Institute of Rock Structure and Mechanics of the Czech Academy of Sciences

ANNUAL REPORT 2022

Translation

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Discussed by the Supervisory Board: 30 May 2023

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Prague, 19 June 2023

For informative purposes only. The legally binding text is the one in Czech.

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I. Information on the composition of the statutory bodies of the Institute of Rock Structure and Mechanics of the Czech Academy of Sciences (IRSM of the CAS) and the activities there of

Composition of the Institute's statutory bodies

Director:	RNDr. Josef Stemberk, CSc., until 31 May 2022 RNDr. Filip Hartvich, PhD., from 1. June 2022

Board of the Institute:

Chairman:	RNDr. Josef Stemberk, CSc.
Vice-chairman:	Mgr. Martina Havelcová, PhD.
Internal members:	Ing. Olga Bičáková, PhD., Mgr. Jan Blahůt, PhD., RNDr. Jiří Málek, PhD., RNDr. Josef Stemberk, CSc. doc. Ing. Tomáš Suchý, PhD. RNDr. Petra Štěpančíková, PhD.
External members:	Mgr. Jiří Adamovič, CSc., (Geological Institute of the CAS), Prof. RNDr. Tomáš Fischer, PhD. (Charles University Prague, Faculty of Natural Sciences), doc. Ing. Jaroslav Kloužek, CSc. (University of Chemistry and Technology Prague) Ing. Pavel Kriegsman, (KM, s.r.o.),

Secretary to the Board: Doc. RNDr. Pavel Straka, CSc., DrSc.

Supervisory Board:

Chairman:	RNDr. Pavel Krejčí, CSc. (Institute of Mathematics of the CAS)
Vice-chairman:	Mgr. Lucia Fojtíková, Ph.D. (Institute of Rock Structure and Mechanics of the CAS)
Members:	doc. RNDr. Bohdan Kříbek, DrSc. (Czech Geological Survey) doc. Ing. Jakub Kostelecký, PhD. (from 1 May 2022) (Faculty of Civil Engineering CTU in Prague) prof. RNDr. Jakub Langhammer, PhD. (Charles University Prague, Faculty of Natural Sciences) Ing. Radek Sedláček, PhD., (Faculty of Mechanical Engineering CTU in Prague),
Secretary to the Board:	RNDr. Filip Hartvich, PhD., until 12 June 2022 RNDr. Jakub Stemberk, PhD., from 13 June 2022

Activities of the Institute's statutory bodies

Director:

- On June 1st, Dr. Filip Hartvich assumed the position of director of the institute. Director issued a total of 8 organisational communications and 4 instructions during 2022. Meetings were held on a monthly basis between the Institute's management and heads of department.

- Contracts were concluded for 2 new Czech Science Foundation (GA CR) projects.

- The publication activities of the Institute's researchers were assessed in the form of a competition and the results subsequently published.

- Members of the International advisory board visited the institute in October, as part of the visit there were presentations of the institute's individual departments and meetings with department heads and the institute's management. Issues of the professional level of the department, the current situation of the institute and the possibility of its further scientific development were discussed,

- A new plan to take over the Department of Physical Properties of Rocks of the Institute of Geology of the CAS as a new laboratory from 1 January 2024 was submitted and approved by the Board of the Institute.

- Based on a request submitted by the heads of the Institute's scientific departments, attestation proceedings were initiated concerning a number of IRSM researchers.

- Construction work was started on the emergency reconstruction of the cellars in building Cb.

- Project for the realization of the photovoltaic power plant on the roofs of institute buildings was started.

Board of the Institute:

The Board of the Institute held five regularly-scheduled meetings during 2022:
18 January, 4 March, 31 March, 16 May and 25 October.

- 18 January - The election of the chairman and vice-chairman of the board of the institution took place. Dr. Josef Stemberk was elected as the chairman and Dr. Martina Havelcová as vice-chairman. The preparation of, and procedure to be applied for the election for the position of director of the institute was also discussed.

- 4 March - The following issues were discussed: proposals for the post of institute director of two candidates: Dr. Hartvich and Dr. Schnabl. Dr. Hartvich was proposed as director of ÚSMH for the upcoming term based on the discussion and secret election. The institute´s financial statements of the 2021 were discussed.

- 31 March - The following issues were discussed: the fulfilment of the budget in 2021 and the IRSM draft budget for 2022 were approved. The equipment investments,
the division of institutional tasks and the method of supporting CzechGeo's research infrastructure were discussed.

- 16 May - The Board approved the transfer of the institute's financial activities results to the Reserve Fund. The Acontip company audited the financial statements of the IRSM for the year 2021, no misconduct in the Institute's activities and management were found. The IRSM Annual Report for 2021 was preliminarily assessed and commented on.

- 25 October - The Board noted of transfer of Department of Physical Properties of Rocks of the Institute of Geology of the CAS to the IRSM next year as part of the Department of Engineering Geology. The Board discussed preliminary information about the workplace, its reconstruction, equipment and content of work to date.

Supervisory Board:

In accordance with the Rules of Procedure, the Supervisory Board met twice in 2022, and discussed of 8 total issue via letter. The Board was provided with the institute's financial activities results, its 2021 Annual Report and the budget for 2022.

The first meeting of the Board, held on 13 June 2022, included the verification and approval of the minutes of the 2nd February 2021 meeting, a discussion on the disbursement of the IRSM budget in 2021 and the outlook for 2022, and a discussion on, and the noting of, the financial and auditor's reports for 2021. Further, the Board discussed and approved the Report on the Activities of the IRSM Supervisory Board for 2021 and the IRSM 2021 Annual Report. The activities and results of the IRSM were discussed and the Board was informed of organisational changes and scientific and management issues. A draft assessment of the director of the IRSM was discussed and subsequently approved. Results of postal votes no. 1/2022, 2/2022, 3/2023 were approved. The members of the Board were introduced to the new Secretary of the Board, Dr. Jakub Stemberk, who took over the agenda after the outgoing Secretary Dr. Hartvich. The Board members also thanked the former director of IRSM Dr. Josef Stemberk for his contribution to the development of the Institute.

At its second meeting, which took place on 12 December 2022, the Board verified and approved the minutes of the January 2022 meeting no. 1/2022 and postal votes no. 4/2022, 5/2022, 6/2022, 7/2022 and 8/2022. The Board also discussed the disbursement of the budget in 2022 and the outlook for 2023. The Board was informed by the Director of transfer of Department of Physical Properties of Rocks of the Institute of Geology of the CAS to the IRSM next year as part of the Department of Engineering Geology. The Board was also informed about the intention of building a photovoltaic power plant on the roofs of the institutional buildings.

During 2022, the Board discussed and approved 8 draft resolutions by letter with concern to:

1) contract extension between the Masaryk Institute and Archives of the CAS (MIA CAS), accepted on 21 January 2022
2) conclusion of a lease agreement for the lease of offices between IRSM and the MIA CAS, accepted on 28 March 2022
3) lease of warehouse space owned by USMH to Dr. Zdeněk Němec according to the lease agreement presented, accepted on 28 March 2022
4) lease of non-residential premises owned by USMH to Mr. Roman Nusl according to the lease agreement presented, accepted on 22 July 2022
5) conclusion of Addendum No. 1 to the agreement on the lease of parking spaces between IRSM and the Jan Kanytur Company and the conclusion of Addendum No. 3 to the agreement on the lease of non-residential space used for business between IRSM and the Jan Kanytur Company, accepted on 5 August 2022
6) conclusion of the contract for the ACONTIP, s.r.o company as the financial auditors of the IRSM for 2022, accepted on 10 October 2022.
7) conclusion of 17 addendum to lease agreements, accepted on 12 December 2022, conclusion of 3 settlement agreements and 5 lease agreements between IRSM and individual tenants, accepted on 12 December 2022

II. Information on changes to the Institute's charter

No changes were made to the Institute's charter during the year.

III. Evaluation of the Institute's main activities

1. Results of the Institute's scientific activities

The scientific activities of the Institute were performed in the context of the Long-term Research Organisation Conceptual Development Project, no. RVO 67985891 and concerned both research in selected geoscientific fields and the socially desirable research of materials.

- **Geoscientific research:**

The study of the properties of rocks employing instrumental methods and the research of rocks focusing on the conditions for the emergence of natural and induced geodynamic processes and activities in the upper layer of the earth's crust, namely:
- processes that threaten the stability of the earth's surface and the minimisation of their adverse impacts;
- the monitoring and study of the propagation of seismic waves in various rock environments;
- the monitoring and analysis of slope and tectonic movements;
- the study of the paleo-stress conditions in the Czech massif;
- the study of neo tectonic phenomena in the Himalayas and Turkey.

- **Materials research:**

The study of raw materials and organic and inorganic materials focusing on their origin and properties and with regard to their use in the medical, glassmaking, construction and environmental technology sectors, namely:
- the preparation and research of the properties of collagen materials for use in the field of vascular surgery, the modelling of smelting processes, the development of new smelting facilities and the vitrification of radioactive waste;
- the preparation of special glass materials that are permeable to infrared radiation and the characterisation thereof;
- the development of hybrid composites with reinforcement for lightweight roofing purposes;
- the preparation of new geopolymer composites aimed at reducing the ecological burden;
- the development of technologies for the heat treatment of sludges, biomass and plastic waste.

