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Seismicity in France / *Sismicité en France*

The historical seismogram collection in Strasbourg

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Abstract. We present a complete inventory of the historical Strasbourg seismograms housed at the École et Observatoire des Sciences de la Terre (EOST), University of Strasbourg, France. Although published seismological records date back to 1892, the Strasbourg seismological station was officially created in 1900, with a structure specifically built for seismological monitoring. The presence of highly motivated and active scientists from the outset, along with the unique geographic and political situation of Strasbourg in the late 19th and early 20th centuries, made the city a central point for seismological research and international exchanges. A wide variety of seismographs were operated at the station throughout the 20th century. More than 130,000 records from Wiechert, Mainka, Galitzin, Peterschmitt, 19-ton pendulum, Nikiforov, and Press–Ewing instruments are preserved within the seismogram collection, with most being the original records. However, for the pre-1930 seismogram records we only have microfilm copies. We also present an inventory of the instrumental constants found in the preserved station books along with the corresponding instrumental responses.

Keywords. Strasbourg, Historical earthquakes, Seismometers, Wiechert, Galitzin, Mainka, Nikiforov.

Online first, 23rd November 2021

1. Introduction

Strasbourg is located in a region of moderate seismicity in northeastern France. The largest known earthquake in the region occurred near Basel ($M \sim 6.5$, Meghraoui et al. [2001], $\Delta \sim 115$ km) over 600 years ago, and the largest felt earthquake since 1900 is the 16 December 1911 Swabian Jura ($M_s \sim 6.2$, $\Delta \sim 104$ km) earthquake [Gutenberg, 1915]. This regular, but moderate, seismic activity does not seem sufficient to explain the vigorous involvement of Strasbourg in seismology in the early 20th century.

After the Franco-Prussian war (1870–1871), Alsace and its capital Strasbourg were annexed to the newly

created German Empire. The German University created in 1872 in Strasbourg attracted many renowned scholars and young students from neighboring German regions. The strategic location of the city, its political role, and the presence of dedicated and motivated individuals who made sound decisions and undertook strategic initiatives at the right time have cemented Strasbourg's role in the early development of seismology.

Strasbourg was a national and international center for seismological data and scientific exchanges during times of both German and French control¹.

¹Alsace was a German territory between 1870 and 1918 and during World War II.

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A wide range of seismological instruments were operated at the Strasbourg seismological station, and the corresponding records now constitute a large body of seismological data. Here we present an inventory of these historical records, and invite the Earth Sciences community to take advantage of this legacy dataset.

Although several publications testify that a large number of seismological stations were operating during the first two decades of the 20th century [e.g. Szirtes, 1911, Rudolph and Tams, 1907, Reid, 1910, Wood, 1921], there are few well-preserved records from that time for a given event; this situation is worsening as time passes. It is therefore urgent to take the necessary measures to protect the seismological records that have survived [Okal, 2015]. Several initiatives in that sense have emerged in recent years [e.g. Paulescu *et al.*, 2016, Bent *et al.*, 2020, Wang, 2020, Murotani *et al.*, 2020, Hwang *et al.*, 2020, Satake *et al.*, 2020]. The inventory presented here is a step in that direction.

2. Historical sketch

2.1. Before World War I

The earliest known seismograms from Strasbourg were published by von Rebeur-Paschwitz [1892] and von Rebeur-Paschwitz [1895]. These are photographic records obtained during the period 1892–1895 using a Rebeur-Paschwitz horizontal pendulum [Fréchet and Rivera, 2012] that operated in the basement of the Astronomical Observatory, and was initially installed to track variations in the plumb line [Ehlert, 1896]. This instrument can be viewed at the Museum of Seismology of the University of Strasbourg (<http://musee-sismologie.unistra.fr>). This instrument, previously installed at Wilhelmshaven, along with another similar instrument in Potsdam, recorded a Japanese earthquake on 18 April 1889 [von Rebeur-Paschwitz, 1889]. These seismograms are considered the first-ever teleseismic records. A new instrument, a Rebeur-Ehlert triple horizontal pendulum, was also installed in the Astronomical Observatory during the period 1895–1900 for both astronomical and seismological purposes [e.g. Ehlert, 1896, 1900, Rudolph, 1901]. This instrument is made of three horizontal pendulums that are mounted on a single rigid platform and oriented at 120° to each other, with each pendulum essentially reproducing

the mechanism of the Rebeur-Paschwitz instrument. The Rebeur-Ehlert instrument was manufactured by J. & A. Bosch Company in Strasbourg, who would soon produce their own seismological instruments, the Bosch-Mainka and Bosch-Omori seismometers [Bosch and Bosch, 1901].

Georg Gerland, director of the Geography Seminars of the Kaiser Wilhelms Universität in Strasbourg, and his colleagues were working to promote the development of seismology in Strasbourg [Gerland, 1884] around the same time. Their efforts led to the creation of the Central Imperial Seismological Station in March 1899, which became operational in 1900 [Gerland, 1900, Schweitzer, 2003] in a specially designed building on the university campus, next to the botanical garden and not far from the Astronomical Observatory [Jaehnik, 1900]. A second Rebeur-Ehlert pendulum was installed in the new station in May 1900, it operated unmodified during the subsequent years. The original Rebeur-Ehlert instrument was relocated from the observatory to the station by November 1900, it was modified several times with damping devices and higher recording speeds. A three-component Vicentini instrument and a Milne pendulum were installed at about the same time [Weigand, 1904]. An Omori instrument was lent by the Japanese government [de Kövesligethy, 1906, Weigand and Gerland, 1901] and installed by Professor Omori himself in May 1901, who was in Strasbourg from early April for attending the First International Seismological Conference [Rudolph, 1902]. The instrument operated for seven years until it was returned to Japan upon Omori's request. The details of the operations during these early years can be found in the annual meeting reports of the directors of German seismological stations [e.g. Gerland, 1901, Weigand and Gerland, 1901, Weigand, 1904, 1905, Gerland, 1906].

The arrival-time readings and amplitudes of the main phases that were picked from the Rebeur-Ehlert, Vicentini, Milne, and Omori records started to be published in July 1900 as part of a monthly report: *Monatsbericht der Kaiserlichen Hauptstation für Erdbebenforschung zu Strassburg i/E*. This publication also included readings from a growing list of other German and global seismological stations. These remarkable advances reflected the increasing interest in seismology, as seismological stations were being constructed around the world at the turn of the

century (e.g. Göttingen, Potsdam, Kew, Perth, Toronto, Pavia, Cartuja, Uccle, Jena, Tokyo, Firenze, Zikawei). This international effort was formalized in 1904 via the creation of the International Seismological Association (ISA), with its Central Bureau located in Strasbourg (see Section 2.3).

Unfortunately, the original Strasbourg seismograms from these early years have not been preserved. The oldest records are microfilm copies of the 1903 seismograms for the 1000 kg astatic horizontal Wiechert pendulum that operated from 1903 to 1968 (with minor interruptions during World Wars I and II). The Milne instrument was moved to a different room to accommodate the installation of the Wiechert pendulum, and a reinforced concrete pier was constructed, directly coupled to the ground at 1.4 m depth and isolated from the building structure [Weigand, 1905]. A Schmidt trifilar gravimeter [Schmidt, 1900] was also installed in 1903, and contributed to the phase readings in the following years. The preserved station books for these early years (1905–1916) are signed by A. Sieberg (1906–1909), C. Mainka (1906–1914), and B. Gutenberg (1915–1916).

