THE KONITSA, EPIRUS-NW GREECE, JULY 26 (MS=5.4) AND AUGUST 5, 1996, (MS=5.7) EARTHQUAKES SEQUENCE
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ABSTRACT

On August 5, 1996, at 22:46 GMT (August 6, 01:46 local time), a strong shallow earthquake of $M_s=5.7$ occurred at the area of Konitsa, Epirus-northwestern Greece. The earthquake caused significant damage in the city of Konitsa as well as the neighbouring villages. In the same area on July 26, at 18:55 GMT (21:55 local time), another strong earthquake of $M_s=5.4$ had occurred, mainly causing damage at the lower part of Konitsa.

In this study, data from seismological stations located in the broader area of NE Greece and neighbouring countries were used in order to study the spatial and temporal characteristics of this earthquake sequence. Focal mechanisms of the stronger shocks were also plotted. All the observations are combined, in order to obtain a better understanding of the regional tectonics and its seismic activity.

KEY WORDS: earthquake sequence, seismicity, earthquake mechanisms, seismotectonics, Epirus, Western Greece

1. INTRODUCTION

The Epirus area is located along the northwestern margin of Greek mainland, at the border of the Aegean and Apulian blocks, where collision occurs. Due to the important location that this area has to understand the current deformation of Aegean, the tectonics and seismicity of the area is relatively well studied. However, the historical seismicity of the area is not well known and our knowledge doesn’t go very far in the past. The instrumental seismicity (Makropoulos et al. 1989; Papanastassiou et al. 2001) is shown not to be as high as in other nearby areas like the Ionian sea or the Gulf of Corinth. The seismicity in this area is concentrated along the coast, while the mainland of Epirus seems to be free of earthquakes (Fig. 1).

The tectonic framework of the area is mainly compressive, so reverse faulting is observed along the westernmost mainland of Epirus, while extensional tectonics are observed in the interior (Sorel 1989; Underhill 1989; Waters 1993; Hatzfeld et al. 1995; Baker et al. 1997). The transition between compression and extension, however, is not precisely located as microearthquake surveys contacted in the area have shown a wide variety of fault types and orientations which are not consistent with simple zones of shortening or extension (King et al. 1983; Kiratzi et al. 1987; Amorese 1993).

As the events of 26th of July and 6th of August 1996, are the strongest instrumentally recorded earthquakes in this area, it was a great opportunity to study them and drew conclusions for the tectonics and seismicity of the area.

In this work the results of the spatial and temporal distribution of the earthquake sequence are presented, lasted from the beginning of July through the end of December of 1996. Data from seismological stations located in the broader area of western Greece, southern Albania, and FYROM were used. Focal mechanisms of the stronger events were also plotted.

The results suggest that this earthquake sequence can be correlated to the activation of the Konitsa normal fault zone having a SW-NE direction and dipping to the NW.

2. GENERAL GEOLOGIC AND TECTONIC SETTING OF THE AREA

The geology and tectonics of Epirus have been carefully studied by different researchers like Aubouin (1959); the “Institut Greque de Geologie et de Recherches Sous Sol–Institut Francais du Petrole” (1966); BP (1971); Bouquet (1974); Anderson and Jackson (1987); Brooks et al. (1988); Underhill (1989); King et al. (1993).

The main topographic features of the area of Epirus, NW Greece, follow the Pindus mountain chain, having a northwest - southeast strike. Subsequently, the area is characterized by the existence of a series of ridges,
which are composed of Mesozoic carbonates. This structure is the expression of large synclines and anticlines, having a NNW-SSE direction, accompanied with several thrusts, and is the result of extensive compression resulted in the shortening of the area by several tens of Kilometers. Characteristic for the area is the existence of large strike slip faults, almost E-W direction, with horizontal throws of tenths of kilometers (Figure 2).

Moreover, N-S extension is taking place across normal fault zones, with mean E-W direction, which have affected the limestone bedrock with vertical displacement of several hundreds of meters.

