THE WESTERN PART OF GULF OF CORINTH (GREECE) STRONG MOTION NETWORK (RASMON). PRELIMINARY RESULTS.

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A B S T R A C T

In July, 1991, a strong motion network (RASMON) consisting of 8 SSA-1 and 7 SMA-1 stations was installed around the western part of the Gulf of Corinth (W. Greece), in order to assist the investigation of the complex seismotectonic regime of the area and provide the basis for strong ground motion attenuation and site effect studies. The first phase of operation lasted until September 1992 and during this period 453 3-component accelerograms from 100 events with epicentral distances from 1 to 100 km and magnitudes ranging from 2.5 to 5.0 R were recorded, providing more than 1200 recordings. The examination of the corrected accelerograms and corresponding response spectra obtained for the October 25, 1991 M_L=4.5 event at different stations indicated that the available data provide important information on the effects of the local geological conditions on the frequency content, amplification and energy distribution of the signals recorded at different sites.

ΤΟ ΔΙΚΤΥΟ ΕΠΙΤΑΧΥΝΣΙΟΓΡΑΦΩΝ (RASMON) ΣΤΗΝ ΠΕΡΙΟΧΗ ΔΥΤΙΚΟΥ ΚΟΡΙΝΘΙΑΚΟΥ ΚΟΛΠΟΥ. ΑΡΧΙΚΑ ΑΠΟΤΕΛΕΣΜΑΤΑ

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Π Ε Ρ Ι Λ Η Ψ Η

Τον Ιούλιο του 1991, ένα τοπικό δίκτυο αποτελούμενο από 8 επιταχυνσιογράφους τύπου SSA-1 και 7 τύπου SMA-1 εγκαταστάθηκε στο δυτικό τμήμα του Κορινθιακού κόλπου, προκειμένου να διευκολύνει τη διερεύνηση του σύνθετου τεκτονικού καθεστώτος της περιοχής παρέχοντας ταυτόχρονα δεδομένα για τη μελέτη του τρόπου απόσβεσης της σεισμικής ενέργειας και τη σύγκριση φασμάτων απόκρισης ισχυρών εδαφικών κινήσεων σε διαφορετικούς γεωλογικούς σχηματισμούς. Η πρώτη φάση λειτουργίας του δικτύου διήρκεσε μέχρι το Σεπτέμβριο του 1992. Τα πρώτα αποτελέσματα από την ανάλυση των δεδομένων έδειξαν ότι κατά την περίοδο αυτή καταγράφηκαν 453 επιταχυνσιογράμματα τριών συνιστωσών, που προέρχονται από 100

σεισμούς με μεγέθη 2.5 έως 5 R και επικεντρικές αποστάσεις από 1 έως 100 km περίπου. Επίσης η εξέταση των διορθωμένων επιταχυνσιογραμμάτων και των αντιστοίχων φασμάτων απόκρισης του σεισμού της 25 Οκτωβρίου 1991, M_L=4.5 από διάφορους σταθμούς έδειξε ότι τα δεδομένα αυτά προσφέρουν σημαντικές πληροφορίες για την επίδραση των τοπικών γεωλογικών συνθηκών στο συχνοτικό περιεχόμενο, τη μεγέθυνση και την κατανομή της ενέργειας των σεισμικών καταγραφών σε διάφορες θέσεις.

INTRODUCTION

Within the framework of the co-operation between the Geophysics-Geothermy Department of the Athens University, the Bureaux of Seismic Risk Evaluation for the Safety of Nuclear Installations of CEA in Paris and the Laboratory of Tectonophysics and Geophysics of the Interior of the Joseph Fourier University of Grenoble, a strong motion network of 8 digital SSA-1 and 7 analog SMA-1 3-component instruments was installed in the western Corinthiakos Gulf area in Greece (figure 1). The installation was concluded in July 1991 and the first phase of the network's operation lasted until the end of September 1992.