Rudolph and Tams [1907] state that the Wiechert (horizontal components), Rebeur-Ehlert, Vicentini (three components), Schmidt, horizontal Bosch pendulum, and Milne instruments recorded the 1906 Valparaiso and Rat Island earthquakes, but only reproduced the records from the Rebeur-Ehlert, Vicentini and Schmidt instruments. The Carnegie Institution report on the 1906 San Francisco earthquake [Reid, 1910] also mentions an Omori record, but the companion atlas only included the E–W record of a Rebeur-Ehlert horizontal pendulum. The Vicentini instrument is last mentioned in the station books in 1906. However, the instrument (without its recording system) still resides at its original location in the Strasbourg seismological station.

The installation of the first horizontal pendulums built at J. & A. Bosch also occurred around this time [Kintz, 1984]. J. & A. Bosch manufactured a wide range of optical and mechanical instruments, including the Rebeur-Ehlert triple pendulum. They had constructed a conical pendulum in their workshop (*Strasbourg Pendulum*) by 1902 [Stöck, 1903], and were given permission to install one at the seismological station in 1903 [Weigand, 1904], followed by a long list of various models (different masses and damping systems: air, oil, and magnetic), including

those designed by C. Mainka. J. & A. Bosch produced diverse instruments for the German army during World War I [Kintz, 1984]. At the end of the war the company was dissolved and the Société d'Optique et de Mécanique de Haute Précision (SOM) was subsequently charged with production of the Mainka pendulums [Rothé and Labrouste, 1927].

The Vicentini instrument was the only vertical-component seismometer operating at the Strasbourg seismological station during these early years. Some vertical-component Wiechert records (microfilm) are available for a few months during the period 1907–1908. These are from an instrument that was sent to Disko (Greenland) in 1908 [Gerland, 1909]. That instrument returned to Strasbourg in 1910 [Hecker *et al.*, 1912] and was installed next to the horizontal Wiechert instrument, where it operated until 1968. Today, it still resides on the same pier at Strasbourg seismological station.

There was a clear focus on the study of various instruments and a comparison of their records during the first decade of operations at Strasbourg seismological station [de Kövesligethy, 1906, p. 193]. A large variety of seismometers operated at the station on either a routine basis or for limited periods. C. Mainka designed a shaking table for testing purposes [Mainka, 1909, Rothé and Rémy, 1927], thereby providing a remarkable complement to the seismic observations. G. Gerland retired in 1910 and O. Hecker, previously in Potsdam, was appointed as the new director of the station and the Central Bureau.

Although the Galitzin instruments (three components) are mentioned in the station books as early as 1912, we only have a few seismograms (microfilm) from 1914. These instruments were out of service during World War I, and were back in operation only in 1921 [IPGS, 1920]. On the contrary, from the preserved records (microfilm), we conclude that the Wiechert instruments operated almost continuously during World War I.

2.2. *After World War I*

The years between the two wars were marked by the installation of the 19-ton pendulum (19T). The need for a very-high-sensitivity short-period instrument was recognized very early at Strasbourg, as it would provide the ability to properly record and analyze the regional and local seismicity (e.g. Vosges, Alps, Jura,

Black Forest, Rhine Graben). The installation had begun before World War I (steel beams and a cylindrical container were found in one of the station rooms after the armistice [Rothé and Lacoste, 1927]), and it was resumed in May 1924. The Strasbourg seismological station received a visit from Dutch physicist H. P. Berlage from July to November 1924. He had just defended a PhD in Zurich on the De Quervain–Piccard seismograph, and he assisted in designing the plan of the instrument and filling the cylindrical container [Rothé and Lacoste, 1927, IPGS, 1925]. The 19T pendulum was successfully installed in March 1925, and was routinely reported in the seismological bulletin from 1926 [IPGS, 1926]. It is a simple pendulum that is sensitive to horizontal acceleration. Composed of a large cylindrical container that is filled with 19 tons of random pieces of weapons, military materials, and sand, the 19T pendulum is suspended by four parallel rods, with each fixed to the ceiling by a helical spring. The purpose of these springs was to allow for the recording of the vertical component. However, only the two horizontal components were initially recorded due to a lack of funds. The installation of the recording system for the vertical component was postponed until 1927 [Bois, 1933]. The amplification of the movement for each component is achieved by three successive lever arms, with a net magnification of about 1000 for all of the components (see Figure 3). The vertical component never worked properly, but some seismograms have been preserved. The recording system for the vertical component was removed in 1946 [Cara *et al.*, 1987]. The 19T pendulum was one of three large pendulums that were operating in the region for regional seismicity studies. The other two pendulums were in Göttingen (17T, installed in 1904, two horizontal components; Wiechert [1906]) and Zurich (20T, installed in 1923, one vertical and two horizontal components; de Quervain [1927]).

Two Mainka-type seismographs (450 kg) manufactured by the SOM were installed in 1923 to replace the Bosch–Mainka instrument [Rothé and Labrouste, 1927]. They were dismantled in December 1924 to accommodate the installation of the 19T pendulum. However, it is unclear as to when they were installed again because they are not routinely reported in the seismological bulletins. They are mentioned a few times in the 1926 and 1928 bulletins, and in the 1932 and 1933 station books. However, few records have been preserved, with most between 1919 and 1924,

and some later records between May 1938 and May 1939. This later period corresponds to a mention in the station books of dismantlement, repair, and reinstallation of the Mainka instruments. The lack of preserved records prevents us from knowing their precise operating period. One of these instruments is currently on display in the seismological museum.

The Mainka shaking table was a simple instrument capable of generating a single sinusoidal motion. Rothé and Rémy [1927] developed a more sophisticated model that was capable of superposing four sinusoidal components with different periods, amplitudes, and phases. This table was used in particular to calibrate a Milne–Shaw instrument that was purchased in 1923 [Rothé and Lacoste, 1924], followed by a visit by J. J. Shaw in 1924 [IPGS, 1924, 1925]. The Milne–Shaw instrument [Shaw, 1927] operated between 1924 and 1931, but no records have been preserved. Similarly, a Wood–Anderson seismograph was installed in 1931 (noted in the station books). The instrument has been preserved but we have no seismograms and no details on the precise operating time period.

One problem with the vertical Galitzin seismograph was that it drifted due to the effects of temperature changes on the elasticity of its steel helical spring, thereby requiring frequent adjustments. This problem was addressed in 1927 by replacing the steel spring with an elinvar spring after a detailed study of its performance [Dammann, 1927, station book]. The vertical Galitzin instrument showed remarkable stability after this replacement [Bois, 1933]. A similar study and replacement were performed at Kew observatory in 1928 [Scrase, 1929]. The free period of the horizontal Galitzin instruments (seismometer and galvanometer), which was initially 11–12 s, was switched a few times between 11 and 22 s in 1933. It was finally set to 22 s on 30 October 1933 for both horizontal components.

Due to World War II the University of Strasbourg was evacuated to Clermont–Ferrand from September 1939 to August 1945, and the Institut de Physique du Globe and the Bureau Central Sismologique (see Section 2.3) were no exception [IPGS, 1949, 1950]. A few people stayed in Strasbourg to maintain the station operations as much as possible. The Galitzin instruments were dismantled in 1939 and transported to Clermont–Ferrand. Some time later, they were moved by the Germans to Göttingen and they

eventually returned to Strasbourg at the end of the war. As a result, they did not operate during the whole wartime. Only the mechanical seismographs (the Wiechert instruments and the two horizontal components of the 19T) were kept in operation. Recording was only interrupted from September to November 1939, June to October 1940, and August 1941 to March 1942 [IPGS, 1948]. In November 1943 the Russian seismologist A. Polumb moved from Yalta to Strasbourg, under the supervision of the Germans. He worked in the Strasbourg seismic station until 1955. Polumb was the former head of the seismic station in Yalta, he brought with him a set of two horizontal Nikiforov seismographs. They operated until June 1948 and had to be returned to the USSR soon after. The Nikiforov seismometer is a horizontal short-period (2 s) instrument that was developed in the USSR in the early 1920s; very little is known of this instrument outside of the former USSR countries. It equipped most of the regional stations in the Soviet territories until 1949 [Savarenski and Kirnos, 1955]. Their mechanism is close to that of the Wood–Anderson seismometer: torsion spring, electromagnetic damping, and optical registration. A quite complete collection of the original records has been preserved in Strasbourg.

