100 Years Seismological Service of Austria at the Central Institute for Meteorology and Geodynamics in Vienna/ Austria

by
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FOREWORD

With the Imperial Resolution of the 23. June 1851, Emperor Franz Joseph authorised the establishment of the "k.k. Centralanstalt für Meteorologie und Erdmagnetismus", the Central Institute of Meteorology and Geomagnetism, which can be traced back to an initiative of the Austrian Academy of Sciences. In 1848, the Academy had already formulated a request to Karl Kreil, director of the Prague Astronomical Observatory and member of the Academy, to develop a meteorological observation system for the Austrian Empire.

In 1872, the Central Institute moved to its new and final quarters, built by Heinrich Ferstel on the “Hohe Warte” grounds in Döbling, Vienna. A year later, in 1873, the Central Institute organised the first international meteorological congress in Vienna, where the International Meteorological Organisation (IMO) was founded as predecessor to the World Meteorological Organisation (WMO).

In 1895 a strong earthquake occurred in Ljubljana/Slovenia, causing massive damage to numerous buildings in the epicentre. Within two weeks, the “Erdbebenkommission” was founded and situated at the Academy of Sciences in Vienna. Because seismic observations were already carried out at the Institute at the Hohe Warte, the responsibility of the Seismological Service was officially transferred to the Institute in 1904, which also resulted in a change of name to “Zentralanstalt für Meteorologie und Geodynamik – ZAMG (Central Institute of Meteorology and Geodynamics”.

VICTOR CONRAD – FIRST HEAD OF THE SEISMOLOGICAL SERVICE

Victor Conrad 1876 – 1962

Victor Conrad was born on 25. August 1876 in Vienna. In 1896 he started to major in biology. Conrad's teacher at the University of Vienna, the physiologist Sigmund Exner, soon realised his special talent for the experiment and he insistently encouraged Conrad to study physics. Conrad's teachers among others were the physicists Franz Exner and Ludwig Boltzmann, but he attended also lectures on meteorology held by Julius Hann, Josef Maria Pernter and Wilhelm Trabert, directors of the "k.k. Centralanstalt für Meteorologie und Erdmagnetismus". Following a suggestion of Franz Exner he began to work on problems concerning "air electricity". In 1900 Conrad graduated and was employed as University Assistant at the "k.k. Centralanstalt für Meteorologie und Erdmagnetismus" in 1901.

His first scientific research tasks dealt with physical meteorology. For this purpose he carried out analyses at the Sonnblick mountain observatory. In 1905 Conrad received his *venia legendi* for Meteorology from the University of Vienna.

In 1904, the Seismological Service of Austria was established at the Institute, and Victor Conrad, previously in charge of the Ehlert-horizontal pendulum and the Vicentini-seismographs at ZAMG, was appointed Head of the new department and consequently responsible for the seismic monitoring on Austrian territory. Conrad started to organise a microseismic survey and equipped the new established seismic observatory with two Vicentini-seismographs and a new Wiechert horizontal pendulum (1000 kg) in 1905.

During a study trip to Göttingen Conrad had the possibility to discuss relevant questions with the Head of the seismic observatory, the well-known seismologist Emil Wiechert. As an outcome of this journey, a Wiechert vertical pendulum (1200 kg) was purchased

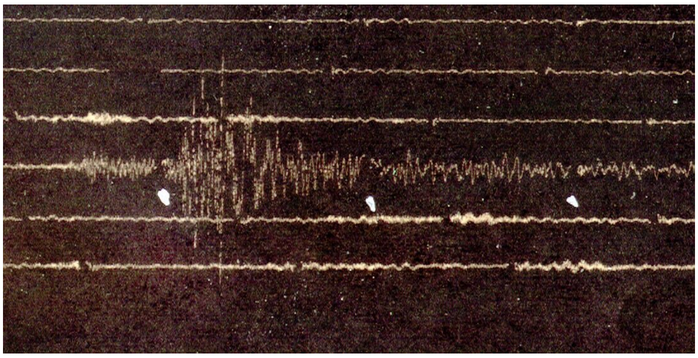
Personnel of ZAMG around 1910 in front of the Institute with the former inscription "k. k. Central-anstalt für Meteorologie und Erdmagnetismus".

1. Wilhelm Trabert, Director of ZAMG; 2. Victor Conrad; 3. Rudolf Schneider, Conrad's successor.

and put in operation in 1908 at the Hohe Warte (ZAMG). Conrad also developed an own small version of a seismograph – the Conrad-pendulum –, capable of recording stronger ground motions.

