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ΠΡΟΕΔΡΙΑ ΜΕΝΕΛΑΟΥ ΠΑΛΛΑΝΤΙΟΥ

ΦΥΣΙΚΗ.— **Parameters of the electrotelluric precursors to earthquakes of Kefallinia,** *by P. Varotsos - K. Alexopoulos - K. Nomicos - E. Dologlou-Revelioti - M. Lazaridou-Varotsou* *. Ἀνεκοινώθη ὑπὸ τοῦ Ἀκαδημαϊκοῦ κ. Καίσαρος Ἀλεξοπούλου.

ABSTRACT

The lead times between electrotelluric precursors and earthquakes of all regions studied until now lied between 6 and 11 hours. Recently cases were registered where events of the west coast of Greece have larger values, up to 56 hours, much larger than had been hitherto detected.

On April 26th 1982 after a period of seismic quiescence a serie of earthquakes (EQ) occured on the western coast of Greece near Katakolon starting at $9^h\ 25^{min}$ local time. At the time, the closest electrotelluric stations operating were at Patras and Joannina and had showed a series of intensive signals (ES) starting at $23^h\ 17^{min}$ local time of April 24th; they were n o t followed by earthquakes within 6 to 11 hours as usual [**1**]. The suspicion remained that the two types of events were connected which would give a lead time around 36 hours. A connection of each individual ES to each EQ could not be studied because of the temporal density of signals and aftershocks (around 40 in 24 hours).

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During the period between the fifteenth and the thirty first of January 1983 a number of earthquakes larger or equal to 5R (around 9 in 14 days) occured in the region of Kefallinia about 120 km to WNW of Katakolon. During the same period a station at Pyrgos about 10 km from Katakolon detected a number of ES. The relevant data are given in Table I. No significant EQ (larger or equal to 5R) occured for 20 days either before or after the period mentioned. The same holds for the ES. As the time between consecutive events was in some cases relatively short it is not possible to

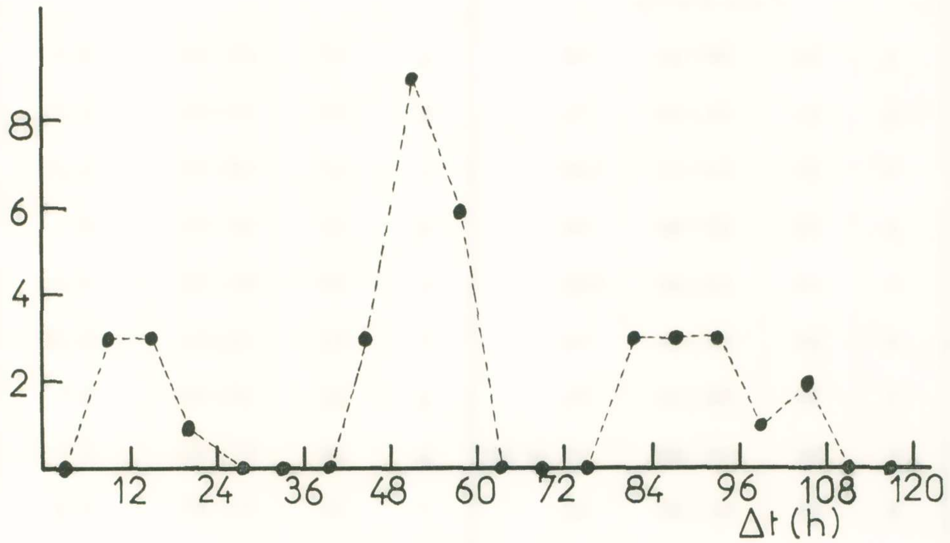

Fig. 1. Correlation of events of Table I.

ascribe at first glance a certain ES to a certain EQ. A correlation curve between the two series of events in function of the time difference $\Delta t = t_{EQ} - t_{ES}$ can, however, be calculated. In Fig. 1 we give the number of coincidences of values of t_{ES} and of $t_{ES} + \Delta t$ that occurred within the time-span of 6 hours in function of Δt. One notices 3 groups. The group that maximizes between 8 and 14 hours is clearly separated from the 51 h group. This shows that some precursors have much larger lead-times than the values 6 to 11 h, usual to the cases studied up to now. The statistics are insufficient to show if the 86 h group is real because it could be possible for an EQ to follow an ES after 86 hours although the two events are independent. In Table II we propose a one to one corre-

TABLE I

Events on the west coast of Greece.

