this paper, we present a quantification of current displacements by GPS with two data sets: permanent GPS stations allow an accurate quantification of displacements and a dense GPS network allows the localization of the main changes in the displacements field. This study has allowed distinguishing a western Albania affected by westward motions relative to both Eurasia plate and south Adria microplate, whereas local multidirectional extension affected the Korea and the Ohrid active grabens in the inner Albanides. GPS data also allow identifying the Shkodra-Peja Fault, between Dinarides and Albanides, as the northern limit of an area, Albania – western Greece, affected by a clockwise rotation relative to Eurasia. The other transverse fault zone, the Diber-Elbasani fault, appears to be mainly affected by a moderate extension. Compilation of published GPS data with our data set allow to identify the external-inner Albanides limit as the western border of the domain (inner Albania, northern Greece, Macedonia, Bulgaria) affected by southward displacements relative to stable Eurasia, whereas Shkodra-Peja fault form probably its northern limit.

Key words: *Permanent GPS stations, dense GPS network, Albanides, Dinarides, Shkodra-Peja Fault, Vlora-Elbasani-Dibra fault, Adria microplate*

INTRODUCTION

Current tectonics of Albania is characterized by an important microseismicity, small and medium size earthquake and a few large events as shown by the occurrence of 6 earthquakes with Ms magnitudes exceeding 6 during the last century (1905, Shkodra earthquakes Ms 6.6, 1911 Ohrid lake earthquake Ms 6.7, 1920 Tepelena event Ms 6.4, 1926 Durres earthquake Ms 6.2, 1967 Dibra earthquake Ms 6.6 and 1979 Montenegro earthquake Ms 6.9).

Focal Mechanisms (Sulstarova *et al*., 1980, Louvari, 2001), as well as neotectonics investigations (Aliaj *et al*., 2000; Carcaillet *et al*., in press) underline the existence of a current E-W shortening across external Albanides whereas internal Albanides experience an E-W to N-S extension (Tagari *et al*., 1993). Moreover Albanides are crossed by two transversal faults, the Vlora-Elbasani-Dibra fault zone and the Shkodra-Peja (Scutari-Pec) one (Roure *et al*., 2004). This last fault zone seems to be the northern boundary of the Albania and Greece area characterized by NNW-SSE structural direction and affected by the important post Miocene rotation as shown by Speranza *et al*., 1995. North of the Scutari-Pec fault, the Dinarides have not experienced such rotation and are characterized by NW-SE structural directions. To quantify current deformation, we have installed since 2003 a network of five permanent GPS stations designed to record present-day displacement across the main active tectonic zones of Albania. This network has been densified with a dense GPS network measured two times in order to better localize area undergoing present-day deformation and the boundary between external Albanides affected by current shortening and inner Albanides affected by extension.

GPS data acquisition carried out by the Permanent GPS Albania, to sampled Network of present-days displacements in both sides of the main structures identified in Albania (Fig. 1).

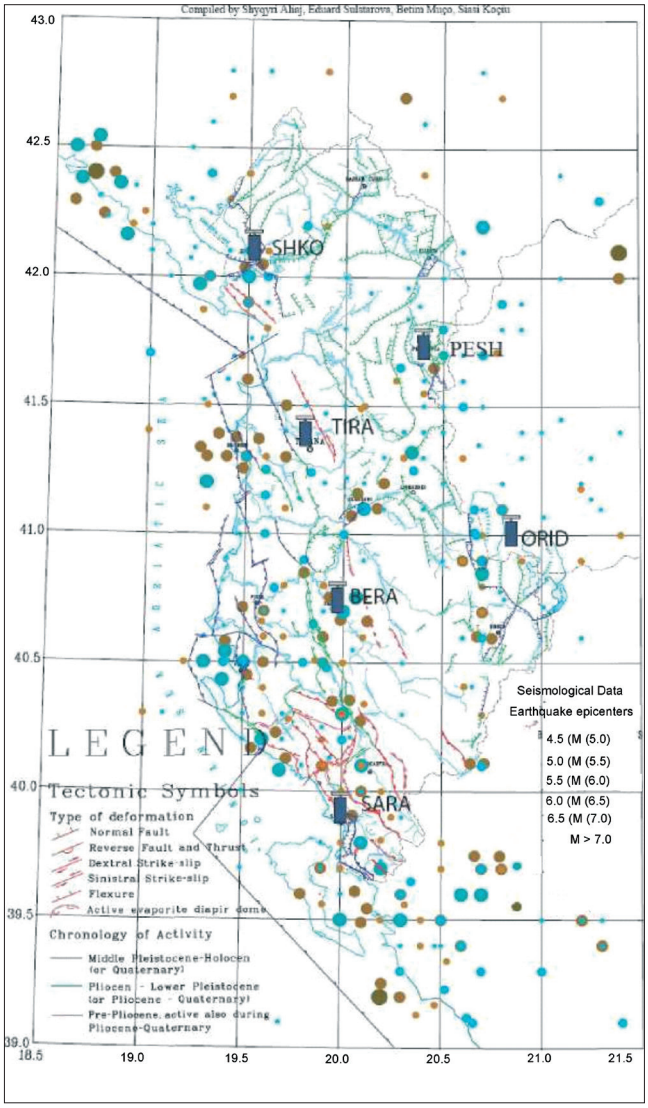

Figure 1. Neotectonic map of Albania, with location of recent seismicity and position of permanent GPS stations installed in Albania and the Ohrid station in Macedonia (EUREF network)

