ΣΕΙΣΜΟΛΟΓΙΑ. — **Tectonoelectric zonation in the Hellenic Arc,** by *M. Lazaridou-Varotsou* and *D. Papanikolaou**, διὰ τοῦ Ἀκαδημαϊκοῦ κ. Καίσαρος Ἀλεξοπούλου.

ABSTRACT

The electrical (apparent) resistivities (P) have been measured by means of the magnetotelluric effect at twenty sites of Greece in two directions, EW and NS. In most of the sites P_{EW} differs considerably from P_{NS}. These results allow the distinction of the following three zones: (1) an external zone along Western Greece with $P_{EW} > P_{NS}$; (2) an intermediate zone along the main mountain chain in Continental Greece where $P_{NS} > P_{EW}$ and (3) an internal zone in the Northern Aegean where $P_{EW} > P_{NS}$.

The above resistivity zons are compared to data of geotectonic, neotectonic, seismotectonic and in situ stress measurements which all show a similar geometry of zonation almost parallel to the active Hellenic Arc.

INTRODUCTION

Since March 1981 a systematic study of the variations of the electric field of the earth has been carried out at various sites of Greece. The basic scope of this study was the detection of transient variations of the electric field that precede earthquakes (Varotsos et al 1982, Varotsos and Alexopoulos 1984). These variations (hereafter called Seismic Electric Signals; SES) depend on the epicentral distance and the magnitude of the impending event and are not accompanied by a detectable variation of the magnetic field.

Varotsos and Alexopoulos (1984) mentioned that the so called magnetotelluric variations (MT) i.e. variations of the electric field induced by disturbances of the magnetic field, renders the identification of the SES more difficult especially during periods of magnetic storms. However, when measuring the magnetotelluric response function of each station (i.e. by estimating the corresponding impedance tensor elements) the subtraction of the magnetotelluric disturbances from the recordings of the electrotelluric stations is straightforward (Varotsos and Alexopoulos 1984). One should emphasize that the fundamental difference between SES and magnetotelluric disturbances is that the latter appear (almost simultaneously) at all stations of the network in contrast to the SES that are recorded only at a restricted number of sta-

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tions. This difference mainly arises from the so called «directivity effect» of the SES.

The study of magnetotelluric disturbances can lead to a good estimate of the apparent resistivities (P) of each site. Twenty sites have been investigated and most of them showed a large difference of their resistivities between the two measuring directions i.e. EW and NS. A detailed analysis of the p-variations versus frequency will soon be published separately. The only scope of the present paper is to draw the attention to the fact that sites exhibiting similar «electrical anisostropy», in the sense that $(P_{EW}/P_{NS}) > 1$ or $(P_{EW}/P_{NS}) < 1$, form zones that show a significant correlation with tectonic data.

EXPERIMENTAL RESULTS AND DISCUSSION

Details of the experimental procedure can be found elsewhere (Lazaridou-Varotsou 1986). An example of analog recordings is given in Fig. 1. The twenty sites at which measurements have been carried out are depicted in Fig. 2. Note that since the end of 1982 most of these sites are telemetrically connected to Athens through telephone lines and electrotelluric data (sampling rate: 3 samples per sec) are continuously collected up to date (Varotsos and Alexopoulos 1986, Varotsos et al 1986).

Approximate equality of the two resistivities P_{EW} and P_{NS} were found only for the following four sites: Thiva, Patra, Komotini and Syros. For the other sites the resistivity of the one direction is appreciably larger than the other. The phenomenon is more intense for the following four sites: Astakos, Rentina, Anchialos and Gorgopotamos. For the first three sites the value of P_{EW} exceeds the corresponding P_{NS} value by one order of magnitude or larger (the exact value of the ratio P_{EW}/P_{NS} depends on the frequency under consideration). On the other hand for the case of Gorgopotamos: $P_{NS} >> P_{EW}$.

A more or less systematic distribution of the «electrical anisotropy» (in the sence that $P_{EW} \neq P_{NS}$) can be seen in Fig. 2. In this figure the NS-directed double arrow (↕) identifies cases where the predominant resistivity is in the NS-direction i.e. $P_{NS} > p_{EW}$ whereas the symbol (↔) indicates that $P_{EW} > P_{NS}$. For the four sites for which $P_{EW} \approx P_{NS}$ both symbols are used. An inspection of this figure indicates the following «electrical resistivity zones» excluding the cases of islands: Kefalonia, Crete and Syros (where the so-called «island effect» influences the measurements of the electric field, Lazaridou-Varotsou 1986):

zone I: in Western Greece comprising 4 sites (Ioannina, Astakos, Alfioussa, Kalamata) with $P_{EW} > P_{NS}$,

zone II: in the central zone of continental Greece comprising 6 sites (Veria, Gorgopotamos, Sigeritsa, Nafplio, Megara, Chalkida) with $P_{NS} > P_{EW}$,

zone III: in northeastern Greece around the North Aegean comprising 4 sites (Assiros, Rentina, Anchialos, Thisvi) with $P_{EW} > P_{NS}$.

The site of Patra (where $P_{EW} \approx P_{NS}$) lies on the boundary between zones I and II, whereas the site of Thiva (where $P_{EW} \approx P_{NS}$) lies on the boundary between zones II and III. (Fig. 3).

It is known that resistivity structure is an ensemble of inhomogeneities at different scales and that is some cases large structures may have comparable MT response with small structures. However it seems that the observed zonation of the electrical resistivity can not be attributed to small scale phenomena, e.g. influence by special lithologies, because there is a great variety of rocks participating in each zone and the composition of the upper crust in the similar zones I and III is very different. On the contrary it is remarkable that the «electrical zonation» observed for areas of Continental Greece has almost a NS-direction, which is parallel to the geotectonic trend of the Hellenides. Thus, a comparison of the electric zonation with the available data on neotectonics, seismotectonics and in situ stress measurements may drive to conclusions regarding tectonic stresses and electric resistivity.

Neotectonics and Seismotectonics. The neotectonic research on faults in Greece activated during the last few million years (Mercier et al 1979, Angelier 1979, Lyberis 1984, Mariolakos et al 1985) can be summarized as follows: (a) in Western Greece there is a compression in the ENE-WSW direction (maximum horizontal stress σ_1) as indicated by thrust faults, (b) in continental Greece and the Southern Aegean there is a predominance of normal faults with extension towards directions depending on the analysed area. In northwestern Peloponnese and Sterea E-W faults with N-S extension predominate whereas in southeastern Peloponnese, Attica, south Evia and Cyclades NW-SE faults with NE-SW direction of extension (minimum principal horizontal stress σ_3) and (c) in northeastern Greece and the northern Aegean there is a predominance of strike-slip faults both dextral and sinistral and also normal faults.

Seismotectonic research (Ritsema 1974, Mckenzie 1978, Nakamura and Uyeda

1980, Drakopoulos and Delibasis 1982) has shown that in western Greece the dominant shallow earthquake mechanisms show horizontal compression with the slip vector trending in the ENE direction. The same focal mechanisms are observed for deep earthquakes occuring below western and southern Greece along a Benioff zone reaching 200 km south of Attica and Cyclades in the modern volcanic arc whereas the focal mechanisms of shallow earthquakes are tensional in the same area. The existence of strike-slip movements is also confirmed by fault plane solutions in the northern Aegean sea, especially at the westward prolongations of the north Anatolian fault zone in the Saros basin.

Thus, summarizing the neotectonic and seismotectonic data it is possible to distinguish three zones (a), (b), (c) across the Hellenic arc which can be correlated to the previously distinguished electric zones I-III (Fig. 3).

The comparison of the neo- and seismo- tectonic zones of the Hellenic arc with the electric zones shows the same geometry indicating not only that the general direction of the zonation is similar to the geotectonic structure, as was shown before but also that each electric zone corresponds to a tectonic zone with special character as far as the overall stressfield and the position of the principal axes σ_1, σ_1 and σ_3 are concerned. Thus, a predominant resistivity in the EW-direction is observed where σ_1 is in the ENE direction (zones (a) and (c)) whereas predominant resistivity in the NS-direction where σ_1 is vertical (zone (b)).

In situ stress measurements. Paquin et al (1982), presented the results of their survey in Greece with the overcoring method in drillholes measuring the actual stressfield and the directions in the horizontal plane of maximum and minimum horizontal stress (compressive or extensive). Their data can be distinguished in four zones: (A), (B), (C), and (D) each characterized by a compressional or extensional stressfield. Three of them can be correlated to the electric zones I, II, III and also to the neo- and seismo-tectonic zones a, b, c (Fig. 4). «stress zone» D occurring in Thraki lies outside the area investigated.

The comparison of the zonation of the in situ stress measurements with the electric zonation shows a remarkable similarity and verifies the result of the comparison between the electric zonation and the neo- and seismo-tectonic zonation with $P_{EW} >$ P_{NS} where horizontal compression along the ENE or EW-direction occurs (zones A and C) and with $P_{NS} > P_{EW}$ where horizontal extension along various directions occurs (zone B).

CONCLUSIVE REMARKS

The electric anisotropy of resistivity identified in Greece shows a systematic distribution which permits the distinction of electric zones. The latter are compared to data of geotectonic, neotectonic, seismotectonic and in situ stress measurements which all show a similar geometry of zonation parallel to the active Hellenic arc. The main three tectono-electric zones are (Fig. 5):

— an external zone (1) along western Greece, adjacent to the Hellenic trench characterized by excess resistivity in the EW-direction; it is subparallel to the horizontal «E to ENE compression» deduced from focal mechanisms of shallow earthquakes, from in situ stress measurements and from neotectonic observations,

— an intermediate zone (2) along the main mountain chain of continental Greece which is characterized by larger resistivity values in the NS-direction and extension in various directions. In northern Peloponnese and central Sterea E-W normal faults predominate with σ_3 in the N-S direction whereas in southeastern Peloponnese and the south Aegean NW-SE faults predominate with σ_3 in the NE-SW direction,

— an internal zone (3) at the core of the Hellenic arc in the northern Aegean, characterized by excess resistivity in the EW-direction, which is subparallel to the horizontal compression deduced from in situ stress measurements and to the main direction of strike-slip faulting.

