

## Seismographs, seismograms and related materials preserved in Catalonia (NE Spain)

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### Abstract

Instrumental seismology in Catalonia (NW of the Iberian Peninsula) starts in 1904 at Observatori de l'Ebre (EBR), followed in 1906 by Observatori Fabra (FBR). Both stations have been operating, almost without interruption, up to now. Different seismographs have been in use in different periods and they have been preserved at diverse degrees up to the present (the Mainka seismographs are still in use at FBR). The original seismographic records have been kept, almost completely, up to the present at both observatories as well as many seismic station operation journals, notes and complementary information for some periods (above all at FBR). In addition, libraries of both observatories keep many old seismic bulletins from other stations, books, manuscript letters and scattered notes and reprints showing the activity of their respective seismic sections. Notice for two more stations (Girona and Olot) now disappeared has been obtained, but up to the present, it has been impossible to obtain any valuable information from these stations. The present article reviews the seismological instrumentation used at these seismic stations, its actual preservation level and the preserved related materials of historical and scientific interest.

**Keywords** *mechanical seismographs – macroseismology – seismic stations*

### Introduction

Two seismic stations have been operating in Catalonia (NE of the Iberian peninsula), up to now, since the beginning of this century. *Observatori de l'Ebre* (1904) near the river Ebre and the town of Tortosa and *Observatori Fabra* (1906), near Barcelona. They are at the origin of instrumental seismology in the western Mediterranean area and the Pyrenees. Up to the Seventies, they have been the only seismic stations in the NE part of the Iberian peninsula. This makes them important regional stations and their records very valuable for the studies of this area. At both places, old seismographs, records and other valuable materials have been preserved.

Two more seismic stations of lower importance were set up in the second decade of this century. They were located in the towns of Girona and Olot. Right now, it is difficult to follow their respective history. Just some references (even some records) about them have been found.

In the following sections, the historic instrumentation of these stations as well as the related materials and its present preservation conditions will be presented. Fig. 1 shows the location of the historic seismic stations in Catalonia.

### Observatori de l'Ebre

Observatori de l'Ebre (EBR;  $40^{\circ} 49.23' \text{ N}$ ,  $0^{\circ} 29.60' \text{ E}$ ) was founded by the Society of Jesus. Since its inauguration in 1904, it has been holding a small building called "Seismic Pavilion" and has been devoted to instrumental seismic recording. As explanatory note, and to avoid some literature confusion, let us say at this point that "Ebre Observatory", "Observatori de l'Ebre" and "Observatorio del Ebro" are three different identifications for the same site. The difference lies in the used language, English, Catalan or Spanish respectively. Even though Ebre observatory was devoted to the study of the Solar and Terrestrial physics, seismographs were installed because at that time it was believed there was a possible relation between seismicity and solar activity. The seismic recording has been maintained up to the present.

Since 1904, the structure of the seismic pavilion has suffered two main reconstructions coincident in time with the main changes of the seismographic equipment. We will call