The Institute achieved a number of significant research results during the year via international cooperation, especially with foreign research institutions, cooperation with domestic research facilities, universities and other institutes of the Academy of Sciences of the Czech Republic and cooperation with industrial organisations (Asron, s.r.o., Devro, a.s., UJP Praha, a.s., DIAMO, ŘSD ČR, Energoprůzkum Praha, s.r.o. SÚRAO, etc.).

One outcomes are described below as example of successful international cooperation:

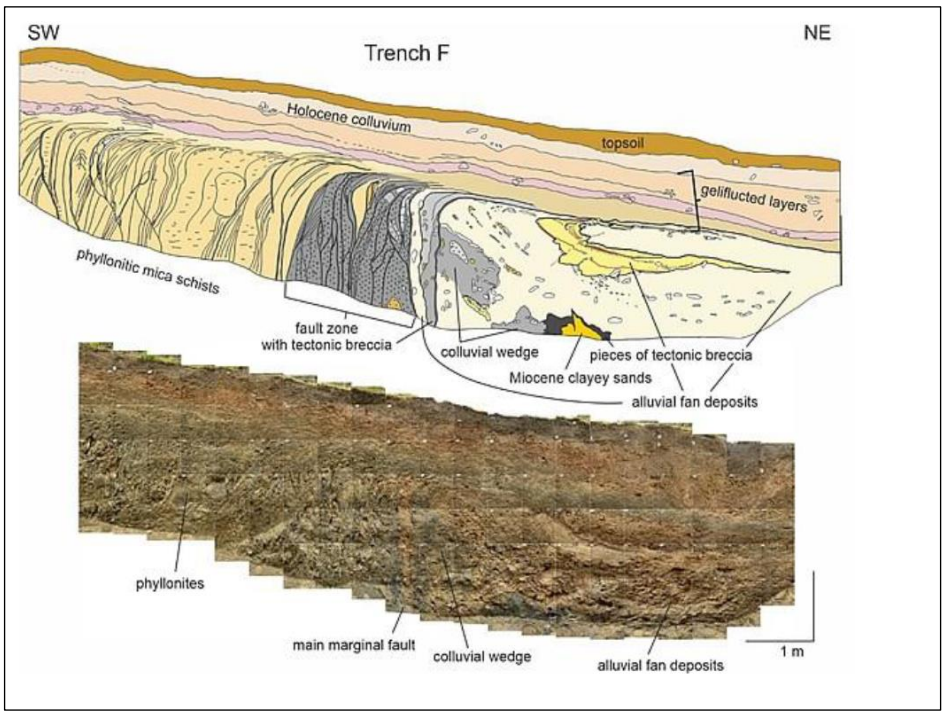
1) **The discovery of acceleration of movements on the marginal Sudeten fault at the end of the Pleistocene caused by the loading of the earth's crust by the continental glaciers. Repeated large earthquakes at the end of the Pleistocene have been detected.**

Summary:
Paleoseismic exploration on the Sudeten marginal fault using several dating methods and geophysical survey revealed repeated earthquakes at the end of the Pleistocene. Because the left-laterally displaced alluvial cone exhibited large rates of movement on the fault, mathematical modelling of crustal loading and deformation by a continental glacier was used. Due to the temporal coincidence of increased crustal stresses by its loading and the occurrence of large earthquakes and accelerated motions, their causal relationship was proposed.

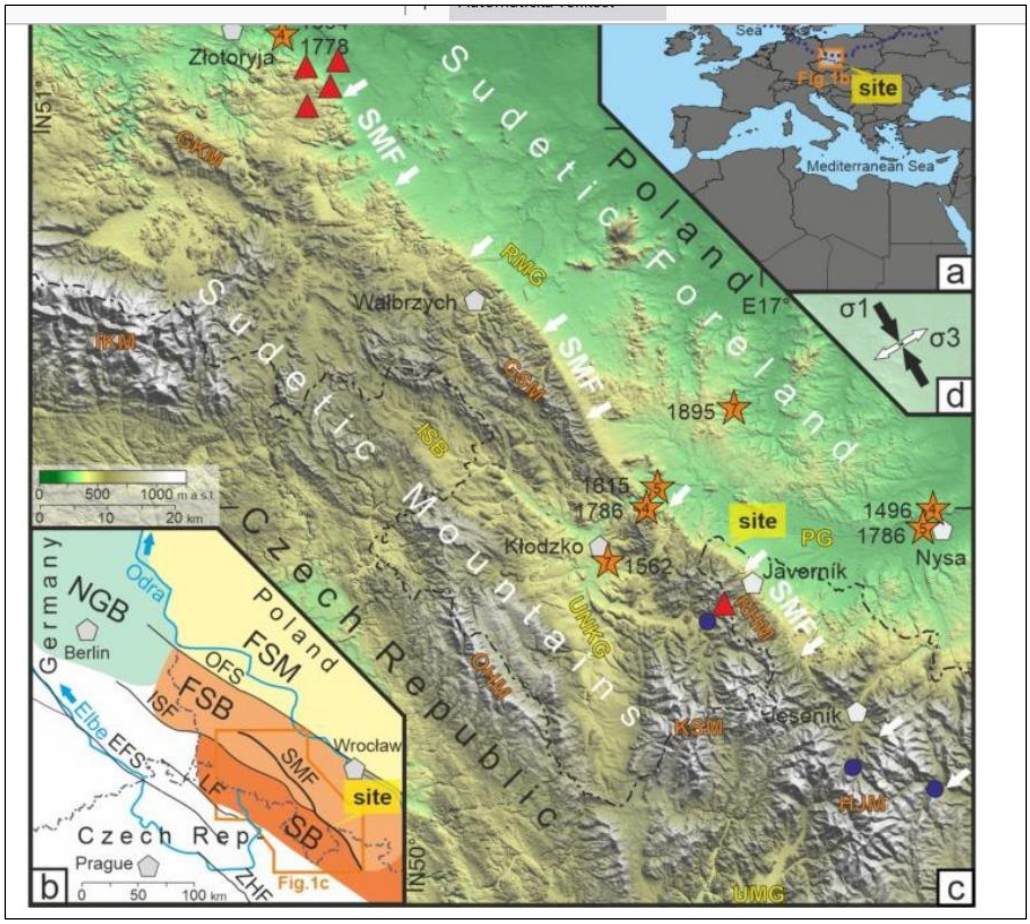
The result was achieved in collaboration with San Diego University, California; University of Sheffield, University of California Los Angeles; Louisiana State University; Queen's University, Kingston/Ontario Canada; Imperial College London; The Hebrew University of Jerusalem; University of Barcelona; Comenius University in Bratislava, Slovakia.

Publication:
Štěpančíková P., Rockwell T. K., Stemberk Jakub, Rhodes E. J., Hartvich F., Luttrell K., Myers M., Táborík P., Rood D. H., Wechsler N., Nývlt D., Ortuño M., Hók J. (2022): Acceleration of Late Pleistocene Activity of a Central European Fault Driven by Ice Loading. Earth and Planetary Science Letters, Volume 591, 117596.
DOI: https://doi.org/10.1016/j.epsl.2022.117596

Illustration:
The figure shows the geological profile of the southeast exposed wall of Trench F and the corresponding photo mosaic of the same below. The fault zone separates the crystalline SW from the sediments of the alluvial cone (NE). Colluvial wedges containing tectonic breccia and tectonic clay (black clay), which must have fallen from the exposed fault zone, indicate that they were deposited after rapid movements on the fault and are thus evidence of large earthquakes. (image on the following page)



The Following figure shows the location of the site of interest on a map of Europe, a simplified tectonic map, a relief map of the Sudetenland and the stress current field from the focal mechanism.



a) Site location on the Europe map. Blue dotted line shows Last Glacial Maximum (LGM) ice sheet extent (Ehlers et al., 2011); **b)** Simplified tectonic map modified after Scheck et al. (2002). Main faults and fault zones: EFS – Elbe fault system zone, ISF – Intra-Sudetic main fault, LF – Lužický fault, OFS – Odra fault zone, SMF – Sudetic Marginal fault, ZHF – Železné hory fault; Main geological units: BM – Bohemian Massif that includes also FSB and SB, FSB – Fore-Sudetic block, FSM – Fore-Sudetic Monocline, NGB – North German basin, SB – Sudetic block; **c)** Relief map of the Sudetes using SRTM (resolution 30 m; Farr (eds.), 2007). Orange stars: epicenters of historical earthquakes with intensity (I0) and year; Rectangles: Tertiary volcanoes; Blue dots – thermal and mineral springs; Basins: ISB – Intra-Sudetic Basin, PG – Paczków Graben, RMG – Roztoki–Mokrzeszow graben, UMG – Upper Moravia Graben, UNKG – Upper Nysa Kłodzka Graben. Mountains: GKM – Góry Kaczawskie Mts., GSM – Góry Sowie Mts., HJM – Hrubý Jeseník Mts., OHM – Orlické hory Mts., IKM – Izera – Krkonoše Mts., KSM – Kralický Sněžník Mts., RHM – Rychlebské hory Mts./Góry Złote Mts; **d)** current stress field from focal mechanism adopted from Špaček et al. (2006).