Thus, the general result seems to be a parallel development of the electric excess resistivity in the E-W or ENE-WSW horizontal axis of compression in the cases of the external and internal tectonoelectric zones parallel to the direction of the plate movement. In the intermediate tectonoelectric zone -where σ_1 is vertical and extension prevails in the horizontal plane- an excess resistivity is developed in the NS-direction.

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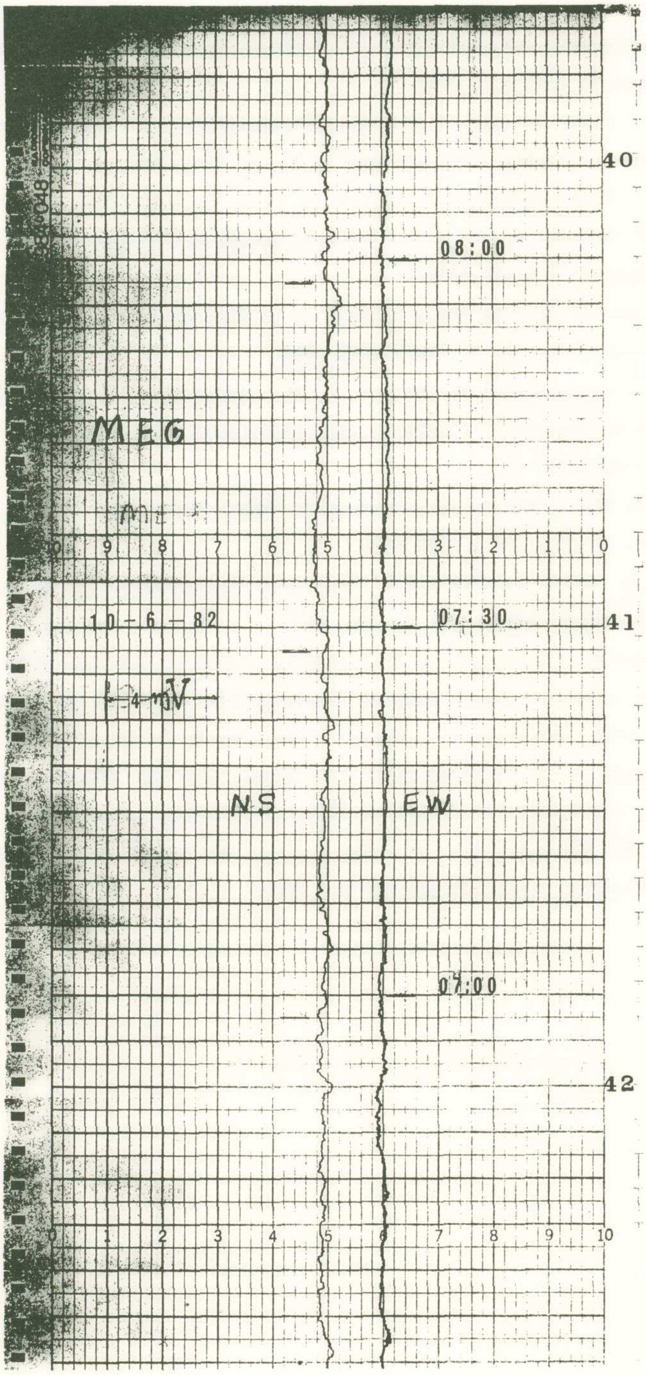
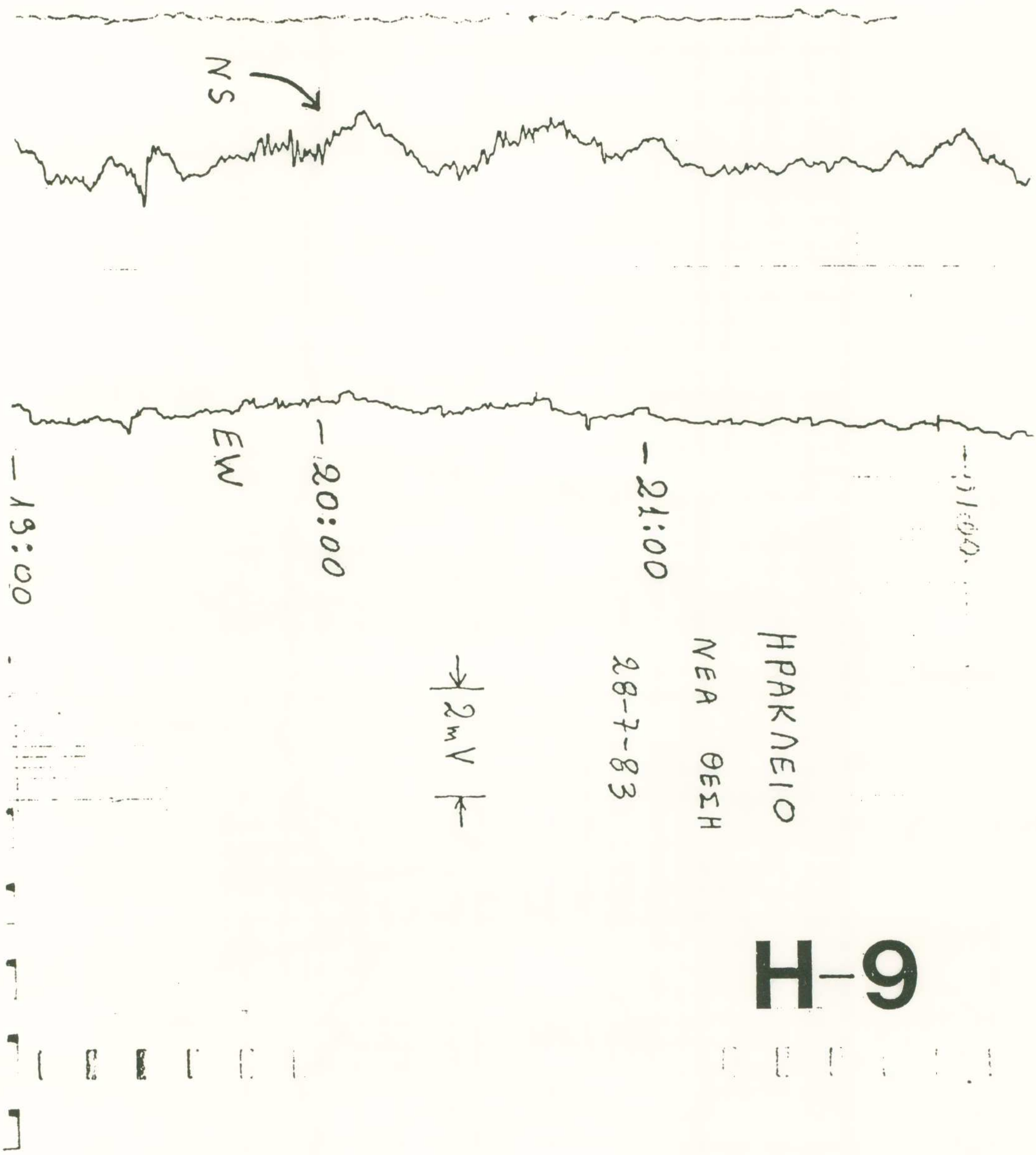
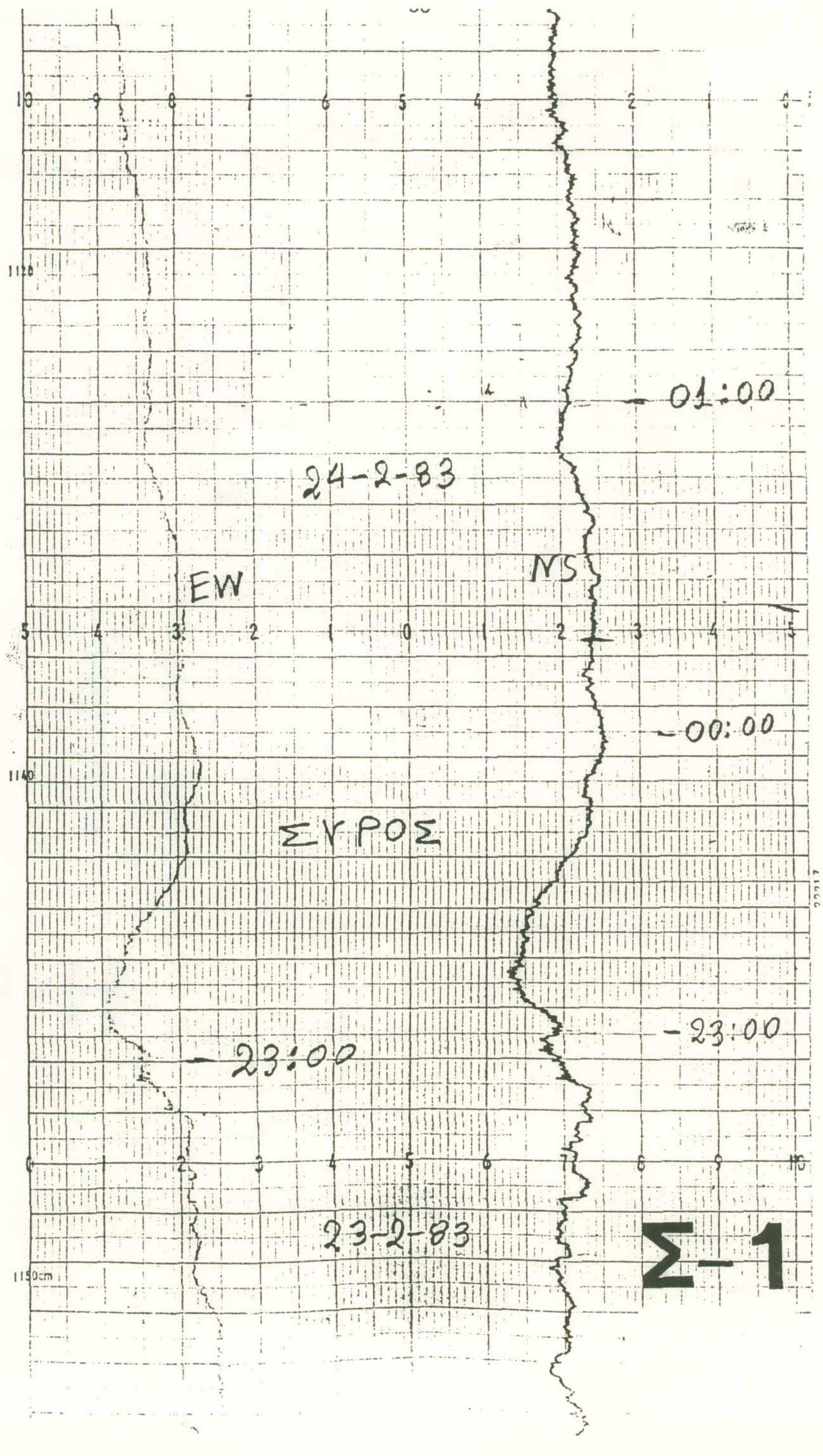
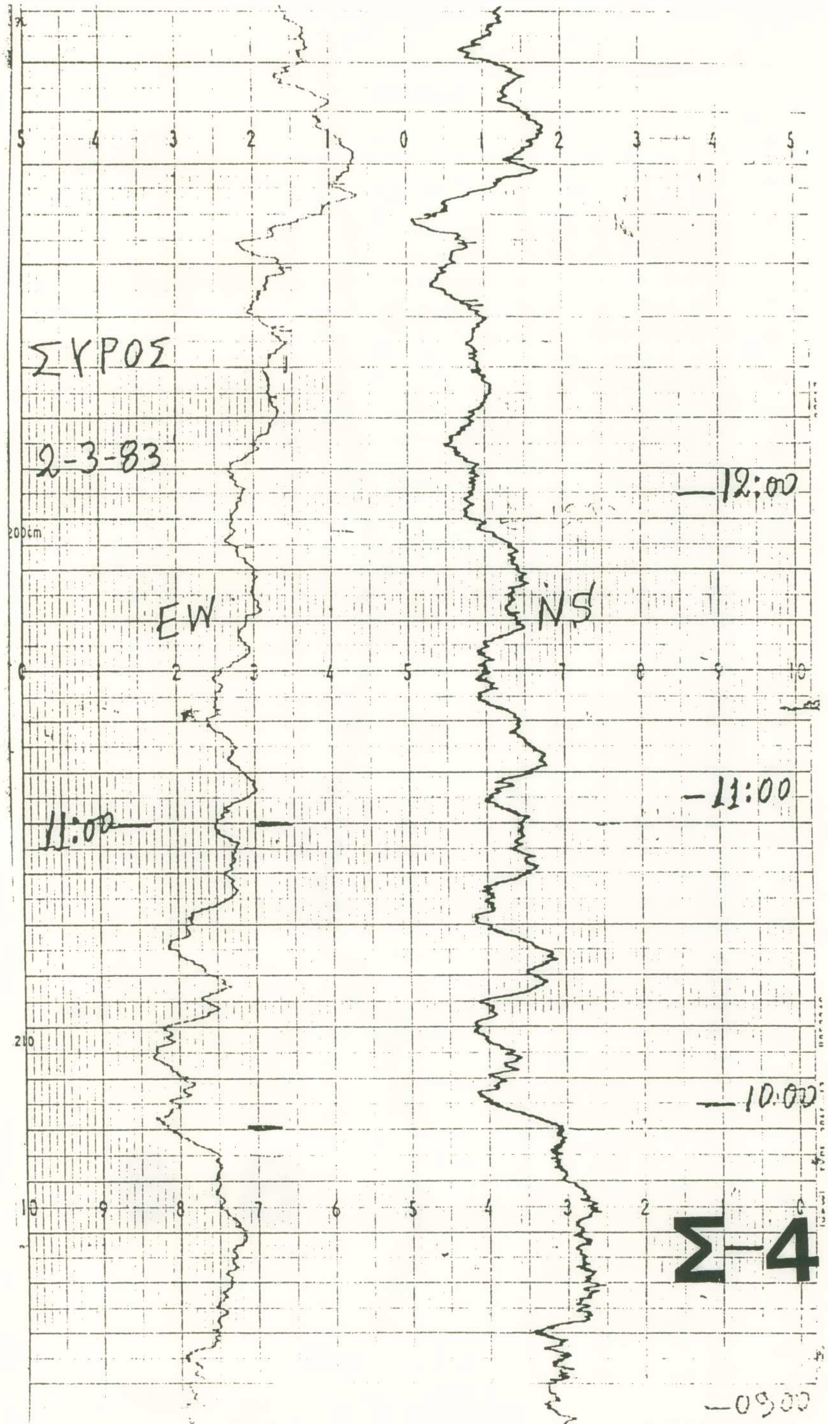
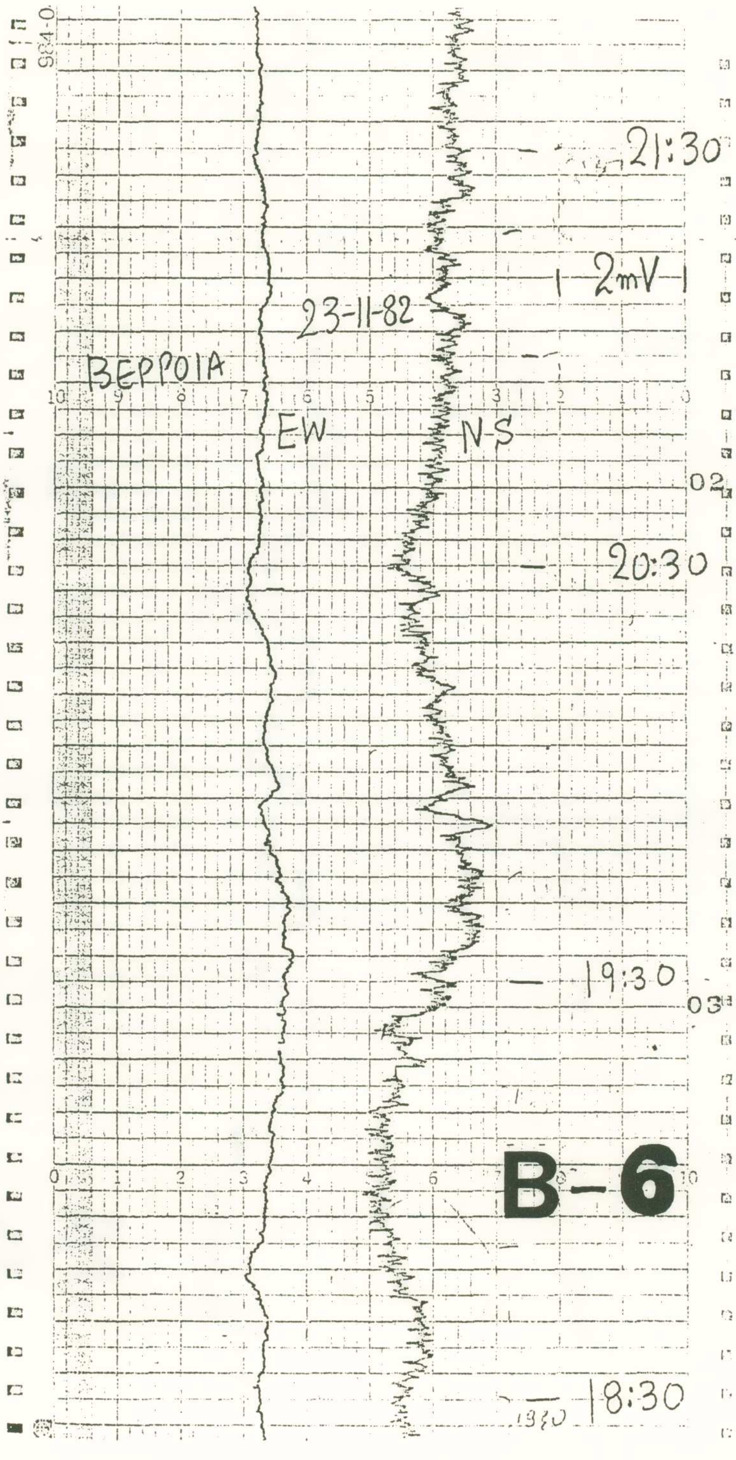