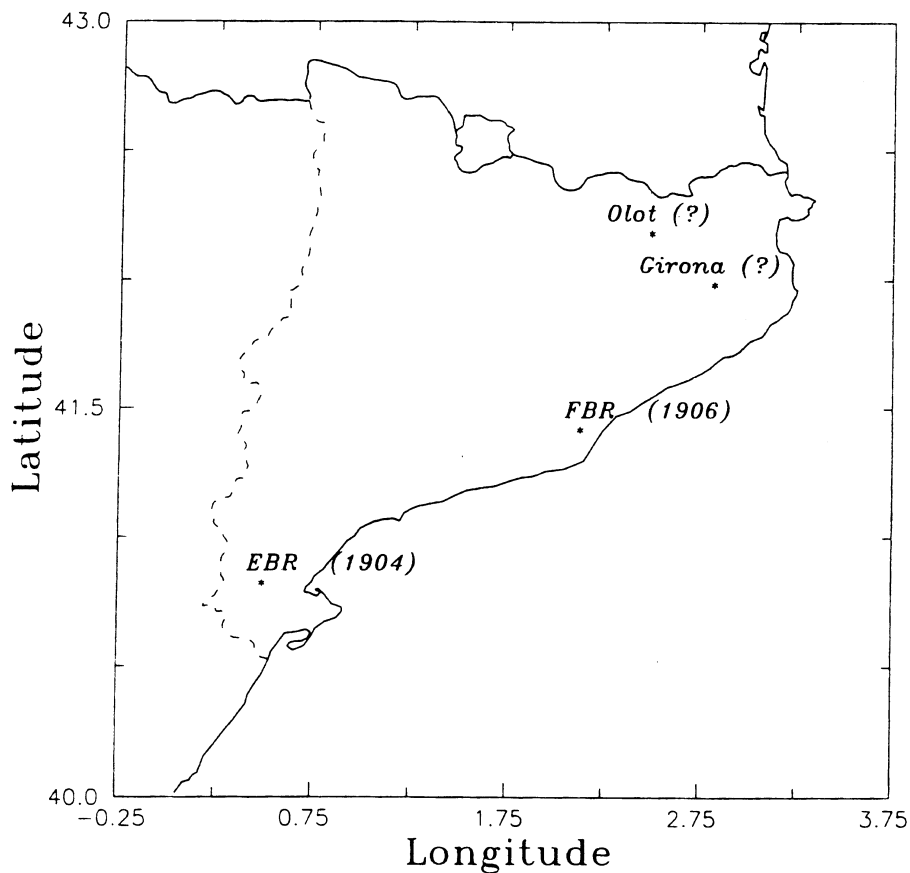


Fig. 1. Map of the north-eastern part of the Iberian peninsula showing the location of Observatori Fabra (Barcelona), Observatori de l'Ebre (Tortosa), and the towns of Girona and Olot.

them epochs. The first epoch last from the inauguration of the observatory in 1904 to 1913. Seismographs used at that time were the Vicentini microseismograph (recording the ground motion in Z, N-S and E-W directions), and the Grablowitz seismograph (called Grablowitz pendulum with NE-SW and NW-SE horizontal components). Both were acquired respectively from Prof. Vicentini, in Padova, and Prof. Grablowitz, in Ischia and the recording was performed on smoked paper. Actually, only several pieces from those seismographs, corresponding mainly to the Vicentini stylus mechanism, are preserved. Grablowitz records, due to the natural period of the instrument and its low magnification, are very useful to obtain information from surface waves of main earthquakes (*e.g.* Giardini *et al.* 1991).

From September to December 1913, the seismographs were stopped and the seismograph hall was totally readapted. This is the beginning of the second epoch. Three new seismographs, with smoked paper recording, were incorporated at that time. A Mainka-type pendulum of 1500 kg recording the N-S ground motion, a second Mainka-type pendulum of 150 kg recording the E-W ground motion and, finally, a zenithal pendulum recording, during 1914 in NE-SW and NW-SE direction, and from May 1915, only in the N-S ground motion direction. The three seismographs were built at the observatory and only the Mainka-N was damped. In 1916 the Vicentini N-S component was stopped and the Grablowitz was stopped in 1918. In 1928 the E-W Vicentini component was stopped, too. Normal operation of the seismographs continued until the Spanish Civil War (1936-39), when it became extremely difficult to maintain it operating in continuity. On 20 July 1938, after the occupation of the Observatory site by the nationalist army, only Mainka N-S and the Vertical Pendulum were still in use, even though there was no time signal. Table 1 summarizes the different seismographs operating at the observatory, some of their main characteristics and the main epochs of the EBR seismic station.

**Table 1. Seismographs and recording periods at Observatori de l'Ebre Seismic Station**

Epoch	Recording period	Seismograph	Component	Mass (kg)	Natural period (s)	Magnification
1904	1904-1918	Grablovitz	NE-SW	12	13	8
	1904-1918	Grablovitz	NW-SE	12	13	8
	1904-1936	Vicentini	Z	50	0.85	150
	1904-1916	Vicentini	N-S	100	2.3	90
1914	1904-1928	Vicentini	E-W	100	2.3	90
1914	1914-1940	Mainka	N-S	1501	14.8	175
	1914-1937	Mainka	E-W	157	7.8	60
	1914-1915	V. Pendulum	NE-SW	316		
	1914-1915	V. Pendulum	NW-SE	316		
	1915-1941	V. Pendulum	N-S	316	2.6	125
		Vicentini	Z			
1941		Vicentini	E-W			
1942	1940-1966	Mainka-Ebro	N-S	1500	15.4	275
	1942-1966	Mainka-Ebro	E-W	1500	10.8	150
1966	1943-1961	V. Pendulum	N-S	635	2.5	230

On 1942, a second reconstruction of the Seismic Pavilion was started. This is the beginning of the third epoch. The new seismographs were held up by a huge concrete column. Two modified Mainka type seismographs of 1500 kg each, recording in the N-S and E-W directions, and a new vertical pendulum (635 kg) recording in the N-S direction were installed. The Mainka's main "modification" with respect to the original system was in the stylus magnification mechanism. Again, the recording was performed on smoked paper and all the seismographs were built at the observatory. This configuration lasted up to 1960 when the vertical pendulum was transformed to record the vertical ground motion. This change was unsuccessful and useful records have never been obtained from this seismograph. Finally, in 1966 the three seismographs were stopped and the "modern seismic record" started at EBR. Fig. 2, taken from the Observatory bulletin, shows the distribution of the Seismic Pavilion in 1910.