In 1910 Victor Conrad became appointed “Professor of Cosmic Physics” at the University of Czernowitz (today Ukraine, former capital of the Austro-Hungarian duchy Bukowina). From 1911 to 1914 he organised the new Institute and held lectures on “Physics of the Earth” and “Principles of Astronomy”. From 1915 on - during war service - Conrad was engaged in establishing a meteorological network from the Save and Danube to the Osum river in South Albania. This task took several years and included many journeys in more or less unknown areas of Montenegro and Albania. Conrad could later use these data for a comprehensive description of the climate of this area, and left a well operating network behind.

After the collapse of the Austro-Hungarian monarchy in 1918 Conrad was forced to leave Czernowitz at the end of July 1919, while accepting the loss of professorship and private means. He came back to Vienna, serving again as Head of the Seismological Service at the ZAMG.



EW-component of the „Tauernbeben“, 1923.

During the following years Conrad concentrated on seismological research, which culminated in his paper “Laufzeitkurven des Tauernbebens vom 28. November 1923” where he detected a further P-wave arrival leading him to suggest the Earth’s crust consists of two layers. The separation of these layers became worldwide known as the “Conrad discontinuity”.

When Conrad became editor of “Gerlands Beiträge zur Geophysik” in 1926 the journal advanced to the most important international publication for geophysical research. The success of Conrad’s editorial activities led to the establishment of an appendix to “Gerlands Beiträge zur Geophysik”: “Beiträge zur angewandten Geophysik” and the series “Ergebnisse der kosmischen Physik”.

After the loss of professorship in Czernowitz other mishaps followed: As a consequence of the Civil War in February 1934 („Februarunruhen“), Conrad - member of the social-democratic labour party - was “suspended with waiting pay”. This abnormal termination at ZAMG on 30. April 1934, he retired in 1936, meant a big loss for the Seismological Service of Austria. The “Anschluss” (Annexation) of Austria into the German Reich in 1938 caused Conrad, who was of Jewish descent, to leave Austria. He gave his last lecture at the University of Vienna in the winter term of 1937/38 on “Precipitation and sunshine on Earth”.

After the assumption of power by the Nazis, Beno Gutenberg (student of Emil Wiechert, in 1930 he became Professor of Geophysics at the California Institute of Technology) maintained his contacts with colleagues in Germany. During these pre-war years, he helped many Jewish scientists to escape from Germany, notable among these were Victor Conrad - he was 62 when he arrived in the USA - and Helmut Landsberg. Landsberg had been Gutenberg's student and was his successor as director of the earthquake service at the Taunus Observatory in Germany before he became professor at Pennsylvania State College. During his inhabitation in the USA Conrad was in steady contact with him.

From 1939 to 1940 Conrad worked at the Pennsylvania State University, Department of Meteorology. In the history of this department Conrad's research was highly appreciated *"… In the late 1930s, the Penn State Meteorology program benefited from the fifteen-month visit of a European refugee and foremost Austrian climatologist, Victor Conrad, of the University of Vienna. He not only provided intellectual stimulation, but also performed research on worldwide rainfall variabilities. In fact, he made a study of periodicities, using an uninterrupted series of temperature and rainfall data recorded at the Penn State Agricultural Experiment Station since 1880."* From 1940 to 1942 he joined the New York University, the California Institute of Technology, the University of Chicago and finally the Harvard University in Cambridge, Mass., where he worked as teacher and researcher until the age of 80.

Victor Conrad published more than 240 papers concerning Meteorology, Climatology and Seismology. He died on 25. April 1962 in Cambridge/ Massachusetts.

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HEADS OF DEPARTMENT OF GEOPHYSICS

1904 –1910	Victor Conrad
1910-1919	Rudolf Schneider
1920 –1934	Victor Conrad
1935	Anton Schedler
1936	Max Toperczer
1940 – 1943	Anton Schedler
1943 – 1964	Max Toperczer
1964 – 1974	Erich Trapp
1974 – 1991	Julius Drimmel
Since 1991	Peter Melichar

THE SEISMOLOGICAL SERVICE OF AUSTRIA

One of the frequent questions addressed to the department is “What do you do when no earthquake has occurred”? One might be tempted to reply “What’s the use of a fire brigade, if it’s not burning”? The answer might sound similar: “Preparation and introduction of preventive measures to mitigate losses”. This approach requires research and development of new methods and techniques as well as continuous activities to maintain international standards and requirements.