Although the vertical component of the 19T pendulum operated between 1927 and 1940, it never really worked satisfactorily. This was a problem, as it was the only vertical short-period instrument in Strasbourg, making it a critical instrument for studying regional seismicity. To overcome this problem, E. Peterschmitt designed a specific instrument [Peterschmitt, 1951] that is referred to as the CPP seismometer. This instrument consists of a vertical short-period pendulum coupled with a galvanometer (with periods $T_s \sim T_g \sim 1$ s). A specific feature of the CPP seismometer is the inclusion of its own mechanical calibration system. It operated continuously from June 1948 to December 1975, yielding a remarkably complete seismogram collection. A matched set of three Press–Ewing seismometers operated in Strasbourg from 1963 to 1981. They have natural periods of $T_s \sim 30$ s and $T_g \sim 90$ s, similar to the natural periods of the World-Wide Standardized Seismograph Network (WWSSN) LP systems [Peterson and Hutt, 2014].

The mechanical recordings on smoked paper ceased in June 1968 due to the health risks associated

with the preparation of the smoked paper; only the Galitzin, CPP, and Press–Ewing instruments remained in operation after this decision. It was also decided to bring back the horizontal Galitzin instruments to their “shorter” period version ($T_s \sim T_g \sim 10$ s), and to reduce their gain by a factor of 10. The Galitzin and Press–Ewing sets were complementary in this new frequency band.

The horizontal component (E–W) of the 19T pendulum was modified in 1970 by installing a velocity transducer and replacing the smoked-paper recording with ink recording, as there were no remaining short-period horizontal-component instruments. On 6 May 1976, this instrument was damaged by the Friuli earthquake ($Mw = 6.5$, $\Delta = 478$ km). But the recording had already been interrupted in December 1975, when station operation was almost completely stopped due to increasing anthropogenic noise from traffic and town activities. The Press–Ewing seismometers remained in operation until June 1981 with ink recording. All of the operations at Strasbourg seismological station ceased at this point². An international workshop was held in September 1992 to celebrate one hundred years of the first seismological record in Strasbourg, and the creation of a seismological museum in the building of the historical seismological station (<http://musee-sismologie.unistra.fr>).

2.3. *International seismological association*

The second international conference on seismology took place in Strasbourg during July 1903 [Rudolph, 1904]. In addition to the presentation and discussion of scientific results, the question of the creation of an *International Seismological Association* (ISA), which had already been suggested during the first conference [Rudolph, 1902], was discussed extensively. These discussions led to the official creation of the ISA on 1 April 1904. The original convention that created the ISA was initially valid for 12 years (Article 16 of the convention) [Rudolph, 1904, Gerland, 1905]. The Central Bureau of the ISA was attached to the Central Station in Strasbourg under a common director (G. Gerland; later succeeded by O. Hecker).

²In 1986, the 19T instrument was repaired and modified by installing displacement transducers and a digital recording system [Cara *et al.*, 1987]. This setting is still in operation.

The Central Bureau was in charge of the collection, processing, editing, and dissemination of microseismic and macroseismic observations [Schweitzer, 2003].

Global seismic activity during 1906 was exceptionally intense, including the Colombia–Ecuador (31 January, M8.6), Rat Island and Valparaiso (17 August, M8.3 and M8.2, respectively), New Guinea (14 September, M8.0), San Francisco (18 April, M7.9), and Xinjiang (22 December, M7.8) earthquakes. During the first meeting of the Permanent Commission of ISA (Rome, October 1906) the idea arose of preparing a significant publication dedicated to one of these large events (H. F. Reid was present among several other participants). The San Francisco earthquake was quickly discarded and an explicit recommendation was adopted supporting the idea that all the San Francisco earthquake records should be published by the “Earthquake Investigation Committee” [Reid, 1910]. The decision was then made for ISA to focus on the Rat Island and Valparaiso earthquakes that occurred only 30 minutes apart from each other, and to prepare a special publication [de Kövesligethy, 1906]. Noteworthy results were published, as well as an impressive collection of over 200 nicely reproduced and well-documented seismograms from 78 global seismological stations [Rudolph and Tams, 1907, Okal, 2005].

In addition to the routine work of preparing the annual microseismic and macroseismic catalogues, the period 1911–1914 was marked by the occurrence of the Swabian Jura earthquake (16 November 1911, $M_s \sim 6.2$) and its largest aftershock (20 July 1913). An exceptional amount of macroseismic data was collected (8600 localities from France, Germany, Switzerland, Austria, Italy, and Belgium) and analyzed [Lais and Sieberg, 1912]. A collection of 250 seismograms from 68 seismological stations were also reproduced and analyzed to prepare a special publication [Gutenberg, 1915]. The work done on the 1906 Colombia–Ecuador earthquake was published in 1911 [Rudolph and Szirtes, 1911a,b]. C. Mainka also tested many instruments on his shaking table during this period before sending them to various international seismological stations (e.g. Argentina, Canada, Chile, Austria, Switzerland, Brazil, England, Iceland) [de Kövesligethy, 1922].

The 12-year lifetime of the convention that created the ISA was approaching, and it was time to

discuss the future of the ISA. A general assembly was scheduled to be held in St. Petersburg at the end of August 1914 [de Kövesligethy, 1922], but the volatility of global geopolitics changed everything. World War I was declared one month before the meeting, resulting in the meeting being canceled, and global seismological efforts were disrupted for the next four years. Both the Strasbourg seismological station and Central Bureau were strongly impacted by the war, but the work efforts at both institutions continued. Some researchers were called to contribute to the war effort. For example, A. Sieberg and B. Gutenberg had to alternate between their seismological work in Strasbourg and their war duties [Schweitzer, 2003, de Kövesligethy, 1922, annexe VI, p41]. Strasbourg was returned to France at the end of the war, which meant the German researchers had to leave the city [Schweitzer, 2003].

E. Rothé was entrusted to run the current affairs of the ISA and prepare its (overdue) dissolution, which occurred during its last meeting on 24–25 April 1922. The Seismology Section of the International Union of Geodesy and Geophysics (IUGG) was officially created one week later [Rothé, 1922, 1981]. The decision was made to keep the Central Bureau of the Seismology Section in Strasbourg, with an additional task consisting of the rapid compilation of seismological observations using telegraphic and radiotelegraphic transmissions with a specific code. It was also decided to maintain in Oxford the work on the bulletin in continuity of Milne’s effort published under the name *International Seismological Summary* (ISS). A French Bureau, the Bureau Central Sismologique Français (BCSF), was created in 1921. The BCSF was attached to the new Institut de Physique du Globe de Strasbourg (IPGS), and was tasked with collecting microseismic and macroseismic information on French seismicity [JORF du 4 août, 1921].

