*E. AVRAMOVA-TACHEVA, N. DOBREV

AN APPROACH TO PREDICTION OF EARTHQUAKES BASED ON 3-D MONITORING OF ACTIVE FAULTS

CONTENTS

ABSTRACT

In Krupnik area (SW Bulgaria), 3-D monitoring has been realized since 1982 by TM-71 extensometer in three measurement points. It is the place where the Struma fault zone and the Krupnik fault intersect each other. The displacements found at point B-6 (Krupnik fault zone) is most significant. The obtained information gives a possibility for an approach to searching earthquakes prediction indications. Two types of abrupt displacement reactions on the background of long-term trends are established. The first is a displacement with a high amplitude after a manifested earthquake, and the second is a sharp displacement usually 1-2 months before the earthquake. By substituting the three displacement components with the total deformation vector U_{xyz} and its velocity V_{xyz} Shanov & Dobrev established clearly expressed fluctuations of the total deformation with seismic activity in a radius of 300-400 km. An approach based on model of the anomaly in the extensiometric graphs shows an encouraging probability for prediction of distant to 300-400 km earthquakes with magnitudes M≥5 1-2 months before the seismic events and local earthquakes with M≥3 and such ones in neighbouring areas with M≥4. The probability for successfully forecasting a coming earthquake is about 60%.

KEY-WORDS: Earthquakes, Prediction, Faults, Displacements

1. INTRODUCTION

With a full knowledge of the complexity and disputability of the problem of predicting earthquakes, we present an approach to this matter worked out in Bulgaria. In the region of Krupnik, SW Bulgaria, 3-D monitoring of displacement on active faults has been realized since 1982 by TM-71 extensometer in a close cooperation with IRSM of Czech Academy of Sciences and with the active participation of Dr. B. Košták. In a number of publications, as well as during the COST Action 625 meeting in Greece (May 2001), some monitoring data and the corresponding interpretation were presented. In this most seismic region in Bulgaria the Struma fault zone and the Krupnik fault are intersected (Fig. 1). There were the epicenters of two disastrous earthquakes, occurred on April 4th 1904 with M=7,1 and 7,8. At present, about 10-20 earthquakes with M≤3 each month are registered here. The monitoring is carried out in three measurement points. The main purposes of the monitoring are: determining the contemporary activity of faults and finding out any predicting indications for earthquakes.

* Department of Engineering Geodynamics, Geological Institute, Bulgarian Academy of Sciences, Sofia, Bulgaria. E-mail: nddobrev@geology.bas.bg

2. MONITORING OF ACTIVE FAULTS

The contemporary activity of the faults has been proved. The deformation in measurement point B-6, where the extensometer crosses the actual Krupnik fault zone is most significant. The information from B-6 gives a possibility for an approach to searching earthquakes prediction indications, based on the local mechanism of deformations on meso- and micro-scale in the fault zone and on the dynamics of the registered movements, as well as of manifested reactions to closer or more distant earthquakes.

Generally, delayed or temporarily stopped horizontal and vertical shearing displacements show an accumulation of energy and increasing shearing stresses to a degree enough to overcome the rock material shearing strength. At the moment of shearing, depending on the amount of accumulated energy, a corresponding dynamic activation of the fault is realized, manifested with an earthquake or unusual by value and/or direction displacements in the different sections along the fault.

Two types of abrupt displacement reactions on the diagram of B-6 on the background of long-term trends are established (Košták & Avramova-Tacheva, 1988; Dobrev & Košták, 2000). The first is a displacement with a high amplitude after a manifested earthquake, and the second is a sharp displacement usually 1-2 months before the earthquake. The first reaction is related mainly to local seismic events with magnitudes about 3 and higher or it could be a result of stronger distant earthquakes. The second type of reactions precede strong earthquakes with M≥5 and epicenters in S and SW direction, or weaker seismic events in the region of Simitli graben and its frame. Shanov & Dobrev (1997) discovered clearly expressed fluctuations of the total deformation with seismic activity in a radius of 300-400 km by substituting the three displacement components with the total deformation vector U_{xyz} and its velocity V_{xyz}. A decrease of the total deformation several months before earthquakes with M≥5, followed by an increase in the same, is established. After detailed quantitative analysis a model of the anomaly in the extensiometric graphs 5 months before a strong earthquake is detected (Fig. 2a). Among 12 registered seismic events with M≥5 during the period 1982-1984 in an area with a radius of 300 km two have no