Victor Conrad laid the foundation for the first seismic network in and around Austria. Despite several instruments at hand, such as two “Wiechert seismographs”, the main source of information regarding earthquakes consisted of macroseismic reports of the public at that time, which were painstakingly evaluated, to make up for the sparseness of the seismic network. These seismograms had to be collected from seismic stations via surface-mail, taking sometimes few weeks to arrive in Vienna for analysis.

During the Second World War, most seismic stations were damaged or destroyed. It took many years to recover from these losses, and to repair the remaining instruments. In the 70’s new seismometers were installed again on Austrian territory, such as in Molln in Upper Austria (1975) and the Kölnbrein Barrage in Carinthia in 1979. The earthquakes in Friuli in 1976 resulted in an enhanced interest in the nature of earth tremors and their effects, culminating in the first building code for earthquake resistant building design in Austria.

Since the introduction of four digital seismic stations in Tyrol in 1989 and capabilities to transfer data to the Seismological Centre at the ZAMG in Vienna in real-time, fast evaluations of tremors worldwide became possible. Hazard studies became state of the art during this time, and the Seismological Department was requested in 1993 (Österreichische Staubeckenkommission) to calculate a hazard map according to worldwide standards. This work formed the basis for the first building code adhering to EUROCODE-8 standards for earthquake resistant buildings in 1997 in German speaking countries. In 2002 a further revision of the building code was accomplished, which serves now as National Application Document for the EUROCODE-8 for Austria (ÖNORM B 4015).

Historical Earthquake Research became prominent during the “Zwentendorf” dispute, questioning the suitability of the selected site of the planned nuclear power plant near Zwentendorf in Lower Austria. Research in historical earthquakes has flourished since then, culminating in an extensive research project covering Styria and parts of Slovenia (former parts of the Austro-Hungarian Monarchy), and in a study concerning Lower Austria, which is conducted at the moment. Those investigations are capable to alter hazard studies to quite an extent, for recurrence times of crucial events can hardly be estimated from data based on the recent past, that is 100 years, since when more conclusive material is at our disposal. In addition, geologists become more and more interested in the data, which provide ample information about the current state of kinematics in the Alps.

More than 50% of all tremors recorded in Austria can be attributed to man-made explosions. These data need to be carefully treated for they must be excluded when calculating a seismo-tectonic hazard. However, they must be analysed and flagged in the database accordingly on a continuous basis. Besides, all other recorded events from remote regions must be investigated. For one, to decide whether they locate on Austrian territory, and to decide if the event might be of international concern. Catastrophic earthquakes must be interpreted immediately in order to permit rescue forces to be informed in time. Every hour of delay in information reduces the chance to rescue earthquake victims.

Another very practical application concerns the verification of nuclear tests. The Department of Geophysics of the ZAMG acts as National Data Centre (NDC) for the Comprehensive Test Ban Treaty Organization (CTBTO). Hence, the Seismological Division is also requested to report to the Ministry of Foreign Affairs (BMAA) suspicious seismic recordings on demand.

All of these activities are carried out in the background, and might answer the question “What do you do when no earthquake has occurred”? There will be always seismic tremors, whether of tectonic origin or not, somewhere.

The tectonic regime, earthquakes, landslides, induced seismicity, explosions, or simply carrying out studies for earthquake-resistant building design, require permanent monitoring and the analysis by the Seismological Service of Austria.

SEISMICITY IN AUSTRIA

Earthquake activity in Austria is normally limited to certain regions. More than hundred earthquakes caused damage to buildings in Austria since 1201 A.D. One of the latest earthquakes of this kind occurred southeast of Vienna in Seebenstein on 16. April 1972 resulting in widespread damage to buildings even in Vienna. Only recently, on 11. July 2000 the Vienna Basin was again shaken by a stronger earthquake, which damaged many buildings in the epicentre “Ebreichsdorf” south of Vienna.

