BEGINNINGS OF REGULAR SEISMIC SERVICE AND RESEARCH IN THE AUSTRO-HUNGARIAN MONARCHY: PART I

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ABSTRACT

The paper mentions the first attempts of European savants and scientists in the past centuries to study in a more systematic way the phenomenon named 'an earthquake'. Discussed in this context are the activities developed in the second half of the 19th century by Viennese and other Austro-Hungarian physicists, geologists, geographers and specialists in geomagnetism, geodesy and other geo-disciplines with the aim to initiate regular seismological research in the Monarchy. These efforts resulted in the idea to organize an effective seismic survey which would supply the researchers with continuous earthquake data, first on the macroseismic level, later on the basis of instrumental observations.

We speculate upon the reasons which stimulated such a difficult and long-term project at that time and discuss the impact of the new ideas on one particular region of the Monarchy – the territory of Bohemia the seismic activity of which had been described as low or moderate. We link these efforts to the all-European endeavour of the time to promote (up to that time only sporadic) earthquake observations and studies to the rank of systematic seismological research.

The paper deals with these activities as they had been accomplished by the end of the 19th century. In Part II, the continuation of the efforts in the first decade of the 20th century will be discussed. The pioneering works reported in both papers quite naturally created a solid fundament for the later development of seismology in former Czechoslovakia and in the present Czech Republic.

Keywords: earthquake research, history, Austro-Hungarian Monarchy

1. INTRODUCTION

It is not easy to give the names of the researchers of the past who tried better to understand the causes and physical manifestations of an earthquake and not to forget important persons. If we omit the names and simple ideas of ancient and middle-age savants, the name of the 17th century polyglot and natural scientist *Athanasius Kircher (1601 – 1680)*, who spent a great deal of his life in Italy, cannot be passed. He devoted a great deal of his life to the study of volcanism and earthquakes and formulated his analysis and speculative conclusions in his book 'Mundus subterraneus' *(Kircher, 1664)*. Paradoxically, his considerations about the inner parts of the Earth, although prepared with maximum care and thoroughness, appeared to be counter-productive: they misleadingly influenced geosciences for more than 100 years since they were based purely on (unfortunately incorrect) speculations. This was one of the reasons which prevented geo-savants from fundamental progress also in the first half of the 18th century. More detailed information about this period presented, e.g., *Kraemmer (1902)*.

As far as the all-European scene in the second half of the 18th century is concerned, two disastrous seismic events, the 1755 Lisbon and the 1783 Calabrian earthquakes, occurred. These catastrophes moved forward seismological knowledge considerably. We have full right to classify this period as the beginning of a new era in the study of earthquakes: that of observatory seismology. Kircher's speculative constructions were forgotten at last, and most of the geo-savants of the continent began to collect seismic data and other information about earthquakes the analysis of which would enable them to draw out more correct interpretations. From the long list of tracts and other works of this kind published in this period, let us mention the works by *Amezua (1756), Bronner (1756), Seyfardt (1756), Moreira de Mendoca (1758), Vivenzio (1783)* and *Sarconi (1784)*. Also the famous 'Encyclopedia' published in Paris by *Diderot et al. (1776 – 77)* corresponded with the new approach to the natural sciences study.

Also northwards from the Alps, in Central Europe, in the region roughly identical with that of the later Austro-Hungarian Empire, many regional earthquakes were felt, widely discussed and speculated. Let us mention at least the strong earthquakes in Central Slovakia in 1443, near Neulengbach in 1591, and near Komárno in 1763. The latter stimulated local savants to speculate upon the nature of earthquakes and to compile historical earthquake catalogues of the region, e.g., *Grossinger (1783)* and *Sternberg (1786)*.

In the course of the 19th century it gradually became quite evident that geophysical and especially seismological research are data-based, that means observatory-dependent disciplines. The famous geophysical works by *Humboldt (e.g. 1859)* and their reflections in the cartographic output of *Berghaus (1850)* should be mentioned in the name of many others, such as, e.g., the splendid analysis of the 1857 Basilicata earthquake by *Mallet (1862)*.

Regardless of the indisputable progress in seismological studies in the second half of the 19th century, seismology had not yet been recognized as an independent discipline of geosciences. In the best case it was considered to be a poor relative endured to participate in international geographical congresses or surviving as a younger sister of well-established disciplines of geology, volcanology, geomagnetism and astronomy.

2. ESTABLISHMENT OF GEOPHYSICAL RESEARCH IN VIENNA

The foundation of scientific institutions in Vienna directed at advanced geo-research was accompanied by efforts to promote also geomagnetism and astronomy. The central personality in this endeavour was *Karl Kreil (1798 – 1862)*, born in Ried in Upper Austria, who worked in Prague since 1838 as assistant at the Prague astronomical observatory. In 1845 he was appointed director of this observatory and professor of astronomy at the Prague German University.

New foundations for the development of science and research were settled in Vienna at the end of the reign of Ferdinand the 'kind-hearted'. First, the *Kaiserliche Akademie der Wissenschaften* was established in 1846, together with its seven new periodicals (among them the famous *Sitzungsberichte d. k.k. Akademie d. Wissenschaften in Wien*), where the results of the research were published. The newly installed emperor, Franz Joseph I., continued in supporting scientific efforts: he founded several new geoscience institutions, among them the *Kaiserliche koenigliche geologische Reichsanstalt (1849)* and the *Centralanstalt für Meteorologie und Erdmagnetismus (1851)*. By these establishments, the basic conditions necessary for a successful development of geoscientific research in the Monarchy were laid.

Karl Kreil left Prague in 1851 for Vienna since he was appointed director of the newly established Central Institute for Meteorology and Earth Magnetism, and he simultaneously became professor of these disciplines at the Vienna University. Kreil's Institute, the present *Zentralanstalt für Meteorologie und Geodynamik*, is regarded to be one of the oldest geophysical institutions in Central Europe. In 2001, the 150-anniversary of the foundation of this institute was celebrated in Vienna. Its establishing, its development from the first years of K. Kreil's presidency, and the scientific achievements of the Institute researchers up to the present days were detailly recorded and analyzed by *Hammerl et al. (2001)*. How Kreil contributed to the beginnings of earthquake observations in the Monarchy becomes more clear from the following complementary comment by Christa Hammerl:

At the sitting of the Austrian Academy of Science in Vienna in March 1849, Kreil´s statement concerning the foundation of a "*Centralstation*" in the Austrian Monarchy was presented [*Sitzungsberichte d. k. Akademie d. Wissenschaften, Math.- naturw. Klasse, 2. Bd., H. 1, Wien 1849, p. 169ff*]. In point 9 of his statement Kreil emphasized that not only meteorological phenomena but also earthquakes should be observed. With the Imperial Resolution of the 23rd of June 1851, Emperor Franz Joseph authorized the establishment of a 'central institute for meteorological and magnetic observations' – the *Centralanstalt für Meteorologie und Erdmagnetismus*. Kreil established a meteorological observation system for the entire territory of the Austrian Monarchy and carried out the first national geomagnetic survey; seismographs didn't exist yet.

