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THE SHKODER-PEJA (NORTHERN ALBANIA) TRANSCURRENT FAULT AND ITS SEISMIC ACTIVITY, 1976-1995

B. MUCO[1]

ABSTRACT

It is known that the Shkoder-Peja transcurrent fault situated in Northern Albania, is very significant in understanding of geodynamics of the area, not only in local scale but even on the confrontation between Adria and Albanian orogen.

In this approach, the seismic activity of the Northern Albania for the period 1976-1995 is carefully analyzed focusing on the seismicity in and near Shkoder-Peja transcurrent system. The epicentral distribution clearly shows the most active segments and some gap area along the fault. The method of inferring the lineaments by dynamics of epicenters migration, is used for this fault. The microseismicity of this fault, some times it seems to be influenced by groundwater factors and induced seismicity of three reservoirs situted there.

KEY WORDS: Active faults, seismic activity, epicenter migration, induced seismicity, focal mechanism.

1. GEOLOGICAL CONSIDERATIONS

Shkoder-Peja transversal system (see FIG.1) is a zone of rapid paleogeographic transitions constituting the natural margin between Dinarides and Helenides. During the early geological evolution up to the Eocene, this system, being a multiphase tectonic fault with a trend northeast 45±10°, has influenced the displacement in right sense of Mirdita ophiolites for more than 100 km (Papa et al., 1991). It seems that Shkoder-Peja transversal system has been an transform fault displacing in extension oceanic basin of Mirdita during Middle and Upper Jurassic (Aliaj, 1988). There are evidence that it is not only Mirdita zone affected by the tectonics of this system; it also changed the external zones, cutting, displacing and deviating their structures and giving rise to a different paleogeographic development of separating blocks (Papa at al., 1991).

Auboin and Dercourt (1975) consider the Shkoder-Peja system as very important for European Alpine tectonics. There are opinions that this transcurrent system has noted the margin between Laurasia and Gondwana-Tethys in Lower Jurassic (Smith, 1971).

In the frontal part of the Albanian orogen this system is wide 20-30 km. The Ulqin-Shkoder and Drini Bay-Lezhe transversals are segments of Shkoder-Peja great transversal (Aliaj: personal communication, 1997). Going northeastward, this transversal reduces its width. Shkoder-Peja transversal system has also played an important role in the evolution of molasses basins (Aliaj, 1988; Papa et al., 1991). During the Neotectonic etape this fault system is elaborated with normal faults delineating a graben unit from Tropoja up to Qerret of Puka and Vig. Observing the history of this great transcurrent system, we can say that it is very significant in understanding of the geodynamic of the region and further.

2. MONITORING OF RECENT SEISMIC ACTIVITY

During this century, along the Shkoder-Peja transversal system are recorded the following earthquakes: September [illegible] August 27, 1948, M=5.5,

[1] Prof. Dr., Seismological Institute, Tirana, Albania

Trush, Shkoder; December 13, 1956, M=4.9, Iballe, Puke; November 1968, M=5.5, Ulqin, Montenegro. Historically, it is noted that on February 11, 1662, an earthquake with I_o=VIII struck Peja, Kosovo, Yugoslavia and on July 3, 1855, another one with the same intensity happened near Shkodra (Sulstarova et al., 1980, Aliaj, 1988). In the contact between this transversal with fault zone Shkoder Mat-Librazhd-Bilisht, it is thought to be the epicenter of the strong earthquake of Shkodra, June 1, 1905 (Aliaj, 1988). It is evaluated that expected seismic potential of Shkoder Peja transversal is M_{max}= 5.5 - 5.9 on all its extend (Aliaj, 1988).