Considering all earthquakes, which were registered since 1900, we are able to outline Austria's seismo-tectonic active regions. The main regions are the

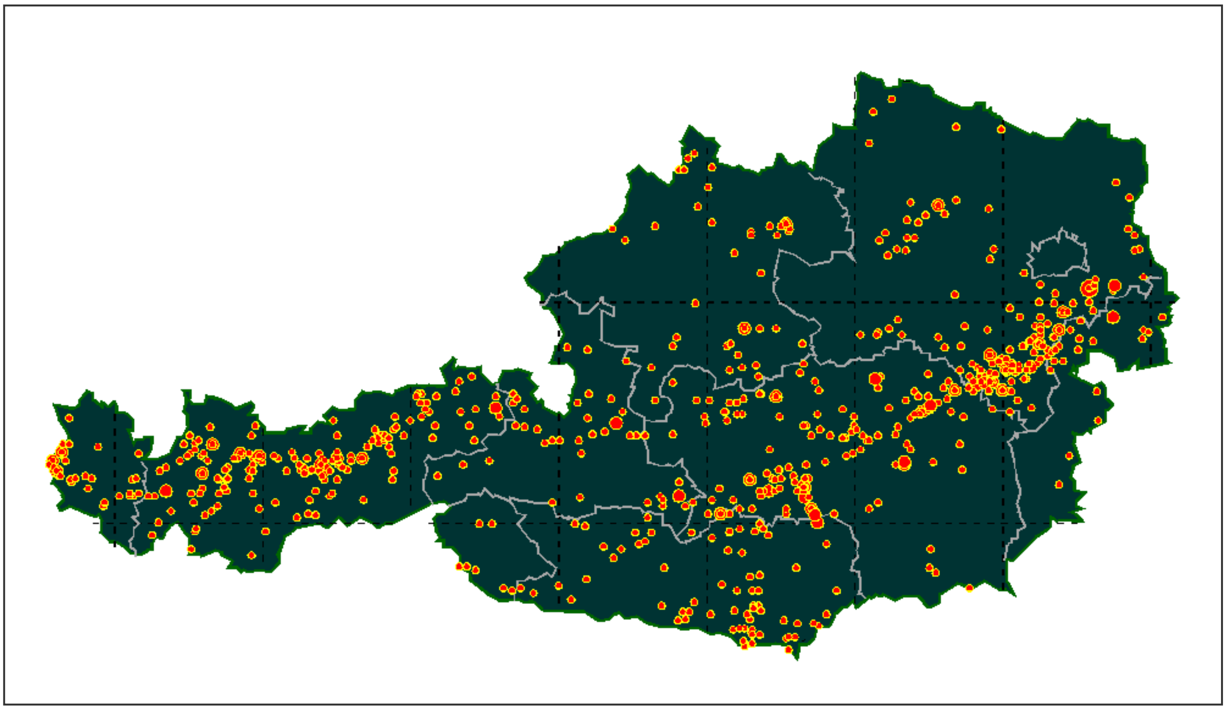
- Mur-Mürz Valley,
- Vienna Basin, and the
- Inn Valley

Major earthquakes in historical times resulting in massive building damage on Austrian territory are known to have happened near Innsbruck (1572, 1670, 1689), in the region of Katschberg (1201), Neulengbach (1590), Schwadorf (1927), near Wiener Neustadt (1768), Leoben (1794), Kindberg (1267, 1885), but also from adjacent areas outside of Austria (e.g. Friuli, 1348).

On average a magnitude M > 3 earthquake occurs in Austria every 2-3 months, a magnitude M > 4 earthquake every 1-2 years and an earthquake exceeding a magnitude of M = 5 every 10 - 15 years.

The focal depths of earthquakes in the Alpine region range from 2 to 20 km but concentrate between 6 and 10 km. Shallow earthquakes having a focal depth of 4 km are known from Pregarten in Upper Austria, where relatively small magnitudes lead already to rather large effects on surface. During the recently concluded project "Alpine Carpathian Online Research Network" (ACORN) not only data regarding past seismic tremors could be gathered from the Bohemian Massif but also faults could be traced at depth horizons which are usually not accessible. In the area of Pregarten these faults seem to terminate at a depth of 4 km thus explaining this phenomenon.

Other regions of past seismicity could also be successfully correlated with fault traces derived from gravity data, thus shedding some light on mechanisms of historical earthquakes like Neulengbach (1590) and Molln (1967).



More than 2000 earthquakes were felt in Austria since 1900.

Future plans include the automatic evaluation of macroseismic data, which are based on information received from the public via electronic mail (please make use of the questionnaire at www.zamg.ac.at/fix/beb-meld.htm in case you felt an earthquake in Austria), historical earthquake research to complete the earthquake catalogue, and improved signal detection for easier analysis of the nature of seismic tremors. The latter is important for the distinction between man-made seismic tremors (e.g. explosions) and tectonic earthquakes.