Electrotelluric signals at Pyrgos				Earthquakes near Kefallinia			
	Date	Time GMT	Relative amplitude		Date	Time GMT	Magnitude Ms (R)
	January						
1	15	08:20	50	a	17	12:41	6.5
2	15	11:00	75	b	17	15:54	5.3
3	15	14:15	130	c	17	16:54	5.3
4	16	22:00	90	d	19	00:02	6
5	18	14:30	160	e	19	05:42	5.5
6	20	07:05	50	f	22	12:55	5.2*
7	20	08:50	75	g	22	16:02	5*
8	28	06:00	45 or 90	h	28	17:43	5*
9	31	04:20	85	i	31	15:27	5.8
	March						
10	6	06:15	16	k	8	03:05	4.3
11	11	14:30	16	*l*	13	13:53	4
12	13	17:10	50	m	15	21:20	4.5
13	13	18:10	50	n	15	23:31	4.2

* Earthquakes f and g were announced as having magnitudes 5.2 and 5. Later, the 10-day list of the National Observatory of Athens gave 4.9 and 4.6. A similar uncertainty arrises for earthquake h which was given later the value 4.4. Using the new value the correlation coefficient of Fig. 3 increases slightly.

TABLE II

Proposed connection of events.

ES	EQ	Δt	
1	b	55	30
2	c	53	50
3	a	46	30
4	e	55	40
5	d	9	32
6	g	56	10
7	f	52	00
8	h	11	40
9	i	11	10
10	k	44	50
11	*l*	47	20
12	m	52	10
13	n	53	20

spondence of each ES to each EQ based on the relative magnitude and signal strength. The three first signals (1, 2, 3) were collected at times well separated from the other signals and can, therefore, be anyhow attributed to the first three earthquakes (a, b, c). The proposal of Table II allows a one to one correspondance without having to consider the 86 h group as real. Figure 2 gives the resulting histogramm.

On the hand of Table II we procede to a comparison of the amplitude of the signal to the magnitude M of the earthquake. All ES were collected at the same station (Pyrgos) which ensures a constant value for the resistivity under the station. Furthermore, since all EQ occurred approximatively in the same area (Kefallinia) the epicentral distance is the same for all events. This allows the ES to be given in arbitrary units. The results are plotted in Fig. 3. Assuming that the points lie almost on a straight line we have calculated the best fit for a linear connection. As the relative

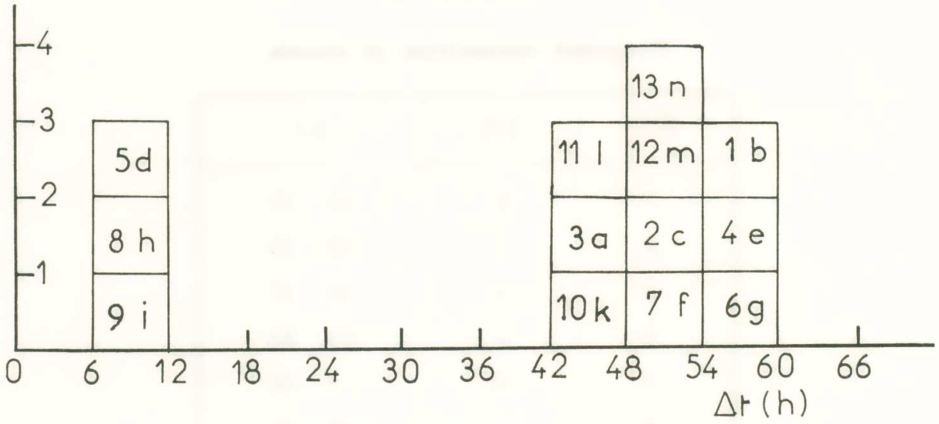

Fig. 2. Histogramm of the assumption of Table II.