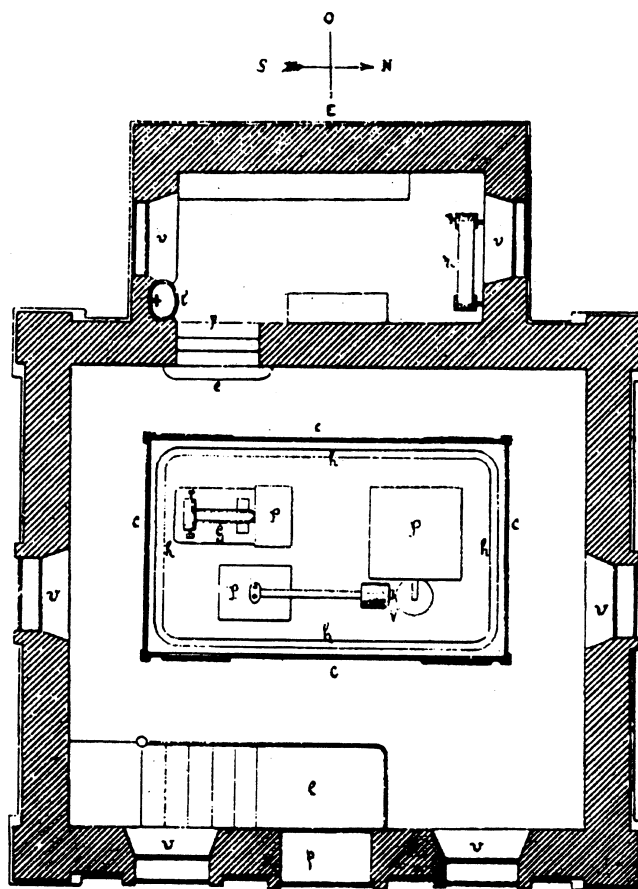


Fig. 2. The seismic pavilion at Observatori de l'Ebre. Distribution from 1904 to 1913. V: Vicentini microseismograph; G: Grablowitz pendulums; P: Pillars (From *Boletín del Observatorio del Ebro*, Vol. 1, no. 1, 1910).