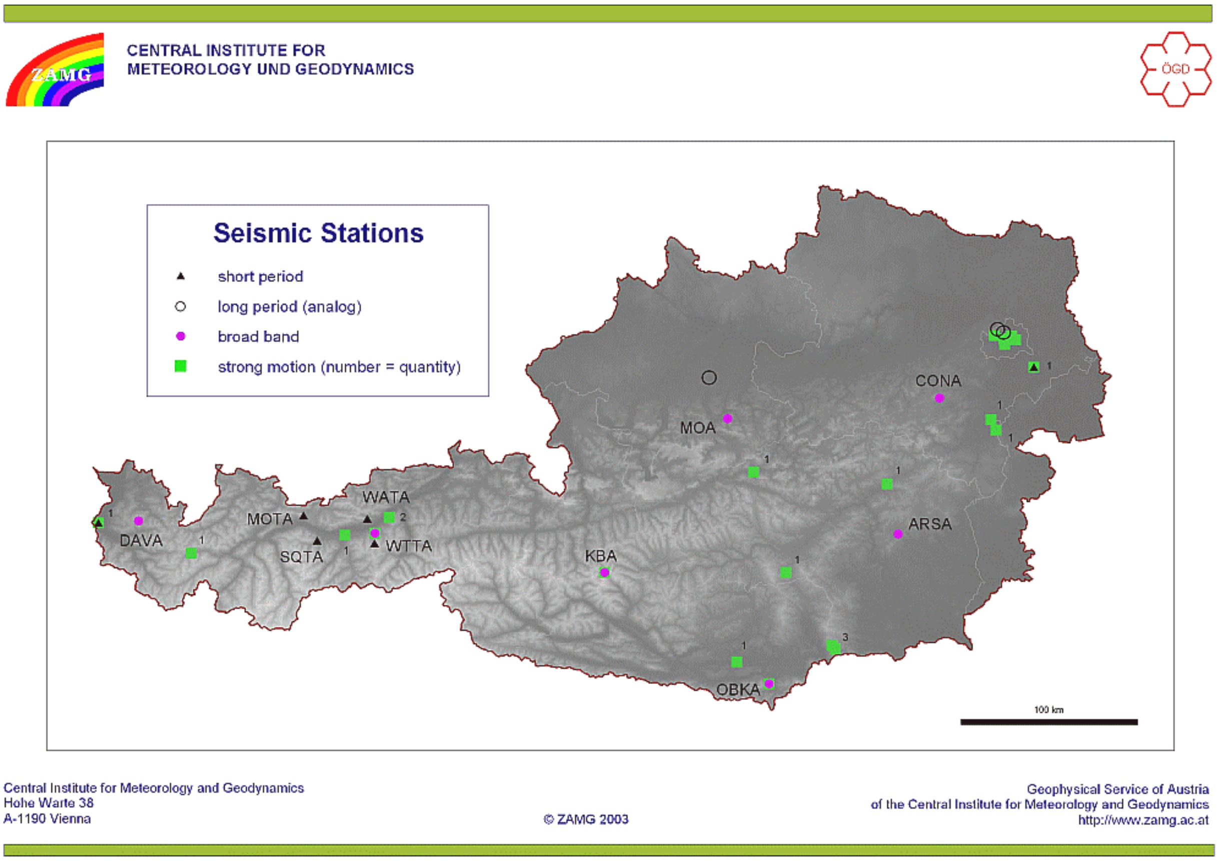
For a list of recently located earthquakes in and around Austria see also our homepage www.zamg.ac.at/quakemap.

SEISMIC NETWORK IN AUSTRIA

The “Zentralanstalt für Meteorologie und Geodynamik” – ZAMG - maintains the complete network of Austria. Seismological and technical demands have to be met by the staff of the Austrian Geophysical Service. To enhance the accuracy of locations and determinations magnitudes – and subsequent scenario estimates – thirteen agreements for real-time data exchange were signed since 2001. This exchange enables Austria to utilize stations abroad for improved tremor locations, - a vital achievement, when considering the needed location accuracy for establishing accurate scenarios.

All our broadband stations are also accessible by research institutions. Strong-motion and short-period stations add to these records, giving us an improved idea of what might have happened shortly after a tremor occurred. The Seismological Service still releases only messages confirmed by the seismologist on duty within an hour after the event was recorded. For local earthquakes in Austria, this process starts already 10 seconds after the event, but requires a review; otherwise wrong conclusions could be born, which would result in false alarms.