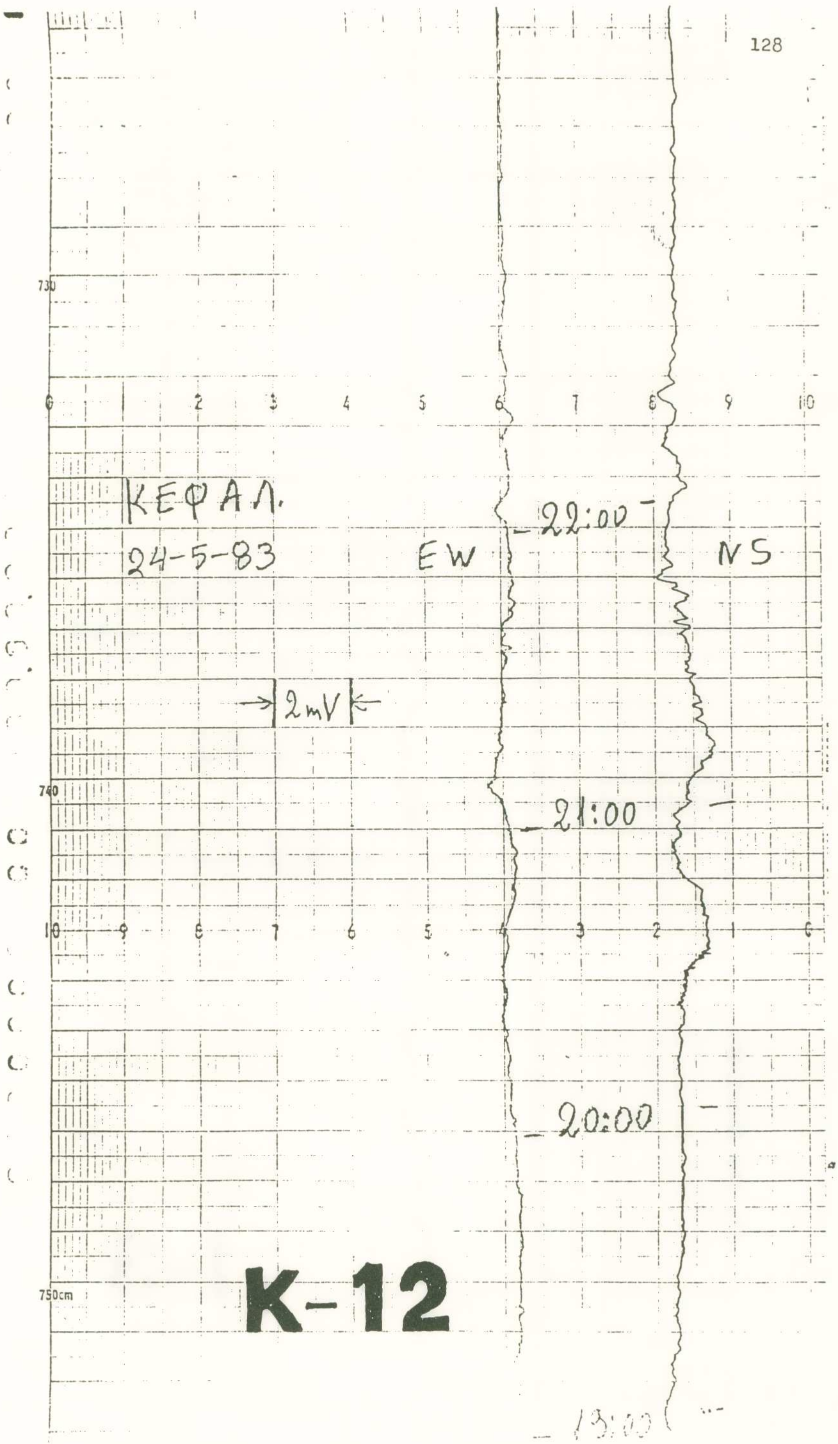
Fig. 1. Comparison of the two components (EW, NS) of the magnetotelluric disturbances at various stations: a) Heraklion; b,c) Syros; d) Veria; e) Kefallinia; f) Joannina; g) Alfiousa; h) Halkida; i,k) various-tations.