In 1851 Boué, member of the Austrian Academy of Science, gave a lecture on ' … the necessity to observe more precisely earthquakes and volcanic phenomena …'. V. Baumgartner, president of the Austrian Academy of Science, responded to Boué's appeal immediately (*Sitzungsberichte d. k. Akademie d. Wissenschaften, Math.- naturw. Klasse, 7. Bd., H. 6-10, Wien 1851, p. 570.*): '… It is true that in the course of equipping (remark: the *Zentralanstalt*) with meteorological instruments, tools for the observation of earth tremors have not yet been taken into consideration since it is not easy to obtain instruments of such a sensitivity as desired by the esteemed member (remark: meant is Boué) because, according to his knowledge, such instruments have not yet been invented; however, in respect of their programme, the Instute should not exclude them and the head of the Institute Mr. Kreil will surely not refrain from directing his attention to this important subject in due time...' [1)].

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1) *Bei der bereits Statt gefundenen Anschaffung meteorologischer Instrumente (Anm.: für die Zentralanstalt) hat man allerdings Werkzeuge zu Beobachtungen von Erderschütterungen noch*

And Kreil took this'subject' seriously indeed. In July 1855 he submitted to the K.k. Ministry of Education an application for the 'permission to purchase and deploy earthquake-meters at different stations' of the Austrian Monarchy (*Antrag um die Bewilligung zur Anschaffung und Vertheilung von Erdbebenmessern an verschiedenen Stationen, AVA MCU Nr. 11376, 1855*). He attached to this application an article about a 'new earthquake-meter' (*Über einen neuen Erdbebenmesser, Sitzungsberichte d. k. Akademie d. Wissenschaften, Math.- naturw. Klasse, 15. Bd., Wien 1855, p. 370-371*) written by himself, in which he mentioned that '... a good earthquake-meter is a desideratum still to be devoutly wished for. It should not only show the commencement of the stronger, but also of the weaker shocks, as well as their duration, direction, and strength – a task which is too great even for a self-registering apparatus. Therefore every idea towards the improvement of such instruments must be welcome; and on this account I venture to bring forward the following design ...'[2)]. To his printed text and the instrument's sketch, Kreil added the following hand-written explanatory notes: 'To record vertical shocks serves a pencil Q attached in vertical position to a non-elastic arm beneath which a plate R is fixed to an elastic clasp PR; a vertical shock should cause swinging of the plate and get it in touch with the pencil which then draws points or short lines on it'[3)].

The question about the cause of earthquakes could not be answered yet at that time, and this made the construction of a suitable seismograph difficult.

Note: After the second World War, in 1946, when physical instruments were relocated from the depository of the German University in Prague into the depositories of the National Technical Museum in Prague, an instrument possibly designed by K. Kreil during the period of his activities at the Prague German University, was found, described, inventoried and safely lied. This instrument has been sometimes linked with the device described in Kreil's paper discussed above by Christa Hammerl. The body of this instrument, a presupposed torso of the original device, survived up to present days. We thoroughly compared it with *Kreil'*s *(1855)* description and found out that it might have been a part (the 'pendulum') of some 'Kreil earthquake-meter', but if actually, than

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nicht berücksichtigt, weil es nicht so leicht ist, Instrumente von solcher Empfindlichkeit zu erhalten, wie sie das verehrte Mitglied (Anm.: gemeint ist Boué) wünscht, da seines Wissens solche noch nicht einmal erfunden sind; allein das Institut soll deren Programm zu Folge auch solche nicht ausschliessen und der Leiter dieses Institutes Hr. Kreil, werde es gewiss nicht unterlassen, seiner Zeit diesem wichtigen Gegenstande seine Aufmerksamkeit zuzuwenden.

2) *...ein guter Erdbebenmesser noch immer unter die frommen Wünsche gehört; er soll nicht nur den Eintritt der stärkeren Stösse, sondern auch jene der schwächeren, die Zeit, die Richtung und Stärke des Stosses angeben, eine Aufgabe, die für einen selbstzeichnenden Apparat zu gross ist. Es muss daher jede Idee zur Verbesserung solcher Vorrichtungen willkommen sein und aus diesem Grunde erlaube ich mir den beifolgenden Entwurf vorzulegen.*

3) *Zur Verzeichnung der verticalen Stösse dient ein an einem nicht elastischem Arme angebrachter Bleistift Q, dessen Richtung senkrecht ist, und unter welchem sich die Platte R befindet, welche an der elastischen Spange PR befestigt ist, daher bei einem senkrechten Stosse in Schwingungen versetzt werden und mit dem Bleistifte in Berührung kommen muß, wodurch auf derselben Punkte oder kurze Striche verzeichnet werden.*

a predecessor rather than a relic of it. Since there are also major discrepancies between the descriptions of the drawing mechanism in the printed paper and in Kreil's hand-written notes (horizontal in the former, vertical in the latter; no magnification) we suspect that no functional Kreil earthquake-meter was ever constructed. Even if some had been built, it could have hardly yielded interpretable records.

3. INCREASING DANGER OF OCCURRENCE OF STRONG EARTHQUAKES IN THE EMPIRE IN THE LAST DECADES OF THE 19th CENTURY

The newly established Institute, as followed from its name and from Kreil's qualification, was mainly aimed at meteorological and geomagnetic studies and at regular survey and routine measurements of physical parameters in these disciplines. Seismological research and service had not been established or at least initiated in any center of Austrian geo-research, inclusive of the Vienna Academy of Sciences. This however was true only for the first decades of the second half of the 19th century. The reason for relatively low activity in seismic studies in this time was most likely, as far as the territory of the Empire is concerned, relatively low seismic activity in the 1850s and 1860s.

Note: This however did not mean that the earthquake-researchers of the Empire had stagnated. Let us remind, e.g., Johann F.J. Schmidt, an astronomer by education, who made a brilliant analysis of the January 15, 1858 West-Slovakia earthquake (*Schmidt, 1859*). Schmidt, since 1858 director of the 'Sternwarte' (Astronomical observatory) in Athens, compiled a comprehensive summary of volcanic and seismic activities in Greece in the 19th century (*Schmidt, 1880*). New contributions to understand the causes of re-occurrence of earthquakes whose epicentra lined up along or clustered within '*Stosslinien'*, today called fault lines or fault zones, were attributed to the Viennese geologist *Eduard Suess* (*1872 and 1885*) and his 'Austrian school of earthquake research', see *J. Ruska's (1910)* translation of *(Hobbs, 1907)* for details. Finally, let us mention the Czech astronomer Václav Láska who was active at the Lvov[1)] University in Galizien (today West Ukraine) at the turn of the 19th century. He developed the method of determining epicentral distances of earthquakes by measuring the time difference between the arrival times of the '*erste Vorphase*' (P waves) and '*zweite Vorphase*' (S waves) – the Láska principle (*Láska, 1903*).