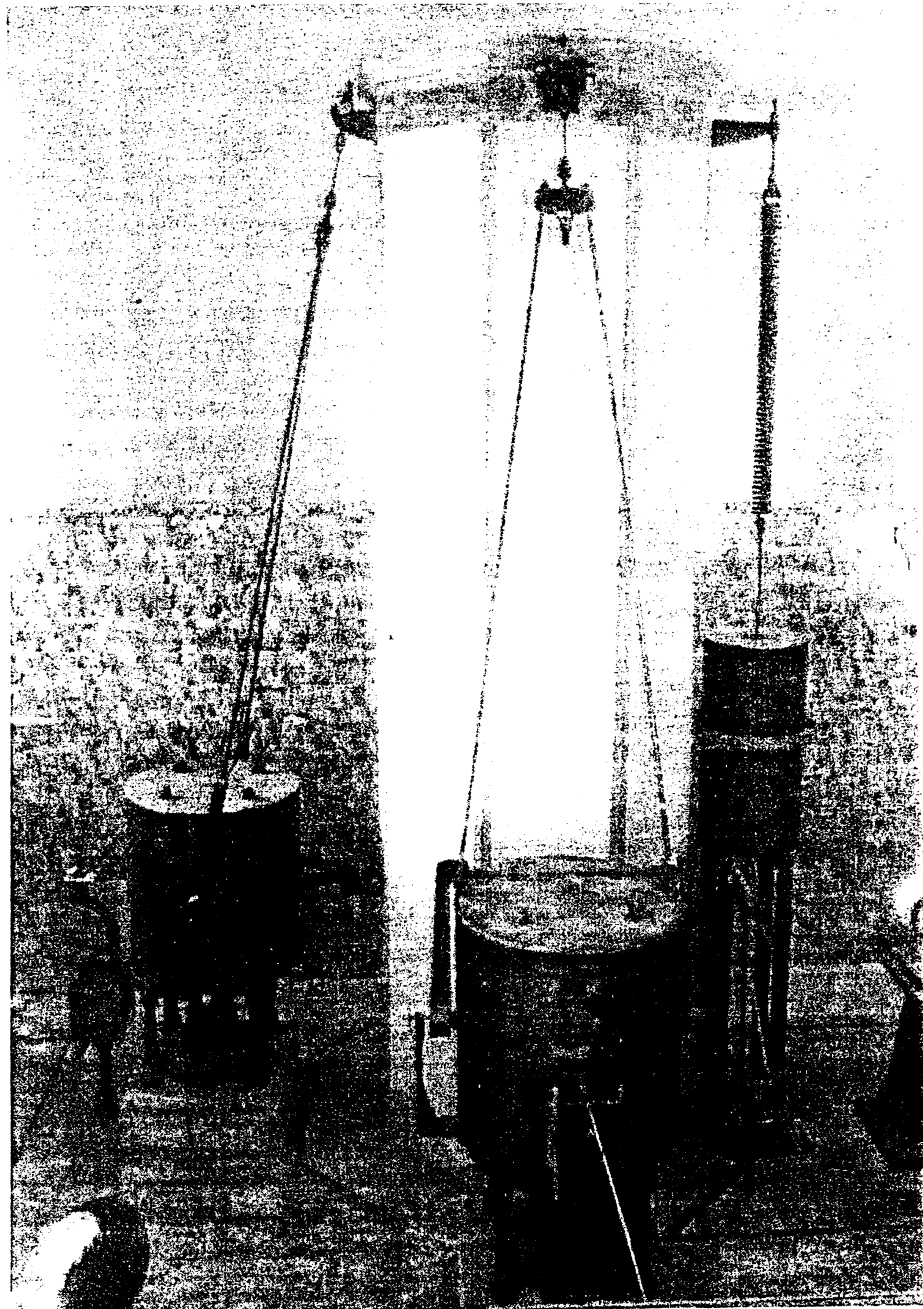


Fig. 3. Observatori de l'Ebre. Photograph of the modified Mainka seismographs (center and left) and the vertical pendulum (right) at present.

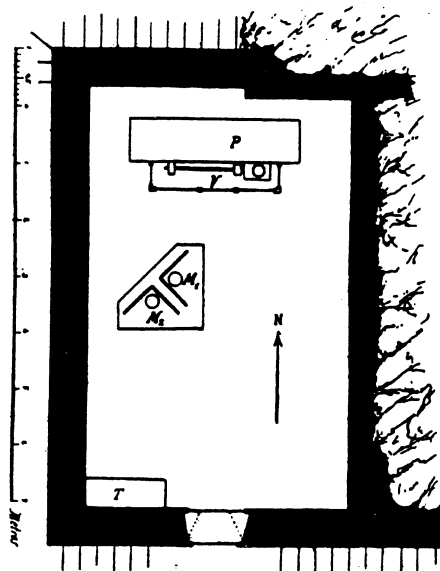


Fig. 4. The seismograph room at Observatori Fabra. Room distribution in 1914 after remodeling. P: Pillar; V: Vicentini microseismograph;  $M_1$  &  $M_2$ : Mainka N-S and Mainka E-W seismographs (From Fontseré 1915).

Fig. 3 shows a picture of the present state of the seismographs of the third epoch.

Original seismographs of all the seismographs operating at EBR have been kept up to the present. During the first years of operation and following the generalized practice at that moment, only records "with earthquake" were kept; but from the early Twenties or earlier, depending on the seismograph type, all the the records were kept.

Printed bulletins for years 1910-1913, 1921-1937 and 1943-1951 were published. From 1952 to 1966 typed provisional bulletins are available. Other scattered documents preserved are handwritten notebooks, log-books, original letters of many seismologists, etc. Also, the Observatory library keeps many old seismic bulletins from other seismic stations, books on seismology and scattered notes and reprints showing the activity of the seismic section.

To ensure their preservation, on December 1995, Instituto Geográfico Nacional (IGN) began the microfilmation of the whole

collection of seismograms and related documents. More information about the Observatori de l'Ebre history and about the seismic section can be found in Batlló and Cardús (1993), Cardús (1983) and Batlló (1995).

### Observatori Fabra

Observatori Fabra (FBR;  $41^{\circ} 24.98' N$ ,  $2^{\circ} 7.50' E$ ) is slightly older than Observatori de l'Ebre, but it started the earthquake record later, in 1906. It was founded by the *Academia de Ciencias de Barcelona* and instead of Observatori de l'Ebre, seismology was a main research line at FBR. From the beginning it was projected to use the seismic record to improve the knowledge of the seismicity of Catalonia.