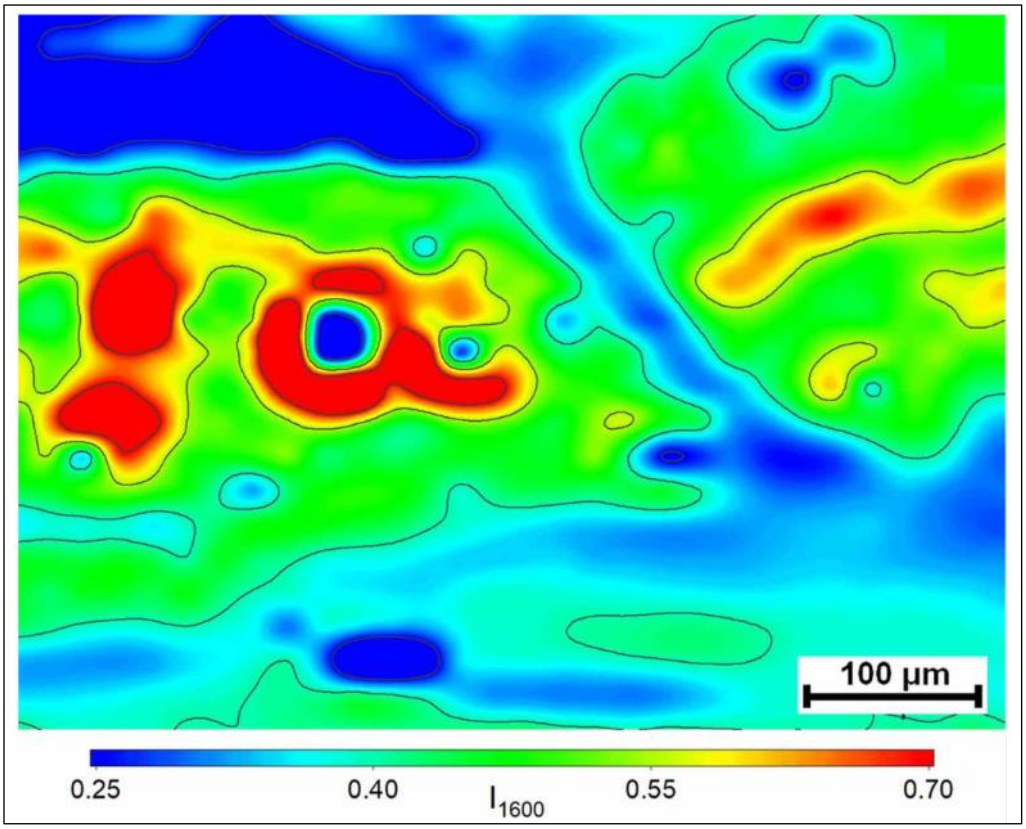
As an example of **cooperation with universities and institutes of the Czech Academy of Sciences**, we present the following result:

2) **Chemical character and structure of uraniferous bitumens (Vrchlabí, Czech Republic). Characterization of chemical and structural changes induced by radiation in naturally occurring black shale uraniferous bitumens.**

Summary:
Black shales from the Permian rocks at Vrchlabí in the Krkonoše Piedmont Basin (Czech Republic) contain bitumens with uraninite grain inclusions and bulk uranium concentrations up to 4.8 wt%, determined by instrumental neutron activation analysis. . Detailed characterisation of the radiation-induced chemical and structural changes in the naturally occurring uraniferous bitumens will contribute to the general understanding of the nature and behaviour of organic matter in other uraniferous environments or in the radioactive waste repositories.

Publication:
Vladimír Machovič, Martina Havelcová, Ladislav Lapčák, Jiří Mizera, Ivana Sýkorová (2022): Chemical character and structure of uraniferous bitumens (Vrchlabí, Czech Republic). International Journal of Coal Geology, Volume 264, 104137.
DOI: https://doi.org/10.1016/j.coal.2022.104137

Illustration:
Infrared mapping of a uranium bitumen sample with a uranium concentration of 35535 ppm provided a record that was calculated based on the intensity of the C=C aromatic bond band (~1600 cm-1). It shows a heterogeneous chemical structure, distinguishing between regions of higher (yellow and red) and lower (green and blue) aromaticity, and highlighting the highest aromaticity (red) in the region of halos around uranium inclusions.



As an example of **applied research**, we present the following result:

3) Slow pyrolysis of waste polyethylene terephthalate (known as PET) yielding paraldehyde, ethylene glycol, benzoic acid and clean fuel

Summary:
The waste PET is produced by low-temperature slow pyrolysis (i) paraldehyde, which is used in medicine to treat convulsions, for good sleep and falling asleep and as a safe sedative for calmness and relaxation, (ii) ethylene glycol for antifreeze, (iii) preservative (iv) pure fuel. An important technological step is to avoid unwanted agglomeration of the PET waste fraction during heating, which would make melting and degradation of PET more difficult. Higher heating rates during the 20-200 °C (40 °C/min-1) phase have been found to provide rapid drying of the particles, preventing agglomeration of the flakes and facilitating their melting. Waste PET can thus be completely and efficiently processed into useful products after thermal activation.

Publication:
Pavel Straka, Olga Bičáková, Monika Šupová (2022): Slow pyrolysis of waste polyethylene terephthalate yielding paraldehyde, ethylene glycol, benzoic acid and clean fuel. Polymer Degradation and Stability, Volume 198, 109900.
DOI: https://doi.org/10.1016/j.polymdegradstab.2022.109900

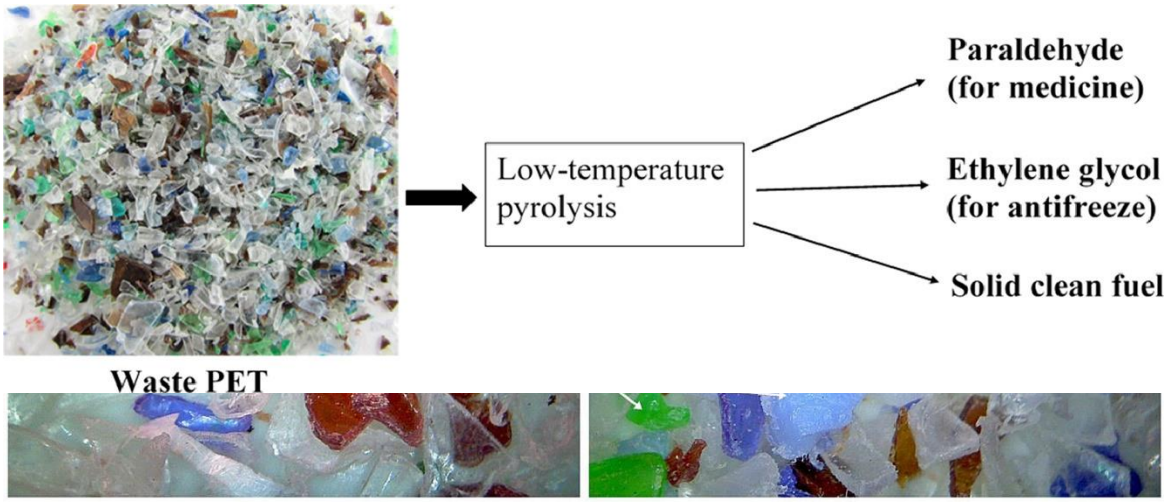


Illustration:

Waste PET flakes before and after heating to 200 °C at a heating rate of 40 °C min−1. The photo on the right shows the creation of turbidity; no agglomeration of flakes occurred.