As can be seen from Tab. 1, the seismic activity within the territory of the Empire and in adjacent regions gradually increased since the end of the 1860s. As a natural consequence, anxiety of the public was growing and scientists began to engage themselves more seriously in the study of geological and geophysical processes. According to the data given in Tab. 1, the concerned period can be divided into three subintervals:

1) Lvov in English and Czech; Lviv in Ukrainian; Lwów in Polish; and Lemberg in German.

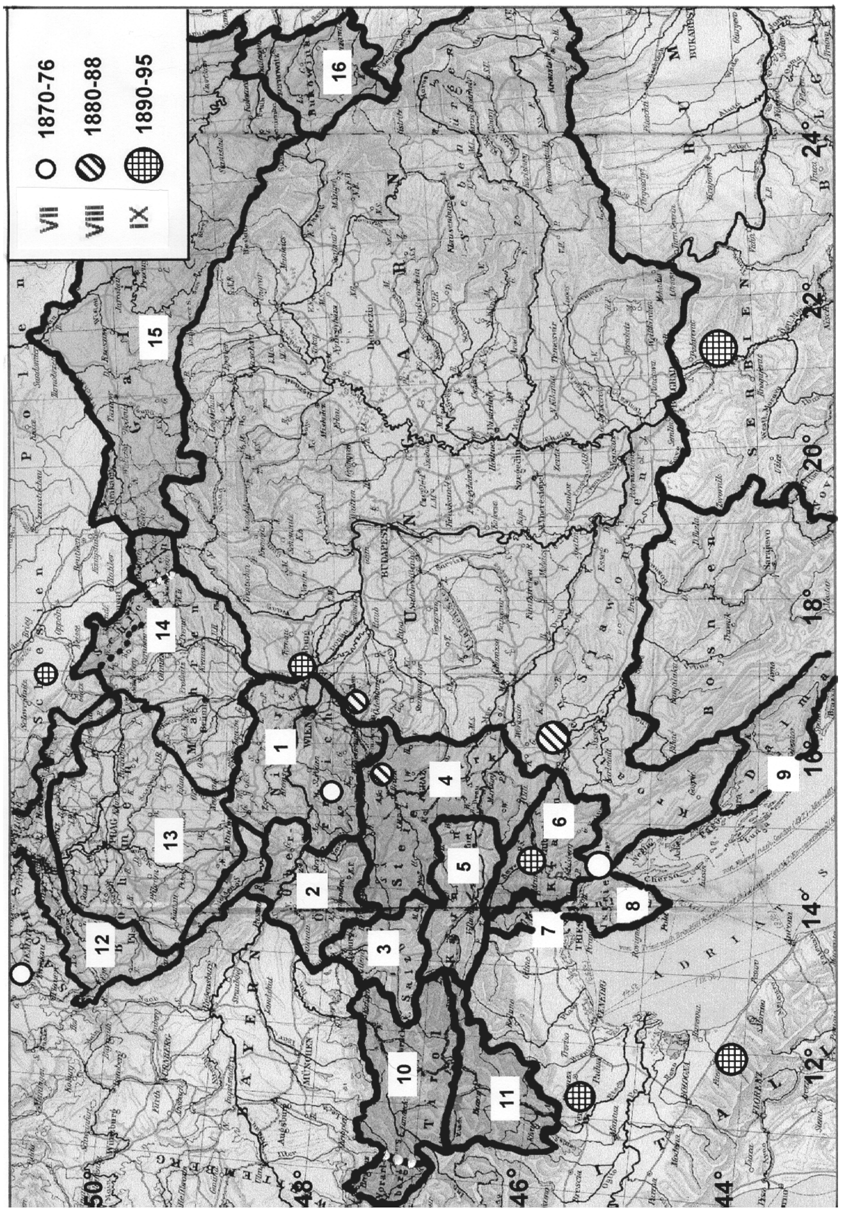

Fig. 1. Map of the Austro-Hungarian Monarchy, epicenters and intensities of earthquakes 1870 – 1895 (circles) and provinces in which systematic seismic observations had been organized in 1896 – 1914 (numbers). The size of the circles indicates the largest observed macroseismic intensity (small – VII, medium – VIII, large – IX); for details see Tab. 1. The individual provinces are numbered according to the 'new' numbering, see column 4 of Tab. 2.

Table 1. List of strong earthquakes in the Austro-Hungarian Monarchy and adjacent countries in 1870 – 1895. In the map of the Monarchy (Fig. 1) their epicenters are denoted by circles whose size is proportional to the observed maximum intensity. The three grey-shadowed events occured outside the territory shown in the map in Fig. 1.

Date	Intensity	ϕ, λ	Location	Symbol in Fig. 1
1870 Mar 01	VIII-IX	45.4N, 14.4E	Istria, Slovenia	○
1872 Mar 06	VII-VIII	50.9N, 12.3E	Vogtland, Upper Saxony (M=5.1)	
1876 Jul 17	VII-VIII	40.0N, 15.2E	Lower Austria (M=5.1)	
1880 Nov 09	IX	45.9N, 16.1E	Zagreb, Croatia	
1881 Mar 04	VIII	40.8N, 13.9E	Ischia, Central Italy	
1883 Jul 28	IX	40.8N, 13.9E	Casamicciola, Central Italy	
1885 Apr 30	VIII	47.5N, 15.5E	Styria (M=5.4.)	
1887 Feb 23	IX	43.4N, 8.1E	Menton, S. France	
1888 Apr 12	VII	47.8N, 16.5E	Burgenland, Austria	
1890 Feb 28	VII	48.3N, 17.0E	W. Hungary	
1891 Jun 07	VIII	45.5N, 11.2E	Tregnano, N. Italy	
1893 Apr 08	IX	44.3N, 21.3E	near Beograd, Serbia	
1895 Apr 14	VIII-IX	46.1N, 14.5E	Ljubljana, Slovenia	
1895 Jun 11	VII	50.7N, 16.9E	Silesia, S. Poland	
1895 Sep 04	VIII	44.1N, 11.9E	SW of Ravenna, N. Italy	

In the first ten years (1870 – 1879), altogether three stronger seismic events occurred in the Monarchy and in adjacent countries (for their epicenters see Fig. 1).

In the next decade (1880 – 1989), further six earthquakes were macroseismically felt in the region.

During the following six years (1890 – 1895), six serious seismic events were observed in the region, one per year on average.

The respective historical materials indicate that it was especially the 1895 Ljubljana earthquake which set the inhabitants of the country into alarm and stimulated responsible persons to react rapidly and decisively (the extensive macroseismic data of this event were described and analyzed in admirable detail by *Suess, 1897*).

Among Austrian geologists and geophysicists it was the esteemed member of many European scientific societies and excellent organizer Edmund v. Mojsisovics who accepted the challenge.