One of these normal fault zones is the Konitsa fault group (Doutsos & Koukouvelas 1998). Three faults trending SW-NE, consist this group: the Sarantaporos fault in the northern part, the Konitsa fault in the middle and the Aristi fault in the southern part. These faults are the southern bounds of three homonymous asymmetric grabens. Konitsa fault is the biggest of all three having a length of almost 15km, a direction of N55° and a dip to the NW. The southern last 3km are turning at a N15° direction. In the central part vertical displacement of almost 1000m could be measured.

3. THE EARTHQUAKE SEQUENCE

The strong Konitsa earthquakes of July 26, August 6, 1996 and the resulted aftershock sequence occurred in a mountainous area very close to Albania, as the borders are at a distance of 5 to 10Km. Although these shocks are the strongest in this area and their study is of great importance, the deployment of a seismic array was very difficult till impossible. In order to study these events, seismological data from Greek and Albanian stations as well from FYROM, covering the period of the last 6 months of 1996, were used. The events were located using
a velocity model based on previous local seismological studies (King et al. 1983; Kiratzi et al. 1986; Amorese 1993) which has as follows: \( \text{layer} / \text{Vp (km/sec)}: 0 - 4 / 5.0, 4 - 10 / 5.5, 10 - 20 / 6.0, 20 - 30 / 6.8 \) and \( > 35 / 8.0 \). For the Vp/Vs ratio the value 1.75 was used. The events were located by applying the HYPOELLIPE computer program (Lahr 1996).

183 events, of \( M_L 3 \) 2.5, were located at depths shallower than 15km and are plotted in figure 2. The source parameters of these events are listed in the Appendix. The seismic activity was intense during the period end of July – beginning of September. From different International centers, Harvard provided a CMT solution only for the event of July 26. So in order to determine the focal mechanisms of the strongest of these events, polarities of P-waves provided by the International Seismological Centre were used. The solutions of 3 well-constrained mechanisms are determined showing normal faulting. These are presented in Table 1 and are plotted in Figure 3. In Table 1 the Harvard solution for the event of July 26 is also given, indicating that our solution is in good accordance with that one.

Moreover a cross-section perpendicular to the fault trace was drawn (Fig. 4), as well as time-spatial distribution plots at directions along and perpendicular to the Konitsa fault (Fig. 5).
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Harvard solution for the event no 1
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4. CONCLUSIONS

In this study, from the spatial distribution of well located earthquakes occurred in the area of Konitsa, NW Greece, in the time period of the last 6 months of 1996, the determined focal mechanism of some of the strongest events and the local seismotectonic characteristics of the area, it is concluded that this sequence was caused by the reactivation of a normal fault, having direction N 55° and dipping to the NW, which is in accordance with the characteristics of the Konitsa fault.

Concerning the relation of the spatial distribution of the aftershocks with the morphological surface traces of the faults of the area, the shocks are located on the hanging wall of the Konitsa fault, north of the fault trace.

A cross section perpendicular to the fault trace was also drawn (Fig. 4). In this some interesting points of the aftershock's distribution in depth could be seen. The majority of the aftershocks are located in the depth range of 2 to 10km. This observation is in accordance with previous studies, which have shown that the seismogenic layer has a width of 15km. The aftershocks could be located north of a fault dipping to the NW with a dip of about 55°-60° near the surface, which decreases, 45°-55° at depth. The seismic activity started at the greater depths at about 10Km, earthquake of 26th of July, afterwards it expanded at shallower depths, 8km. The late aftershock on November 14 had a depth of only 5km.

Figure 3. Map view of the well-located earthquakes. The main faults are also shown, Sar for Sarantaporos, Kon for Konitsa and Ari for the Aristi faults after Doutsos and Koukouvelas (1998), as well as the determined fault plane solutions. Their focal parameters are given in Table 1.
The time-spatial distribution plots, at directions NE-SW, along the Konitsa fault trace and NW-SE perpendicular to it (Fig. 5), show that the foreshock of the 26th of July, followed by an intense activity which moved to the NE, where the epicentre of the strong event of 5th of August occurred. After this event it expanded and lasted as intense for a month. A late aftershock, November 14th, occurred after a quiet period of 2 months.

Moreover the fault plane solutions of the most important events show normal faulting with characteristics compatible with the local tectonics.

Figure 4: Cross section perpendicular to the fault zone.

Figure 5: Spatial distribution versus time of the earthquake sequence.
REFERENCES


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