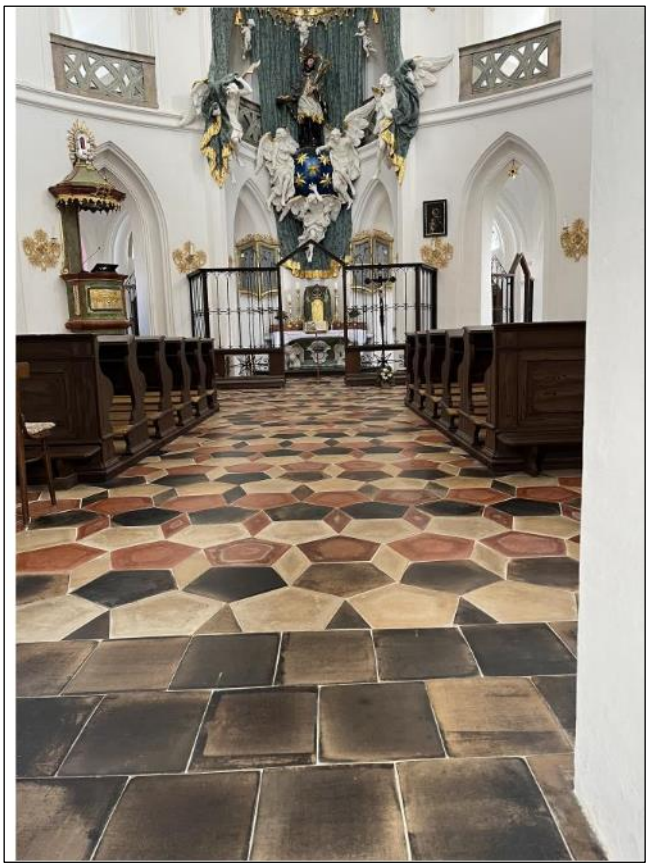
For an example of the **use of research results in practice**, we present the following result:

4) Repair of historical tiles in the Pilgrimage church of St. John of Nepomuk at Zelená Hora in Žďár nad Sázavou in South Moravian Region, UNESCO World Heritage Site

Summary:
As part of the restoration of the Pilgrimage church of St. John of Nepomuk on Zelená hora in Žďár nad Sázavou town, Dr. Ivana Perná and Dr. Tomáš Hanzlíček from Department of Material Structure and Properties participated in the repair of the historical tiles of the church. Zelená hora Pilgrimage church of St. John Nepomuk is one of the most important cultural heritage site not only of the town, but also of the South Moravian Region and the Czech Republic. It is the most important building of the architect Jan Blažej Santini-Aichl, which was registered for its cultural and historical value in 1994 UNESCO World Heritage List.
In its original state, the pavement in the most stressed parts of the church were worn or damaged and without original engobe. Earlier, some of the damaged tiles had been replaced, but completely inadequate pieces of both in shape and material. The solution was to replace of the non-original tiles with new ceramic tiles, replacing the missing parts of the tiles with artificial stone on geopolymer-based tiles and grouting and bonding the cracked pieces using the developed geopolymer technology, which was by the appointed staff of the Institute in collaboration with the restorer was successfully implemented.

Publication:
Tomáš Hanzlíček, Ivana Perná, Dagmar Michoinová, Jakub Raf (2023): The characterization and renovation of parterre floor tiles in the pilgrimage church of St. John of Nepomuk (Czech Republic). Case Studies in Construction Materials Volume 19, e02297. DOI: https://doi.org/10.1016/j.cscm.2023.e02297

Illustration:



Repaired pavement in the interior of the Pilgrimage church of St. John of Nepomuk on Zelená hora. The cooperation of Dr. Perná and Dr. Hanzlíček was appreciated gold medal of the Roman Catholic parish of Žďár nad Sázavou.

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2. Activities and selected results of the Institute's scientific departments

The Institute conducted its scientific activities during the year via all **six of its research departments**, four of which focused on geoscientific and two on materials disciplines:

Geoscientific research was conducted by the **Departments of Engineering Geology**, **Department of Neotectonics** and **Thermochronology**, **Department of Seismotectonics** and **Department of Geochemistry**.

Materials research was performed by the **Department of Composite and Carbon materials** and the **Department of Material Structure and Properties**.

The institute's scientific departments benefit from the sharing of research facilities with various universities. Laboratory of Sorption and Porosimetric Analyse of institute´s Geochemistry Department is joint laboratory established by the Institute of Rock Structure and Mechanics together with the Faculty of Science, Charles University. Similarly, the Department of Material Structure and Properties Materials' Inorganic Materials Laboratory is shared with the University of Chemical Technology, Prague.

In 2022, the Institute's scientific departments were involved in the following Strategy AV21 research programmes: Water for Life, Systems for Nuclear Energy, QUALITAS - Quality Life in Health and Disease, New Materials Based on Metals, Ceramics and Composites, Efficient Energy Conversion and Storage, and the City as a Laboratory of Change: buildings, cultural heritage and environments for a safe and rewarding life.

The staff of the Institute's scientific departments continued to be involved in teaching at various universities in 2022.

The Department of Engineering Geology focuses on the analysis and interpretation of dangerous geodynamic phenomena associated with exogenous processes, i.e. slope deformations and weathering. Particular attention was devoted during the year to the development of reliable and accurate monitoring methods for the monitoring of slope phenomena, especially landslides, and the prediction of their future occurrence and development.

The department was involved in international research on slope deformations and tectonic structures via the use of the following **monitoring networks**:

- Name: **TecNet**

Monitored issue: slow movements along tectonic faults.
Operator: IRSM (RI/OP VVV programme).
Content: tracking of seismic tectonic movements along faults.

- Name: **Geonas**

Monitored issue: GNSS fixed point movements.
Operator: IRSM (RI/OP VVV programme)
Content: background materials for the monitoring of tectonic movements.

- Name: **Landslides, rockfalls and debris flows described in the media since 2011**

Monitored issue: the emergence and reactivation of slope deformations in the Czech Republic
Operator: IRSM (NASA programme)
Content: to determine the location and time of the occurrence of landslides and the damage they cause.

- Name: **SlopeNet**

Monitored issue: slope movements and landslides and rockfalls.
Operator: IRSM (RENS programme)
Content: the monitoring of slope movements and rockfalls.

Main outcomes:

Differentiating between artificial and natural sources of electromagnetic radiation at a seismogenic fault.

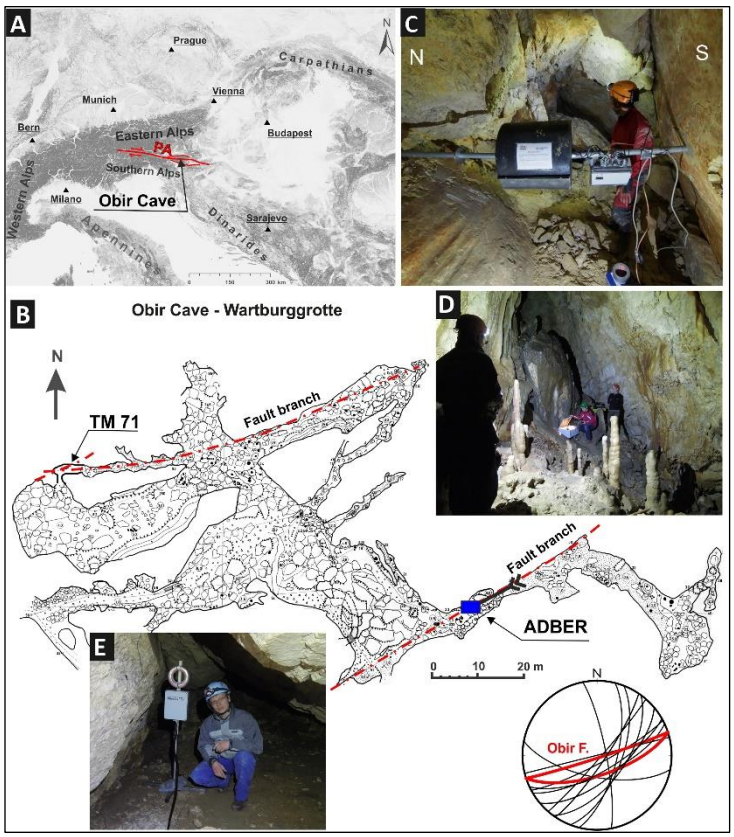
Summary:

Six-month measurement of ultra-low to low frequency electromagnetic radiation at seismogenic fault in the Obir Caves in the eastern Alps allowed the detection of constant narrowband artificial signals at specific frequencies, long series of 13 short pulses and high-energy and low-energy broadband pulses.
The high-energy signals were correlated with atmospheric lightning activity across the large parts of Europe and were found to unfortunately often overshadow low-energy signals from mechanical rock disturbance.

Publication:

Baroň I., Koktavý P., Trčka T., Rowberry M., Stemberk Josef, Balek J., Plan L., Melichar R., Diendorfer G., Macků R., Škarvada P. (2022): Differentiating between artificial and natural sources of electromagnetic radiation at a seismogenic fault. Engineering Geology 311, 106912.
DOI: https://doi.org/10.1016/j.enggeo.2022.106912

Illustration:



The study site in the Eastern Alps: (A) location of Obir Cave and the Periadriatic Lineament (PA) in the context of central Europe; (B) a schematic map of the Wartburggrotte chamber in Obir Cave (Solar et al., 1970) - the northern branch of the Obir Fault is instrumented with a moiré extensometer while its southern branch hosts the ADBER - along with a Schmidt lower hemisphere stereoplot of the main faults exposed in Obir Cave - the red lines represent the

two branches of the Obir Fault; (C) the moiré extensometer used for monitoring fault displacements in three dimensions and plane perpendicular angular rotations; (D) the digital part of the ADBER; (E) the analogue loop antenna of the ADBER.