Dense GPS network has been installed to better localize areas undergoing current deformation. Benchmarks allow direct centering of antennas to avoid centering errors and bad determinations of antenna heights. Dense GPS data have been analyzed together with permanent stations of Albania and European network using absolute phase center determination. The GPS network has been completed by new points installed and measured in 2006 in south-eastern Albania, north of Tirana, between Tirana and Peshkopia and around Shkodra.

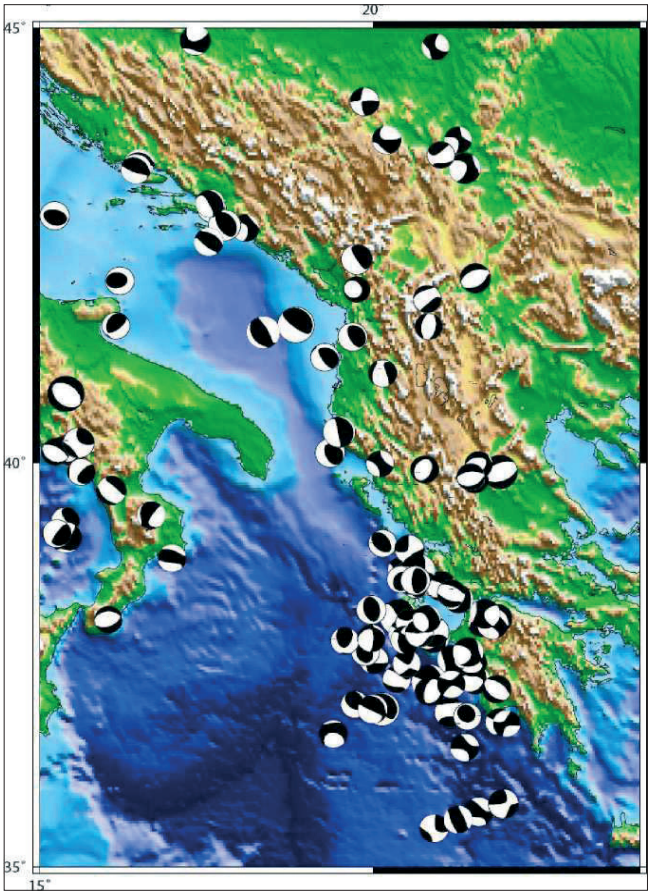

Figure 2. CMT Focal mechanisms of Dinarides-Albanides-Helenides (Woodhouse & Dziewonski, 1984)

DATA ANALYSIS

Results were obtained using IGS final precise orbits (Beutler *et al.*, 2001), as recommended by IGS Earth rotation parameters and data from nearby permanent GPS stations. We used the antenna phase center offsets models. Data have been analyzed using the following strategy: (1) initial ionosphere-free analysis with residuals computation, (2) residuals analysis; (3) resolution of the wide-lane ambiguities using the Melbourne-Wubbena linear combination; using DCB files when available, (4) a computation of the ionosphere free solution introducing the resolved Melbourne-Wubbena linear combination ambiguities, and (5) the computation of normal equations. Troposphere-induced propagation delays were estimated from the observations every 2 h.

DISCUSSION

Dinarides

The anticlockwise rotation of northern Adria microplate induced N-S shortening in the Friuli area with an evolution to a NW-SE shortening along the Dinarides coast north of Dubrovnik, which is well evidenced by strain rates tensors and focal mechanisms. Current deformation affected the entire Dinarides, not only the offshore part of Dinarides as shown by the shortening of 1.9 mm/year measured between Matera and Dubrovnik but also by the shortening rate of 2.5 mm/year between Dubrovnik and Sarajevo across inner Dinarides and by the dense GPS network established in Croatia (Grenerczy *et al.,* 2005).