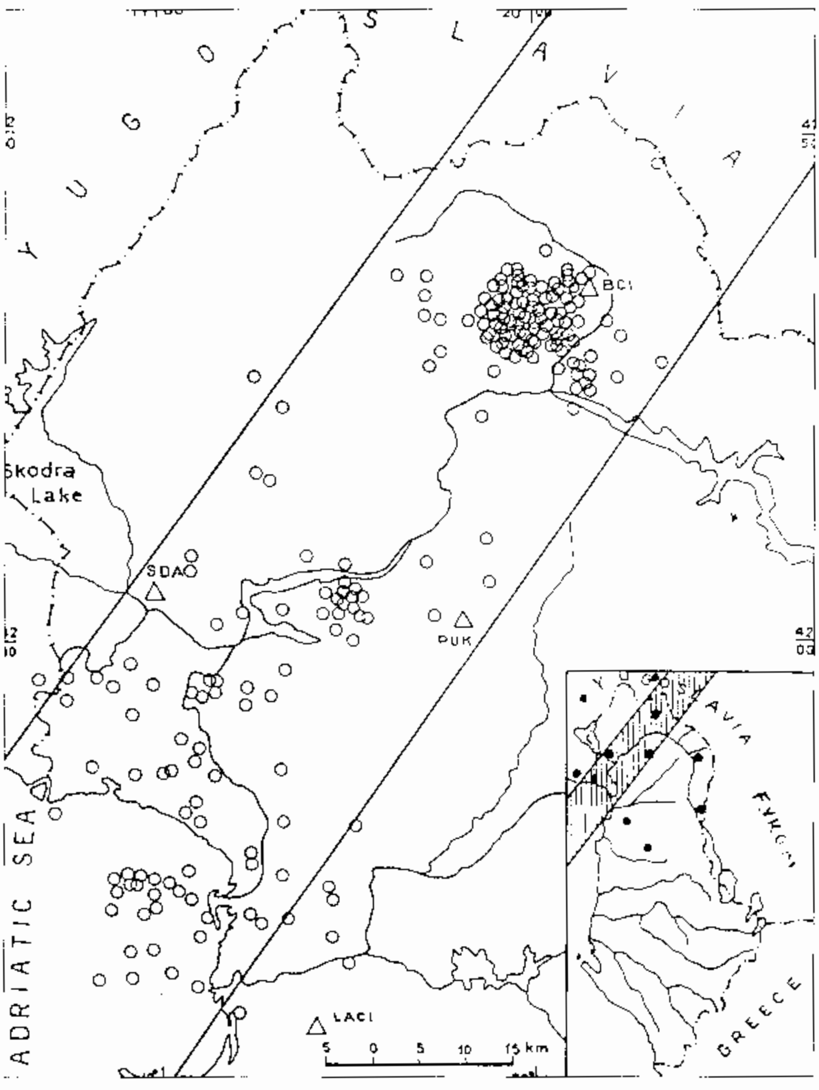


Fig. 1: The earthquakes with Ml >3.0 localised in and near the Shkoder-Peja trasversal during 1976-1995. With black dots to the anex map are shown the seismological stations near around.

During two last decades about 20 seismological stations are implemented in and around Shkoder-Peja transcurrent system (see FIG. 1). Since 1976, the Albanian Seismological Network (ASN), compounded by 13 seismological stations of short period analog type instruments, has been able to record and localize all seismic events of Northern Albania with local magnitude M_L>2.5. FIG. 1 shows the earthquakes with M_L>3.0 and epicenter along the Shkoder-Peja transversal for the period 1976-1995. The seismic data obtained from ASN enlarged the seismic history of the zone giving a new and valuable evidence (Muço, 1995.a).

During the above mentioned period, the most distinct seismic activities generated by the tectonic stress implication of Shkoder-Peja system of faults are: 1. The burst of microearthquakes of June July 1976 (with maximum magnitude M_L=3.5); 2. The burst of March 1977 (M_L=3.3); 3. The sequence of April-May 1979 (M_L=2.6); 4. The sequence of November-December 1979 (M_L=2.8); 5. The sequence of November 1981 (M_L=3.6); 6. The sequence of Puka, November-December 1985 (M_L=4.1); 7. The sequence of Nikaj-

Merturi, November 1985- August 1986 (M_L=4.2); 8. The sequence of Drini Bay- Lezha, November-December 1985 (M_L=5.1); 9. The sequence of October- November 1986 (M_L=4.5); 10. The sequence of January 1987 (M_L=3.3); 11. The sequence of June-July 1988 (M_L=3.3); 12.The sequence of January-May 1989 (M_L=3.7); 13. The sequence of June-July 1991 (M_L=3.5); 14. The sequence of November 1992-January 1993 (M_L=3.3). Apart of above sequences, there were also separate earthquakes not exceeding M_L=4.0. FIG. 2 shows the cumulative energy released for the zone of Shkoder-Peja transversal. As one can see, the largest increase is by the end of the year 1985 and this is due to Nikaj-Merturi and Drini Bay - Lezha sequences.

From the seismic activity of this zone during 1976-1995, we couldn't say precisely which fault or segment of fault of the system is activated due to certain seismic disturbation. For this it need to have special monitoring with portable seismometers. In the Shkoder-Peja system take place several active tectonic faults and in the frontal part of Albanian orogen they are dissected by longitudinal faults going parallel with Dalmatian coast. As it is already evidenced, the tectonic fault structures constituting one sole fault in the depth, they branched in several ones, going to the surface giving the so-called "flower" structures (Aliaj, 1988).