Further outcomes:

- Loche M, Scaringi G, Blahůt J, Hartvich F (2022): Investigating the Potential of Infrared Thermography to Inform on Physical and Mechanical Properties of Soils for Geotechnical Engineering. Remote Sensing 14(16), 4067. DOI: 10.3390/rs14164067

- Bruthansová J, Bruthans J, Van Iten H, Rak Š, Schweigstillová J (2022): Monospecific mass associations of Anaconularia anomala (Cnidaria, Scyphozoa) from the Upper Ordovician of the Czech Republic: sedimentological and palaeobiological significance. Lethaia 55(2), 1–18. DOI: 10.18261/let.55.2.7

- Baroň I, Plan L, Grasemann B, Melichar R, Mitrović-Woodell I, Rowberry M, Scholz D (2022): Three large prehistoric earthquakes in the Eastern Alps evidenced by cave rupture and speleothem damage. Geomorphology 408, 108242. DOI: 10.1016/j.geomorph.2022.108242

- Grasemann B, Plan L, Baroň I, Scholz D (2022): Co-seismic deformation of the 2017 Mw 6.6 Bodrum–Kos earthquake in speleothems of Korakia Cave (Pserimos, Dodecanese, Greece). Geomorphology 402, 108137. DOI: 10.1016/j.geomorph.2022.108137

- Nguyễn T-T, Dong JJ, Tseng C-H, Baroň I, Chen C-V, Pai C-C (2022): Three-Dimensional Engineering Geological Model and Its Applications for a Landslide Site: Combination of Grid- and Vector-Based Methods. Water 14(19), 2941. DOI: 10.3390/w14192941

- Kusák M (2022): Application of fractal and multifractal analysis on Blue Niledrainage patterns in the morphostructural analysis of the Ethiopian highlands, Ethiopia. Progress in Physical Geography: Earth and Environment 46(3), 357–370. DOI: 10.1177/03091333211059419

- Rowberry M, Gunn J (2022): Atmospheric pressure anomalies at the British Cave Science Centre triggered by catastrophic volcanic eruption in Tonga on 15 January 2022. Cave & Karst Science 49, 14–18. DOI: www.researchgate.net/publication

- Blahůt J, Klimeš J, Meletlidis S, Balek J, Rowberry M, Baroň I: A decade of monitoring and research on the San Andrés megalandslide on El Hierro, Canary Islands, Spain. Advances in Natural Hazards and Volcanic Risks: Shaping a Sustainable Future - Proceedings of the 3rd International Workshop on Natural Hazards (NATHAZ22), Terceira Island - Azores 2022, Springer ASTI Series. DOI: 10.1007/978-3-031-25042-2_12

- Rowberry M, Klimeš J, Blahůt J, Balek J, Kusák M (2022): A global database of giant landslides on volcanic islands. Progress in Landslide Research and Technology, Volume 1, Issue 1. Springer, Cham. DOI: 10.1007/978-3-031-16898-7_22

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The Department of Neotectonics and Thermochronology in 2022 addressed neo-tectonic and geodynamic processes in various tectonic regions and paleo-stress conditions in the Bohemian Massif, including the monitoring of fault structures: the marginal Sudeten, Marianske Lazne, Železnohorské, Čirá-Kopanina and Lusatian (Lužický) faults. Foreign tectonic and geophysical research was conducted in the US in the San Andreas fault zone and in the Indian part of the Himalayas. In Turkey, field research and sampling focused on thermochronological evolution of areas at the lithospheric plate interface. In cooperation with other geoscience institutions, the department participated in research on slope deformations and the structural-tectonic development of sandstone reliefs in the Czech Republic and Poland as well as using geophysical methods in interdisciplinary studies.

The department was involved in international research on slope deformations and tectonic structures via the use of the following monitoring networks:

- Name: **SlopeNet**

Monitored issue: The monitoring of slope deformations, landslides and rockfalls.
Operator: IRSM (RENS programme).
Content: The geophysical and geotechnical monitoring of slope deformations, active involvement in international research and the taking over of co-responsibility for monitoring.

- Name: **Network EU TecNet**

Monitored issue: Tectonic structures in the EU.
Operator: IRSM (Czech/Geo programme).
Content: active involvement in the EU network, meter reading and service, and data evaluation.

Main outcomes:

1) **Multiphase deformation, fluid flow and mineralization in epithermal systems: Inferences from structures, vein textures and breccias of the Kestanelik epithermal Au-Ag deposit, NW Turkey**

Summary:
Multiphase deformation, fluid flow and mineralization in epithermal systems were investigated by detailed study of the vein textures and breccias of the epithermal Au-Ag deposit Kestanelik. The spatial distribution of breccias on veins in fault zones suggests that the intensity of coseismic hydrothermal brecciation is controlled by the proximity of the boiling level. Miscellaneous number of mineralization events suggests that each individual earthquake reopened only one or more closed veins, but not all at once.

Publication:
Gülyüz N., Shipton Z.K., Kuşcu İ. (2022): Multiphase deformation, fluid flow and mineralization in epithermal systems: Inferences from structures, vein textures and breccias of the Kestanelik epithermal Au-Ag deposit, NW Turkey. Turkish Journal of Earth Sciences, Vol. 32: No. 1, Article 4. DOI:10.55730/yer-2206-13

Illustration:
Hypothetical models of the internal structural evolution of host vein and mode I vein disorders on Kestanelik Au-Ag deposit, NW Turkey.