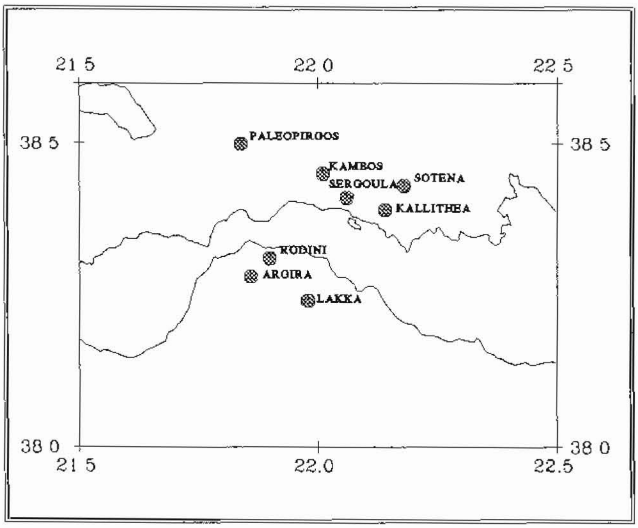

Fig.1. Location map of SSA-1 accelerograph stations of RASMON network.

The first one of this experiment's main objectives was to contribute to the study of the complex seismotectonic regime of the area in combination with a microseismicity study in the same area during the period of July - August 1991. The second objective was the collection of acceleration data in order to provide the basis for strong ground motion attenuation studies and the calculation of the corresponding laws. This target is of great importance since the number of strong motion records available from earthquakes in the area of Greece is limited, a fact that is especially pronounced for the case of near field records. In addition, in order to obtain unavailable up to now strong motion records for events of small magnitude, which may permit the extension of attenuation laws at lower acceleration values, the trigger level of the instruments was set at a very low level.

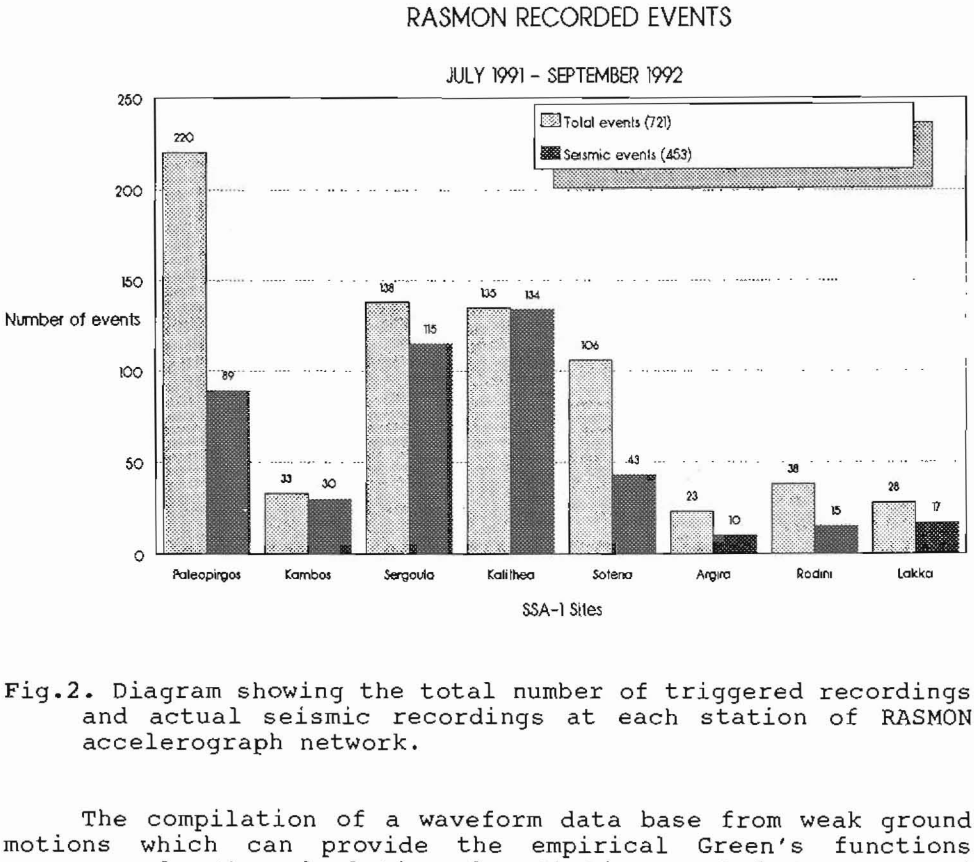

Fig.2. Diagram showing the total number of triggered recordings and actual seismic recordings at each station of RASMON accelerograph network.