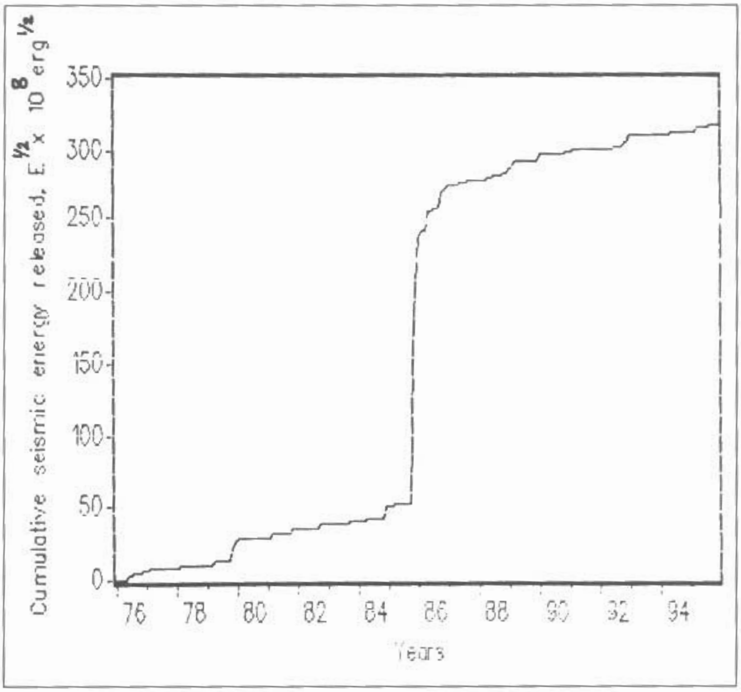


Fig. 2: The cumulative energy released, 1976-1995.

3. RESERVOIR-INDUCED SEISMICITY

There are three large reservoirs in and near the zone dissected by the Shkoder-Peja system of fault: Va-Deja, Komani and Fierza, all situated in Drini River (see FIG. 2) and constructed for the hydroelectricity exploitation. Va-Deja reservoir was constructed and filled in the 1968 - 1971, when in Albania existed only Tirana seismological station. Its capacity is 06 x $10^9 m^3$. People around it say that after the filling up of this reservoir, a lot of microearthquakes were felt (Muço, 1992). Some burst of microearthquakes near Va-Deja in 1976-1978 and a sequence of microearthquakes with maximum magnitude M_L=4.2 between Puka and Va-Deja, in November-December 1994, could be connected with the influence of this reservoir.

The reservoir of Fierza is the Albania's largest reservoir and it is one of the world's largest reservoir of high dams (reservoir volume at maximum water level, 2.8 x $10^9 m^3$; dam height , 167 m and dam capacity, 8 x $10^6 m^3$) (Muço, 1991,a; 1997). The filling of reservoir began in October 1978 and maximum depth of 130 m was attained in April 1981. Depending on the weather and Drini River's flow, from 1978 up to now, very significant fluctuations of water level occurred in this reservoir. Some detailed studies about induced seismicity in and around Fierza reservoir have demonstrated that the filling of reservoir has modified the releasing mode of seismic energy of the region increasing mostly the occurrence of microearthquakes (Muço, 1991, 1992, 1997). The focal depth of earthquakes in the vicinity of the reservoir were in the range 0 - 12 km and the maximum magnitude for the earthquakes of the zone of Shkoder-Peja fault system is M_L=3.6.

The Komani reservoir (reservoir volume at maximum water level, 1.6 x $10^9 m^3$; dam height 130 m) began to be filled by the end of October 1985. Because of the role of Fierza reservoir as the regulator, the water level of Komani reservoir has shown only minor changes. Just after the raising of new reservoir, a big microearthquake swarm occurred here. This is Nikaj-Merturi swarm, which has already been object of detailed studies (Muço, 1991,b; 1992; 1997). The swarm began on November 10. 1985, grew steadily and the first earthquake with M_L=4.0 occurred at November 19. 1985. The most intensive time was during November - December 1985 and January 1986. The swarm drew to its end in August 1986 producing more than 17.000 shocks (recorded at Bajram Curri seismological station, the closest to the epicentral area). The maximum magnitude was M_L=4.2 and cumulative magnitude of all the series is M_L=4.9. The Nikaj-Merturi series is the most distinct seismic activity of Northern Albania since 1976 (Muço, 1997).