Architecturally, Observatori Fabra is erected as a unique building. The recording room was placed in the basement of this building, on a rocky outcrop. Relatively to the used seismographs, only two main recording periods can be defined. During the starting years (1906-1913), the operating instruments were the Vicentini microseismograph (Z, N, E), the Cancani microseismometrograph (two components) and Agamennone microseismograph (two components) as well as an electric seismoscope. All of them recorded on smoked paper except Agamennone, that was recorded on ink. In 1911, a thorough reconstruction was made. From that moment Cancani was rebuilt and called conic or horizontal pendulum

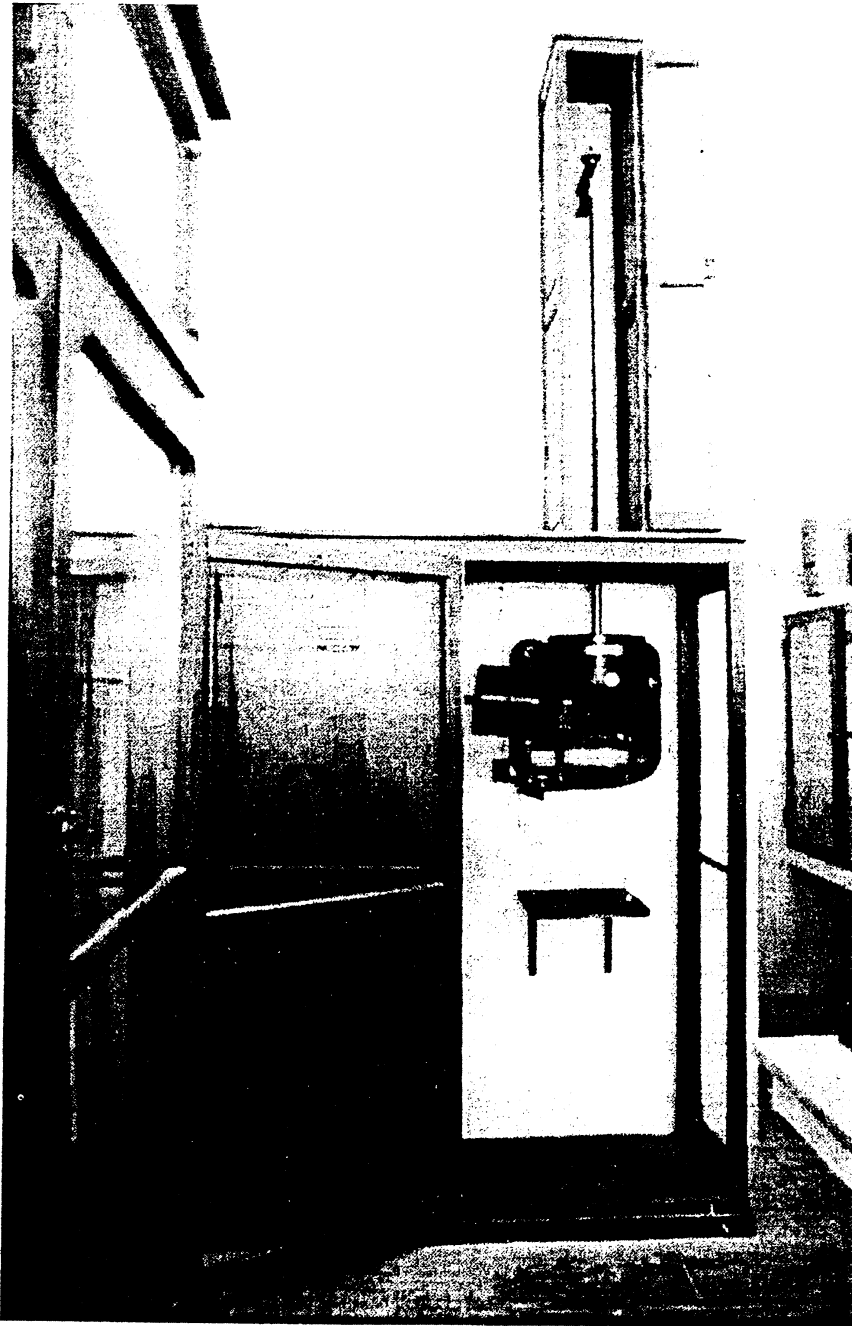


Fig. 5. Observatori Fabra. Photograph of the Vicentini microseismograph at present.