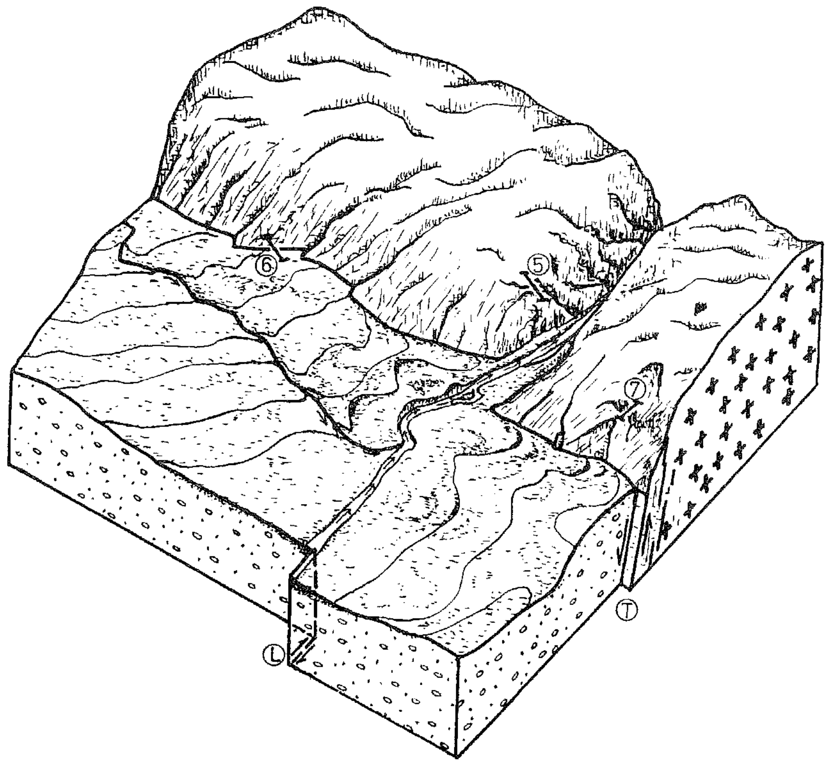

Fig. 1 - The fault junction at the reasearch area and the locations of the measurement points (after KOŠTÁK, AVRAMOVA-TACHEVA, 1988): 5, 6, 7 - measurement points S-5, B-6, K-7; L - longitudinal faults (Struma Liniament); T - transverse fault (Krupnik Fault).