3. Seismogram collection

3.1. Strasbourg seismological station

The present status of the collection for the Strasbourg seismological station spans the period from 1903 (Horizontal Wiechert) to 1981 (Press–Ewing seismograph). It contains seismograms from Wiechert, Mainka, 19T, Galitzin, CPP, Nikiforov, and Press–Ewing seismographs. The start and end times, and

Table 1. Available records for the various instruments

Instrument	Comp.	Start	End	Number of Seismograms		
				Microfilm	Original record	Total
Wiechert	E	June 1903	June 1968	9918	1905	11,823
Wiechert	N	June 1903	June 1968	9925	1904	11,829
Wiechert	Z	December 1907	June 1968	7064	1846	8910
Galitzin	E	January 1914	December 1975	2027	15,995	18,022
Galitzin	N	February 1914	December 1975	2021	16,007	18,028
Galitzin	Z	February 1914	December 1975	2120	15,296	17,416
Mainka	E	January 1920	May 1939	0	954	954
Mainka	N	March 1915	May 1939	0	1142	1142
19T	E	January 1926	June 1968	1978	4308	6286
19T	N	January 1926	June 1968	2313	2841	5154
19T	Z	September 1927	November 1940	2273	57	2330
Nikiforov	E	February 1944	June 1948	0	1498	1498
Nikiforov	N	February 1944	June 1948	0	1494	1494
Peterschmitt	Z	June 1948	December 1975	0	10,993	10,993
Press–Ewing	E	May 1963	June 1981	0	5831	5831
Press–Ewing	N	May 1963	June 1981	0	5869	5869
Press–Ewing	Z	May 1963	June 1981	0	5880	5880
Total				39,639	93,820	133,459

number of corresponding seismograms for each instrument are given in Table 1.

The seismogram collection for each instrument and component is shown in Figures 1a–1d. Each panel represents a 10-year period, and the colors indicate the recording media: microfilm (blue), smoked paper (gray), photographic paper (orange), and ink (green). The non-colored regions indicate periods for which no corresponding seismograms are available. Some of the most valuable information in the station books is the instrument calibration information; the small red dots on the figure indicate when a set of instrumental constants was reported in the station books.

A portion of the seismogram collection (1903–1933) was copied to microfilm in 1967, with very few of the originals preserved as a result. The 16-mm rolls are preserved, but they have deteriorated and the image quality is irregular. In addition, the 19T and Wiechert collection was strongly decimated, with only about 15% of the records being preserved. The choice to preserve these records was presumably based on a visual inspection of the records, with only the sheets containing a visible event selected for preservation (e.g. Figure 1b). The collection is there-

fore quite complete for the Galitzin, Nikiforov, and Press–Ewing instruments, but rather sparse for the 19T and Wiechert instruments. Examples of records are presented in Figures 2a (teleseismic), 2b (regional), and 2c (local).

International researchers regularly request copies of the seismograms for specific events, and we provide scanned images to meet these requests. We welcome researchers to access the collection and use the EOST facilities to copy the required seismograms when large data volumes are requested. We currently have no specific plans to scan the entire collection. An important subset of event records (1471 seismograms) for pre-defined Euro-Mediterranean historical earthquakes (1910–1962) was scanned as a component of the EuroSeismos project [Ferrari and Pino, 2003] in 2004. The resultant seismogram images are available upon request from the EuroSeismos website (http://storing.ingv.it/es_web).

The Strasbourg seismograms have contributed to the analyses of numerous earthquakes at teleseismic distances, while few of them have been exploited for studying regional events [e.g. Baroux *et al.*, 2003, Cara *et al.*, 2008, Amorèse *et al.*, 2020, Stich *et al.*, 2005, Pino, 2011].

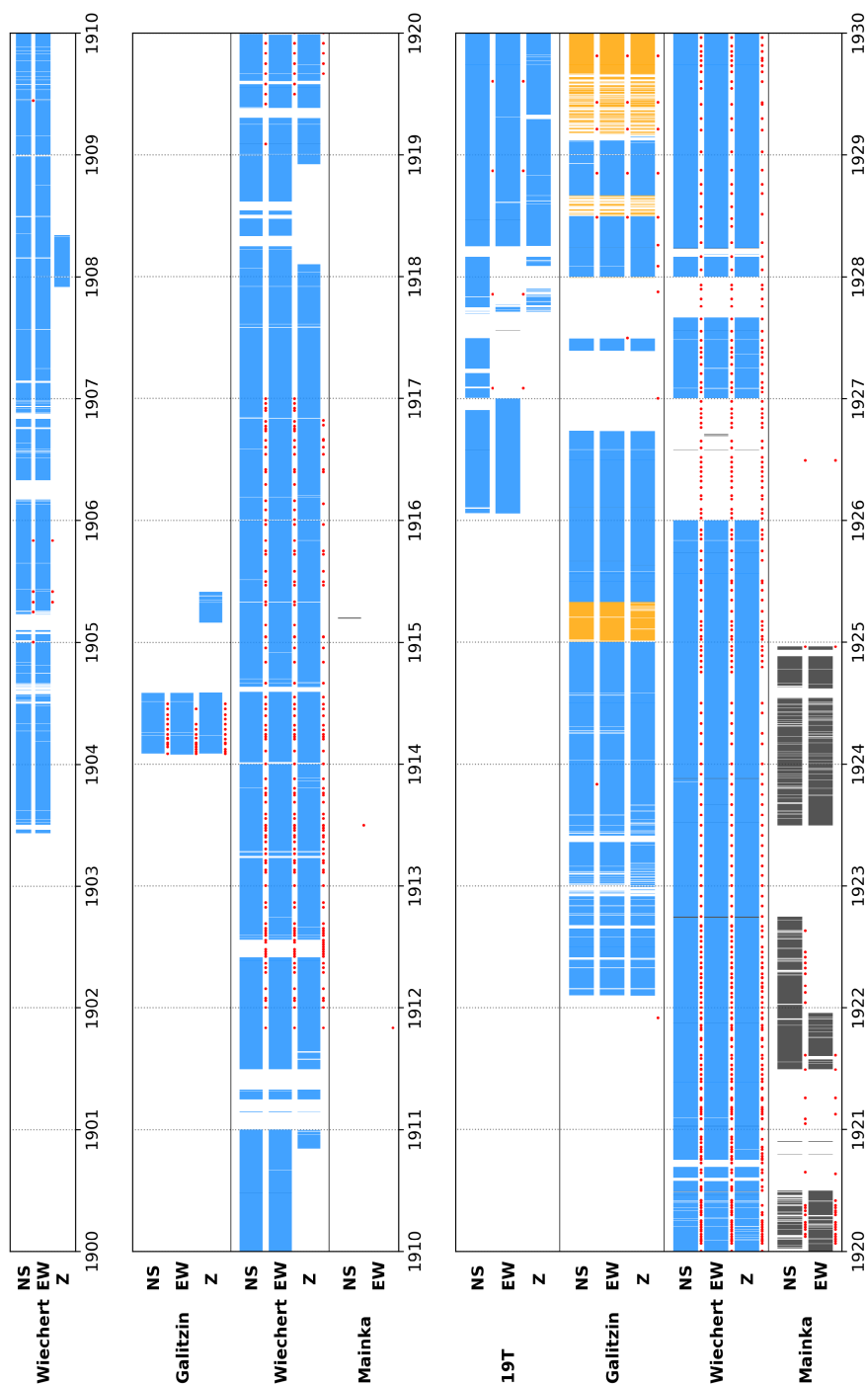


Figure 1a. Contents of the seismogram collection for each instrument and component for the period 1900–1929. The colors indicate the media type: microfilm (light blue), photographic paper (orange), smoked paper (gray), and ink (green). Each red dot indicates when a set of instrumental constants was reported in the station books for a given instrument.

