ΠΡΑΚΤΙΚΑ ΤΗΣ ΑΚΑΔΗΜΙΑΣ ΑΘΗΝΩΝ

ΣΥΝΕΔΡΙΑ ΤΗΣ 27ΗΣ ΜΑΪΟΥ 1993

ΠΡΟΕΔΡΙΑ ΚΩΝΣΤΑΝΤΙΝΟΥ ΔΕΣΠΟΤΟΠΟΥΛΟΥ

ΣΕΙΣΜΟΛΟΓΙΑ.— **Electrical signals observed before the catastrophic earthquake in Armenia in 1988,** by *Kh. V. Kirakossian**, διὰ τοῦ Ἀκαδημαϊκοῦ κ. Καίσαρος Ἀλεξοπούλου.

ABSTRACT

Since 1986, the variations of the electric field of the earth were monitored at a station lying 60-70 km from the epicenter of the 6.9 earthquake that occurred in Armenia on December 7, 1988. Twenty one days before the earthquake, a sequence of transient electric signals were observed with duration from a couple of minutes to a few hours. These signals had the same characteristics (i.e. form, duration, amplitude and time-lag) with the Seismic Electric Signals (SES) observed in Greece.

Furthermore, before a 5.0 aftershock that occurred on December 31, 1988 precursor variations of the electric resistivity and land deformation were observed.

The well known Spitak earthquake (EQ) took place at 11 : 41 local time on December 7, 1988 in the north part of Armenia. The epicenter was 10 km N-W of the town Spitak which had a population of about 20.000 of which 18.000 were killed. The magnitude of this EQ was 6.9 according to the Richter scale and the intensity in the epicentral area was 9-10 balls according to the MSK-64 scale and the depth was 9 km. Nearly 30% of the Armenia territory was completely or heavily destroyed and almost 30.000 people were killed.

It is the scope of this paper to report on the variations of the electrotelluric field observed before this Spitak EQ as well as on some other geophysical precursors detected before a strong aftershock that occurred on December 31, 1988.

I. ELECTRIC SIGNALS BEFORE THE SPITAK EQ

Since 1986 we have installed electrodes in a tunnel of the Geophysical Laboratory at Garni which lies at a distance of 60-70 km from the epicenter of

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* ΚΗ. V. KIRAKOSSIAN, **Πρόδρομα ἠλεκτρικὰ σήματα πρὸ τοῦ καταστροφικοῦ σεισμοῦ τῆς Ἀρμενίας τὸ 1988.**

the Spitak EQ. In order to be compatible with the VAN group in Greece (Varotsos and Alexopoulos 1984a, b, 1987; Varotsos et al 1986), we were measuring the electric field of the earth with one sample per minute. No abnormal signals were observed for a period of almost two years. However during the period from November 16, 1988 until November 23, 1988 a significant number of short period variations of the electric field were observed. These consequent signals had a duration from a few minutes to a few hours. The form of these variations were similar to those repeatedly observed by the VAN group in Greece, i.e. by Prof. P. Varotsos and coworkers. In figure 1 one may see the

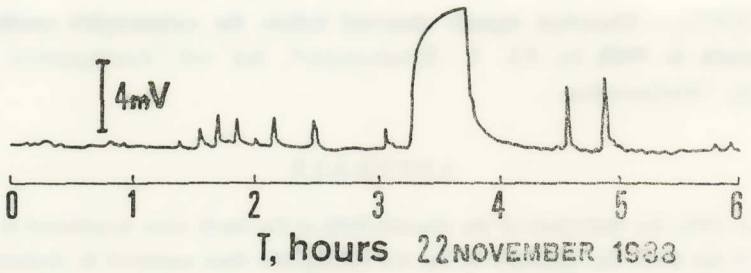

Fig. 1. Example of typical recording of the variations of the earth's electric field in the NS direction (electrodes spacing 100 m) during six hours on November 22, 1988. The vertical scale is in mV.

continuous recordings during 6 hours on November 22, 1988. One can easily recognise that the transient changes depicted are similar with the so called Seismic Electric Signals (SES) of the VAN group (Varotsos and Alexopoulos 1984a, b; Varotsos and Lazaridou 1991). Their amplitude varied between 0.5 mV to 8 mV for an electrode spacing of 100 m as reported by Varotsos and coworkers. As the signals started on November 16, 1988 and the EQ occurred on December 7, 1988 we see that there is a time lag of 21 days. This time lag is comparable to that of around 22 days observed by the VAN group in Greece (Varotsos and Lazaridou 1991) for the cases of the so called electrical activities (i.e. when a series of SES is followed by a series of EQs). The compatibility of these time lags, may reflect a similarity in the geodynamic processes before the EQs in the two countries.

II. ELECTRICAL RESISTIVITY AND DEFORMATION CHANGES BEFORE THE 5.0 AFTERSHOCK OF DECEMBER 31, 1988

The variations ($\Delta\rho$) of the electrical resistivity (P) were measured after

the main shock of December 7, 1988 with *four* high sensitivity variometers (0.001%) at various epicentral distances. They were installed on tuffs because the deformation sensitivity $(\Delta\rho/\rho) / (\Delta l/l)$ of the electrical resistivity of these rocks is more than 1000 (Marrau and Brace 1981; Yamazaki 1968, 1975).