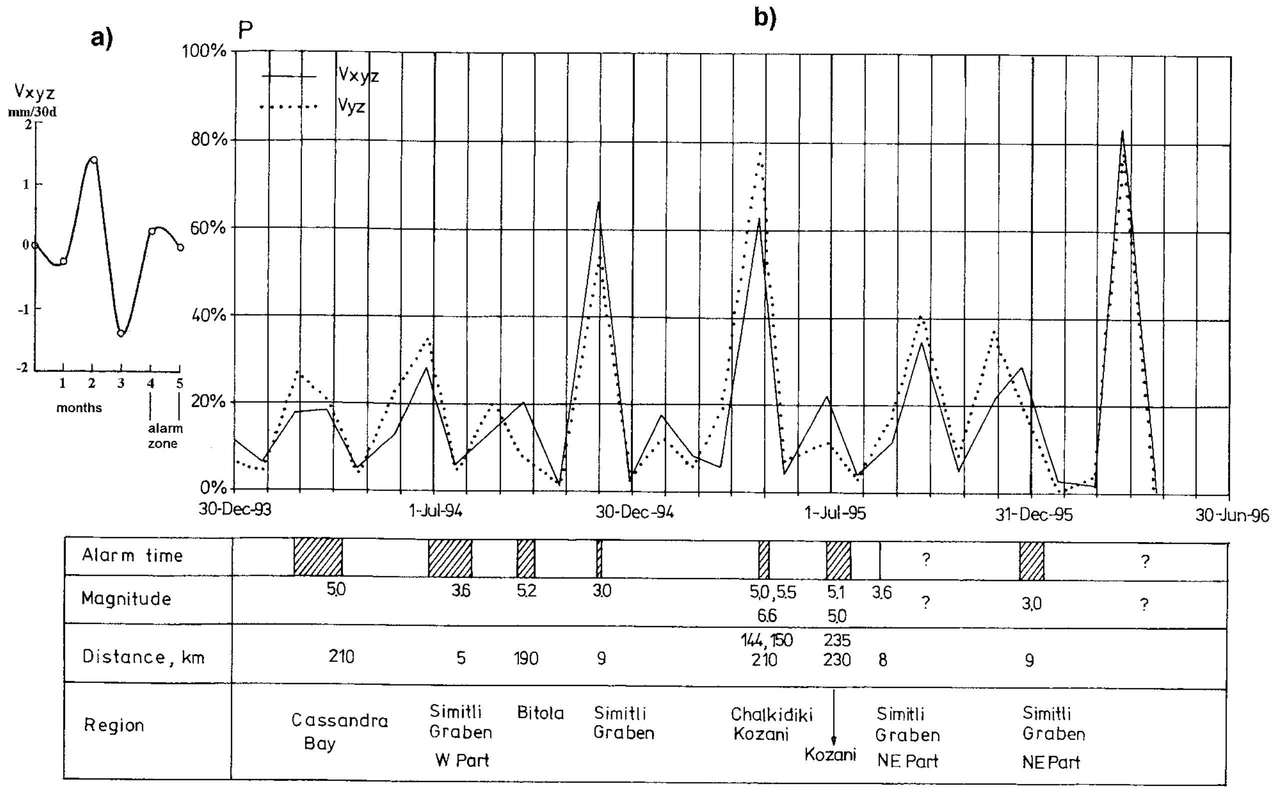

Fig. 2 - Basic diagrams for prediction of earthquakes on the example of SW Bulgaria (after SHANOV, DOBREV, 1997): a) Normalized models of the deformation rate velocity changes before strong earthquakes for the total vector V_{xyz}, b) Probability P of strong earthquake occurrence for the period January, 1994 to April, 1996 and the possible events related to this probability

clearly expressed preceding reactions and 5 out of 15 alarms were false. The probability for successfully forecasting a coming earthquake is about 60%. During the period January 1994 to March 1996 among 9 anomalies manifested on both V_{xyz} and V_{yz} it was possible 7 to be related to realized earthquakes with M from 3.0 to 6.6 (Fig. 2b).

3. CONCLUSIONS

The approach discussed in this paper, based on anomalies in 3-D extensiometric monitoring data, shows an encouraging probability for prediction of distant to 300-400 km earthquakes with magnitudes M≥5 1 - 2 months before the seismic events. The same can be said for local earthquakes with M≥3 and such ones in neighbouring areas with M≥4. The success of this approach depends on regional deep structures, local geological conditions and the time interval of displacement registration. It is with a relatively better short-term accuracy in relation to the time of manifestation and a weaker binding to the location and the intensity of a coming event.

Some other methods for earthquake prediction were experimented by Bulgarian specialists: by reconstructing the seismic regime in the seismoactive zone and the forerunning changes in the regime at a low energy level (GLAVCHEVA, 1988); by anomalies in the natural earth electric potentials (RALCHEVSKY *et alii,* 1986) and in radon and helium gas emissions in mineral water sources (RANGUELOV *et alii,* 1991); and by abrupt change in the velocity ratio of seismic waves V_p/V_s (SOKEROVA & VELICHKOVA, 1989).

REFERENCES

DOBREV N. & KOSTÁK B. (2000) - *Monitoring tectonic movements in the Simitli Graben, SW Bulgaria.* Engineering Geology, **57**, 179-192.

GLAVCHEVA R. (1988) - *Seismological evidences for the preparedness stage of the 1986 earthquakes in the Gorna Oryakhovitsa zone.* Compt. Rend. de l'Acad. Bulg. des Sciences, **41**, 5, 63-66.

KOŠTÁK B. & AVRAMOVA-TACHEVA E. (1988) - *A method for contemporary displacement measurement on a tectonic fault.* Journal of Geodynamics, **10**, 115-125.

RALCHEVSKY T., JEKOV I. & RANGUELOV B. (1986) - *An experimental result for the earth electric potential and the earthquakes.* Compt. Rend. de l'Acad. bulg. des Sciences, **39**, 11.

RANGUELOV B., SOLAKOV D. & DELIBATOVA B. (1991) - *Continuous helium measurements and seismic activity: first interactions in Bulgaria.* Compt. rend. de l'Acad. bulg. des Sciences, **44**, 12, 21-23.

SHANOV S. & DOBREV N. (1997) - *Impact of the seismic processes on the movements along the Kroupnik fault zone (SW Bulgaria).* Compt. rend. de l'Acad. Bulg. des Sciences, **50**, 6, 95-98.

SOKEROVA D., VELICHKOVA K. (1989) - *Velocity characteristics of the Earth's crust in Bulgaria.* Gerlands Beitr. Geophysik, Leipzig, **98**, 5, 398-408.