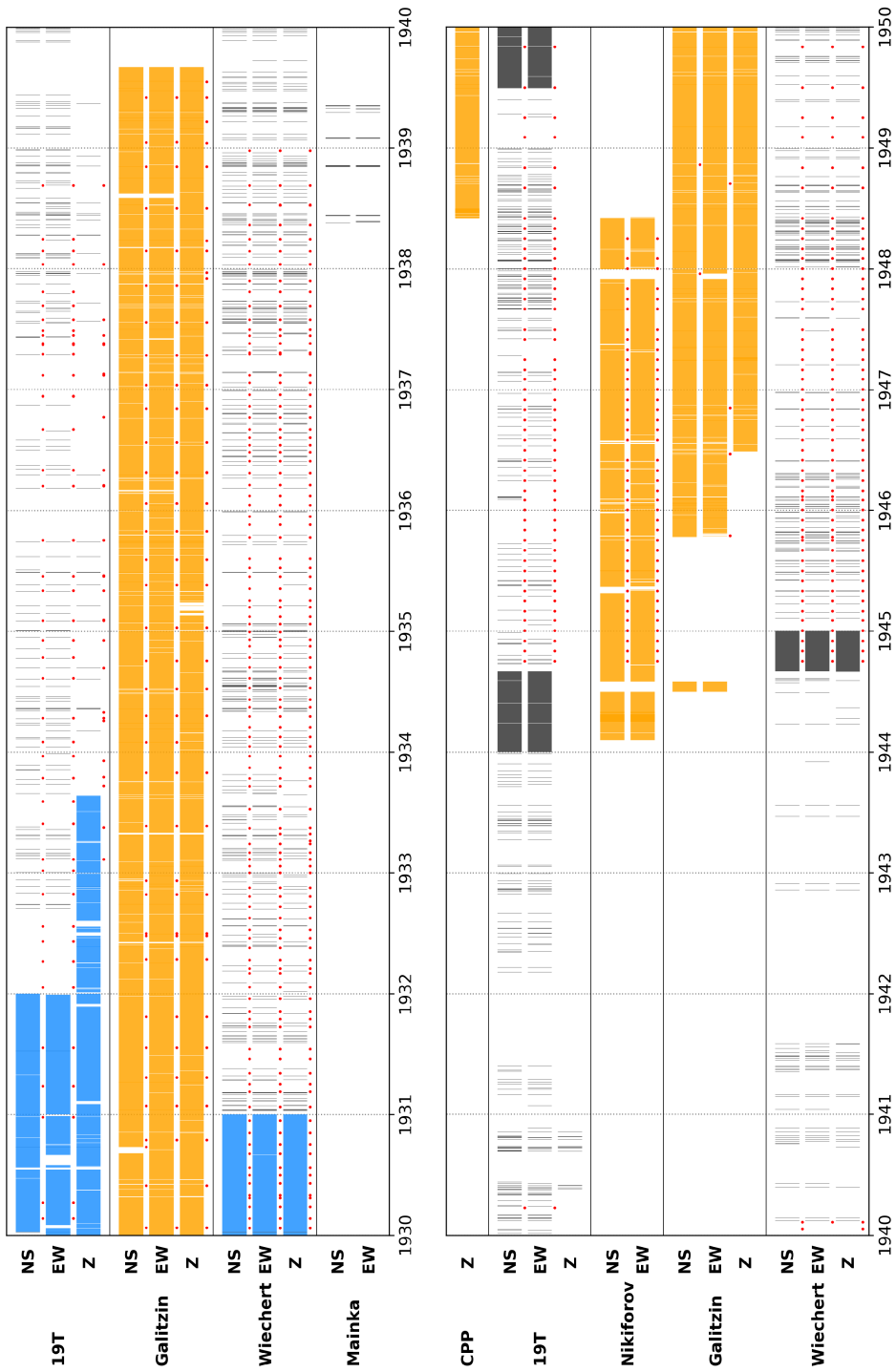


Figure 1b. Same as for Figure 1a, for the period 1930–1949.

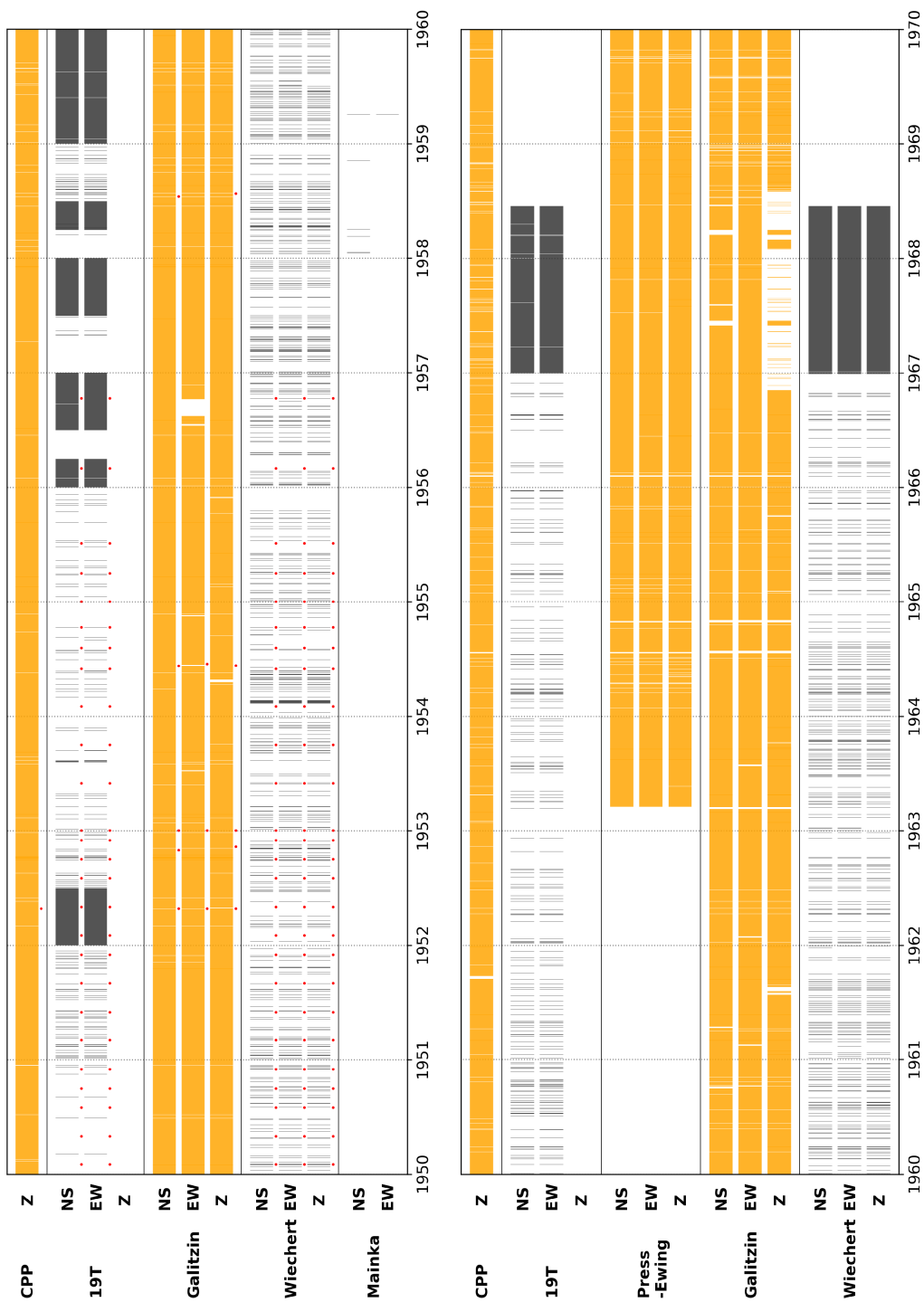


Figure 1c. Same as for Figure 1a, for the period 1950–1969.