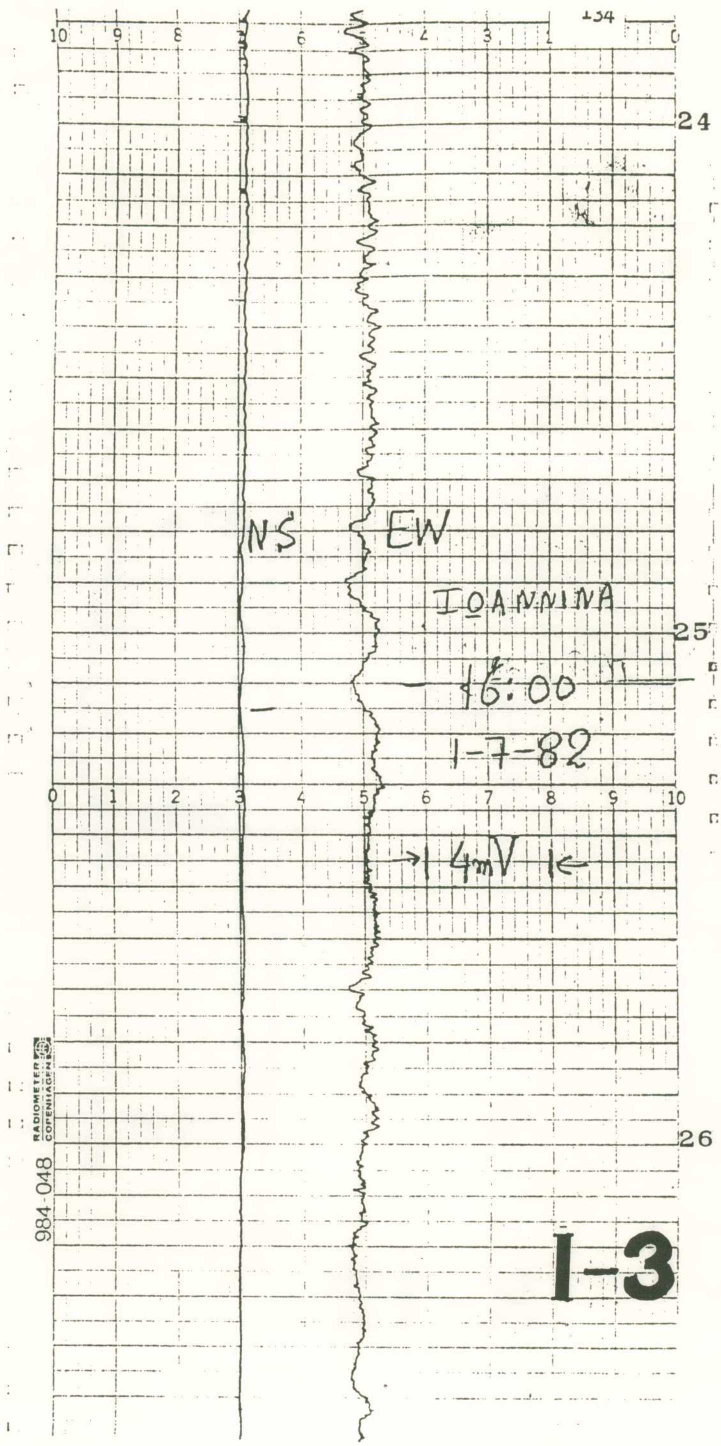

NS
EW
19:00
20:00
21:00
ΗΡΑΚΛΕΙΟ
ΝΕΑ ΘΕΣΗ
28-7-83
2mV
H-9


01:00
24-2-83
EW
NS
00:00
ΣΥΡΟΣ
23:00
23:00
23-2-83
Σ-1
1150cm

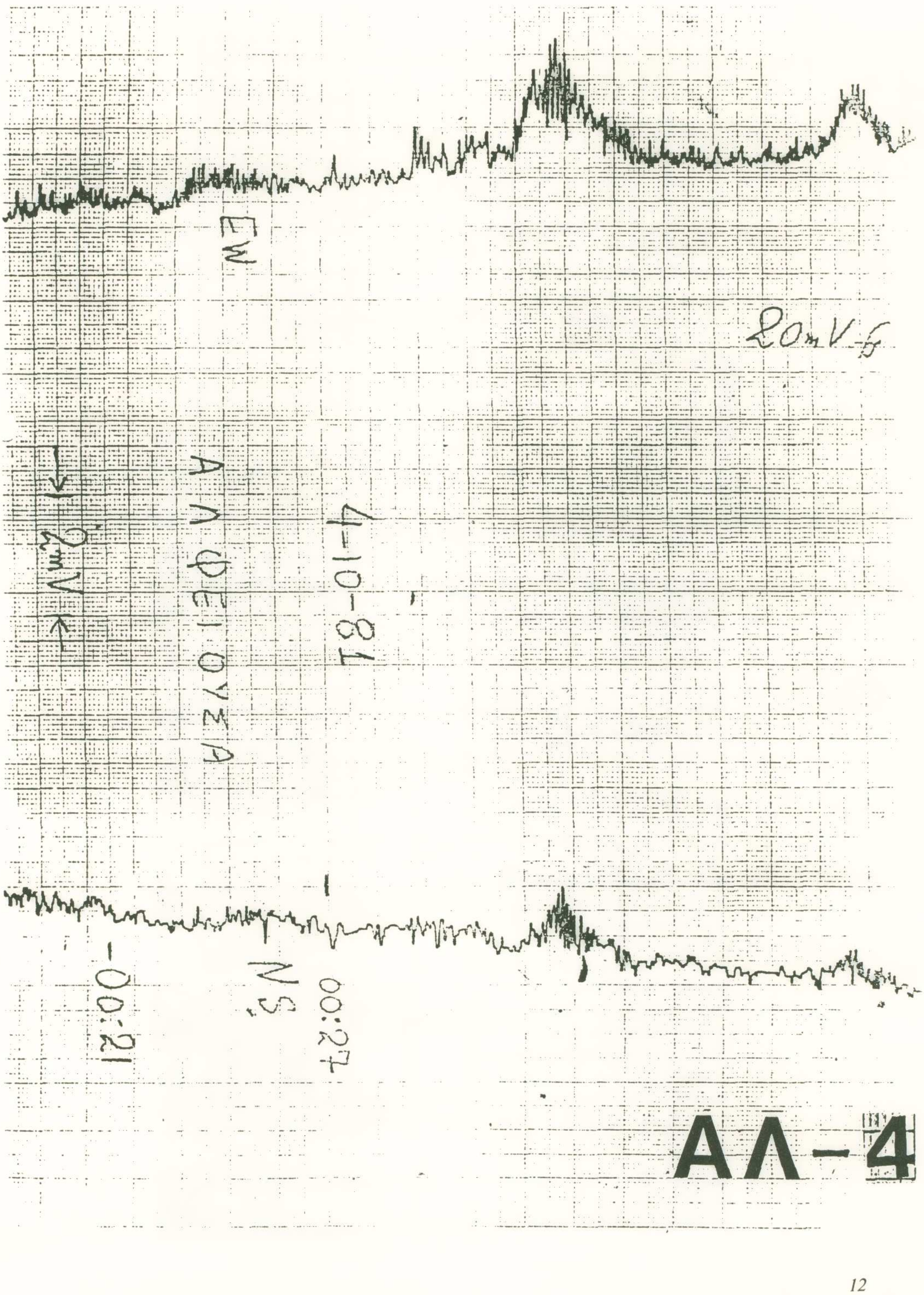

ΣΥΡΟΣ
2-3-83
EW
NS
—12:00
—11:00
11:00
—10:00
—0900
Σ-4

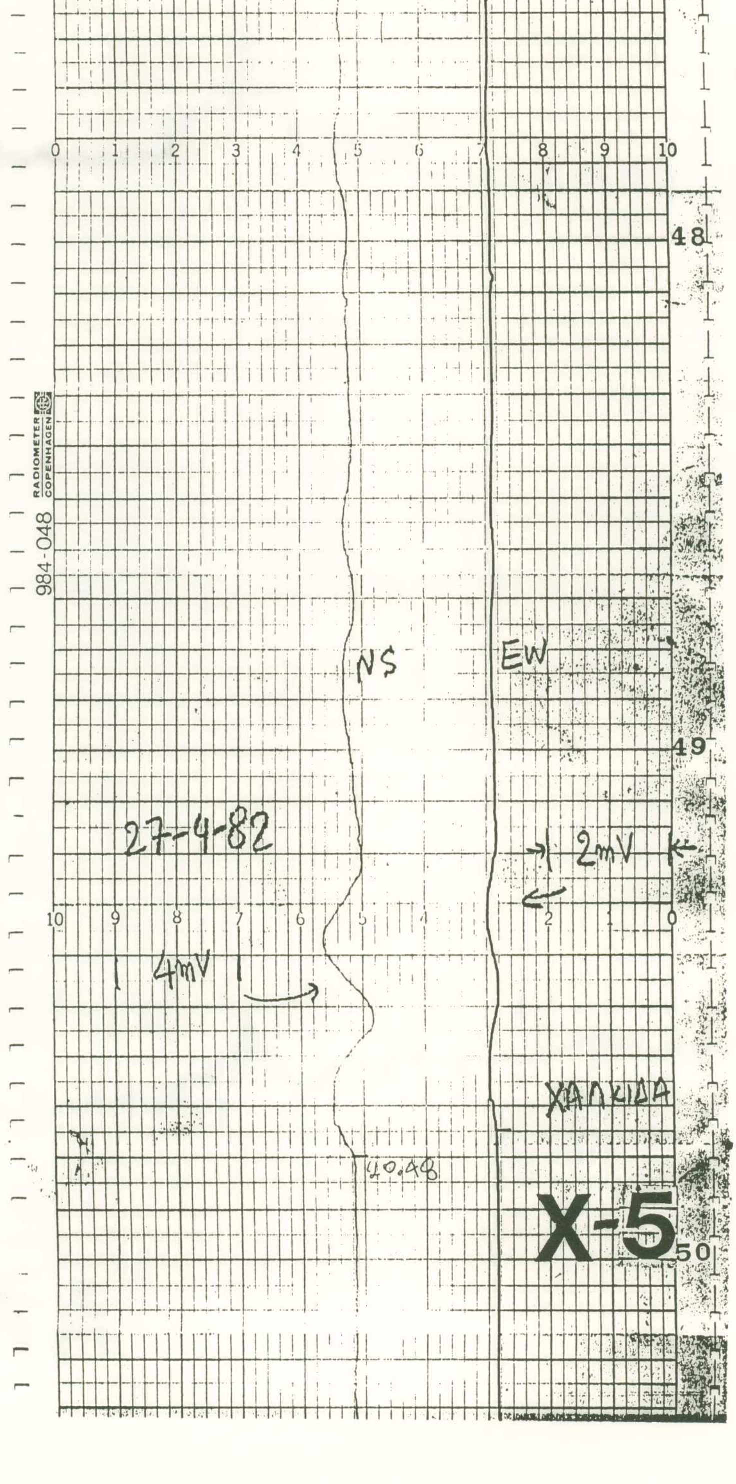

21:30
2mV
23-11-82
ΒΕΡΡΟΙΑ
EW
N-S
20:30
19:30
18:30
B-6


128
730
0 1 2 3 4 5 6 7 8 9 10
ΚΕΦΑΛ.
24-5-83
EW
22:00
NS
2mV
740
21:00
10 9 8 7 6 5 4 3 2 1 0
20:00
750cm
K-12