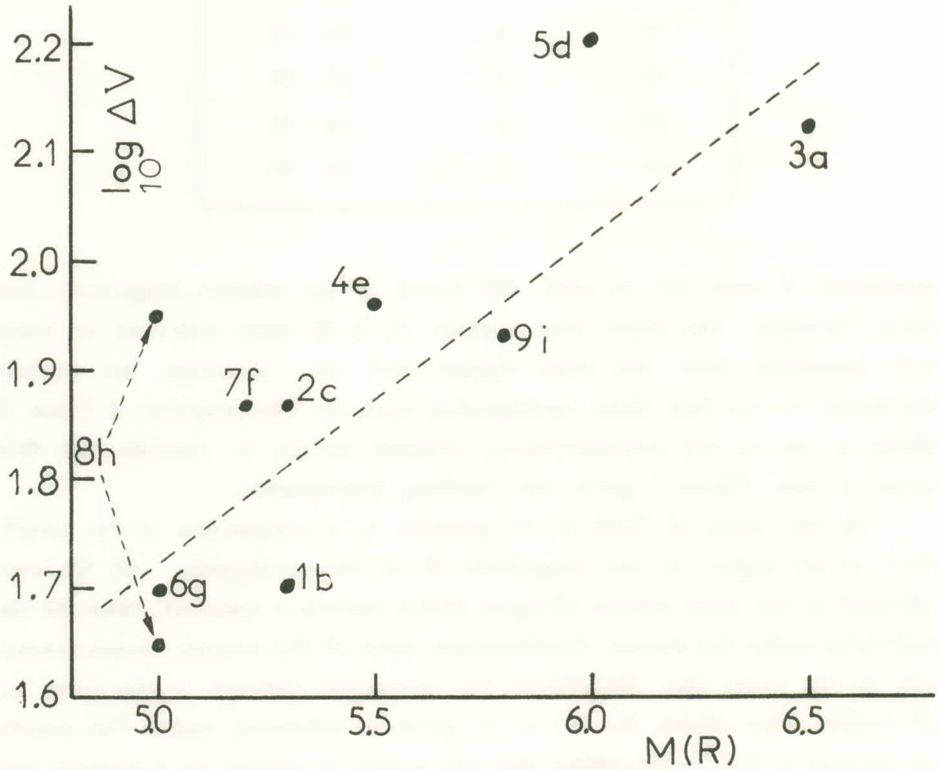

Fig. 3. Relation between signal amplitude (in relative units) and magnitude.

amplitude of signal number 8 was ambiguous, we have marked the point (8, h) twice. The broken line is the best fit to a straight line if one accepts the lower of the two values. Its correlation coefficient is 0.87; for the higher value it becomes 0.63.

Between the 6th and the 13th of March 1983 after a long period of quiescence some weak signals (No 10 to 13) were collected at PYR. During the same period some relatively weak earthquakes (between 4 and 4,5 R) occured in the same region near Kefallinia. These events have been added to Table I and have been connected to each other in Table II and in Figs. 1 and 2. Because of the weakness of these latter signals they were not considered in Fig. 3 although this would have considerably increased the correlation coefficient of the broken line. As can be seen in Fig. 2 they increase the credibility of the existence of a 51 hour group of lead-times.

ΠΕΡΙΛΗΨΙΣ

Ἐνῶ ὅλα τὰ μέχρι τοῦδε μελετηθέντα γεωηλεκτρικὰ σήματα προβλέψεως σεισμῶν προέτρεχον κατὰ 6 ἕως 11 ὥρας, εἰς σεισμοὺς ὡρισμένης περιοχῆς τῆς δυτικῆς ἀκτῆς τῆς Ἑλλάδος παρετηρήθησαν χρόνοι μέχρι 56 ὡρῶν.

Note added on the proofs: The study of many events from the Ionian Sea until the end of October 1983 has shown that the time-lag between the precursor signals and the seismic events has a minimum of 6 hours and a maximum value of $4\,^1/_2$ days.

REFERENCES

1. P. Varotsos - K. Alexopoulos and K. Nomicos, Practica of the Academy of Athens 57, 341 (1982).

Ἀκολούθως ἔλαβεν τὸν λόγον ὁ Ἀκαδημαϊκὸς κ. **Ἰωάννης Ξανθάκης** καὶ εἶπεν τὰ ἑξῆς:

Concerning the results which are presented by the authors in the present paper I have to notify the following:

1. If we accept the proposed combination between the parameters ES and M(R) given by the authors in Table I, then it seems to me prefer-

able to give instead of a logarithmic relation a linear one of the form :

$$M(R) = 4{,}12 + 0{,}002\ h$$

(see Fig. 1) where M(R) represents earthquakes magnitudes in Richter's scale units and h the relative amplitude of the pecursors signal. The correlation coefficient between M(R) and h is in this case equal to $r = +0.83$.