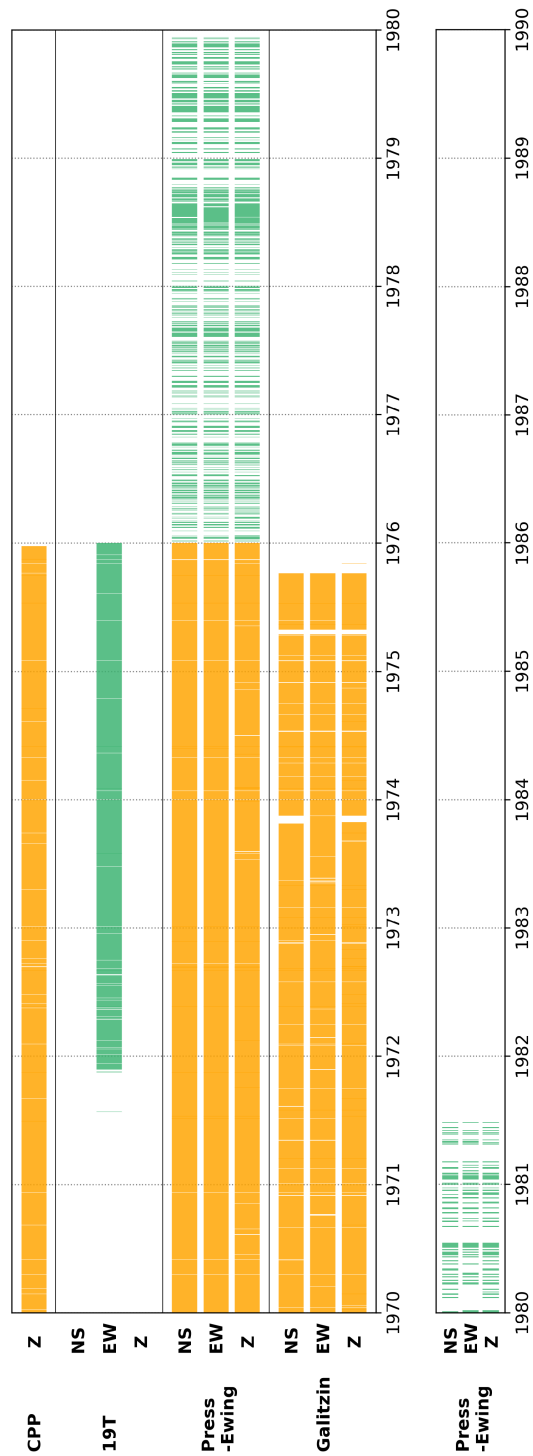


Figure 1d. Same as for Figure 1a, for the period 1970–1989.

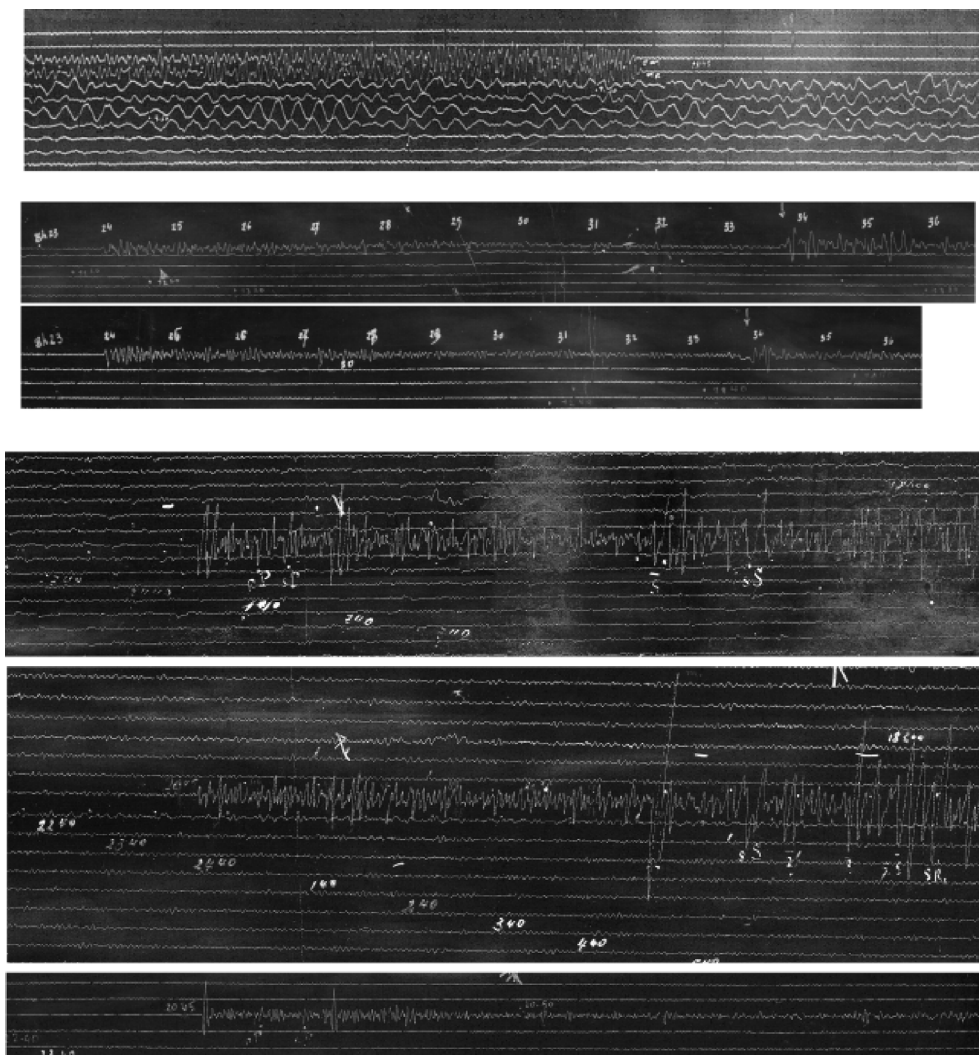


Figure 2a. Examples of teleseismic records. From top to bottom: Galitzin: Tonga, 18 June 1923, E–W and N–S components (microfilm copy, the two components are recorded in parallel on the same sheet). Mainka: Kurils, 18 October 1920, E–W and N–S components (original smoked-paper record). Wiechert: Hindu-Kush 15 November 1921, E–W, N–S, and Z components (original smoked-paper record).

3.2. Other stations

We also host a collection of World-Wide Standardized Seismograph Network (WWSSN) microfilms from 124 seismological stations for the period 1964–1988. This collection contains a largely complete set of 35-mm microfilm rolls for the period 1964–1978 (the 1966 seismograms are missing except for station AKU). This collection also contains a set of microfiche films from 1978–1988

that is rather complete until 1979 and more sparse thereafter. Minor collections of the original seismograms from other seismological stations (Marseille, Bagnères de Bigorre, Besançon, Vouglans, Tunis, Garchy, Dumont-d’Urville, Granges-Gontardes) are also hosted in Strasbourg, but an inventory of these records has yet to be compiled. We unfortunately have almost no calibration information on the instruments that recorded these seismograms.