Note: E. v. Mojsisovics was born in 1839 in Vienna. He graduated at the University of Vienna as a lawyer but inclined to the geo-disciplines later on. In 1867 he was affiliated member of the Imperial Geological Institute in Vienna, and in 1870 he was appointed Supreme Geologist of the Institute and got the post of a Mining Councilor. In 1892 he became the vice-director of the Geological Institute. One year earlier, in 1891, he was awarded membership in the Academy of Sciences in Vienna. Many of his works in the field of paleontology and geology were published in the '*Abhandlungen der geologischen Reichsanstalt in Wien*' and in the '*Abhandlungen*' of the Academy. In 1880 he founded in Vienna the regular periodical '*Beitraege zur Paleontologie und Geologie Oesterreich-Ungarns und des Orients*'.

It is not easy to recover the advancement and all the particularities of Mojsisovics' activities after more than hundred years. Details could likely be found in the archives of the *Zentralanstalt für Meteorologie und Geodynamik* and of the *Österreichische Akademie der Wissenschaften* in Vienna. The fundamental landmarks of his projects are nevertheless commonly known and enable us to assess the time schedule of their formulation and successive implementation.

Edmund v. Mojsisovics evidently became fully aware of the necessity and importance of an 'intensification' of seismic observations and earthquake studies shortly after the strong Ljubljana (March 14, 1895) earthquake. He promptly, most probably together with colleagues, formulated the ideas for a respective project, and six weeks later (on April 25, 1895) the 'Commission for the purpose of promotion of a more intensive study of seismic phenomena in the Austrian countries' (*Erdbeben-Commission*) was established by the Department (*Classe*) of Mathematical-Natural Sciences of the Imperial Academy of Sciences in Vienna. According to the report presented by Mojsisovics at the February 11, 1897 session of the *Erdbeben-Commission*, efforts aimed at the organization of a network of earthquake observers/reporters had begun immediately after the establishment of the commission. Systematic observations and central collection of reports were started in January 1896.

4. THE PROJECT BY EDMUND V. MOJSISOVICS

The full text of the report on the state of Mojsisovics' project at the end of 1896, entitled 'Reports on the organization of earthquake observation and communications on earthquakes that occurred in the course of the year 1896', appeared in February 1897 as the first (No.I) of a series of '*Mittheilungen der Erdbeben-Commission der kaiserlichen Akademie der Wissenschaften in Wien*' (*Sitzungsberichte der kaiserl. Akad. d. Wissensch. in Wien, Mathem.-naturw Classe; Bd. CVI, Abth. I, Februar 1987*). The goals of the project, formulated by Mojsisovics probably together with other members of the *Erdbeben-Commission*, were twofold:

1. Compilation of a historical catalogue of earthquakes on the territory of Austria, especially of reliably documented historical events in the region of the Eastern Alps.
2. Organization of a seismic survey in the Austrian countries. This was specified as 'the most important task' of the project and involved two subprojects:

(a) 'Establishment of a number of seismographic stations equipped with autonomously recording earthquake-meters',
(b) 'Establishment of a network of permanent observers' (of macroseismic effects of earthquakes).

Ad 1. Prof. Dr. Rudolf Hoernes, Graz, was entrusted with the organization of this part of the project, and three years were estimated to be necessary for its accomplishment. In the respective introductory comments the importance of search for relevant data in old chronicles, provincial archives etc. was emphasized, and existing former compilations by E. Suess for Lower Austria, by H. Hoefer for Kaernten, by H. Mitteis (with a gap in 1691 – 1799) for Krain, and by K. Deschmann for the Laibach 1855 – 1885 earthquakes, were mentioned. However, none of the altogether 21 reports of the *Mittheilungen der Erdbeben-Commission 1897-1900*, with partial exception of *Nos. VI* and *XV* in which data for the Krain-Gradiska and Upper and Lower Austria regions from the last fifty years were briefly summarized (for details see par. 5, sections on Seidl's and Schwab's contributions), reported any remarkable progress in the intended compilation of historical catalogue.

Ad 2(a). Two principal tasks were outlined in Mojsisovics' first report (*Mittheilungen No. I*) presented to the *Erdbeben-Commission*: (i) 'to conduct preliminary studies concerning the choice of instruments', and (ii) 'to proceed towards the activation of several seismic stations' in the course of 1897. As appropriate recording sites, the Astronomical Observatories or Physical Institutes of Pola, Graz, Innsbruck, Prague, Trieste, Kremsmünster, Vienna, and Lemberg were suggested (E. v. Mojsisovics: General report and chronicle of earthquakes in the region of observations in the year 1897, *Mittheilungen der Erdbeben-Commission No. V. Sitzungsberichte der kaiserl. Akad. d. Wissensch. in Wien, Mathem.-naturw Classe; Bd. CVII. Abth. I. März 1898*). Later on, most probably at the end of 1897, the Commission decided to reduce the number of stations to the latter four and not to proceed with the installation of the other stations before 'sufficient experiences with the functioning of these instruments' had been gained. The Rebeur-Ehlert 3-component horizontal pendulum system, manufactured by T. & A. Bosch's mechanical workshop in Strassbourg, and the recording device constructed by *L. Pfaundler* (*1897*) were chosen as the most appropriate equipment for all the stations. The necessary financial means were provided by the Treitl-Foundation. According to Mojsisovics' second (March 17, 1898; *Mittheilungen No. V*) report, 'all instruments had been made, sent to the places of designation, and their installation in progress', and systematic instrumental observations within the project began in April 1898. Their further history and major results will be the subject of Part II of this paper.

Note: As a result of incentives of Albin Belar and of financial support by the Krain Savings Bank, two seismometers (a continuously recording horizontal 'pendulum-microseismograph' with a reported optical magnification of about 20 and a device measuring the vertical component of ground motion, both manufactured in Prof. Vicentini's Physical Institute in Padua), and another horizontal pendulum seismometer (manufactured in Gustav Tönnies' locksmith workshop in Laibach/Ljubljana, magnification reportedly about 10) had been installed in 1897 at the high-school (*Oberrealschule*) in Laibach/Ljubljana; in the same year, two simple pendulum seismoscopes with electric contacts were also installed by J.N. Krieger at his private astronomical observatory in Trieste (*Mojsisovics, 1898*).

Ad 2(b). This task represented not only the most important but also the most difficult part of the project. Fast and reliable collection of macroseismic data of contemporary earthquakes was a commonly recognized urgent need, and its realization involved serious, long-term engagement of hundreds of new observers/reporters with no previous experience in this field. In no country all over the world had any such extensive network of laymen observers ever been organized or practiced before.

In order to organize the network as rapidly and effectively as possible, Mojsisovics proposed the following strategy of the *Erdbeben-Commission*:

Selection/establishment of central sites for the collection of earthquake reports in the individual provinces of the Monarchy; nomination of and agreements with regional representatives (persons responsible for the dissemination of questionnaires and for the collection of reports within the individual provinces).

Development of instructions and questionnaires in German and in the languages of the other participating countries of the Empire.

Adherence to the principle of no direct contact between the observers/reporters and the Commission, i.e., questionnaire/report flow Commission <=> regional representative <=> observer/reporter.