Deformation of the earth crust were also measured in two directions, i.e. NS and EW, during the aftershock period in the tunnel at Garni. The rate was 1 sample/min and the scale 10^{-8} meter/50 meters. Figs 2 and 3 show the va-

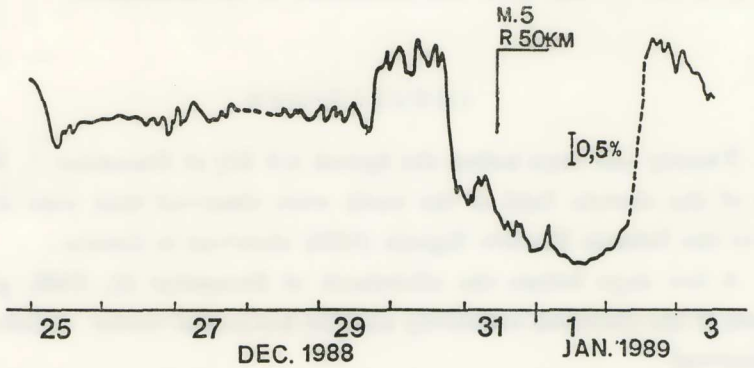

Fig. 2. The variation of the direction and amplitude of the horizontal vector of deformation of the earth's crust before the aftershock occurred on December 31, 1988 with M = 5.

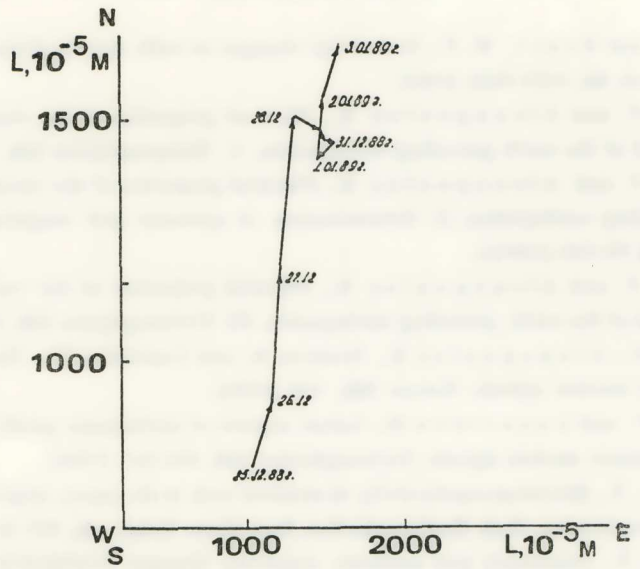

Fig. 3. The variation of the electric resistance of the rocks, observed by the variometer installed on the tuffs, before the aftershock occurred on December 31, 1988 with M = 5.

riation of the horizontal vector of the earth crust and the electrical resistivity respectively since December 25, 1988 at Garni station. On December 29 a change of the deformation starts that is followed by an original loop and a small gradient as compared with the previous days. As for the electrical resistivity one sees (Fig. 3) a decrease of 2-2.5% that starts on December 29, i.e. 2 days before the aftershock of December 31, 1988. The direction of the horizontal vector of deformation as well as the electrical resistivity recover to their normal level 1.5 - 2 days after the occurrence of the aftershock.

CONCLUSIONS

1. Twenty one days before the Spitak 6.9 EQ of December 7, 1988, variations of the electric field of the earth were observed that were strikingly similar to the Seismic Electric Signals (SES) observed in Greece :

2. A few days before the aftershock of December 31, 1988, precursor variations of the electrical resistivity and the horizontal vector of deformation were observed.

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ΠΕΡΙΛΗΨΗ

Πρόδρομα ἠλεκτρικὰ σήματα πρὸ τοῦ καταστροφικοῦ σεισμοῦ τῆς Ἀρμενίας τὸ 1988

Τὴν 7ην Δεκεμβρίου 1988 ἐνέσκυψεν εἰς Ἀρμενίαν σεισμὸς 6,9 Ρίχτερ. Ἀπὸ τὸ 1986 τὸ γεωηλεκτρικὸν πεδίον παρηκολουθεῖτο εἰς σταθμὸν ἀπέχοντα κατὰ 60-70 χιλιόμετρα ἀπὸ τὸ ἐπίκεντρον τοῦ σεισμοῦ. Εἴκοσι μία ἡμέρες πρὸ τοῦ σεισμοῦ παρετηρήθη μία σειρὰ ἀπὸ γεωηλεκτρικὰ σήματα διάρκειας μεταξὺ μερικῶν λεπτῶν καὶ μερικῶν ὡρῶν. Τὰ σήματα εἶχαν τὰ ἴδια χαρακτηριστικὰ (δηλ. μορφή, διάρκεια, πλάτος καὶ πρόδρομο χρόνο) μὲ τὰ σεισμικὰ ἠλεκτρικὰ σήματα SES πού παρετηρήθησαν στὴν Ἑλλάδα.

Ἐπὶ πλέον παρετηρήθησαν ἀπότομοι μεταβολαὶ τῆς ἠλεκτρικῆς ἀντιστάσεως καὶ τῆς παραμορφώσεως τῆς γῆς πρὶν ἀπὸ τὸν μετασεισμὸν 5 Ρίχτερ τῆς 31ης Δεκεμβρίου 1988.