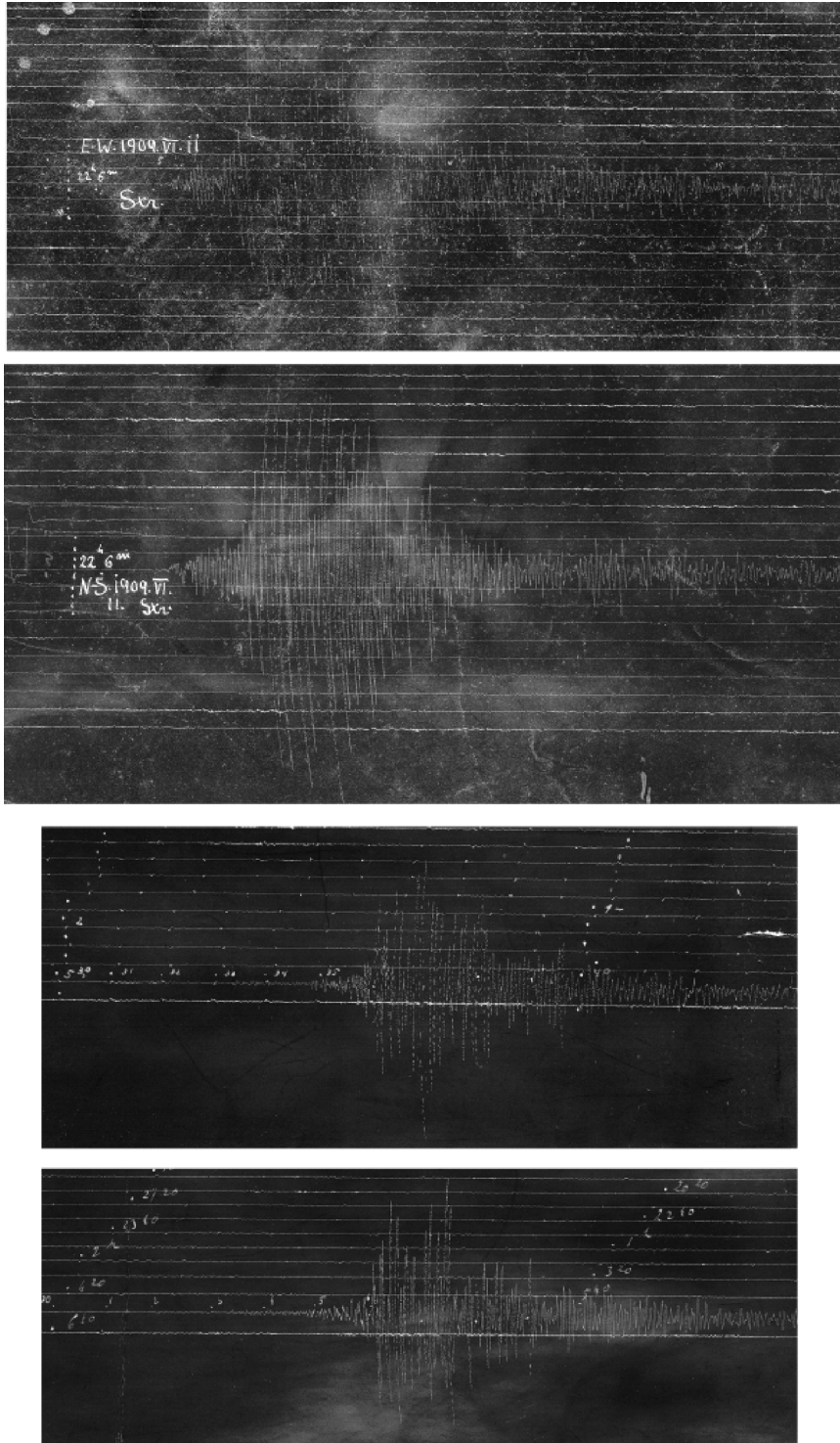


Figure 2b. Examples of regional records. From top to bottom: Wiechert: Lambesc (France), 11 June 1909, E-W and N-S components (original smoked-paper record). Wiechert: Pyrenees, 9 Juillet 1923, E-W and N-S components (original smoked-paper record).

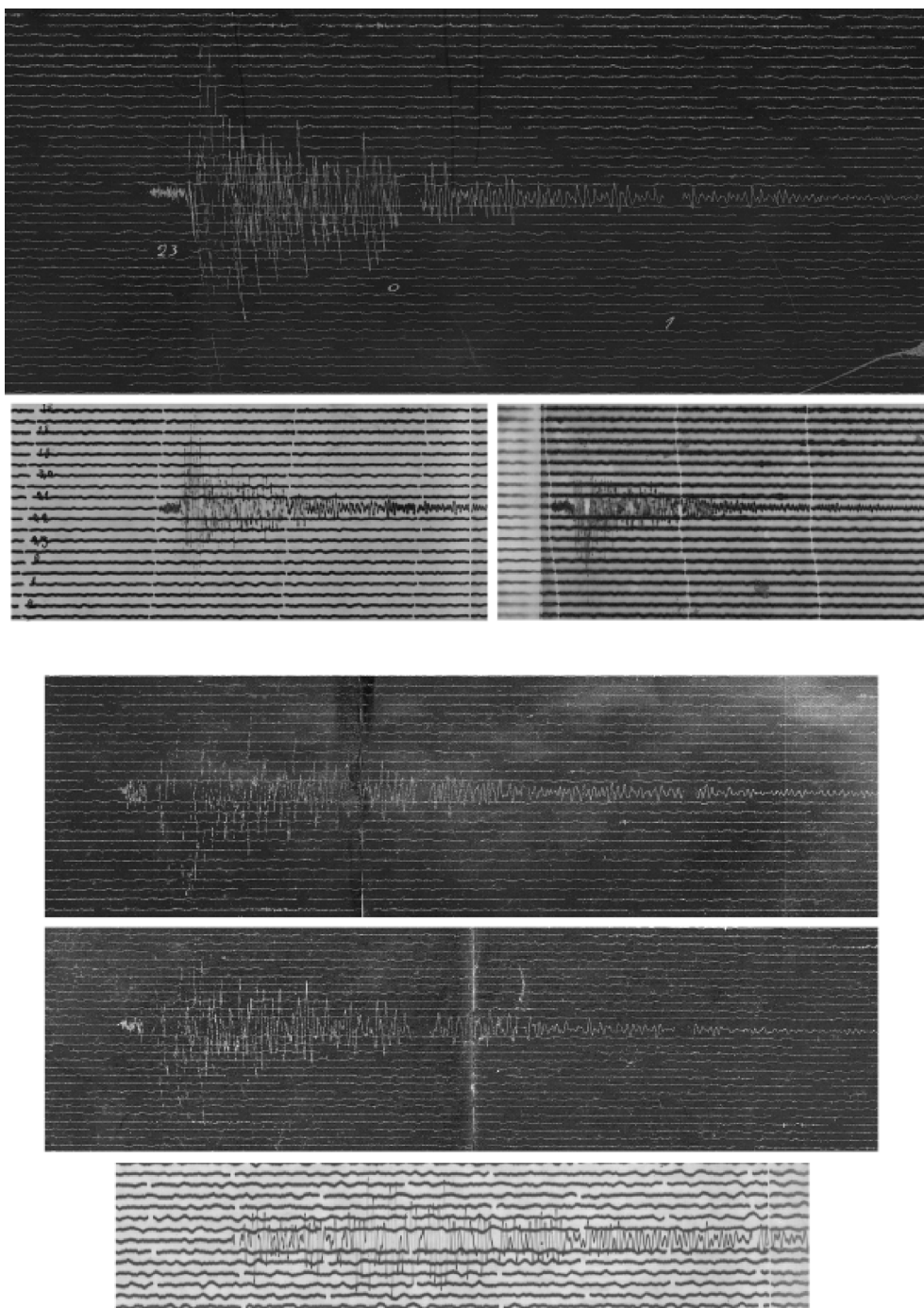


Figure 2c. Examples of local records. From top to bottom: 19T: Jura-Suabe, 14 April 1947, N–S component (smoked paper). Nikiforov: Jura-Suabe, 14 April 1947, E–W (left) and N–S (right) components (photographic paper). 19T: Rhine Graben, 6 June 1948, N–S and E–W components (smoked paper). CPP: Rhine Graben, 6 June 1948, Z component (photographic paper).