According to this scenario, the Commission selected fifteen provinces – Lower Austria, Upper Austria, Salzburg, Steiermark, Kaernten, Goerz and Krain, Trieste, Dalmatia and Istria, German Tirol and Vorarlberg, Waelschtirol, Bohemia (German territory), Bohemia (Czech territory), Moravia and Silesia, Galizia, and Bukovina – and began with the search for regional representatives later in 1895.

We emphasize that the project was pertinent exclusively to the countries of the Austrian part of the Monarchy, i.e., neither Hungary nor the associated countries such as Slovakia ('Upper Hungary' at that time) were considered to participate in it. The reason was that after the Austro-Hungarian settlement of 1867 many disciplines, among them geophysical and seismological research, developed in the Hungarian part of the Empire separately from that pursued in the Austrian part.

Note: The history of the foundation and development of seismology in Slovakia and in Hungary has been recently analyzed and classified by *Moczo et al. (2002)*. As reported in this monography, the first Seismological Commission of the Monarchy was established in its Hungarian part as early as in 1881 on proposal of the geologist Franz X. Schafarzik and on recommendation of the Hungarian Geological Society. We however found no trace in available historical sources indicating that this commission ever developed similar activities in macroseismic data collection and evaluation as the *Erdbeben Commission* within the Mojsisovics Project. Instrumental seismic observations in the Hungarian part of the Monarchy started not before 1901, i.e. twenty years after establishment of the Hungarian Seismological Commission (*Moczo et. al., 2002*).

The course of the organization of the macroseismic observation network, its state at the end of 1896, and earthquake observations reported from the individual provinces in 1896 were comprehensively described by Mojsisovics in the same report as the project

(*Mittheilungen No. I, February 1897*). The for the present study most informative facts can be briefly summarized as follows (in parentheses name and residence of the regional representative and number of observers/reporters in the respective province at the end of December 1896):

1 **Lower Austria** (Prof. Dr. Franz Noë, Vienna; 236).
376 observers were invited, 211 accepted; further 25 were found additionally. Composition: teachers, school directors, physicians, apothecarists, parsons, postmasters, landlords, rangers. Average mutual distances among observation points 5.9 km (minimum 1.8 km, maximum 43 km). No earthquake (EQ) observation report submitted.

2 **Upper Austria** (Prof. Johann Commenda, Linz; 203).
266 observers invited, 203 accepted; two thirds of them teachers and school directors. Composition of the others: clericals, rangers, physicians, technicians. One half of all observers were active at meteorological or ombrographic stations. Official participation of Postal Telegraphic Offices as providers of time information. 3 EQ reports.

3 **Salzburg** (Prof. Eberhard Fugger, Salzburg; 61).
Efforts to 'make the network denser' under way. No EQ report.

4 **Steiermark** (Prof. Dr. Rudolf Hoernes, Graz; 280).
Network of evenly distributed observation points; classified as 'sufficiently dense', even in sparsely inhabited districts (Lower Tauern Mts., Bacher Mts.). 24 EQ reports, among them ground motions of intensities III to IV of the Forel scale at many (>10) sites, accompanied by acoustic effects ('rumbling') on Feb. 2, 21:05 and Nov. 20, 21:55.

5 **Kaernten** (Chief mining councilor Ferdinand Seeland, Klagenfurt; 27)
Many gaps in the territorial coverage of observations, net classified as incomplete. 5 EQ reports.

6 **Goerz and Krain** (Prof. Ferdinand Seidl, Goerz; 126).
Number of originally invited observes 250; 117 sites monitored, 36 of them in Goerz-Gradisca and 90 in Krain; one observer for each 50 km^2 on average. Composition of observers: mostly teachers at primary schools. 63 EQ reports, among them two comparatively strong (up to intensity V) events in the Isonzothal valley (April 5, 22:20) and near Laibach (Nov. 8, 04:35; felt also in Tersain, St. Veit, Stein/Krain, Sct. Marein, Ježica, Kropp), accompanyied by strong acoustic effects ('roll of thunder').

7 **Trieste** (Eduard Mazelle, Adjunct, Astronomical-Meteorological Observatory of the Trade and Marine Academy Trieste; 30).
Originally 26 observers, 10 of them in towns; among them also employees of telegraphic centrals and sea- and port-captains; later on also participation of police (*Landes-Gendarmerie*) station commanders; final number of observers 30. No EQ reports.

8 **Dalmatia and Istria** (Eugen Gelcich, Director, Trade and Marine Academy Trieste; 129).
Territorial distribution considered 'acceptable', larger gap only in the Velisca (Istria) district. 8 EQ reports, strongest Nov. 21, 23:30, reportedly multiple event (three sub-shocks).

9 German Tirol and Vorarlberg (Prof. Dr. Joseph Schorn, Innsbruck; 158).
Delay in the organization of the observer net, caused by the resignation of the first regional representative Prof. Blaas. Schorn took up in mid September 1896 and managed, together with Drathschmiedt and Casper, to find by the end of the year 135 observers in Germany and 23 in Vorarlberg, with special emphasis on coverage of the seismogenic areas of Sterzing, Hall and Nassereit. Number of EQ reports: 6; with the remark that the activity was lower than the year before (18 events felt in this province in 1895).

10 Waelschtirol (Prof. Dr. Joseph Damian, Trient; 12).
Only 20 observers engaged by the end of 1896, efforts continuing; 1 EQ report (included in the list for province 9).

11 Bohemia, German territory (Prof. Dr. Friedrich Becke, Prague; 191).
500 observers invited; 191, covering 171 observing sites, accepted. Density of coverage classified as 'partially satisfactory' for most of the territory but as insufficient for the Šumava Mts. (Böhmerwald) and for South Bohemia. Specific problems: less dense population, 'lower culture of engagement' of appropriate personalities. 1 EQ report – for the Brüx Nov. 3, 1896 event. Becke sent back-queries to the observers and collected materials 'sufficient for a separate seismological study of this event'. This study (*Becke, 1897*) was presented at the same session as Mojsisovics's 'Reports on the organization of earthquake observation .....' (*Mojsisovics, 1897*).

12 Bohemia, Czech territory (Prof. Dr. Johann Woldřich; 262).
Laconic statement, that thanks to the intensive efforts of Woldřich a rather evenly distributed net of 262 observers had been organized, and that no EQ report was submitted by the end of 1896.

13 Moravia and Silesia (Prof. Alexander Makowsky, Brünn; 36)
11 Silesian and 25 Moravian observers accepted the representative's invitation; statement that efforts towards a denser coverage will be continued in 1897. No EQ reported.

14 Galizia (Prof. Dr. Ladislaus Szajnocha, Krakow; 0).
No observer net organized in 1896 yet.

15 Bukovina (Anton Pawlowski, Chief Building-Councillor, Czernowitz; 0).
Organization of the observer net delayed; expectation that a 'larger number' of stations will be established in the first half of 1897.