The compilation of a waveform data base from weak ground motions which can provide the empirical Green's functions necessary for the calculation of synthetic expected strong ground motions in the area, was the third objective of this effort (see Diagourtas et al, 1993). Finally, in order to obtain valuable information about the effects of the site local geological conditions on the amplification of strong ground motion the instruments were installed on different geological formations.

It is evident that these objectives are of especially great importance to engineering seismology since the obtained results can assist seismic hazard assessment studies, improve the capability of calculating synthetic strong ground motion at specified sites of major constructions and improve our knowledge about the effects of local site conditions on strong ground motion.

The scope of this paper is to present and evaluate the preliminary results obtained from the initial processing and the interpretation of the data recorded during the first phase of this experiment.

STATISTICS

During the 15 month period of the network's first phase of operation a total of 721 signals were obtained from the 8 SSA-1 digital stations. Initial examination of the recorded data revealed that 453 of these signals correspond to 100 seismic events. The analysis of the recorded events at each station is presented in the bar chart of figure 2, while in the bar chart of figure 3 the number of seismic events per month and the corresponding number of recorded signals in all stations are depicted.

The number of 3-component records obtained by all stations in relation to the number of actual seismic events is next presented in the diagram of figure 4. Finally in the bar chart of figure 5 the number of records classified in five categories on the basis of the maximum peak to peak horizontal acceleration values obtained, is depicted.

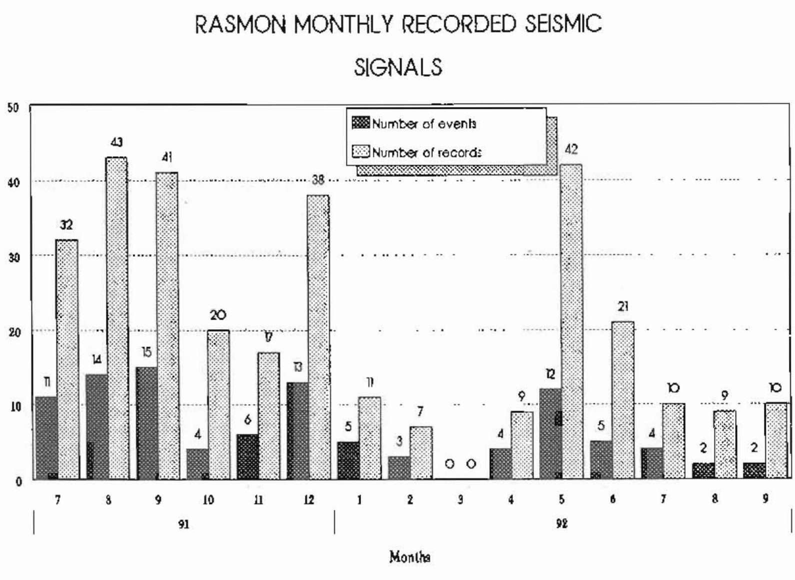

Fig.3. Diagram showing the total number of seismic events and actual seismic recordings at all stations for every month of network operation.

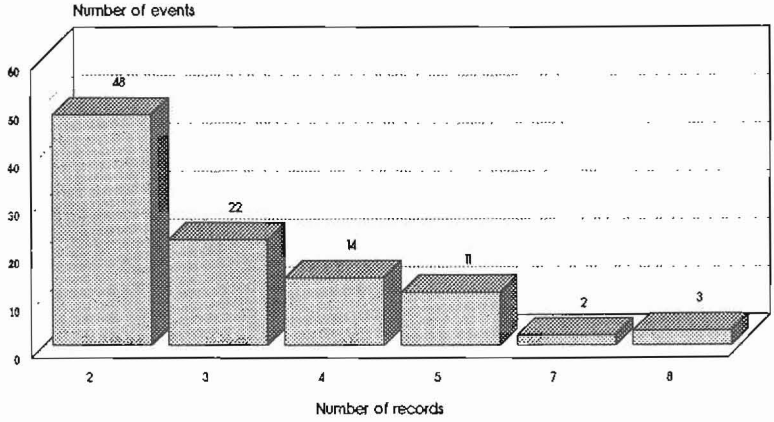

Fig.4. Diagram showing the number of seismic events in relation to the corresponding number of records.