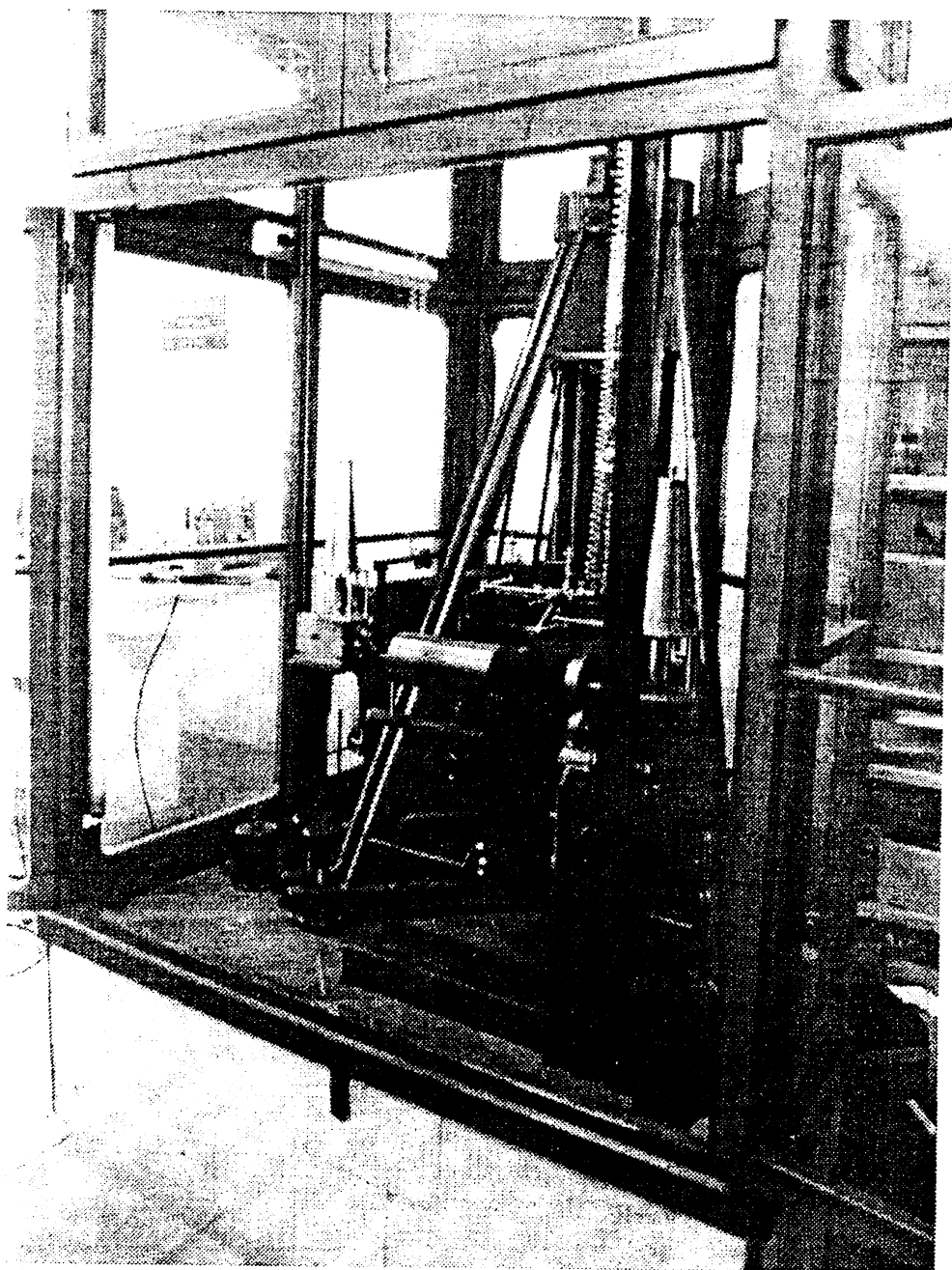


Fig. 6. Observatori Fabra. Photograph of the Mainka seismographs at present.



(it recorded only the N-S component). Agamennone was also rebuilt (reduced also to an unique NE-SW component) and its record changed to smoked paper and Vicentini remained without modification.

After 1914, the second epoch, the seismographs room was kept almost without modification but the equipment was improved. The Vicentini microseismograph was kept and two new Mainka (N-S, E-W, 150 kg each) seismographs were added. All of them (from both epochs) were bought directly from the original constructors. At that time all records were made on smoked paper. Preservation of the seismographs of the second epoch is excellent. Mainka seismographs are still in use and Vicentini has been operating up to the Nineties and is expected to continue its recording. In fact, horizontal components of Vicentini microseismograph been operated discontinuously and since 1915 there is no reference to them in the Observatory printed bulletins. Important parts of the older seismographs and the seismoscope are also preserved. Fig. 4, taken from an old book (Fontseré 1915) shows the seismograph room distribution; Fig. 5 shows the present state of Vicentini microseismograph and Fig. 6 that of Mainka seismographs.