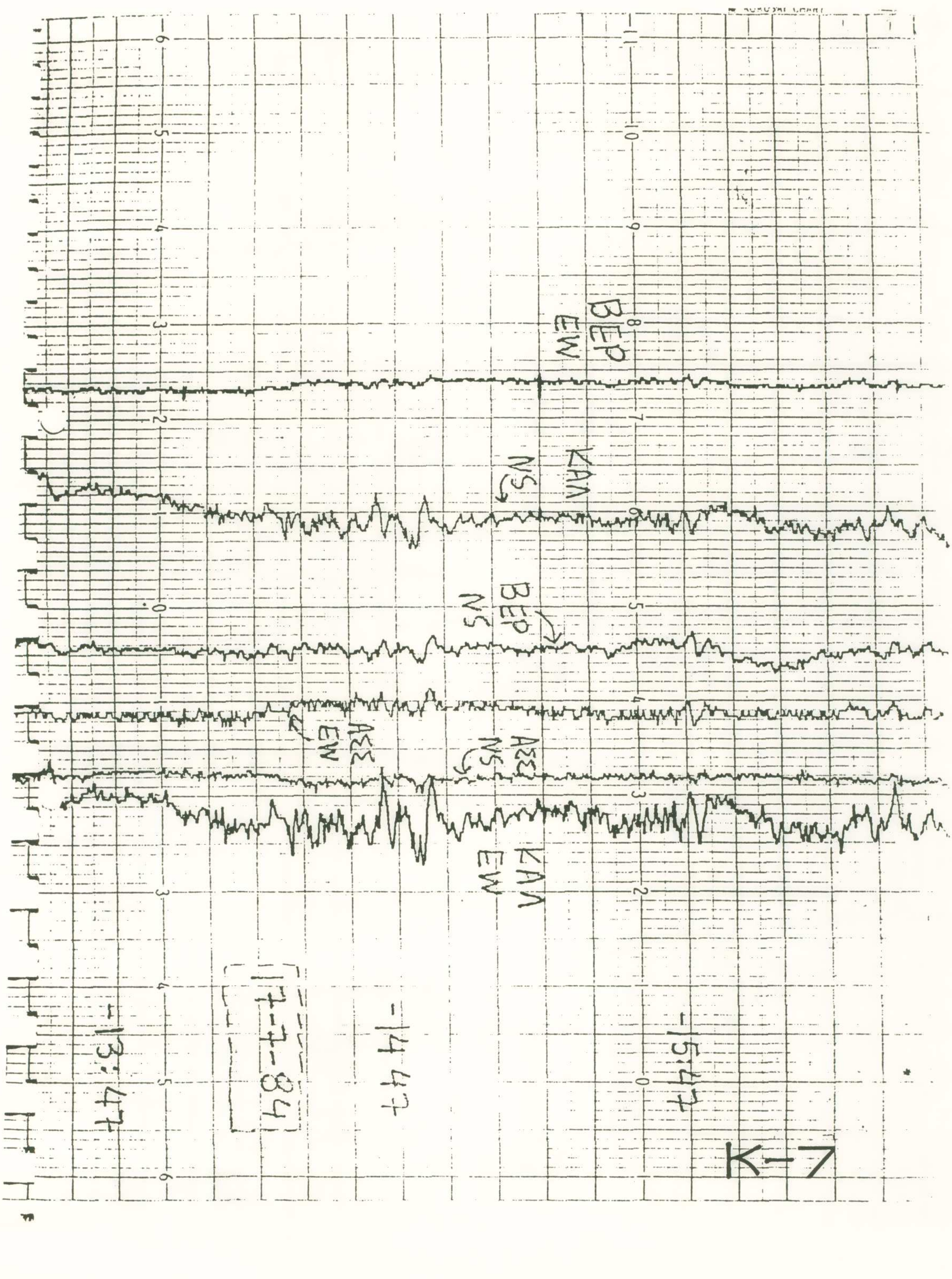

NS
EW
IOANNINA
16:00
1-7-82
4mV
24
25
26
RADIOMETER COPENHAGEN
984-048

I-3


EW
ΑΛΦΕΙΟΥΣΑ
4-10-81
2mV
20mV
NS
00:27
00:21
ΑΛ-4



RADIOMETER COPENHAGEN
984-048
NS
EW
48
49
50
27-4-82
2mV
4mV
ΧΑΛΚΙΔΑ
40.48
X-5


ΒΕΡ EW
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13:47
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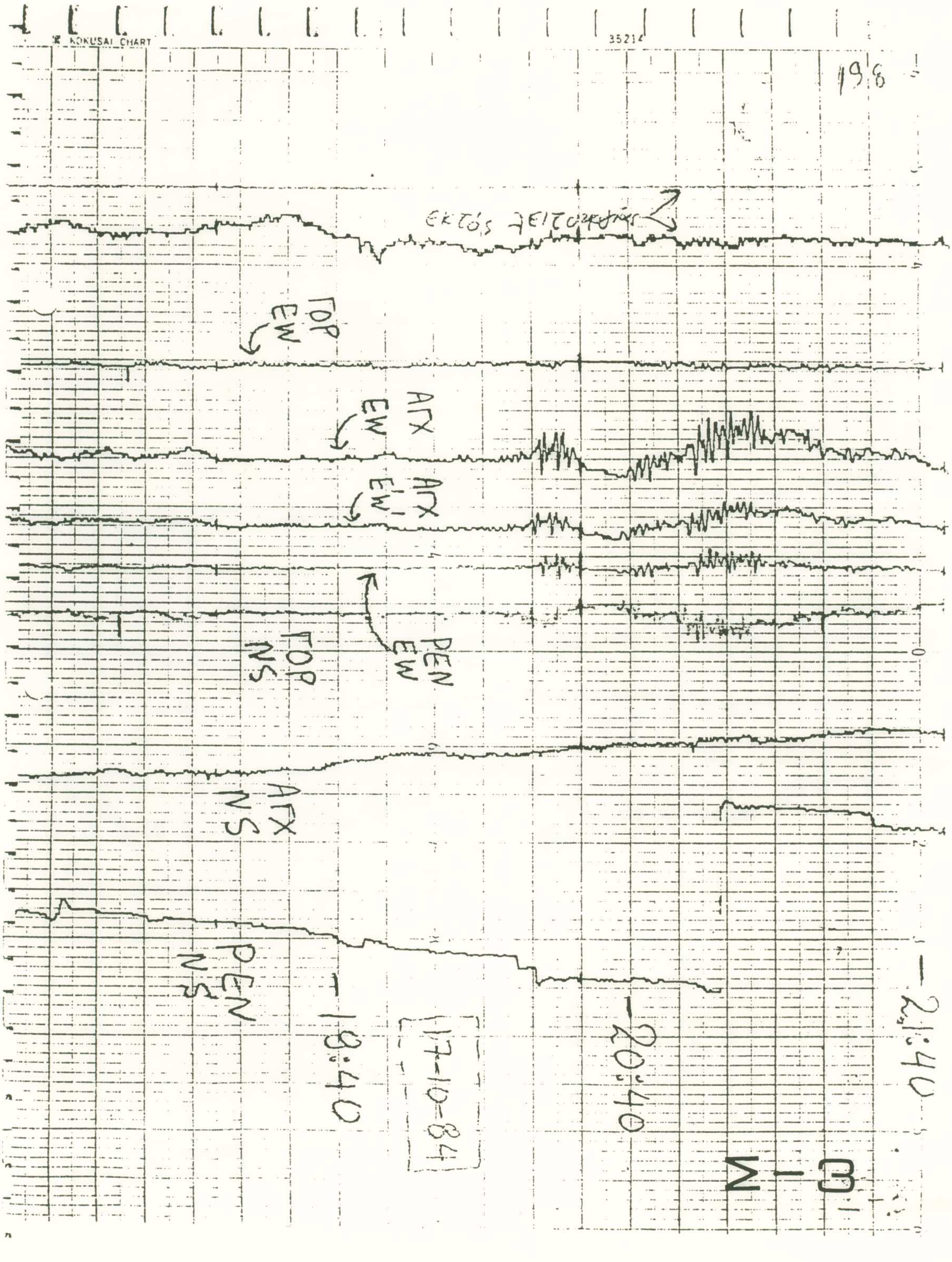
15:47
17-7-84
K-7


KOKUSAI CHART
35214
ΓΟΡ EW
ΑΓΧ EW
ΑΓΧ EW'
ΡΕΝ EW
ΓΟΡ NS
ΑΓΧ NS
ΡΕΝ NS
19:40
20:40
21:40
17-10-84
M-3

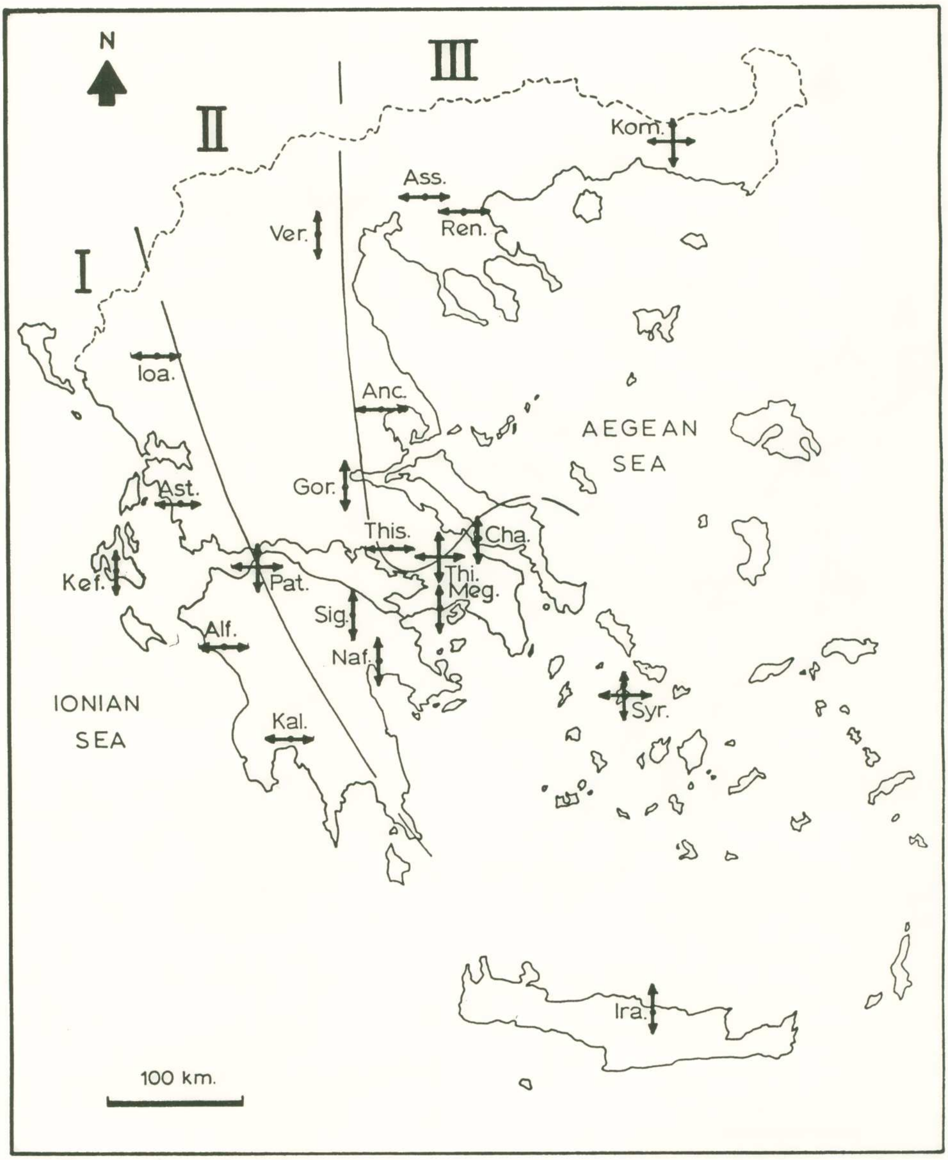


Fig. 2. Schematic representation of the results for T = 10 sec (mean skin depth of the order of 10 km): the north-south oriented double arrow corresponds to $P_{NS}>P_{EW}$ whereas the east-west oriented to $P_{EW}>P_{NS}$: both arrows are used where $P_{NS}=P_{EW}$.

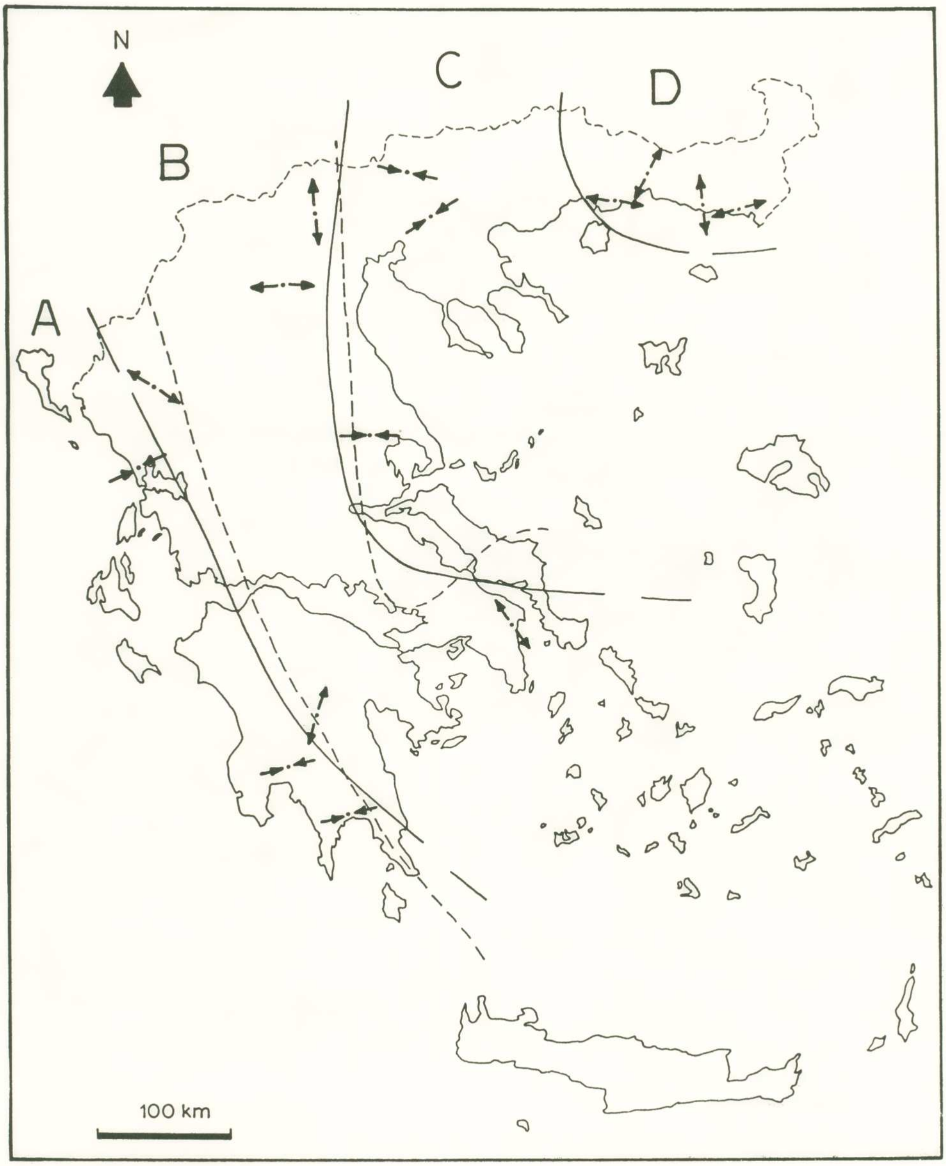


Fig. 3. Summary of the neotectonic and seismotectonic data resulting in three zones a, b, c (continuous lines) which are compared to the electric zones I, II, III of Fig. 2 (broken lines).