Considering the first results given in the summary above, we can detect the degree to which the ideas formulated by Mojsisovics were realized in 1896 in the individual regions of the Austrian part of the Monarchy: in eight of them, especially in the main countries of Austria (provinces 1 and 2) and in both regions of Bohemia (German 11, Czech 12), the nets of the observers of the macroseismic earthquake effects were organized properly, with sufficient density of engaged observers. However, in some mountain regions of the Monarchy, such as Salzburg (3), Goerz and Krain (5), Waelschtirol (10) and also in the north and north-east regions, namely Moravia-Silesia, Galizia and Bukowina (13, 14 and 15), which were not much prone to earthquakes in the past, the effort to build a proper network of observers proceeded slowly in the first years, with only partial success.

Table 2. Regional representatives (reporters) for the individual provinces of the Austrian monarchy from 1896 till the beginning of World War I. After splitting of Istria & Dalmatia into separate provinces, the regions originally denoted as Nos 9–15 were newly re-numbered as No. 10–16 after 1898. The numbers in parentheses are the total numbers of years the individual reporters had been actively engaged in the project.

No.	District	1896	1897	1898	No. new	1899	1900	1901	1902	1903	1904	1905	1906	1907	1908	1909	1910	1911	1912	1913	1914
1	Nieder-Österreich	Prof. Dr. F. Noë			1	Prof. Dr. F. Noë (16)													Doz. Dr. H. Vetters (2)		—
2	Ober-Österreich	Prof. H. Commenda			2	Prof. H. Commenda (4)	Prof. P. F. Schwab (4)				Prof. H. Commenda (11)										
3	Salzburg	Prof. E. Fugger			3	Prof. E. Fugger (19)															
4	Steyermark	Prof. Dr. R. Hoernes			4	Prof. Dr. R. Hoernes (15)												Prof. F. Heritsch (4)			
5	Kärnten	F. Seeland			5	F. Seeland (4)	Prof. F. Jäger (11)											Adj. J. Bücher (4)			
6	Krain Gradiska	Prof. F. Seidl			6	Prof. F. Seidl (19)															
7	Trieste	Dir. E. Mazelle			7	Dir. E. Mazelle (19)															
8	Istria	Dir. E. Gelcich	Ing. A. Faidiga		8	Ing. A. Faidiga (18)															
	Dalmatia				9	Prof. A. Belar (16)															
9	Deutsch Tirol	Prof. Blaas	Prof. Dr. J. Schörn		10	Prof. Dr. J. Schorn (18)															
10	Italien. Tirol	Prof. J. Damian			11	Prof. J. Damian (11)								Prof. Dr. P. Zini (8)							
11	Böhmen Deutsch	Prof. Dr. F. Becke (2)		Prof. V. Uhlig	12	Prof. V. Uhlig (3)		Ing. Dr. J. Knett (14)													
12	Böhmen Böhmisch	Prof. Dr. J. N. Woldřich			13	Prof. Dr. J. N. Woldřich (9)						Prof. Dr. F. Augustin (3)			Prof. Dr. P. Počta (7)						
13	Mähren & Schlesien	Prof. A. Makovsky			14	Prof. A. Makowsky (12)									Prof. Dr. A. Rzehak (7)						
14	Galizien	Prof. Dr. L. Szájnocha (3)			15	Prof. Dr. V. Láska (5)					Prof. Dr. M. Rudski (11)										
15	Bukovina	A. Pawlowski			16	A. Pawlowski (4)	no reference			F. Haberlandt (7)							Dr. V. Conrad (5)				

5. ADVANCES OF THE PROJECT IN 1897 – 1900

Twenty-one contributions on earthquake observations in the individual provinces of the Monarchy appeared in the *Mittheilungen der Erbeben-Commission* in the last four years of the 19th century. They indicate that in all original fifteen monitored regions the situation essentially improved with the time.

Before examining the advancement of the Mojsisovics Project we must remark that the sources accessible to us contained little information about the structure and initial activities of the *Erdbeben-Commission* itself. We are not able to detect from them how and according to which selection criteria the body of the Commission was established. Also the number of Commission members and/or the names of at least some of them remain unknown. Any information about the Commission's mandate and the role it played in the nomination of the '*Referenten*' (= regional representatives, hereafter reporters) for the individual countries of the Empire according to Mojsisovics' project is missing as well.

Note: We are fully aware of the possibility that further texts on the subject carrying pertinent information might have been published also in other research journals of the time, such as, e.g., geological, geographical or astronomical periodicals. A detailed search for respective references however goes beyond the scope of this paper.

Well known are, on the other hand, the names of all reporters and the time periods of their persistence in charge, see Table 2. Sufficient information about their activities in the Project, even though probably not quite complete, by the year 1900 may be easily inferred from the 21 contributions published in the first series of the *Mittheilungen, No. I – XXI, 1897 – 1900*. Analogous information for the years after 1900 is given in the second series, the *Neue Folge* of the *Mittheilungen*, whose first issue (*No. I*) was published in Vienna in 1901.

From Table 2 we learn that two of the 15 originally appointed reporters – **E. Gelcich** and professor **Blaas** – were in charge only for one year, in 1896. Four reporters – **J. Commenda, F. Seeland, F. Becke and A. Pawlowski** – were active only during the two to four first years. Further four were active for many years from the beginning of the project in 1896 – **R. Hoernes** till 1910 and **E. Fugger, F. Seidl and E. Mazelle** until World War I. **A. Faidiga** and **J. Schorn**, who were in charge from 1897, continued till World War I as well. The remaining six reporters – regional representatives **F. Noë, J. Damian, M. Rudski, F. Jäger, A. Makowsky and J. Knett** – had been engaged in the Project for more than 10 years. In late 1898, region No. 8 managed by A. Faidiga since 1897 was split into two regions, Istria (No. 8) and Dalmatia (No. 9) in the new numbering. A. Faidiga went on as reporter for the Istria region till World War I, while the Dalmatia region was entrusted to **A. Belar**.

The major four of the first 21 issues of the *Mittheilungen* were written by **Edmund v. Mojsisovics.** In *No. I* the Project was introduced (for details see section 2(b) of chapter 4), and in *Nos. V, X* and *XVIII* the individual reports for regions 1 to 15 were summarized in the form of annual summaries on the seismicity of the entire Empire in 1897, 1898 and 1899, respectively. In the last but one report, Mojsisovics expressed special thanks to six *Referenten* – **R. Hoernes, E. Mazelle, F, Noe, F. Seidl, J. Schorn** and **J. Woldřich** – for their exemplary activities. Mojsisovics also expressed his appreciation and satisfaction with the usefulness and effectiveness of the macroseismic questionnaires disseminated among the inhabitants of the shaken regions (despite considerable efforts, no copy of the original questionnaire has been found in the Prague archives).

The remaining 17 papers of the first series of the *Mittheilungen* can be divided into three groups. In the majority of them, the individual reporters gave standard macroseismic descriptions of their region (group 1). In two of the papers (*Nos. VI* and *XV*), short lists of previous historical earthquakes in the appurtenant regions were given (group 2). In *Nos. XI, XV and XVII* (group 3), installations and the use of first seismic recording devices were described. The installations of experimental seismic instrumentation were mentioned also in the annual reports by **E. v. Mojsisovics**.