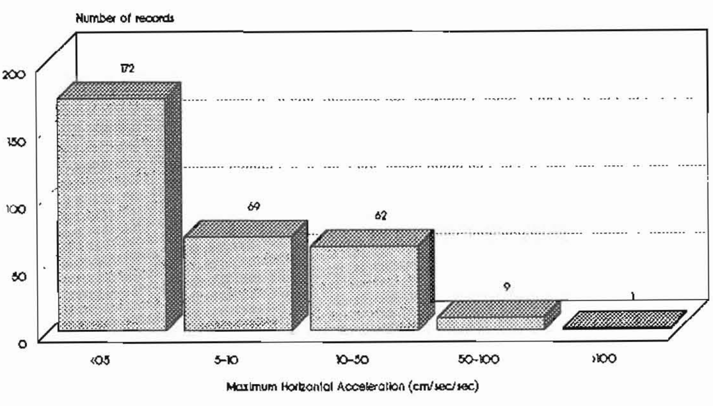

Fig.5. Diagram showing the number of seismic records in relation to the corresponding maximum horizontal acceleration values.

In order to determine the hypocenter location of the recorded events the records of the National Observatory of Athens were initially examined. This examination revealed that during the period of interest a total of 91 events were recorded in the area by the National Seismological Network the epicentres of which are presented in figure 6.

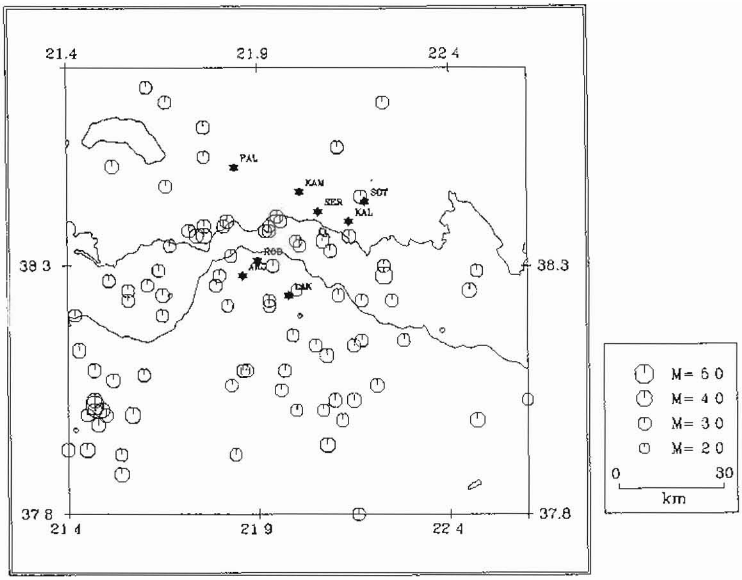

Fig.6. Epicentre location map of events recorded by the seismological network of the National Observatory of Athens during the period July 91-September 92.

Next, from the results obtained during the microseismicity experiment in the area (A. Rigo et al, 1992) for the period July-August 1991 the epicentre locations of the events recorded by RASMON during the same period, were selected. Using this focal parameter data and by re-location of the events recorded by the NOA network the epicentre map of figure 7 was compiled. However, it must be noted that this relocation procedure for the determination of the epicentres of the remaining events is still in progress.

ANALYSIS - DISCUSSION

The recorded events were processed using the PC-based package incorporating the three stages corresponding to the standard processing scheme developed at the Earthquake Research Laboratory of the California Institute of Technology (Trifunac and Lee, 1979). First, the digital data files recorded at 200 samples per second and collected in the field were scaled and converted to acceleration values using the sensitivity and damping of each instrument.

In the following step the scaled accelerograms were corrected for instrument frequency response, and baseline adjustment was performed. Initially, a low pass Ormsby (Ormsby, 1961) filter with a cut-off frequency of 47 Hz and a roll-off frequency of 50 Hz was applied. Next, instrument correction was effected using the instrument specific characteristics. For the baseline correction a high-pass Ormsby filter was used with a cut-off and roll-off frequency of 0.25 and 0.5 Hz respectively. Finally, in order to obtain the corresponding velocity and displacement time histories the corrected accelerograms were integrated once and twice respectively. The application of an Ormsby high-pass filter with the same roll-off and cut-off frequencies as before at every integration step, was performed in order to avoid long period errors resulting from the uncertainties involved in the estimation of the initial velocity