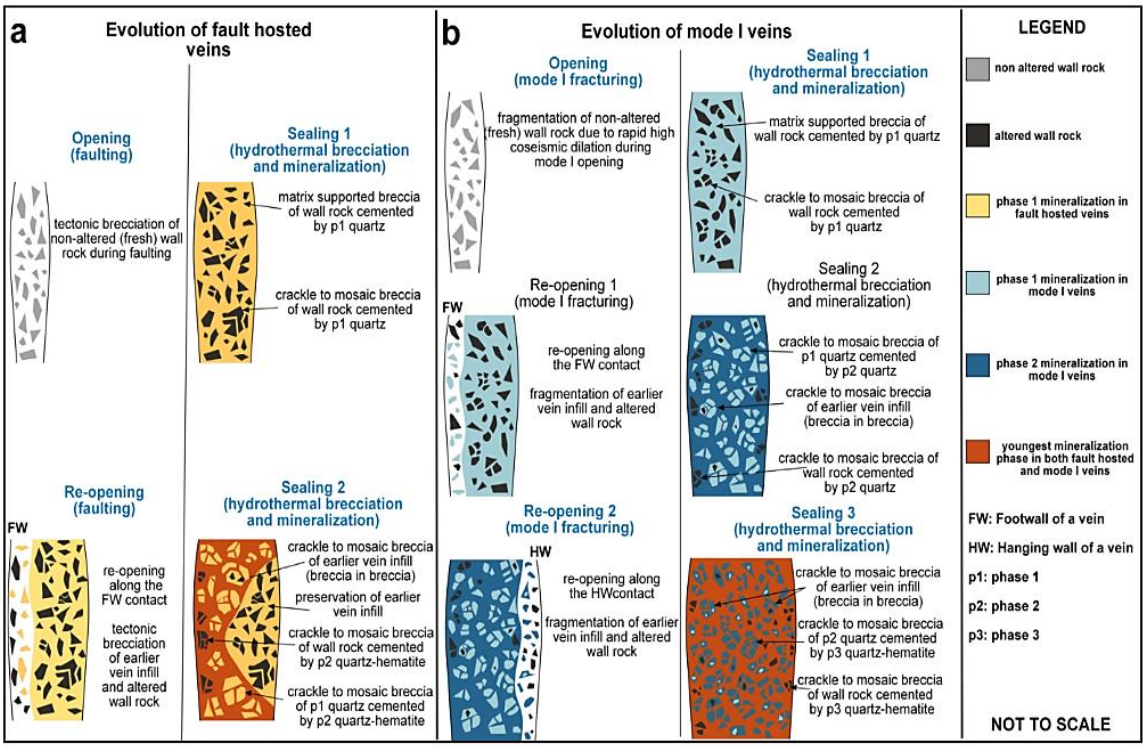


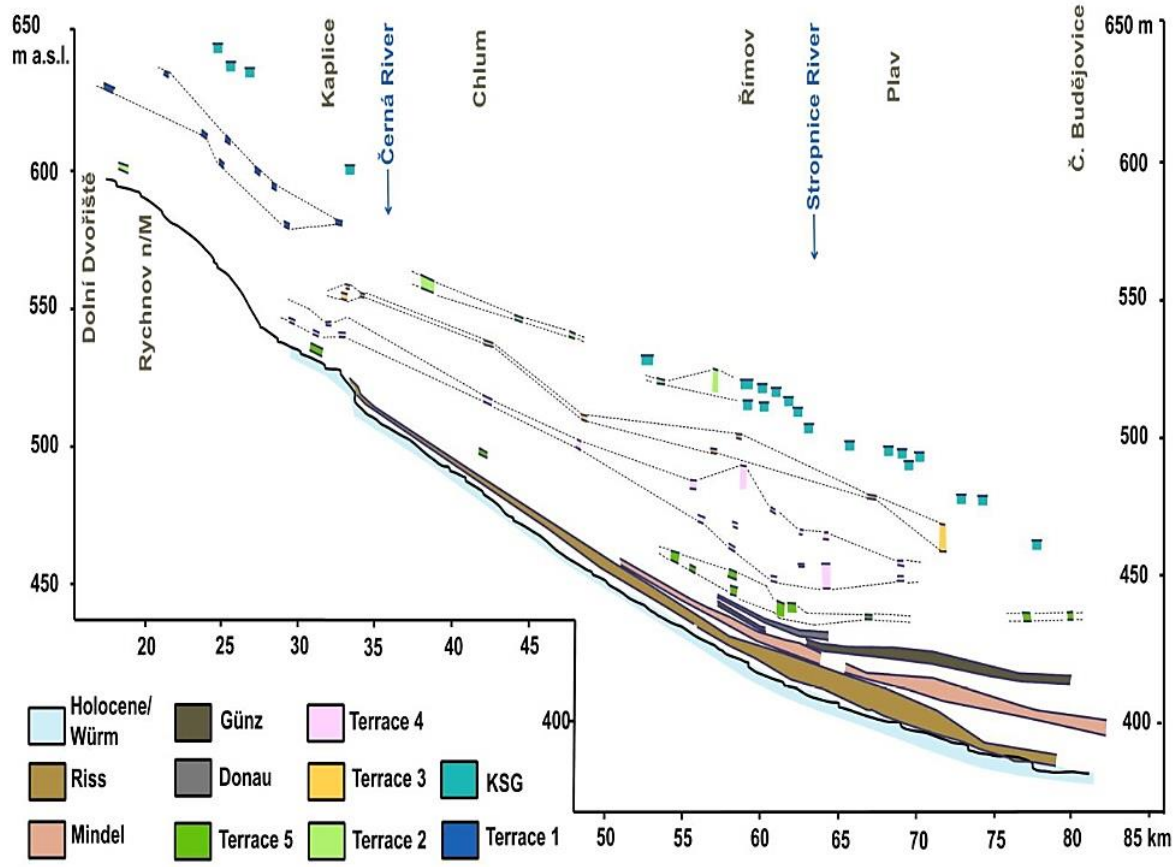
Figure shows: **(a)** a hypothetical model of internal structural evolution of veins in a fault by repeated opening of the fault along the vein contact and subsequent healing (mineralization), **(b)** a hypothetical structural model of the internal evolution of Mode I veins by repeated opening (mode I fracture) along one of the vein contacts and subsequent healing and sealing (mineralization).

2) Plio-Pleistocene paleodrainage reconstruction using moldavite-bearing and morphostratigraphically related deposits (Southern Bohemia, Czech Republic).

Summary:
The area of southern Bohemia between Novohradské hory Mountains and the Třeboň and Budějovice Basins – the Novohradské Foothills (in the south of the Czech Republic) is known for the occurrence of moldavites (vltavines). These tektites are abundant in fluvial Koroseky sands and gravels. Morphostratigraphic analyses of these sediments have newly indicated their Pliocene - Pleistocene age and served as a tool for innovative reconstruction of the river network in this period in the foothills of the Novohradské hory. The results indicate significant changes in the river network caused by intense tectonic activity in the Pleistocene.

Publication:
Flašar, J., Štěpančíková, P. (2022). Plio-Pleistocene paleodrainage reconstruction using moldavite-bearing and morphostratigraphically related deposits (Southern Bohemia, Czech Republic). Palaeogeography, Palaeoclimatology, Palaeoecology 586, 110783. DOI: https://doi.org/10.1016/j.palaeo.2021.110783

Illustration:
(comment on the other side)



Linking the occurrences of Korosec gravel sands to the Novák river terrace system Malše. Comparing the KSG, Pliocene terraces (1–5) and Pleistocene terraces (Donau-Holocene) of the Malše River, according to Novák (1983). Note the traditional terrace setting, MIS stages according to van Husen and Reitner (2011): Würm - MIS 2–4, Riss – MIS 6, Mindel – MIS 12, Günz - MIS 16, Donau – MIS 22. Surfaces and bases (where possible) of deposits are expressed.

Further outcomes:

- Majewski R.S., Valenta J., Tábořík P., Weger J., Kučera A., Patočka Z., Čermák J. (2022): Geophysical imaging of tree root absorption and conduction zones under field conditions: a comparison of common geoelectrical methods. Plant and Soil (in print). DOI:10.1007/s11104-022-05648-2

- Goswami Chakrabarti C., Narzary B., Weber J. C., Jana P., Bhattacharjee S., Jaiswal M. (2022): Preliminary Study of the Manabhum Anticline: A Possible Key to Better Understanding the Quaternary Tectonics of the Eastern Himalayan Syntaxial Zone. In Bhattacharya H. N., Bhattacharya S., Das B. C., Islam A. (eds.): Neotectonic Movements and Channel. Society of Earth Scientists Series. pp 239–260. Springer Nature. DOI:10.1007/978-3-030-95435-2_9

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The Department of Seismotectonics addressed the study of natural seismic phenomena associated with the dynamics and tectonic development of structures in the earth's crust (especially in the upper part of the crust), the development of applications for the evaluation of geophysical measurements, and the development of monitoring devices and methodologies

for seismic activity research purposes. The department continued its assessment of seismic hazards affecting nuclear power plants.

The department was involved in international research on seismic phenomena via the following monitoring networks:

- Name: **Czech Regional Seismic Network**.

Monitored issue: earthquakes in the Czech Republic and worldwide.
Operators: Academy of Sciences (AV CR): Institute of Geophysics (AV CR), IRSM, Institute of Geonics (AV CR); Institute of Earth Physics, Masaryk university; Charles University Faculty of Mathematics and Physics (Czech/Geo programme).
Content: a basic scientific infrastructure for the research of earthquakes, especially concerning long-term seismicity research in Europe and worldwide.

- Name: **REYKJANET**

Monitored issue: earthquakes in Iceland
Operators: Institute of Geophysics (AV CR) and IRSM (Czech/Geo programme).
Content: The detailed long-term international research of the seismic activity in Iceland.

- Name: **MKNET**

Monitored issue: earthquakes in the Lesser Carpathians.
Operators: IRSM; Institute of Geophysics, Earth Science Institute of the Slovak Academy of Sciences and Progseis s.r.o. (Czech/Geo programme).
Content: detailed research of this seismically active area; continuous recording and evaluation of the data.

Main outcomes:

1) **Tools for the efficient analysis of surface waves from active and passive seismic data (2022): exploring an NE-Italy perilagoon area with significant lateral variations.**

Summary:

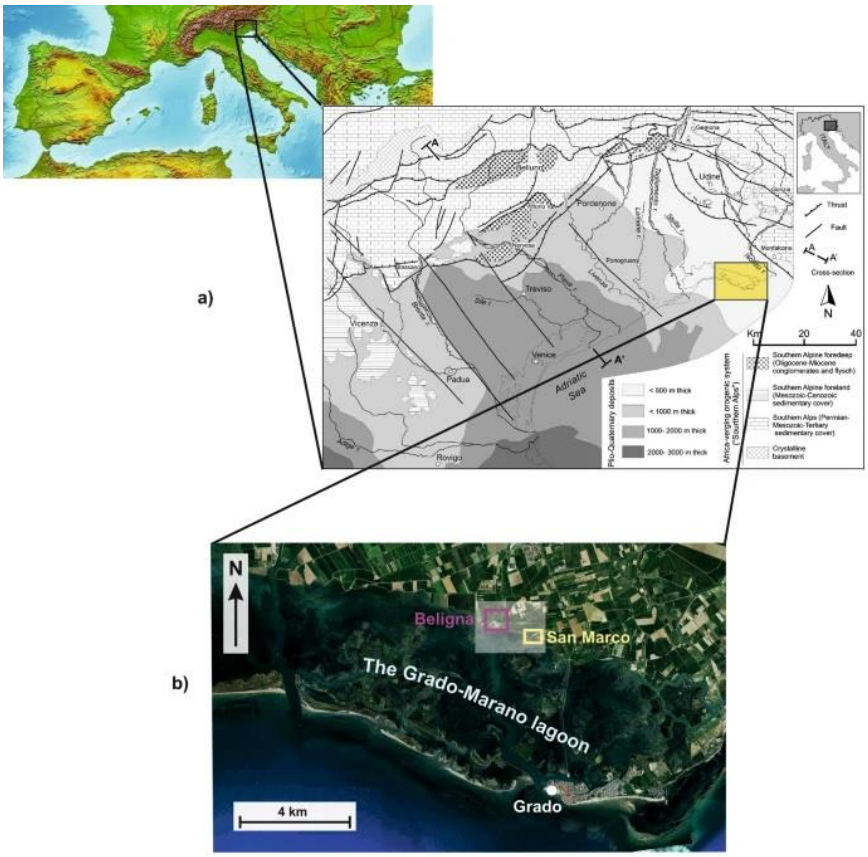
A number of effective and unconventional methods based on the analysis of surface waves from active and passive seismic data in an area with very limited data on local subsurface geological conditions. The main result was the collection of sufficient data to assess the subsurface geological conditions that geologists need to reconstruct the processes of local geomorphological formations. A series of reclamation works that took place during the twentieth century, almost completely destroyed the dune system that characterized the eastern part of the Grado-Marano perilagoonal area (NE Italy). Because of the limited data available, so far very little was known about the local subsurface conditions and the present paper presents the main outcomes of the seismic exploration accomplished with a twofold goal: collecting comprehensive data about the subsurface conditions (which geologists need to be able to reconstruct the formation processes of the local geomorphological elements) and testing a series of efficient and unconventional methodologies based on the analysis of surface waves from both active and passive seismic data. The survey was designed and accomplished also considering the local digital terrain model (DTM) and some resistivity and penetrometer data. In the present paper we focus on three main areas and, from the methodological point of view, special emphasis is given to the Holistic analysis of Surface waves (HS) and the Horizontal-to-Vertical Spectral Ratio (HVSR), since both these techniques require simple field procedures and a light equipment. It is also show the wealth of information that the simple spectral analysis of multi-offset passive data can provide in particular for the identification of possible lateral variations. In fact, in spite of the low-energy depositional environment, the area reveals extremely complex with major and abrupt lateral variations that require special care and prevent from using coarse methodologies that cannot properly handle their identification. Collected geophysical data provide a consistent overall scenario: while the area is in general