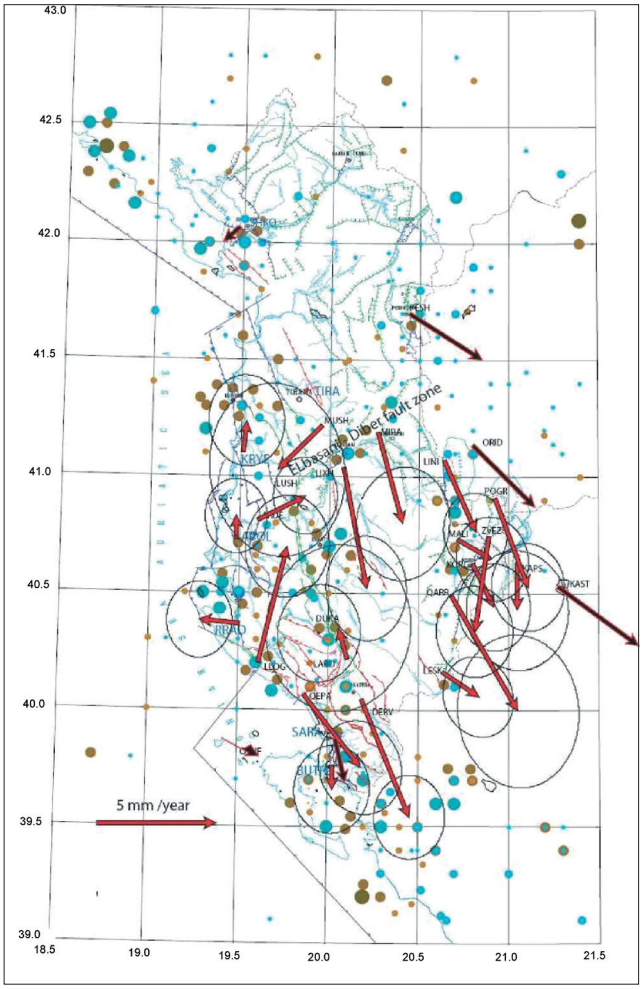

Figure 3. Displacements rates measured in Albania expressed in the western Albania reference frame defined by station with names written in blue (SHKO, TIRA, KRYE, APOL, RRAD, SARA and BUTR). Errors ellipses are drawn for 95% confidence level

A major change occurred between the Dinarides and the northern Albanides: the Dubrovnik station is affected by a northward movement in the Eurasia reference frame whereas stations in external Albanides (SHKO, TIRA, SARA) are affected by westward displacements. Strain rates tensors illustrated clearly these changes: shortening axis are NS north of the Gargano- Dubrovnik fault, N 30° south of this fault and N 60° across Adriatic Sea in northern Albania. Dubrovnik station is affected by a displacement with a 1.25 mm/year eastward component and a 2.78 mm/year northward component by comparison with the Shkodra station (Fig. 3). If the relative displacement between these two stations is accommodated along a single fault, the most probable structure is the Shkodra – Pej (or Scutari-Pec) fault that limits Di-

narides and Albanides. In this hypothesis, this fault would be affected by a 3 mm/year dextral strike-slip displacement (Fig. 3). This fault has been during Neogen, a major limit between Dinarides affected by a moderated rotation and Albanides, north-western Greece and Eubean affected by two successive rotations, a fist one 40° clockwise between 15–13 Ma and 8 and a second one, 10° clockwise, during the last 4 Ma years (van Hinsbergen *et al.,* 2005). To test the existence of a present-day rotation of Albanides and northern Greece we have determined the rotation pole of the clockwise rotation of external Albania relative to Eurasia. We found a rotation pole Western Albania / Eurasia (lat: 43.1 + /- 3, long: 20.76 + /- 3.6, angular rotation rate -0.776 °/Ma + /- 1.22).

GPS results demonstrate the occurrence of a moderate deformation across the inland part of the periadriatic foredeep (2 mm/year at the latitude of Tirana between TIRA and KRYE), but mainly an important shortening across Adriatic sea increasing from Shkodra in northern Albania (6.3 mm/year relative to South Adria microplate) to Saranda in southern Albania with a displacement of 10 mm/year relative to South Adria microplate. This shortening is expressed by offshore active thrusts and back-thrusts and also by numerous focal mechanism (Fig. 2) mainly located along the off-shore active thrusts.

CONCLUSIONS

This study has allowed to characterize a complex current tectonics pattern in Albania: (1) western Albania is affected by westward motions relative to Eurasia and south Adria microplate, the main part of this deformation (up to 10 mm/year in southern Albania) is probably absorbed off shore along N-S to NNW-SSE active thrusts, (2) two major NE-SW transverse active faults affected the collision belt, the Skutar-Pec fault between Dinarides and Albanides (3 mm/year dextral strike-slip displacement) and the Diber-Elabasani fault zone mainly affected by an extensional displacement; (3) external/inner Albanides boundary and the Scutari-Pec fault form respectively the western and the northern limit of the domain (inner Albania, northern Greece, Macedonia, Bulgaria) affected by southward displacements relative to stable Eurasia; (4) local multidirectional extension affected the Korea and the Orid active grabens at the boundary between Albania-Macedonia and Greece as also suggested by neotectonics investigations.

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