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THE FIRST ACCELEROGRAMS OBTAINED IN SPAIN. SOIL AND SOURCE EFFECTS.

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SUMMARY

A magnitude 5.0 earthquake, with epicenter near Granada, triggered a set of strong-motion instruments for the first time in Spain, in 1984. The accelerograms obtained have been processed following two techniques, that operate respectively in the time and the frequency domain. The differences encountered in ground motion at the three recording stations are analyzed. It is concluded that radiation pattern from the source (focal mechanism) and site effects are responsible for such differences; a result to be considered in the program presently in progress related with the assessment of seismic risk in the area of the shock.

INTRODUCTION

The seismic catalogue of Spain includes a few large shocks, responsible for heavy damage in certain areas to the South and Southeast of the country; the last of these earthquakes occurred on the night of the 25th of December, 1884, and partially destroyed more than 20 villages of the Granada and Malaga provinces, causing some 1000 casualties.

In spite of this history, depicted in the hazard map of fig.1, the installation of strong motion recording instruments did not start until the late seventies and even today only a few of them are in operation. Consequent with this situation only one shock of fairly small size has been recorded so far to the present. Although the records of this earthquake may have quite different features from those corresponding to destructive shocks in the area, it was considered worthwhile to make a brief analysis of them. The presentation of this analysis provides the opportunity of commenting briefly on the present situation of strong-motion instrumentation in Spain.

STRONG - MOTION INSTRUMENTS IN SPAIN

Nuclear power plants and large dams were the first candidate sites for the installation of accelerographs in Spain and most of the instruments installed today are still located in them, as shown in fig.2. The distribution by type of these instruments is

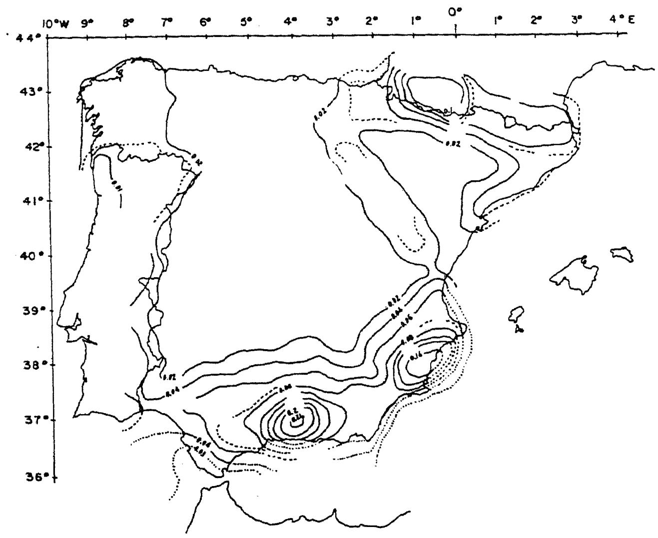
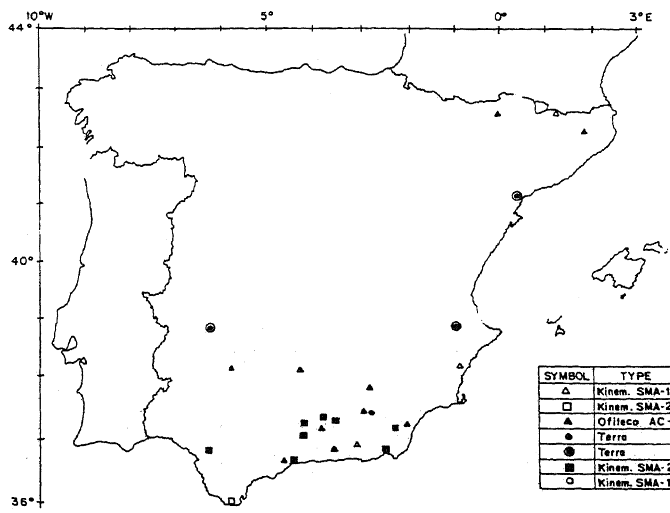


Fig. 1.- Earthquake hazard map. Maximum horizontal acceleration (g) for an annual probability of exceedence of 0,002 (Draft from Spanish Commission for Earthaquke Resistance Regulations).