dominated by soft (silty) sediments, the residual dunes are constituted by cemented sandy materials (medium-grained calcarenite) responsible for anomalously high shear-wave velocity (VS) values already at the surface. Parallel to such residual sandy dunes we also identified a series of peat channels characterized by distinctive low VS values due to a significant amount of organic components.

Publication:

Dal Moro G., Stemberk Josef: Tools for the efficient analysis of surface waves from active and passive seismic data (2022): exploring an NE-Italy perilagoon area with significant lateral variations. Earth, Planets and Space 74, 140.
DOI: https://doi.org/10.1186/s40623-022-01698-z

Illustration:



Location of the investigated area: a general overview (South Europe map) and main geological, tectonic and alluvial elements (Fontana et al. 2008). The Grado-Marano lagoon is the area between the Isonzo and Tagliamento rivers; b study area with highlighted the Beligna and San Marco sites.

2) Multiple-peak HVSR curves: Management and statistical assessment

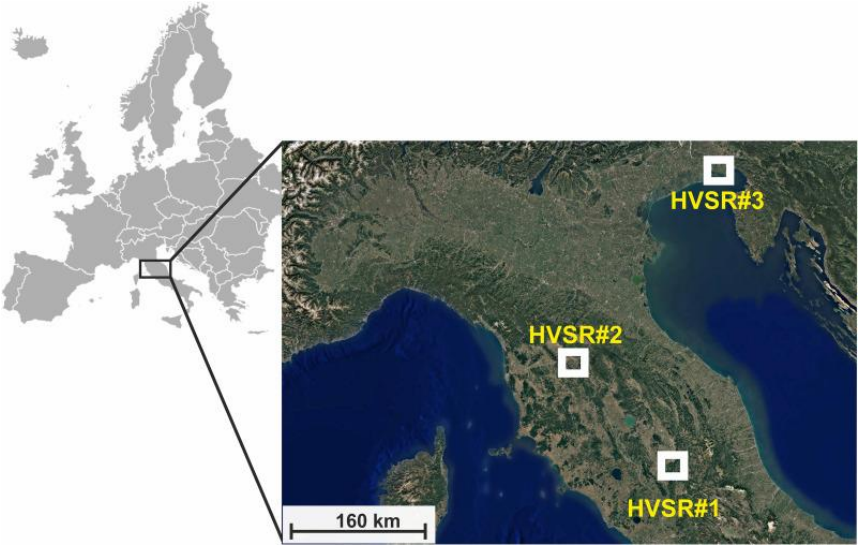
Summary:

The Horizontal-to-Vertical Spectral Ratio (HVSR) obtained from microtremor data recorded at three test sites are analyzed in order to highlight some issues related to the computation of the SESAME criteria that define the statistical robustness of possible peaks. In case of multiple-peak HVSR curves, it is shown that to properly assess the statistical properties of a peak and

avoid the problem of multimodal data distribution, it is crucial to isolate each peak by reducing the frequency range around it.

Publication:
Dal Moro G., Panza G. F. (2022): Multiple-peak HVSR curves: Management and statistical assessment, Engineering Geology 297, 106500.
DOI: https://doi.org/10.1016/j.enggeo.2021.106500

Illustration:



Locations of the three Italian sites where the data presented in the current study were recorded: Spoleto (HVSR#1), Florence (HVSR#2) and the Grado-Marano lagoon area (HVSR#3).

Further outcomes:
- Cabieces R., A. Olivar-Castaño, T. C. Junqueira, J. Relinque, L. Fernandez-Prieto, J. Vackář, B. Rösler, J. Barco, A. Pazos, L. García-Martínez (2022): Integrated Seismic Program (ISP): A New Python GUI-Based Software for Earthquake Seismology and Seismic Signal Processing, Seismol. Res. Lett. XX, 1–14.
DOI: https://doi.org/10.1785/0220210205

- Nováková L. (2022): Tectonically Significant Fault Zones in Central Europe (Germany, Czech Republic and Poland) and Their Surface and Subsurface Outcrops: Franconian Line, Hronov-Porici Fault, Sudetic Marginal Fault and Lusatian Fault. Book: Structural Geology and Tectonics Field Guidebook – Volume 2, Springer. DOI:10.1007/978-3-031-19576-1_3

- Majewski R. S., Valenta J., Tábořík P., Weger J., Kučera A., Patočka Z., and Čermák, J. (2022). Geophysical imaging of tree root absorption and conduction zones under field conditions: a comparison of common geoelectrical methods. Plant and Soil, 1-27. DOI:10.1007/s11104-022-05648-2

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The Department of Geochemistry focused on the study of organically rich materials, in which systematic characterization of fossil samples, identification of biological resources, reconstruction of accumulation conditions, charring, matriculation
Geochemical approaches are also used in the study of non-geological problems, for example in the long-term study of the relationship between resins of modern and fossil conifers. Furthermore, the properties of waste materials as sorbents and the properties of natural and synthesized carbonaceous materials as filters and contaminants associated with coal mining. Following to research in previous years, granitic rocks, tektites, foams and uranium ores and the interaction of uranium minerals with organic matter.

Main outcomes:

1) **Free-Blockage Mesoporous Silica Nanoparticles Loaded with Cerium Oxide as ROS-Responsive and ROS-Scavenging Nanomedicine.**

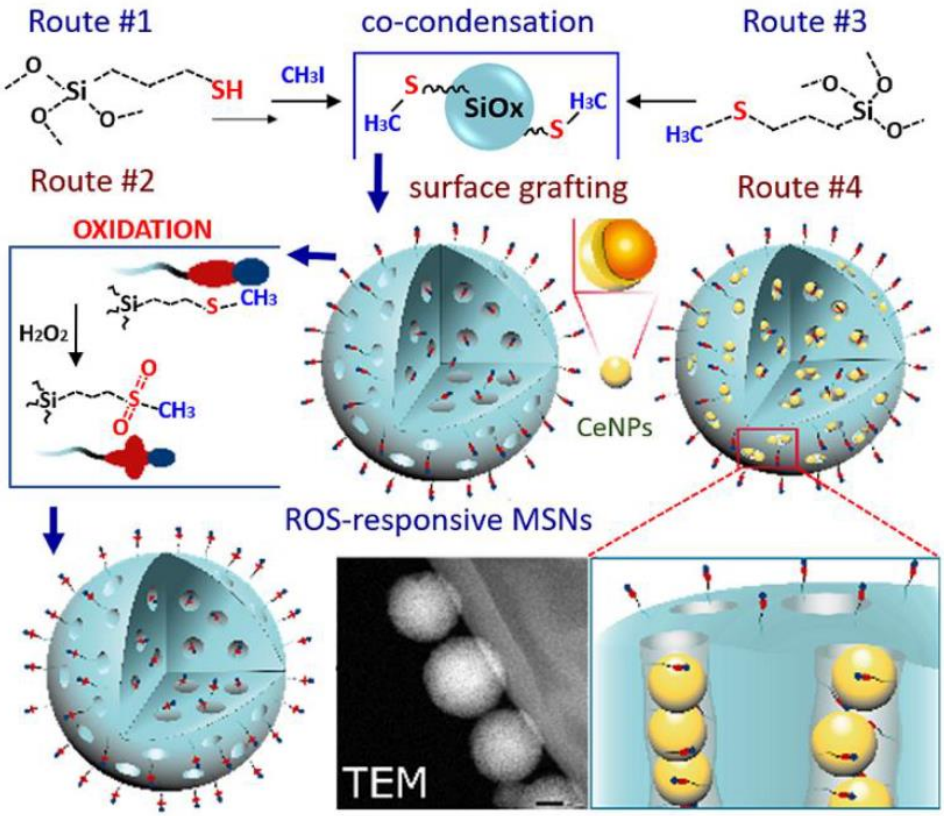
Summary:
The study is part of research on mesoporous silica nanoparticles with unit reactive oxygen species that serve as drug platforms for
antioxidant therapy. A novel nanocomposite with mesoporous nanoparticles has been designed silica nanoparticles functionalized with methylthiopropyl units and filled with cerium oxide nanoparticles. The nanocomposite thus constructed can be used as a platform for drugs for antioxidant therapy due to its ability to trap reactive species
oxygen. Mesoporous silica nanoparticles (MSNs) with reactive oxygen species (ROS)-responsive “nanogate” as drug delivery platforms are extensively investigated for biomedical applications. As a proof-of-concept design, ultrasmall cerium oxide nanoparticles are encapsulated into the functionalized MSNs and released out within 10 min scavenging more than 80% of the H2O2 in an ROS-rich environment. This study provides a novel design of a free-blockage ROS-controlled release system loaded with ROS-scavenging nanoparticles for the future application of targeted drug delivery systems combined with antioxidant therapy