Let us now proceed to the individual papers of the first series of the *Mittheilungen.*

Two papers by **F. Becke**, *Mittheil. Nos. II* and *III*, represent typical examples of macroseismic reports of the time. The described two major earthquakes (Brüx, Nov. 3, 1896; Southern Böhmerwald, Jan. 5, 1897) are characterized by (i) the names of the localities where they were felt, (ii) the time of occurrence of the first shock, (iii) the duration of the first shock, (iv) the time between the first and following shock(s), (v) the duration of secondary shock(s), and (vi) a summarizing map-sketch of all observations.

In his third paper, *Mittheil. No. VIII***, F. Becke** compiled and statistically evaluated hundreds of macroseismic observations of the strongest events of the intensive October – November 1897 earthquake swarm in NW-Bohemia. He considered swarm earthquakes to be ‘intermittent phenomena like volcanic eruptions, sudden glacier movements, rainfalls and many other natural phenomena’, found that the frequency of occurrence of the reported shocks exhibited an apparent daytime regularity (*Periodicität,* see Fig. 2) characterized by a minimum around noon and maxima in the early morning hours (between 1 and 4 a.m.) and in the evening (between 6 and 9 p.m.), and he speculated about the possible causes of this regularity (tides, physiology of observers/reporters, atmospheric pressure, temperature).

Note: To test wether the regularity might have been more than just a subjective result for this particular swarm, *A. Boušková* (Geophysical Institute Prague, personal communication 2002) evaluated the frequency vs. daytime dependence for different time intervals (specific subswarms) of microearthquake swarms that were instrumentally recorded in the same region in December 1985 – February 1986, in January 1997, and in August – December 2000. Boušková’s results indicate that the answer to the question of possible similarity with Becke’s ‘*Periodicität*’ (Fig. 2) would be ***no*** for the 1985/86 and 1997 swarms, and surprisingly ***yes*** for the August – December 2000 swarm.

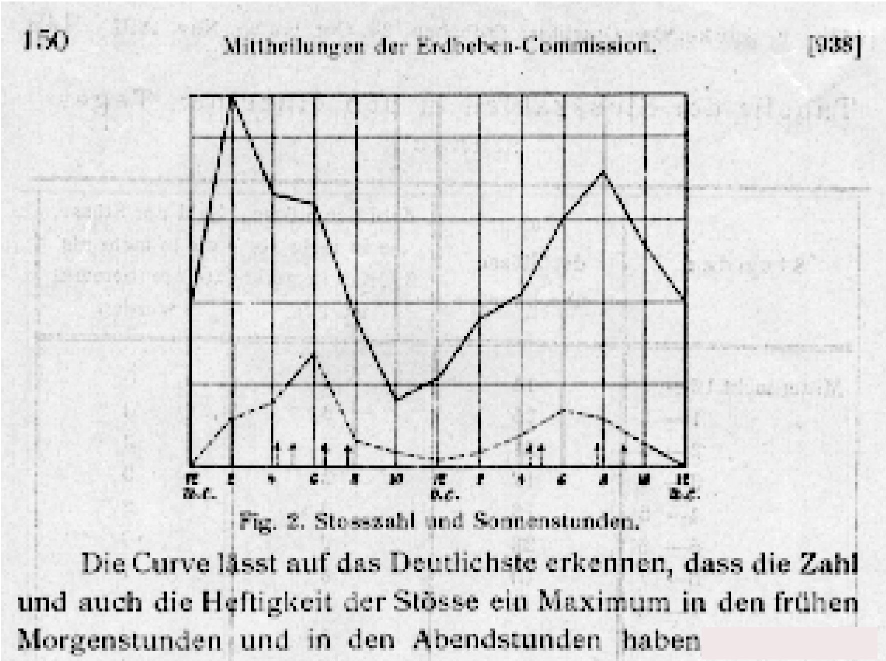

Fig. 2. Daytime regularity (*Periodicität*) in the statistics of macroseismic observations of the October 24 – November 25, 1897 earthquake swarm in NW-Bohemia after *Becke (1898)*. Full curve: total number of shocks (*Stösse*) in 2-hour intervals (all observed shocks); dashed curve: number of 'stronger' shocks in 2-hour intervals; horizontal axis: daytime in 2-hour steps from midnight to midnight; arrows: times of occurrence of 'very strong' shocks.

Four papers of the first series of the *Mittheilungen* were published by **E. Mazelle.** In *No. IV* Mazelle gives a standard macroseismic description of three earthquakes which occurred in the Trieste region in 1892. In *No. XI* he describes the installations of a Pfaundler seismoscope and of a three-component horizontal Rebeur-Ehlert pendulum seismograph (*Rebeur-Paschwitz and Ehlert, 1895*) at the astronomical and meteorological observatory in Trieste in 1898. The constants of the instruments, data on temperature and humidity changes in the recording rooms, and the arrival times and maximum amplitudes of the seismic events recorded by the latter instrument between August 1898 and February 1899 are given in this paper. In paper *No. XVII*, the same data are compiled for March – December 1899. In paper *No. XIX*, Mazelle presented the results of systematic measurement of the daily variations of the zero-positions of the Rebeur-Ehlert horizontal pendulums and of harmonic and polarization analyses of monthly and seasonal averages of these variations. As the major causes of the revealed periodicities (24-, 12- and 8-hours), Mazelle considered meteorological factors, especially the influences of daily and long-term temperature variations and of variations of precipitation activity.