The seismic network of Austria consists of seven broadband stations, six short-period seismometers and 23 strong-motion sensors in Austria as well as four analogue stations. Because of their extreme sensitivity, the most important instruments are the group of broadband seismometers. They permit to record even very weak signals down to microcosms, which are generated by pressure systems on the oceans. Due to the sensitivity of these instruments, all stations are installed remote from villages and travelling routes.



THE CONRAD OBSERVATORY

The Conrad Observatory is named after Victor Conrad (1876 – 1962).

Conrad Observatory

The Observatory serves seismological, gravimetric and geomagnetic observations as well as research and development purposes. The Observatory is located about 50 km southwest of Vienna, within a nature reserve at the outskirts of the Eastern Alps, at the so-called “Trafelberg” in Lower Austria at 1044 m above sea level. The remoteness of the location and the undisturbed surroundings of the underground-observatory allow special investigations and long term research projects to be conducted, - tasks, which will gain importance in the near future.

It is the only Geophysical Observatory situated in the Alpine orogene. The site is characterized by extreme low background noise – natural as well as technological ones. In addition, the design as underground observatory reduces the surface vibrations once more. An almost constant temperature in the tunnel and in the adjacent boreholes contributes to the high quality of measurements. No ventilation system is required, which would introduce unnecessary vibrations again.

The underground building-compound of the Observatory has its own power-supply, and is connected via data-transmission lines with the Department of Geophysics at the Central Institute for Meteorology and Geodynamics (ZAMG) in Vienna. Via a remote control system, the operations of all instruments, power-supply, temperature, access to the facilities, etc. can be checked and regulated if necessary.

As already mentioned, the Observatory serves different geophysical disciplines. One of them is Seismology, the science of earthquakes. Understandably, research results in seismology are very strongly influenced by the quality of the seismic system, which is employed to monitor extreme small movements of the ground.

The Observatory can be used to

- monitor the world-wide seismicity with its seismic stations
- monitor underground nuclear tests
- calibrate seismometers
- develop and test new systems
- compare the performance of different instruments

under controlled conditions. These comparisons are necessary to ensure correct long-term observations of changes in the Earth crust, which can only be accomplished with monitoring systems, which perform extremely reliably during the whole period of observation.

In addition, the direct comparison of monitoring the ground movement in a borehole and on a pier in a tunnel lends itself to develop new systems and to improve their performance. In combination with an on-line connection with other research institutions, international development experiments can be carried out. The CTBTO – Comprehensive Test Ban Treaty Organization - is already using this facility for the training of operators of the International Monitoring System (IMS), and for experimental purposes such as the Global Communication System (GCI). The other discipline concerns gravimetry, the science of gravity measurements. Changes of the gravitational field of the Earth are due to tidal forces exerted by the moon, sun and the planets but also uplift or subduction of parts of the Earth's crust, and hence express geodynamical processes which can be monitored with highly sensitive devices. One of these devices, a supra-conducting gravimeter GWR C025 of which only 20 exist world-wide, is used by the Department of Geophysics and the University of Vienna to measure these gravitational forces. The device exhibits only an extreme small drift and the accuracy of the measurements is outstanding. Results from this equipment are already used in the Global Geodynamical Project (GGP). The combination of measurements at different places from several international institutions allows us to study the resonance period of the Earth, which depends on the complete structure of the Earth. In addition, non-periodic signals due to atmospheric and environmental changes – such as rain clouds or ground water variations or changes of the sea level - are also monitored. The GGP-project entered its second phase in 2003.

Finally, within the scope of geomagnetism, the development of new observation methods and systems for the three-dimensional determination of the geomagnetic field originating from natural and industrial sources can be studied with the new Observatory. Further, smallest changes of the earth-magnetic field prior and after earthquakes can be verified. Since the biosphere gained increasing importance during the past decades, the research of the static and alternating magnetic field can be investigated, as well as the physics of the high atmosphere. In the latter case, disturbances of the Earth's magnetic field due to effects from solar activity on telecommunications, navigation systems, power supplies and security-systems have attracted increased attention recently.

Due to the combination of seismological, gravitational and geomagnetic research, the Conrad Observatory near Vienna constitutes a unique laboratory for European and international research and development tasks within Austria.

On 23. May 2002 the Conrad Observatory, construction stage I (Seismology and Gravimetry) was opened officially by the Federal Ministry Elisabeth Gehrer and the Governor of Lower Austria, Dr. Erwin Pröll.

A live-seismogram and a short description of the Conrad Observatory can be found on the Internet at www.zamg.ac.at/geophysik/live_seis.