SYMBOL	TYPE	LOCATION	QUANTITY
△	Kinem. SMA-1	DAM	6
□	Kinem. SMA-2	DAM	4
▲	Ofiteco AC-3	DAM	36
●	Terra	DAM	1
◉	Terra	NPP	4
■	Kinem. SMA-2	BUILDING	9
○	Kinem. SMA-1	BUILDING	1

Fig. 2.- Location of strong-motion instruments in Spain.

also given in the figure; all have analog recorders either on film or on tape.

The Instituto Geográfico Nacional (IGN) that deployed 8 SMA-2 (KINEMETRICS) in Southern Spain some years ago, has now plans to establish a nation-wide network of digital instruments. The first of these (11 in total) has been supplied by the Spanish firm OFITECO, and will be soon installed. An external view of this instruments connected to a portable PC computer, used for data retrieval, is shown in fig.3.

FIRST ACCELEROGRAMS

Earthquake parameters.- The first accelerograms obtained by the instruments mentioned above show the motion at three stations from an earthquake with epicenter in one of the most active areas in Spain. The location of the epicenter, a geologic sketech of the epicentral zone and some focal parameters are given in fig.4. Information on focal mechanism is taken from Buforn et al. (Ref.1), while other parameters come from the IGN data file. To be noted are the fairly small size (5.0 body-wave magnitude) of the shock and the shape of the isoseismals relative to the surface geology.

Records.- The location of the recording stations is also given in fig.4. Instruments in Alhama de Granada and Santa Fe (IGN stations) were placed on the ground floor of 2-storey buildings; in Béznar two OFITECO AC-3 accelerographs were installed on rock in galleries at different levels in one of the abutments of a dam. Epicentral distances range from 20 to 36 km. The (corrected) records obtained are shown in fig.5 (only one from Béznar is presented since the two obtained were identical).

ANALYSIS AND DISCUSSION

Data processing.- The acceleration time histories a(t) given in fig.5 and the corresponding velocities and displacements v(t), d(t) were obtained by Carreño et al. (Ref.2) for the IGN stations and by Pérez Saiz et al (Ref.3) for the Beznar records; according to their own account, no correction for instrument response was introduced by the IGN - University of Granada (U.G.) (Ref.2) group. Both groups obtained also Fourier spectra of all their corresponding set of records as well as response spectra of some of them. The IGN-UG group carried out the processing in the time domain while Perez Saiz et al. did it in the frequency domain. This last procedure was followed by us to compute the data presented in figs. 5, 6 and 7.

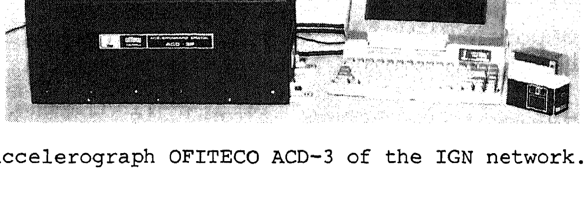


Fig. 3.- Digital accelerograph OFITECO ACD-3 of the IGN network.