From the evidence provided monitoring for twenty years the induced seismicity of Northern Albania, we could say that the influence of reservoirs constructed along the Drini River should be taken into account in the seismicity of Shkoder-Peja transversal zone. It is also of interest to note that studying the relationship between seismic activity and rainfall for Albania, this zone belong to the area where the rainfall and groundwater activity influences mostly on the seismicity (Muço, 1995,b).

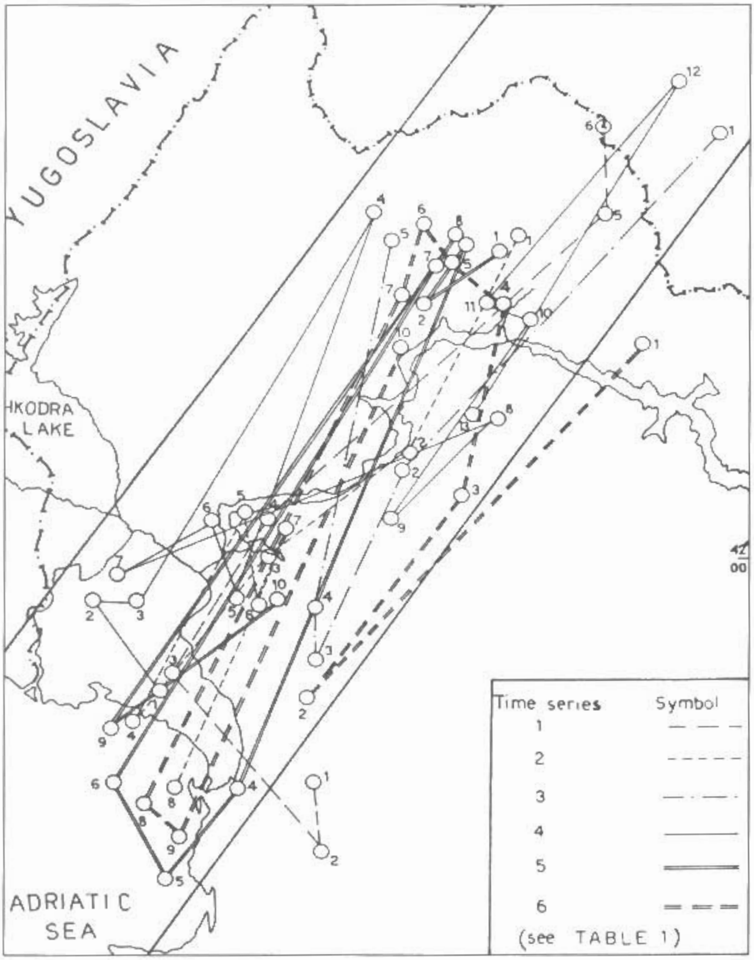


Fig. 3: The delineament of fault system by dynamics of epicenter migration (see TABLE 1).