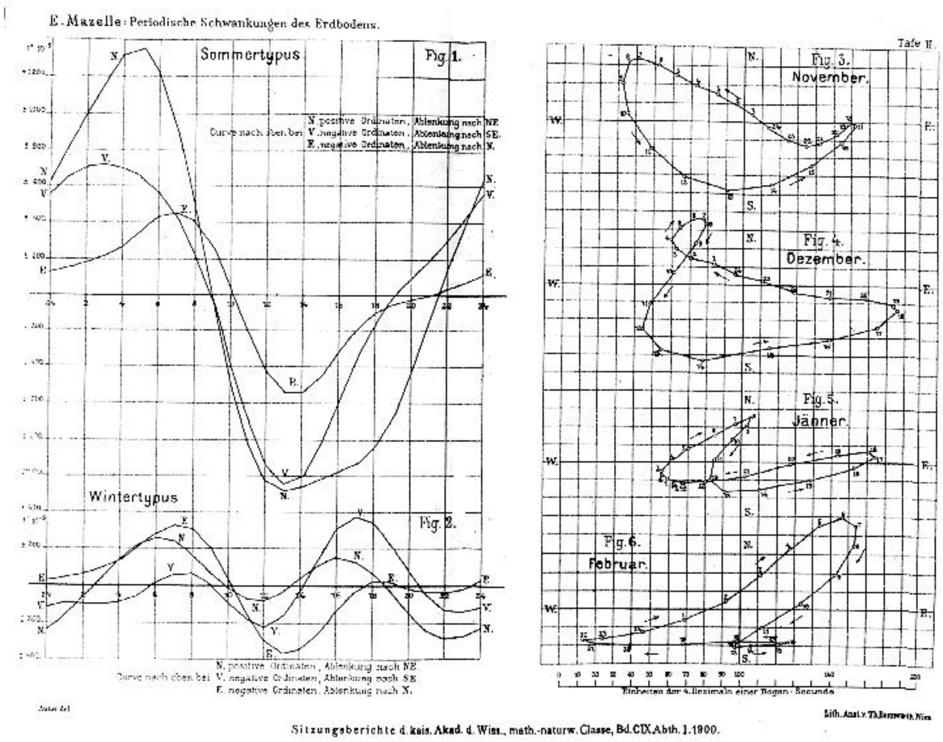

Fig. 3. Average 'periodic fluctuations of the ground' inferred by Mazelle from his September 1898 – August 1899 measurements of daily variations of the zero-positions of the three horizontal (N, E, X) Rebeur-Ehlert pendulum seismographs at the Trieste Observatory and by harmonic and polarization analyses of monthly and seasonal averages of these variations. Left-hand upper curves (*Sommertypus*): summer-time averages; left-hand bottom curves (*Wintertypus*): winter-time averages; right-hand curves from top to bottom: polarization diagrams of the monthly fluctuations from early November 1898 to late February 1899.

Note: The average 'periodic fluctuations of the ground' Mazelle inferred from his September 1898 – August 1899 data are shown in Fig. 3. At first glance, the shapes of the daily fluctuations in the winter months (*Wintertypus*, left-hand bottom part of Fig. 3) strongly resemble those of tidal tilts. However, this possibility can be excluded unambiguously since the maximum amplitudes of the observed fluctuations (200×10^{-5} degrees ~ 7 angular seconds) exceed those of tidal tilts at Trieste by almost three orders. Mazelles' unique observation series have been subjected to detailed analyses by *L. Skalský and B. Chán* (Geophysical Institute Prague, personal communication 2002).

F. Seidl contributed to the project with two papers, *Mittheil. Nos. VI* and *XII*. In *No. VI* he presented a historical earthquake catalogue of the Krain-Gradiska (Laibach) region for the time interval 1851 – 1886, compiled primarily from **K. Deschmann'**s manuscripts. Wether Deschmann prepared his manuscripts as a part of the Mojsisovics project remains unclear (according to the original proposals, it was Deschmann who was charged with the preparation of the 1855 – 85 part of the planned Austrian historical earthquake catalogues). In the other paper, *No. XII*, Seidl presented macroseismic observations of earthquakes that occurred in the Laibach/Ljubljana region between April 1898 and December 1898. The results were given in the form of tables. To explain the 1898 local seismic activities, Seidl tried to find their relation to the results of seismo-tectonic analyses presented by *E. Suess (1873, 1885)*.

In *Mittheil. No. VII*, **J. Knett** reported on the behaviour of the thermal springs in *Karlsbad* (Karlovy Vary) during the Vogtland/West-Bohemia October – November 1897 earthquake swarm. His major conclusions were three rather contradictory statements: that (i) 'there existed neither the least reason to conceal any seismological influence on the Karlsbad thermal springs', (ii) 'absolutely no link between shakings of the ground and the Karlsbad thermal springs had been observed', and (iii) 'nothing is more related to each other than earthquakes and the Karlsbad thermal springs'.

In *Mittheil. No. IX*, **J.N. Woldřich** discussed the macroseismic observations of the Mělník 'underground detonation' and of sound effects related/non-related to the occurrence of the massive landslip at *Hasenburg* (Klapý) in NW Bohemia.

Two papers by **R. Hoernes**, *Mittheil. No. XIII* and *XIV*, dealt with the traditional macroseismic description and evaluation of the Upper Steiermark earthquakes of 1898 and 1899. The main results were presented in the form of simple seismicity maps. Hoernes focused his attention especially on the statistics of foreshocks and aftershock series accompanying the main events. In the paper the effectiveness of the observational questionnaires was stressed.

In contribution *No. XV* written by **F. Schwab** (reporter for Upper Austria, successor of J. Commenda), a summary of the main historical earthquakes observed in the period 1851 – 1898 was given. In the second part of the paper, the installations of a Pfaundler seismoscope and a horizontal Ehlert pendulum in the Kremsmünster seismic observatory were described in detail. Both instruments were put in operation in 1898. In this part, Schwab also published the arrival times and maximum amplitudes determined from his earthquake recordings.

The remaining three papers (*Mittheil. Nos. XVI, XX and XXI*) of the discussed series were written by F. Noe and by J. Knett. In *No. XVI,* **F. Noe** presented a standard macroseismic description of the effects of local earthquakes composed by means of the reports of the observers of the region. Included in the report was also a macroseismic map-sketch.

In *No. XX*, **J. Knett** focused his attention on the phenomenon 'underground detonation' and on speculations about its relation to earthquakes. In *No. XXI* he reported on the macroseismic effects of the 'detonation' in the Doupov Hills of August 1899 in western Bohemia, illustrated by a sketch-map. Worth mentioning is that J. Knett published both papers already in January and June 1900 although he was not appointed *Referent* for the German speaking part of Bohemia before 1901.

6. CONCLUSION

The works accomplished within the Mojsisovics Project can be summarized as follows:

By the end of the 19th century, the works concerning the preparation of a historical earthquake catalogue for Austria (point 1 in par. 4) were initiated but not finished.

The works on point 2b of par. 4 started well in 1896, even though in some regions (14 and 15 in the original numbering in Tab. 2, partly also in regions 3, 5, 10 and 13) the desired activities began with some delay. At the turn of the century, the macroseismic service worked more or less according to the original plans.

The reporters responsible for the individual regions of the Monarchy were properly selected in the course of 1896 – 1899. Some of them, namely those for regions 1, 4, 6, 7, 11 and 12, were evaluated as exceptionally well working specialists.

Regular macroseismic service can be regarded to have been successfully established in the Monarchy in 1900.

The first seismoscopes were installed at the private astronomical observatory in Trieste in 1897 and at the seismic observatory Kremsmünster in the course of 1898. The first photographically recording horizontal pendulum seismographs (point 2a of par. 4) were installed at the *Oberrealschule* in Laibach/Ljubljana in 1897, and in Trieste in February 1899. Simultaneously, other instruments were prepared for installation in Ljubljana and Vienna. This can be claimed to have been the beginning of the instrumental era of seismological observations in the Monarchy.

We close this part with the statement that the main goals of Mojsisovics' Project were accomplished by the end of the 19th century. The dramatic development of the ideas of the Project in the following years, especially as concerns the instrumental equipment of the newly established seismic observatories, will be discussed – in the context of the variety of other European efforts – in Part II of this paper.

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