As it has been seen, Fabra history does not show big reconstructions as in EBR. But, from its unique remodelation in 1914, the seismographic record shows even more regular and continuous operation than Ebre observatory. Table 2 summarizes the different seismographs operating at the Fabra observatory, some of their main characteristics and the main epochs of the seismic station.

As in EBR, the original seismograms (especially after 1914) have been almost totally preserved as well as extremely detailed documentation (calibrations, etc.) on the operation of the seismographs (*e.g.* for many years were noted who entered the seismographs hall,

**Table 2. Seismographs and recording periods at the Observatori Fabra Seismic Station**

<i>Epoch</i>	<i>Recording period</i>	<i>Seismograph</i>	<i>Component</i>	<i>Mass</i> (kg)	<i>Natural period</i> (s)	<i>Magnification</i>
1906	1906-1910	Seismoscope				
	1906-1910	Cancani		220		17
	1906-1910	Cancani		220		17
	1906-1910	Agamennone		200		10
	1906-1910	Agamennone		200		10
	1906-1913	Vicentini	Z	50		150
	1906-1913	Vicentini	N-S	100		80
	1906-1913	Vicentini	E-W	100		75
	1911-1913	Cancani	N-S	220	8.6	30
1913	1911-1913	Agamennone	NE-SW	520	4.4	72
1914	1914-	Mainka	N-S	141	≈9	60
	1914-	Mainka	E-W	144	≈9	65
	1914-	Vicentini	Z	56	0.9	125
	1914-	Vicentini	N-S	106	0.9	70
199-	1914-	Vicentini	E-W	106	0.9	77

the time and the purpose of the visit). Since 1914, records are ordered through a correlative numbering. Since 1914, seismic bulletins for FBR have been published. From 1906 to 1914 there are not standard seismic bulletins, but “seismic activity summaries”. Also, good collections of seismic bulletins of other observatories, letters and other information of scientific interest are kept.

Since its foundation, Observatori Fabra has been carrying macroseismic studies of the earthquakes felt in the Catalan region. The director of the seismic section from 1912, J. Fontseré, conceived an interesting experience, not yet studied. He managed to organize “network of seismic observers” called *Red sismológica de la Región Iberopirenaica*. The network was formed by many devotees distributed almost in every village. Normally, the members were people with some scientific interest and with education level of high school graduation or higher (mainly elementary school teachers, local priests, etc.). It was highly tied to a network of meteorological observers also managed by the Fabra Observatory (normally, their members belonged to both networks). They were in charge of the distribution and the collection of the macroseismic questionnaires issued every time an earthquake was felt. Since 1914 the original macroseismic questionnaires collected after every felt earthquake in this region have been analyzed and stored in the Observatory file. The importance of this collection for the revision of macroseismic effects is clear (Susagna *et al.* 1996).

#### **Girona and Olot seismic stations**

Information for two more stations (Girona and Olot) now closed has been obtained, but up to the present, it has been impossible to obtain any scientifically valuable information from these stations. Both were located in a “more seismic zone” than EBR or FBR and in some way they were connected with or related to Fabra Observatory.

A seismograph has been operating in the town of Girona (41° 59.03' N, 2° 49.27' E) and another at Olot (42° 10.98' N, 2° 29.35' E). We do not know when they were installed exactly. The main reference source for both stations are the *Memorias de la Real Academia de Ciencias de Barcelona* (MRACB).

Even if we do not know when the Girona seismograph was installed, it is clear that its installation is posterior to that of the Fabra Observatory. A record of the Girona seismograph is mentioned for the first time with reference to the felt earthquake of 6 April 1909 (Comas Solà 1909). The latter quotation corresponds to a macroseismic questionnaire (in FBR) for the 1919-11-29 earthquake. Later, Vol. 21 of *Enciclopedia Universal Ilustrada* (Ed. Espasa, Barcelona), pp. 67-68, written in 1923, states that this seismograph was still in operation.

An interesting comment is published in a newspaper (*El Noticiero Universal*, edited in Barcelona) on 6 September 1972. In occasion of a felt earthquake in Girona it states that the seismograph was “carefully kept in a box”. Searching the truth of this assertion it was confirmed (J. Miró, director of the Girona History Museum; personal communication) that an “old seismograph” was kept at that time. But it has been lost since that time. It was located at the *Instituto General y Técnico*. It is referred as seismoscope (Comas Solà 1909 and Vicentini seismoscope (Comas Solà 1913) and since that moment as seismograph.

(Comas Solà 1913) and, later, as Mainka pendulum (Fontseré 1918). In addition, some copies of original records of this seismograph are preserved at FBR, all of them on smoked paper. Probably the timing system was not accurate. This is inferred from the fact that we have never found any reference to arrival time, but always to the S-P time.