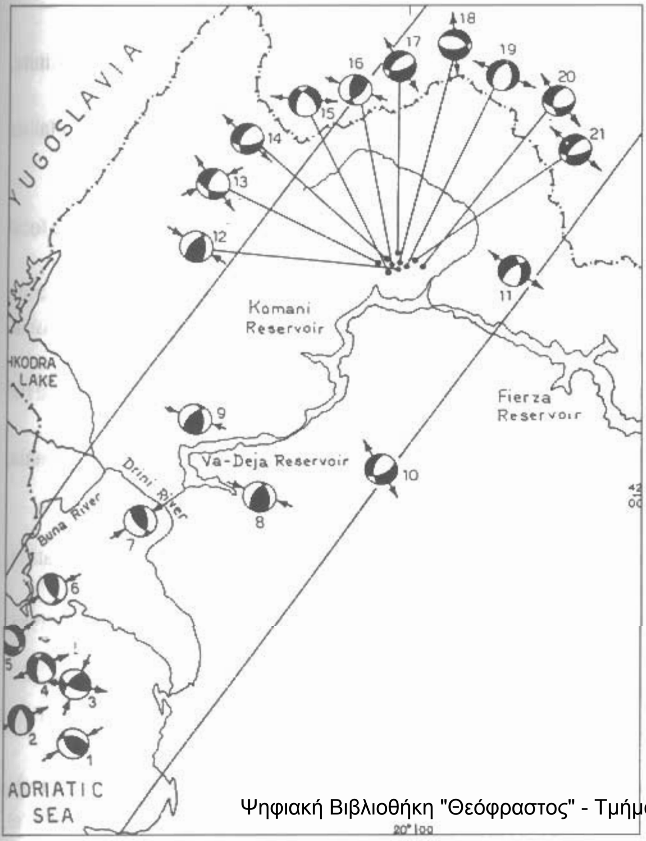
4. DELINEAMENT OF FAULT SYSTEM BY DYNAMICS OF EPI-CENTER MIGRATION

In spite of geological or geomorphic means, the seismic activity can also be used for inferring the active faults (Mizoue and Nakamura. 1976; Mizoue et al., 1978). This method which is based in monitoring of seismic activity of each zone, has been successfully used in different regions of Albania (Muço, 1992). The data processing consists mainly in making linkage systems of consecutive epicenters for each selected sequence of seismic activity. The accurate epicentral data plotted on a map and from the consecutive migration of epicenters, one can see the activation of different parts of fault system during relatively short interval of time. For epicenter localization of Shkoder-Peja fault system, we used the FASTHYPO algorithm (Herrman, 1979), modified for a fine procedure of depth determination (Muço, 1992).

For delineament of fault system of the Shkoder-Peja transversal, we used 6 time histories from the period 1976-1995 (see TABLE 1). The uncertainties for the hypocenter location of 200 events involved in this procedure are less than 7 km for geographic coordinates and less than 5 km for depth. FIG. 4, shows the distribution of epicenters for the time sequences used. The consecutive epicenters for a time history are noted by consecutive numbers. It is very clear the interaction of different segments of the studied fault system, during seismic perturbation. The same interaction is evident during the Nikaj-Merturi series mentioned above. Shortly after this swarm began in Nikaj-Merturi region, the seismic activity was transmitted in the external part of the transversal what is Drini Bay-Lezha area where a series with maximum magnitude M_L=5.1 occurred. Afterwards, for some months, a "ping-pong" process took place between two above areas. The lineaments obtained from dynamics of epicenters migration for Shkoder-Peja transversal, in a good extend are in accordance with general trend of this fault system.

TABLE 1

No	Time history	Period	Number of data	Magnitude range	Symbol used
1	June - July 1976	19 days	6	2.0 - 3.5	- - - - - - - - -
2	March 1977	8 days	12	1.5 - 3.3	------------
3	April - May 1979	45 days	5	1.7 - 2.6	—·—·—·—
4	November - December 1979	32 days	13	2.0 - 3.5	————
5	January 1987	17 days	10	2.0 - 3.3	═════
6	June 1988	12 days	10	2.0 - 3.2	═ ═ ═



5. FOCAL MECHANISM SOLUTIONS

We considered all the focal mechanism solutions (FMS) for the area covered by Shkoder-Peja transversal system (FIG. 4). Mostly these solutions are taken from a study for focal mechanism solutions of Albanian earthquakes with M>4.0 for the period 1964-1988 (Muço, 1994). Some other studies of composite focal mechanism for the microearthquakes of this area are also taken into consideration (Muço,1984). The complete data for the solutions are mapped in FIG.4.

Fig. 4: Focal mechanism solutions for Shkoder-Peja transversal fault.

The general directions of nodal planes obtained from FMS are in good agreement with the fault trend. For the solutions of the external part of the transversal, there are both extensional and pressure stresses (solutions 1-7), dominated by the last one. In this zone it is an intersection of transversal with longitudinal system of Ionian-Adriatic faults and it is expected that FMS to be more complicaed. The solutions 8 and 9, we think that belong to an active longitudinal fault with a northwest-southeast direction, near the Va-Deja reservoir which is evidenced even by dynamics of seismic activity migration. The solutions 10-21 belong to internal part of the transversal. They are mostly of normal type, dominated by extension with a general direction northwest-southeast. The same is concluded from a detailed study of FMS for Nikaj-Merturi series, 1985-1986 (Muço, 1992). We have not to forget that many FMS of Shkoder-Peja transversal have a strong component of strike-slip which demonstrates the present active movement of this transversal.

6. CONCLUSIONS

It is quite clear that Shkoder-Peja transversal system has played a very important role on the geodynamics of the area on the local and regional scale and the evolution of Albanian orogen. Even the seismic evidence for the recent period are presently poor, geologically this system suggests a larger seismic potential that has already been exhibited. In this context, the paleoseismic studies would be very of use for this area.

The seismic monitoring of Albania through the ASN, since 1976 has given new evidence on the seismicity of this transcurrent system revealing new insights for the kinematics and dynamics of the faults taking place here.

The significance of such active transversal system as Shkoder-Peja is, makes necessary the undertaking of other detailed seismic and seismotectonic investigations.

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