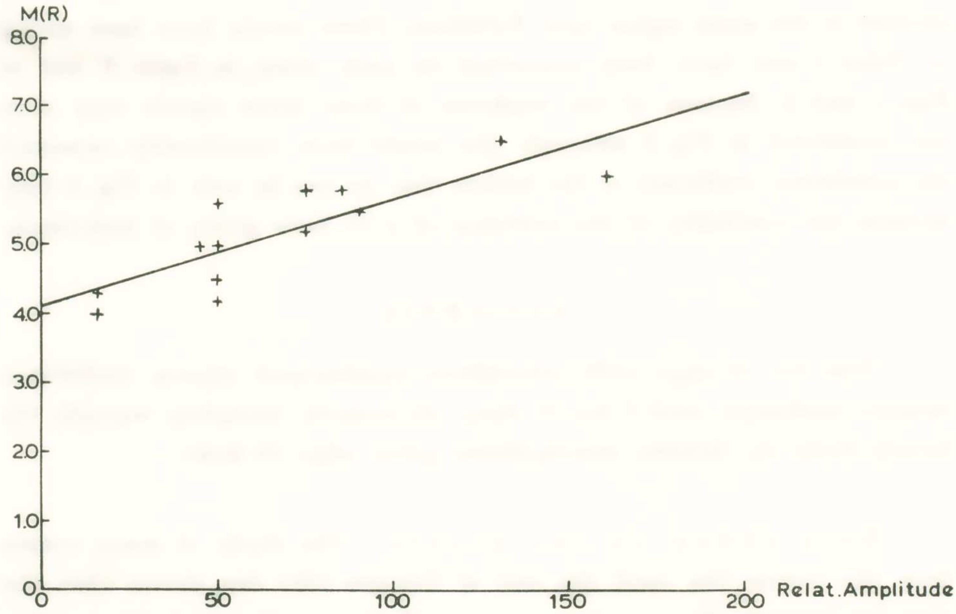

Fig. 1.

2. Unfortunately, the logarithmic relation given by the authors as well as the proposed linear one are both based, in my opinion, on the doubtful assumption, that the main earthquake of 6,5 magnitude which took place on 17.1.1983 at $12^h 41^m$ GMT gave a precursor signal in the VAN equipment 6^h and 3^m later than those of the two following post-seismic quakes of $M(R) = 5.3$ which took place on 17.1.1983 at $15^h 54^m$ GMT and $16^h 54^m$ G.MT respectively. The same also applies for the earthquake of January 22, 1983 at $12^h 55^m$ GMT [$M(R) = 5.2$] which gave a precursor signal 1^h and 45^m later than the following earthquakes of $M(R) = 5.0$ which took place on the same day at $16^h 02^m$ GMT.

I hesitate to accept the theory that postquakes five precursor signals earlier than the main earthquakes.

If the signals do not correspond to the earthquakes as suggested by the authors, that is the signal No. 1 corresponds to the earthquake **b**, the No. 2 to **c** and the signal No. 3 to earthquake **a** etc., and we accept that

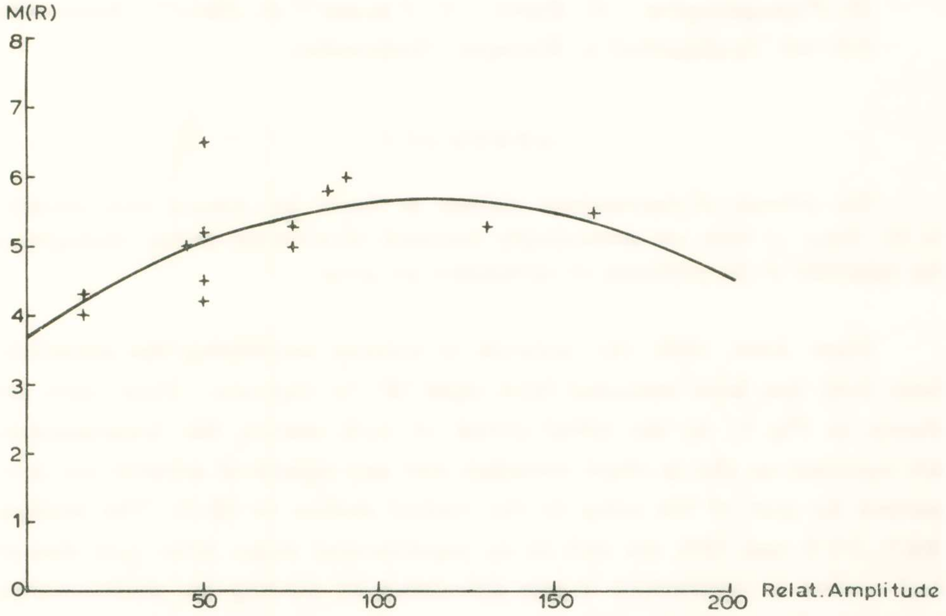

Fig. 2.

the signals 1, 2, and 3 correspond to the earthquakes **a**, **b**, and **c** of Table I, then the relation between the relative amplitude h and the magnitude M(R) is not linear but a quadratic function of the form.

$$M(R) = 3{,}66 + 0{,}0356\,h - 0{,}000\ 16\,h^2$$

In this case the correlation coefficient equals +0,65 (see Fig. 2), a value which is significant at the confidence level above 99%. However, because of the small number of data, especially for values of $h \geqslant 100$ units, the above relation is not convincing.