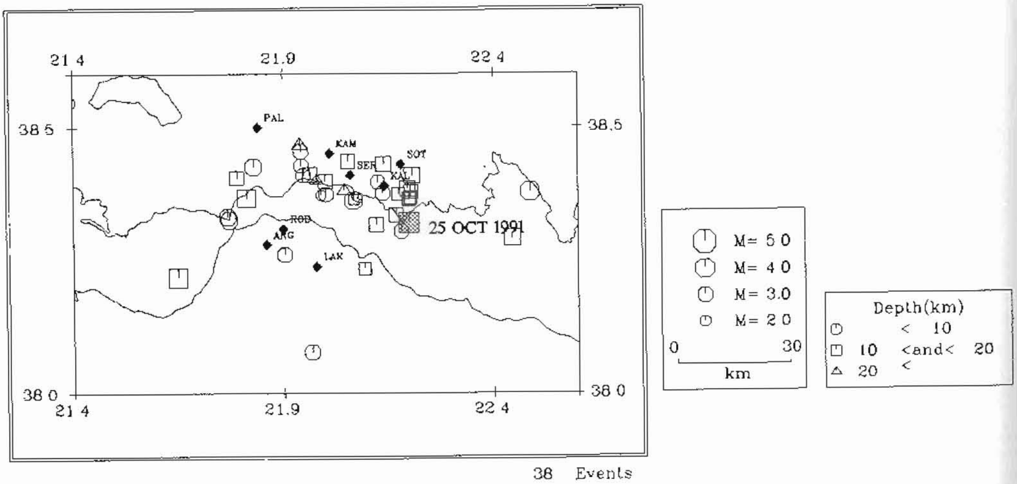

Fig.7. Epicentre location map of the events recorded by the microseismicity network during the period July-August 1991 and the relocated events of the NOA network. Epicentre location of the October 25, 1991 M_L=4.5 event, (shaded rectangular).

and displacement values (Hudson, 1979). From the obtained corrected accelerograms the response spectra were calculated, for different periods and damping values, using the approach based on the exact analytical solution of the Duhamel integral for successive linear segments of excitation.Next, the earthquake of October 25, 1991, 21:24 M_L=4.5 which occurred almost in the centre of the network (figure 7), was selected in order to present the good quality of the recorded data and the different prospects and capabilities provided by the installation and operation of such a local accelerograph network. In figure 8 an example of the corrected acceleration, velocity and displacement time histories of this event, obtained after the previously mentioned processing steps for the case of the longitudinal (N-S) component of the Sergoula station is presented, since a peak to peak maximum acceleration of 360 cm/sec^2 was recorded on that component, while the corrected longitudinal acceleration components of all stations and the corresponding response spectra are presented in figures 9 and 11 respectively.

As it was shown by Scherbaum (1987a,b) and Hutching and Wu (1990), the records obtained from small and average magnitude near field events are not significantly influenced by source characteristics and hence they can provide useful information for site effect studies. Within this concept, the data recorded by RASMON network allow the examination of variations in frequency content, amplification and energy distribution, in relation to the different geological formations upon which the network was installed, a fact which is verified by the analysis of the October 25, 1991 event.

If we examine the corrected acceleration waveforms of the north-south components obtained at different sites (figure 9), we will observe the differences between the first three records of the south stations located on Plio-quaternary sediments and the remaining four stations installed on alpine formations. The larger peak acceleration values in the recordings of the north stations are evident, while more frequency variations can also be observed in the records of the south stations. Furthermore, as it can be seen in figure 10 where an example of the Fourier spectra for the characteristic stations of Lakka and Sergoula is shown, in the south site the released seismic energy is dispersed across a wider frequency band, whereas the spectra of the north station show an energy concentration in a limited and better defined frequency range, resulting larger peak acceleration values.

Similar features can be observed in the response spectra of all stations presented in figure 11. Thus, in the case of the response spectra of the south stations (Rodini, Argira, Lakka, figure 11a,b,c) we can notice once again, that the seismic energy is distributed across a wider period band with a variety of peaks, especially in the lower limit of the band, most likely caused by the energy scattering in the relatively poorly consolidated Plio-quaternary sediments. On the other hand, in the response spectra of the north stations (Kallithea, Sotena, Sergoula, Paleopirgos, figure 11d,e,f,g) located on the older better consolidated alpine formations, the seismic energy release in low periods (less than 0.1 sec) is limited and the energy appears to be concentrated in a narrower band (0.1-0.5 sec). This is more pronounced in the case of the Sergoula station located on Cretaceous limestone which yielded the maximum observed acceleration value of 181.5 cm/sec^2 where the released seismic energy is concentrated in the limited period band of 0.1-0.3 sec peaking at 0.2 sec (figure 11f).