1: Horizontal compression with thrust and reverse faults.

2: Horizontal extension with normal faults.

3: Vertical shear zones with strike-slip faults.

4: Area under compression with slip in the E-W to ENE-WSW direction deduced from the fault plane solutions.

The extensive stress of south Peloponese has been observed only at superficial normal faults. The seismotectonic analysis leads to compressive stress.

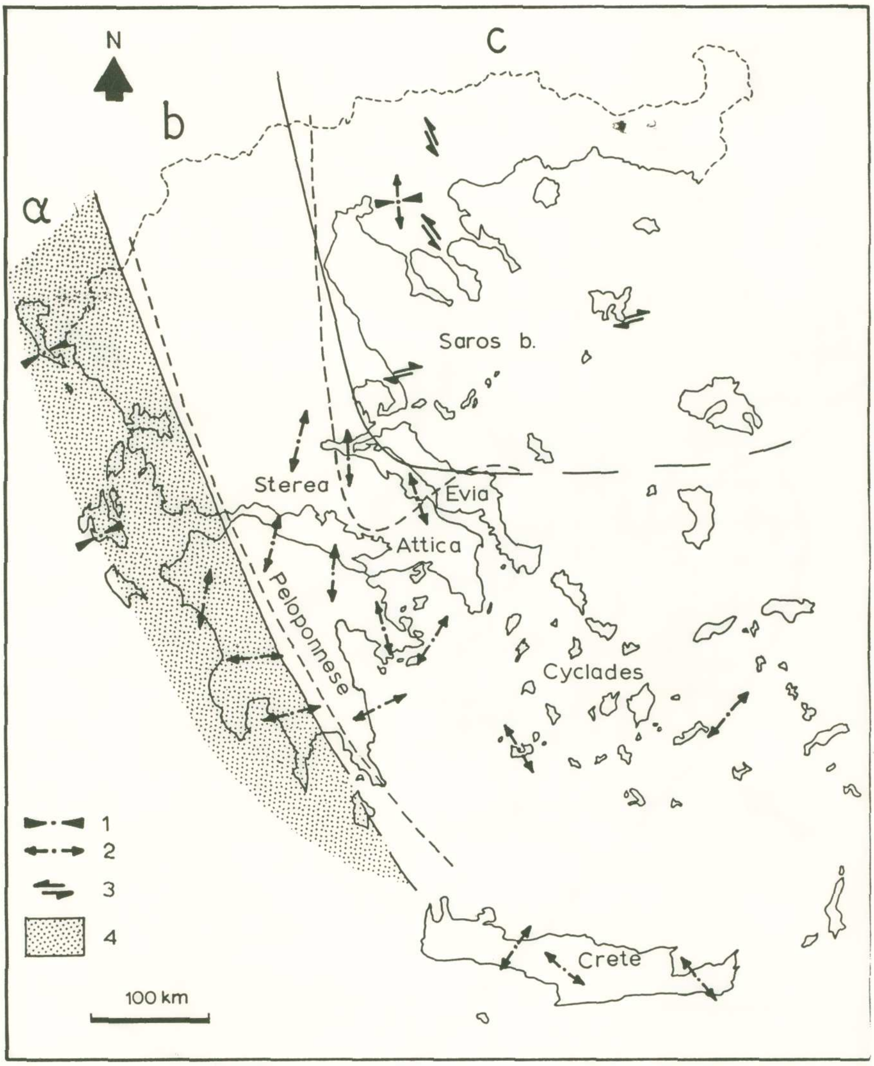


Fig. 4. The data of the in situ stress measurements (Paquin et al, 1982) distinguished in four zones A, B, C, D (continuous lines) separating areas of actual compression and extension, compared to the electric zones I, II, III of fig. 2 (broken lines).

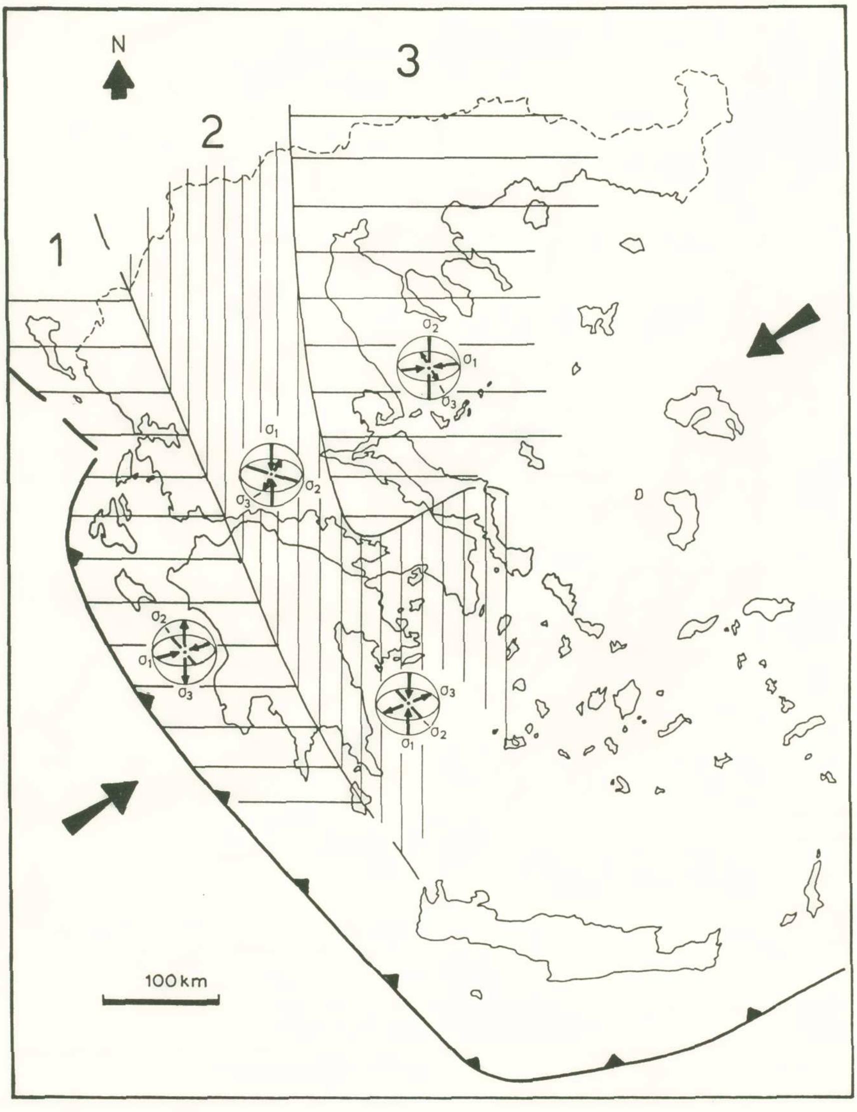


Fig. 5. The tectonoelectric zonation of the Hellenic arc.

1: External zone with (dominance of) E-W direction of electric resistivity subparallel to the σ_1 direction of horizontal compression (σ_3 vertical).

2: Intermediate zone with N-S direction of electric excess resistivity and horizontal extension (σ_1 vertical).

3. Internal zone with E-W direction of electric excess resistivity subparallel to horizontal shear (σ_2 vertical). The black arrows indicate the direction of plate movement.

Ὁ Ἀκαδημαϊκὸς κ. **Ἄγγελος Γαλανόπουλος**, μετὰ τὸ πέρας τῆς ἀνακοινώσεως, εἶπε τὰ ἑξῆς:

Εἴθισται σὲ ἐργασίες ποὺ βασίζονται σὲ μετρήσεις ν' ἀναφέρεται ἡ μεθοδολογία καὶ τὰ ἀναλυτικὰ ἀποτελέσματα τῶν μετρήσεων.

Λόγω ἐλλείψεως ἀπὸ τὴν παρούσα ἐργασία τῶν δεδομένων τούτων, εἰκάζεται ἀπὸ τὴ σελίδα 165 ὅτι οἱ μετρήσεις τῶν φαινομένων ἀντιστάσεων ἐγένοντο μεταξὺ 2 ζευγῶν ἠλεκτροδίων, ἀπεχόντων 50 ἕως 200 μέτρα, κατὰ δύο καθέτους διευθύνσεις, NS και EW.

Στὴ Γεωφυσικὴ εἶναι γνωστό, ὅτι ἡ φαινομένη ἀντίσταση ποὺ μετρεῖται μεταξὺ δύο ἠλεκτροδίων εἶναι ἴση μὲ τὴν ἐνεργὸ ἀντίσταση τῶν ἐπιφανειακῶν στρωμάτων πάχους ἴσου μὲ τὴν ἀπόσταση τῶν ἠλεκτροδίων ἀπὸ τὰ ὁποῖα διαβιβάζεται τὸ ἠλεκτρικὸ ρεῦμα.