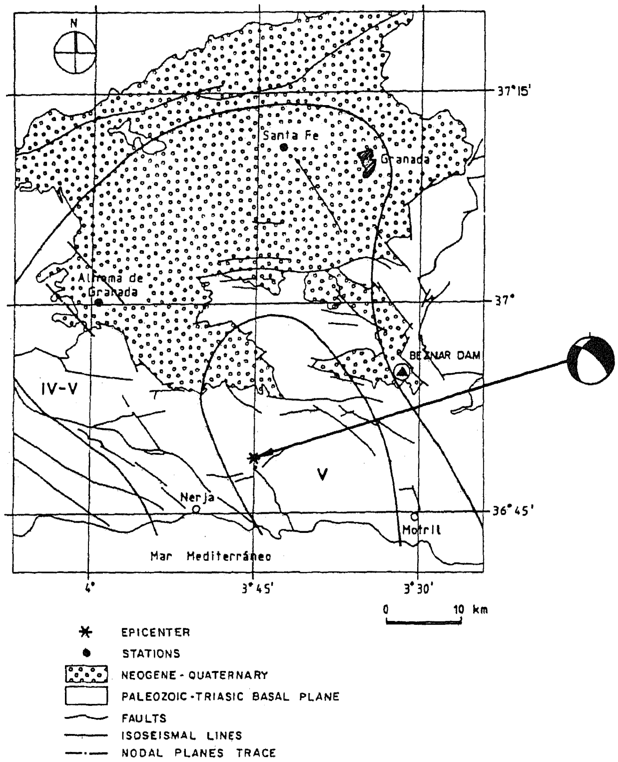


Fig. 4.- Epicentral region.

<u>Discussion</u>.- Maximum ground accelerations, as read from the records of figs. 5, 6 and 7 are given in table I.

TABLE I.- Maximum peak accelerations

Station	Epicentral distance (km)	a_{max}	
		cm/s^2	comp.
Beznar	20	25	V
Alhama	28	14	N
Santa Fe	38	35	E

The value at Santa Fe is clearly anomalous compared with those at Alhama and Beznar. Moreover, the records show that although Alhama accelerograph was triggered by the shock, only for a short interval (about 1 s) the motion recorded by the vertical and east-west components was larger than the noise at the station (no signal is visible on the north-south component).

The weakness of the Alhama signal is more evident in the local magnitude, m_L, computed from Wood-Anderson seismograph