The response spectra of Sotena and Kallithea, located at almost the same epicentral distance as the previous one, indicate that seismic energy is less concentrated a fact that can be attributed to the relative heterogeneity characterising the flysch formation upon which these stations were installed. Finally, the greater dispersion of seismic energy observed in the response spectra of Paleopirgos which was also installed on Cretaceous limestone, like Sergoula station, can be attributed to the effects of the ray path due to the relatively greater distance of this station from the epicentre (≈45km).

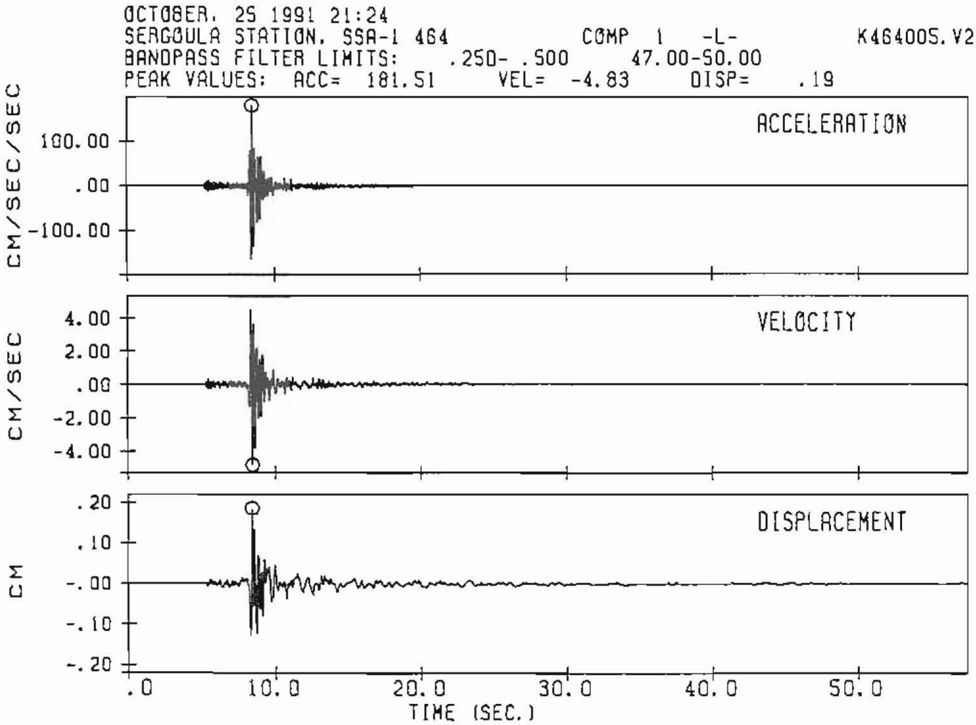

Fig.8. Corrected acceleration, velocity and displacement of the October 25, 1991 earthquake $M_L=4.5$ recorded on the longitudinal component of Sergoula station.