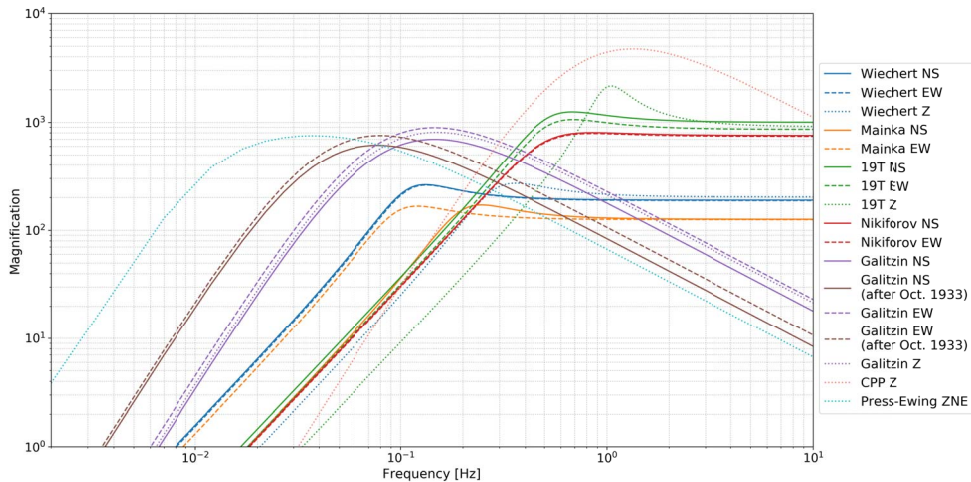


Figure 3. Instrumental responses of the seismographs installed at Strasbourg seismological station. For each component a typical curve computed from the median values of the set of constants extracted from the station books (see the red dots on Figures 1a, 1b, and 1c) is represented.

4. Instrumental responses and station books

The main source of response information for the different instruments is the station books (1905–1916, 1919–1956). This collection contains the constants determined from frequent calibration tests. Some of the values have already been published [Rudolph and Tams, 1907, Reid, 1910, Gutenberg, 1915, Wood, 1921, McComb and West, 1931, Charlier and van Gils, 1953]. For the mechanical instruments (Mainka, Wiechert, Nikiforov, and 19T) this information includes the magnification, free period, damping, and at times, a friction parameter. The Galitzin response information includes the seismometer and galvanometer free periods, the seismometer damping, and a magnification measurement. As it is usual for Galitzin instruments [Galitzin, 1914], the galvanometer is critically damped, and the coupling constant is supposed to be negligible. The complete collection of responses (instrumental constants along with the corresponding amplitude and phase diagrams as a function of time) for the various instruments that were operated at Strasbourg seismological station (Wiechert, Mainka, Galitzin, 19T, CPP, and Nikiforov) is presented in the supplementary material (Figures S1–S7). Figure 3 presents typical magnification curves computed from the median value of the available constants for each instrument. The nominal response of the Press–Ewing seismograph is

also included. Furthermore, the seismograms from some instruments (e.g. Galitzin, Press–Ewing) contain calibration pulses.

In addition, the station books contain routine seismogram readings (arrival times, amplitudes, polarities, and/or microseismic agitation levels), information on event locations (epicentral distance, probable location, and/or information from other seismological stations and/or institutions), and the potential event type when known or suspected (e.g. explosion, quarry blast). They also include limited comments about the operation of both the various instruments and the seismological station itself. The station books from the early period (1905–1916) report macroseismic information for some of the largest events and locally felt earthquakes, as well as a few seismogram reproductions. The station books from the period after World War II include press articles for some of the large felt events. Figure 4 summarizes the available information in the station books for the period 1905–1956 in terms of catalog information (e.g. arrival-time readings) and instrumental constants. The station books for the early period (1905–1911) mainly contain catalogs, limited instrumental constant measurements that are associated with large earthquakes (e.g. the 1909 Lambesc earthquake), and/or experimental instruments (e.g. Mainka pendulum). Those for the period 1912–1940 contain both catalogs and regular

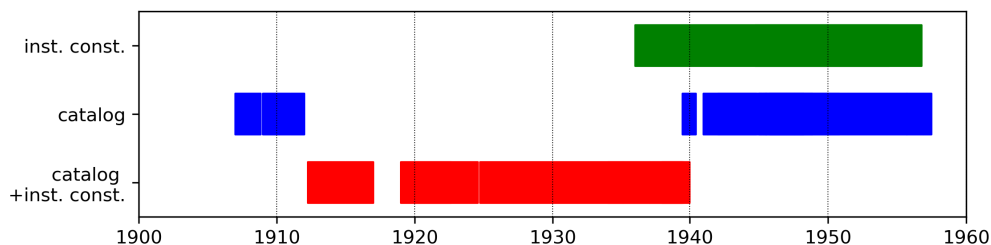


Figure 4. Information on the Strasbourg seismological station book collection for the period 1905–1956. The colors indicate information about the station book content: catalog (phase picking and amplitude reading, location information when available) (blue); instrumental constants (green); both (red).

instrumental constant measurements. Two collections of station books are available for the period 1941–1956: one that contains the catalogs, and the other one devoted to the instrumental constants.

5. Concluding remarks

We present an inventory of the historical seismogram collection housed at the École et Observatoire des Sciences de la Terre de Strasbourg, University of Strasbourg, France. The collection spans the period 1903–1981, with the pre-1930 records being mainly preserved as microfilm copies. There appears to have been a concerted effort to maintain the continuous operation of complementary instruments (e.g. 19T + Wiechert + Galitzin) at Strasbourg seismological station since its inception. A largely complete collection of seismograms has been preserved in spite of the complex regional history. Several other instruments (i.e. Omori, Milne–Shaw, Wood–Anderson) operated for at least a few years; however, no record has survived for these short-term instruments.

It is unfortunate that a severe screening of the smoked-paper records was conducted around 1967, whereby only the sheets with a *visible* event were preserved. However, we have very often experienced that useful information on a seismogram is not necessarily grasped on a first inspection of it. Moreover the experience shows that the *noise* and *signal* concepts depend on the application at hand, and what appears as noise today could be the signal for future applications. The resultant losses primarily affected the Wiechert and 19T records. The Galitzin, CPP, and Press–Ewing collections are largely complete. It is also likely that some of the missing seismograms are due to misplaced records or borrowed records that were never returned, as it was common

practice until the 1960s to lend the original seismograms via the postal service.

A comprehensive overview of the available seismological records held at Strasbourg is provided here. Future work should include scanning these historical seismograms to ensure data preservation.

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Supplementary data

Supporting information for this article is available on the journal's website under <https://doi.org/10.5802/crgeos.90or> from the author.

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