Information about Olot seismograph are more scarce than those from Girona. MRACB is also the main reference. It was installed at the Museum building of that town and only three references have been found. It recorded the earthquake of 24 July 1911 (Comas Solà 1912). Its record is also mentioned in a macroseismic questionnaire of December 1921. Finally, the same *Enciclopedia Espasa* referred to it in 1923. The instrument type is referred to only in 1911 (Comas Solà 1912) as seismoscope.

### Conclusions

A review of the present preservation conditions of the seismological heritage in Catalonia has been done. Instrumentation characteristics and activity is well known (in general lines) for the FBR and EBR stations; but further research should be done for the Girona and Olot stations. Some minor differences in instrument characteristics and operational periods are observed between the results presented in this article and previous ones (López Arroyo *et al.* 1990). Data presented in this article have been checked through the station bulletins and, if necessary, looking at the instrument records. In this sense they may be considered as more accurate.

Seismogram collections for EBR and FBR are well preserved and classified, as well as complementary documentation as seismic bulletins, log-books, notebooks, etc. Almost everything is lost or not found for the Girona and Olot stations. Classification and study of other documents as letters, handworks, etc. should be improved. Materials preserved at EBR and FBR are well known and used from a seismological point of view, but more should be done from a historiographical approach. Also, biographical knowledge of the earlier Catalan seismologists is really poor (with the exception of E. Fontseré).

It has been pointed out that the *Red sismológica de la Región Iberopirenaica* is, from the historical point of view, an unknown and interesting theme for its uniqueness. The main result of their activity (the macroseismic questionnaires) has been reviewed throughout for macroseismic studies purpose; but not in a historiographic sense.

### References

- Batló J. 1995, L'Observatori de l'Ebre, *Revista de Física*, no. 8, 41-46 [in Catalan].
- Batló J. and Cardús J.O. 1993, Historic seismograms and materials preserved at the seismic station of the "Observatori de l'Ebre", in *Activity Report 1990 – 1992 and Proceedings. XXIII General Assembly of the European Seismological Commission, Prague, Czechoslovakia, 7-12 September 1992*, vol. 1, Praha, pp. 232-235.
- Cardús J.O. 1983, El Observatorio del Ebro, in J.O. Cardús (ed.), *Contribuciones científicas para conmemorar el 75 aniversario del Observatorio del Ebro*, Memoria no. 14, Publicaciones del Observatorio del Ebro, Roquetes (Tarragona), pp. 9-23 [in Spanish].

- Comas Solà J. 1909, Nota sobre el terremoto Olotino del 6 de Abril de 1909 y el terremoto peninsular del 29 de Abril de 1909, *Memorias de la Real Academia de Ciencias y Artes de Barcelona* 8, 75-84 [in Spanish].
- Comas Solà J. 1912, Estadística Sismológica de 1911, *Memorias de la Real Academia de Ciencias y Artes de Barcelona* 10, 231-249 [in Spanish].
- Comas Solà J. 1913, Resumen Sismico de 1912 y de 1913, *Memorias de la Real Academia de Ciencias y Artes de Barcelona* 10, 553-569 [in Spanish].
- Fontserè E. 1915, La estación sismica del Observatorio Fabra, *Memorias de la Real Academia de Ciencias y Artes de Barcelona* 12, 107-117 [in Spanish].
- Fontserè E. 1918, Terremotos observados en la región Iberopirenaica desde Junio a Octubre de 1917, *Memorias de la Real Academia de Ciencias y Artes de Barcelona* 13, 407-423 [in Spanish].
- Fontserè E. and Iglésies J. 1971, *Recopilació de dades sísmiques de les terres catalanes entre 1100 i 1906*, Fundació Salvador Vives Casajuana, Barcelona, 547 pp.
- Giardini D., Beranzoli L., Boschi E. and Fregonese L. 1991, Waveform analysis of the December 28th, 1908 earthquake in the Messina Strait (Southern Italy), *Eos* 72, no. 17, 189 (abstract).
- López Arroyo A., Cruz J., Roca A. and Olivera C. 1990, Early seismographic instruments in Spain, in G. Ferrari (Ed.), *Gli strumenti sismici storici: Italia e contesto europeo. Historical seismic instruments: Italy and the European framework*, ING-SGA, Bologna, pp. 161-164 (in Italian with abstracts in English).
- Susagna M.T., Goula X. and Roca A. 1996, Conception of a macroseismic catalogue for Catalonia (Spain), *Annali di Geofisica* 39, 1049-1054.