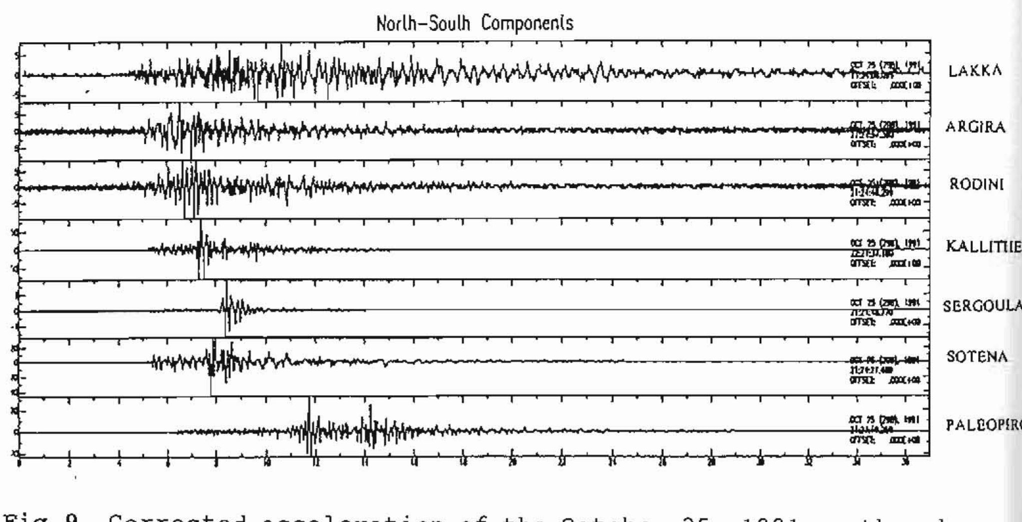

Fig.9. Corrected acceleration of the October 25, 1991 earthquake $M_L=4.5$ recorded on the longitudinal components of 7 stations.

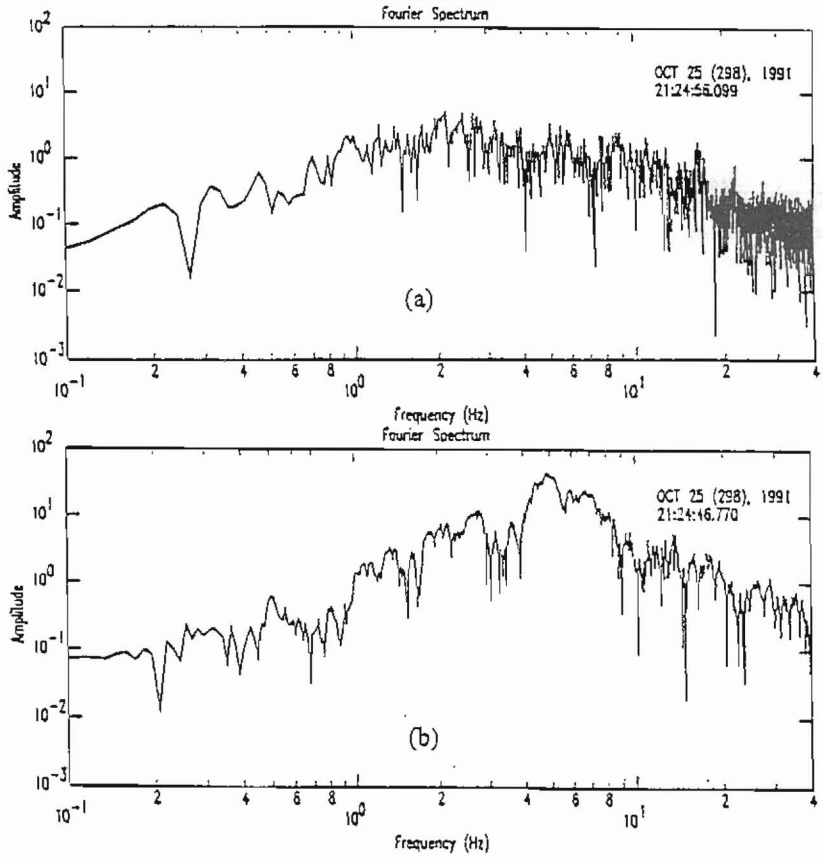

Fig.10. Fourier amplitude spectra derived from the ongitudinal components of the October 25, 1991 earthquake M_L=4.5 recorded by Lakka (a) and Sergoula (b) stations.

CONCLUSIONS

The preliminary analysis of the data obtained during the 15-month first phase of operation of the RASMON accelerograph network in the western Corinthian Gulf, revealed that from the 453 3-component records , 313 corresponding to 100 seismic events with magnitudes (M_L) ranging from 2.8 to 5.0 and epicentral distances from 1 to more than a 100 km, are exploitable. The maximum horizontal acceleration peak to peak values obtained from the analysis of these records range from 2 cm/sec^2 to 360 cm/sec^2.