Κατὰ ταῦτα τὰ μετρούμενα μεγέθη ἐπηρεάζονται ἀπὸ τὴν κατὰ τόπους γεωλογικὴ σύσταση καὶ ἠλεκτρολυτικὴ ἀγωγιμότητα τῶν ἐπιφανειακῶν στρωμάτων, καὶ δὲν μπορεῖ νὰ ἔχουν σχέση μὲ τὴν ἐντατικὴ κατάσταση τῶν γήινων στρωμάτων στὸ βάθος τῶν σεισμικῶν ἑστιῶν, ποὺ εἶναι συνήθως ἄνω τῶν 10 χιλμ.

Τοῦτο φαίνεται καὶ ἀπὸ τὴ σύγκριση τῶν εἰκόνων 2 καὶ 3. Στὴ σελίδα 166 ἀναφέρεται ὅτι στὶς ἠλεκτρικὲς ζῶνες (a) καὶ (c) εἶναι μεγαλυτέρα ἡ ἀντίσταση κατὰ τὴν ἀνατολικοδυτικὴ διεύθυνση, ὅπου ὁ ἄξων μεγίστης τάσεως, σ_1, εἶναι κατὰ τὴν ἀνατολική-βορειοανατολικὴ διεύθυνση (ENE). Ἡ εἰκόνα ὅμως 3 δεικνύει ὅτι στὴ δυτικὴ Πελοπόννησο, ποὺ ἀνήκει στὴ ζώνη (a), ἐπικρατεῖ ὁ ἄξων ἐλαχίστης τάσεως, σ_3, ὅπως καὶ στὴ ζώνη (b), ὅπου ὁ ἄξων μεγίστης τάσεως εἶναι κατακόρυφος. Ἐπίσης, στὴν αὐτὴ εἰκόνα σημειώνεται ὅτι στὴ Χαλκιδική, ποὺ ἀνήκει στὴ ζώνη (c), ὁ ἄξων μεγίστης τάσεως, σ_1, εἶναι κατὰ τὴ δυτική-βορειοδυτικὴ διεύθυνση (WNW) καὶ ὄχι κατὰ τὴν ἀνατολική-βορειοανατολικὴ διεύθυνση (ENE), ποὺ ἐπικρατεῖ στὶς ὁριζόντιες διατμήσεις ποὺ σημειώνονται νοτιότερα, στὸ Βόρειο Αἰγαῖο.

Στὴ σελίδα 167 ἀναφέρεται ὅτι οἱ μετρήσεις τῆς ἐντατικῆς καταστάσεως σὲ διατρήσεις ἐπιφανειακῶν στρωμάτων (in situ) στὶς ἐξωτερικὲς ζῶνες (a) καὶ (c) δεικνύουν ὅτι οἱ ἐπικρατοῦσες τάσεις ἔχουν τὴν ἴδια διεύθυνση μὲ αὐτὴ ποὺ εὑρέθηκε ἀπὸ σεισμοτεκτονικὲς μελέτες, δηλαδὴ ἡ ὁριζοντία συμπίεση εἶναι κατὰ τὴν ἀνατολικο-βορειοανατολικὴ (ENE) ἢ ἀνατολικοδυτικὴ (EW) διεύθυνση. Ἡ εἰκόνα ὅμως 3 δεικνύει, ὅπως ἐλέχθηκε ἤδη, ὅτι στὴ δυτικὴ Πελοπόννησο ποὺ ἀνήκει στὴν ζώνη (a) ἐπικρατεῖ ὁριζόντιος ἐφελκυσμός, καὶ στὴ Χαλκιδικὴ ποὺ ἀνήκει στὴν ζώνη (c) ὁριζοντία διάτμηση.

Τὰ ἀποτελέσματα τῶν μετρήσεων τῶν συγγραφέων εἶναι εὐεξήγητα, ἐὰν λάβομε ὑπόψη ὅτι τὸ σχέδιο ροῆς τῶν γήινων ἠλεκτρικῶν ρευμάτων ἀποτελεῖται ἀπὸ 8 δινορεύματα, ποὺ παράγονται ἐξ ἐπαγωγῆς στὴν ἐπιφάνεια τῆς Γῆς ἀπὸ τὰ ρεύματα τῆς ἰονοσφαίρας. Σὲ δύο γειτονικὰ δινορεύματα, ἡ διεύθυνση ροῆς εἶναι, ἐναλλάξ, κατὰ τὴ διεύθυνση καὶ ἀντίθετα πρὸς τὴ διεύθυνση περιστροφῆς τῶν δεικτῶν τοῦ ὡρολογίου. Τὰ δινορεύματα μετατίθενται κατὰ μῆκος τῆς γήϊνης ἐπιφανείας μὲ τὴν ταχύτητα περιστροφῆς τῆς Γῆς.

Ἐὰν θεωρήσομε ὅτι τὸ ἐλλειψοειδὲς σχῆμα τῶν γήινων ἠλεκτρικῶν δινῶν εἶναι περίπου ὀρθογώνιο, στὶς μικρότερες πλευρὲς δύο γειτονικῶν δινῶν τὸ ρεῦμα ρέει κατὰ τὴ μεσημβρινὴ διεύθυνση (NS), καὶ στὶς μεγαλύτερες πλευρὲς κατὰ τὴν ἀνατολικοδυτικὴ διεύθυνση (EW). Οὕτως ἐξηγεῖται εὐχερῶς γιατὶ ἡ φαινομένη ἀντίσταση εἶναι στὴν κεντρικὴ ζώνη μεγαλύτερη κατὰ τὴ μεσημβρινὴ διεύθυνση, καὶ στὶς ἑκατέρωθεν ζῶνες μεγαλύτερη κατὰ τὴν ἀνατολικοδυτικὴ διεύθυνση. Στὶς γωνίες τῶν ὀρθογωνικῶν δινῶν ἡ φαινομένη ἀντίσταση εἶναι καὶ στὶς δύο διευθύνσεις περίπου ἴση.

Λόγω τῶν γεωγραφικῶν, ἡμερησίων καὶ ἐποχικῶν μεταβολῶν τῶν γήινων ρευμάτων, τὰ ἐξαγόμενα τῶν μετρήσεων σὲ διαφόρους τόπους εἶναι συγκρίσιμα ἐφόσον ἀναφέρονται στὸν αὐτὸν χρόνο.

Διὰ νὰ μὴ κουράσω τὸ ἀκροατήριο δὲν ἐπεκτείνομαι σὲ ἄλλες παρατηρήσεις, τὶς ὁποῖες εὐχαρίστως θὰ συζητοῦσα ἀργότερα μὲ τοὺς συγγραφεῖς, ἐὰν ἐπιθυμοῦσαν τοῦτο.

Ὁ Ἀκαδημαϊκὸς κ. **Καῖσαρ Ἀλεξόπουλος** ἀπαντᾶ στὸν κ. Γαλανόπουλο ὡς ἑξῆς:

Ἡ περιγραφὴ τῆς μεθοδολογίας (ἐγκατάσταση σταθμῶν, τρόπος λήψεως μετρήσεων κ.λπ.) δὲν ἦταν ἀπαραίτητη, διότι ἔχει δημοσιευθεῖ σὲ σειρὰ ἄρθρων εἰς τὰ Πρακτικὰ τῆς Ἀκαδημίας Ἀθηνῶν καὶ εἰς εἰδικὰ περιοδικὰ τοῦ ἐξωτερικοῦ.

Τὸ ἀντιπροσωπευτικὸ βάθος τῶν μετρήσεων ἐξαρτᾶται ἀπὸ τὴν συχνότητα. Οἱ συγγραφεῖς ἔχουν ἀναλύσει μαγνητοτελουρικὲς μεταβολὲς μὲ περίοδον ἀπὸ 1 sec ἕως 1 min, οἱ ὁποῖες φθάνουν στὸ βάθος τῆς τάξεως τῶν 10 km καὶ εἶναι ἄσχετες μὲ τὴν ἀπόσταση τῶν ἠλεκτροδίων.

Ἡ παροῦσα ἐργασία πρόκειται νὰ δημοσιευθεῖ σὲ εἰδικὸ περιοδικὸ τοῦ ἐξωτερικοῦ καὶ οἱαδήποτε κρίση θὰ μπορεῖ συνεπῶς νὰ γίνει ἐκεῖ μετὰ τὴν δημοσίευση.

ΠΕΡΙΛΗΨΗ

Τεκτονοηλεκτρική ζώνωση στὸ ἑλληνικὸ τόξο

Σὲ 20 περίπου περιοχὲς τῆς Ἑλλάδας ἐγκαταστάθηκαν σταθμοὶ μέτρησης τοῦ ἠλεκτρικοῦ πεδίου τῆς γῆς. Οἱ μετρήσεις ἔγιναν κατὰ τὴν περίοδο 1981-1985. Ἀναλύθηκαν μεταβολὲς τοῦ ἠλεκτρικοῦ πεδίου ποὺ ἐπάγονται ἀπὸ μεταβολὲς τοῦ μαγνητικοῦ πεδίου τῆς γῆς (μαγνητοτελουρικὲς διαταραχές). Οἱ περίοδοι τῶν μεταβολῶν ποὺ ἀναλύθηκαν ἀντιστοιχοῦν σὲ ἐνεργὸ βάθος 10 ἕως 20 χιλιομέτρων.

Διαπιστώθηκε ὅτι πολλὲς περιοχὲς ἐμφανίζουν ἔντονη γραμμικὴ πόλωση τοῦ ἠλεκτρικοῦ πεδίου. Οἱ περιοχὲς αὐτὲς δὲν κατανέμονται τυχαῖα στὸν ἑλληνικὸ χῶρο ἀλλὰ ταξινομοῦνται σὲ 3 ζῶνες. Ἡ ἠλεκτρικὴ αὐτὴ ζώνωση ἐμφανίζει ἔντονη συσχέτιση μὲ τὴ γεωτεκτονικὴ ζώνωση τῶν Ἀλπικῶν σχηματισμῶν καὶ τὴ ζώνωση ποὺ περιγράφει τὴν ἐντατικὴ κατάσταση στὸν ἑλληνικὸ χῶρο.