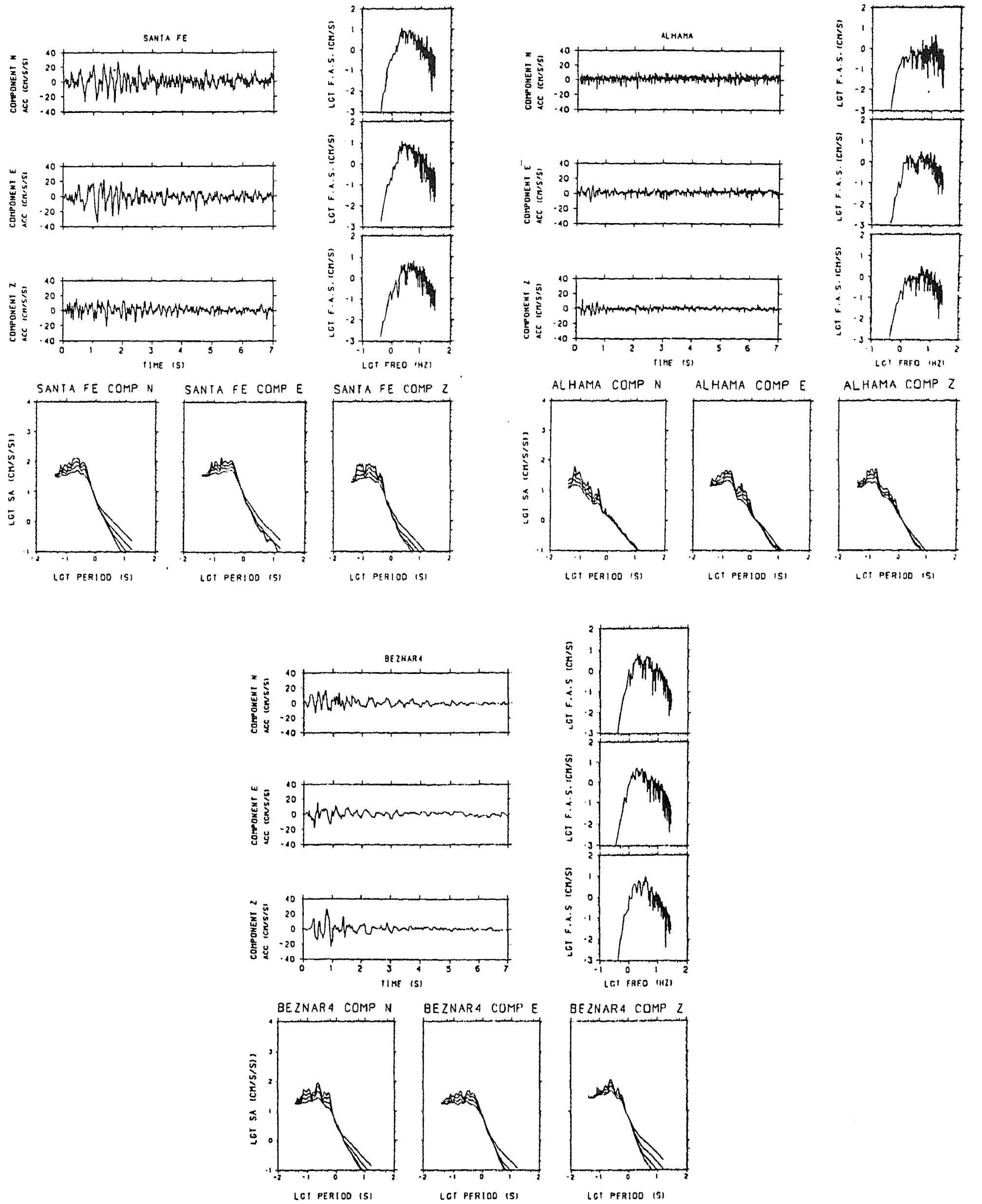


Fig. 5, 6 and 7.- Corrected accelerograms, Fourier Acceleration Spectra and Acceleration Response Spectra (Sa) obtained from Santa Fe, Alhama and Beznar records (Sa computed for damping 2, 5, 10 and 20%).

records, simulated (see fig.8) by a procedure developed by Roca (Ref.4); the values obtained are

Santa Fe	$m_L = 5.6$
Alhama	$m_L = 4.4$
Beznar	$m_L = 4.8$

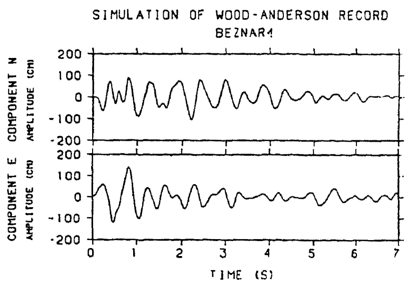


Fig. 8.- Simulated Wood-Anderson records from accelerograms obtained in Beznar.

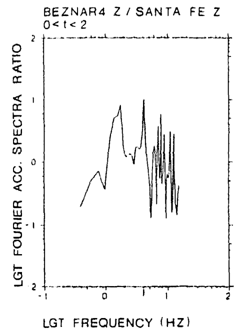


Fig. 9.- Fourier Acceleration spectra ratio Beznar Z/ Santa Fe Z. Only first 2s of records are considered.

As both the Alhama and Béznar sites have very similar soil conditions (a layer of about 100 m of calcarenites) the explanation of this low value of m_L (Alhama) must be searched in the energy distribution at the source; one of the modal planes of the solution given by Buforn et al. (Ref.1) passes very close to Alhama site.

As regards to Santa Fe, the station is located on top of a 200 m thick layer of soft sediments (clay, silt) intercalated by conglomerates, which is underlayed by the calcarenite horizon. Computation of the theoretical response of such soil profile will be made when more accurate information is available, but it is our belief that this is responsible for the observed amplification of ground motion apparent not only in the frequency associated to the maximum acceleration but in the whole range of the signal, as seen in fig.9.

ACKNOWLEDGMENTS

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