The obtained data set satisfies our expectations while designing such a network and proves its necessity for more detailed earthquake engineering and seismic hazard assessment studies. This is even more important when dealing with a seismotectonically complex area like the one covered by RASMON network. Furthermore the preliminary analysis of the October 25,

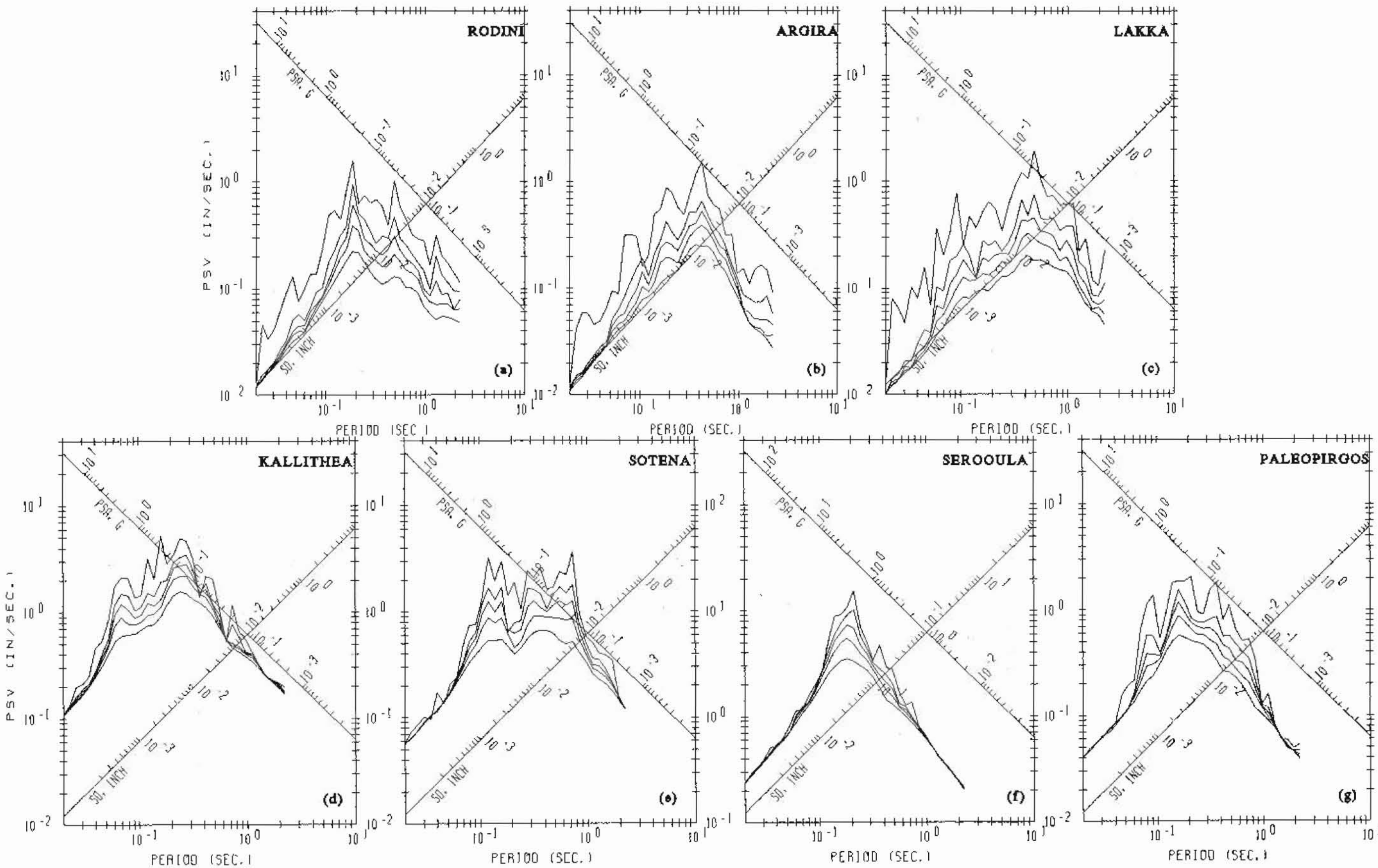

Fig.11. Response spectra of the October 25, 1991 earthquake derived from the longitudinal components recorded at Rodini (a) Argira (b) Lakka (c) Kallithea (d) Sotena (e) Sergoula (f) and Paleopirgos (g) stations for 0%, 2%, 5%, 10% and 20% damping.

1991 event shows relatively large variations in peak acceleration values as well as in frequency content at different sites with comparable epicentral distances, underlining the importance of considering the role of site conditions in aseismic design studies. However, it is well understood that realistic aseismic design requires a multidisciplinary approach involving not only the above mentioned site effect but also local and regional attenuation laws, high quality local event recordings to be used as empirical Green's functions in order to synthesise expected strong ground motion etc. The above data set can be used as a basis for such detailed studies towards which further work is oriented.

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