Publication:
O. Purikova, I. Tkachenko, B. Šmíd, K. Veltruská, T. N. Dinhová, M. Vorokhta, V. Kopecký Jr., L. Hanyková, X. Ju (2022): Free-Blockage Mesoporous Silica Nanoparticles Loaded with Cerium Oxide as ROS-Responsive and ROS-Scavenging
Nanomedicine. Advanced Functional Materials 32, 2208316.
DOI: https://doi.org/10.1002/adfm.202208316

Illustration:
Design of mesoporous silica nanoparticles functionalized with methylthio propyl units and loaded with cerium oxide nanoparticles as a potential platform for antioxidant therapeutics. The figure shows the functionalization of mesoporous silica nanoparticles (MSNs) through 4 co-condensation and grafting methods, followed by the incorporation of cerium oxide nanoparticles (CeNPs) serving as a reactive oxygen species (ROS) scavenging agent. In an environment rich in reactive oxygen species, mesoporous silica nanoparticles undergo changes in structure and polarity to release cerium oxide nanoparticles that trap reactive oxygen species.

(Mesoporous silica nanoparticles (MSNs) with units reactive to reactive oxygen species (ROS) are considered as drug platforms. Herein, a design is proposed mesoporous silica nanoparticles with methylthiopropyl units for blocking reactive oxygen species. Four synthetic routes (with different precursors) are compared and co-condensation or grafting methods) to obtain methylthio-functionalized mesoporous silica nanoparticles. Methylthiopropyl groups reacting to reactive oxygen species are oxidised to sulfoxides. To validate this design, cerium oxide nanoparticles (CeNPs) were encapsulated in functionalized mesoporous silica

nanoparticles and released within 10 minutes, trapping more than 80% of the hydrogen peroxide creating an environment rich in reactive minutes, capturing more than 80% of the hydrogen peroxide creating an environment rich in reactive oxygen species. The study thus provided a new design for a system to block reactive oxygen species and the controlled release of nanoparticles to absorb these reactive oxygen species. The design is for a future drug platform for antioxidant therapy.)



Further outcomes:

- Havelcová M., Sýkorová I., René M., Mizera J., Coubal M., Machovič V., Strunga V., Goliáš V. (2022): Geology and Petrography of Uraniferous Bitumens in Permo-Carboniferous Sediments (Vrchlabí, Czech Republic). Minerals 12, 544. DOI:doi.org/10.3390/min12050544

- Mizera J., Havelcová M., Machovič V., Borecká L., Vöröš D. (2022): Neutron Activation Analysis in Urban Geochemistry: Impact of Traffic Intensification after Opening the Blanka Tunnel Complex in Prague. Minerals 12, 281. DOI:doi.org/10.3390/min12030281

- Vöröš D., Geršlová E., Šimoníková L., Díaz-Somoano M. (2022): Late Carboniferous palaeodepositional changes recorded by inorganic proxies and REE data from the coalbearing strata: An example on the Czech part of the Upper Silesian Coal basin (USCB). Journal of Natural Gas Science & Engineering 107, 104789. DOI: doi.org/10.1016/j.jngse.2022.104789

- Švábová M., Vorokhta M. (2022): Water sorption and transport in Silurian shales. Journal of Petroleum Science and Engineering 210, 109980. DOI: doi.org/10.1016/j.petrol.2021.109980

- Suchý V., Zachariáš J., Sýkorová I., Kořínková D., Pešek J., Pachnerová-Brabcová, K., Qingyong Luo, Filip, J., Světlík, I., (2022): Paleothermal history of the Blanice Graben (the Bohemian Massif, Czech Republic): The origin of anthracite in a late-Variscan strike-slip basin. International Journal of Coal Geology 263, 104129. DOI: doi.org/10.1016/j.coal.2022.104129

- Rasina M., Lusens M., Racek M., Přikrylová J., Weishauptová Z., Řimnáčová D., Přikryl R. (2022): Distinction between consecutive construction phases by combined microscopic study and quantitative pore space analysis: Case study of Horn's Bastion, Riga Castle (Latvia), Journal of Cultural Heritage 57, 88–96. DOI: doi.org/10.1016/j.culher.2022.08.004

- René M. (2022). Investigation of accessory minerals from the Blatná granodiorite suite, Bohemian Massif, Czech Republic. In: René M. (ed.) Mineralogy, IntechOpen Ltd., London, 165–185.

- René M. (2022). Jak vznikaly šumavské žuly. Vesmír, 101, 5, 327–329

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The Department of Composite and Carbon Materials focused principally on the study of the (a) properties of collagen materials for medical and food applications, and the delamination properties of native human tissues and degradable magnesium materials; (b) climate resistance of partially pyrolysed polysiloxane matrix composites.

The potential use of collagen in the form of hydrogels was studied in the project aimed at developing bioartificial cardiovascular patches and vascular replacements for porcine collagen-based, nano/microfiber reinforced remodeled stem cells in bioreactors (AZV MZČR NV19-02-00068). resorbable arterial bandages based on a composite material composed of synthetic PCL/PLA copolymer nanofibre reinforcement and combined with collagen matrix for the purpose of reducing blood flow through the arterial circulation to protect arterial wall against pathological deformation and rupture (AZV MZČR NU20-02-00368).
In 2022, research activities were mainly focused on the description of the degradation behaviour of of the developed composites under simulated body conditions and on the description of delamination properties of the human aorta. This is material research dealing with the physical chemical and mechanical properties of biological tissues to answer questions related to the propagation of arterial tears and arterial rupture, conditions that clinically occurring in arterial dissection and rupture (GAČR 20-11186S). In the framework of basic research on collagen materials, we have also been studying the physical chemical parameters of the collagen material, especially the effect of high pressures and monoenergetic accelerated electron beam on the internal structure of collagen (GAČR 21-07851S). magnesium wires with degradable polymers and optimization of their degradation time (TAČR GAMMA 2 TP01010055 4GEO). Testing the applicability of the prepared wires was performed during sternotomy operations on a pig model. The last area that was the validation of collagen dispersion processing technology for impregnation of the porous surfaces of the anchoring parts of implants (TAČR GAMA 2 TP01010055 4GEO), in particular finding a suitable simulated body environment that most corresponds to real body conditions and its verification (degradation of structural and mechanical properties) on an *in vivo* model.
In the field of special composite materials, the main focus was on the problem of climate resistance of composites with partially pyrolyzed polysiloxane matrix reinforced with basalt fibres. In the framework of the TAČR GAMA project 2 TP01010055 4GEO, the development of test equipment and measurement methodology was completed of freeze-thaw cycling. In contrast to testing in climatic chambers, this development equipment allows for rapid freeze

cycles to be carried out with periodic automatic humidification of samples at very low energy consumption of this experiment. The development composites for lightweight roofing have shown after 240 freezing cycles, some decrease in flexural strength, but the values exceeded the results obtained by an identical experiment on commercial fibre cement roofing materials. The solution to this negative phenomenon should be to reduce the porosity of the development.

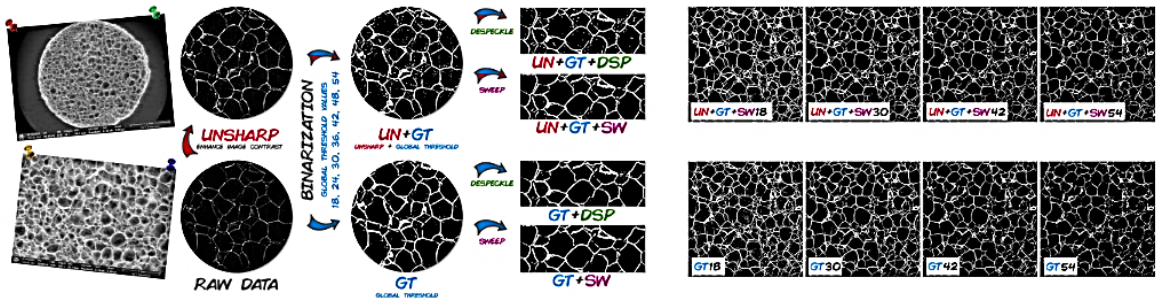
Main outcomes:

1) **The micro-CT analysis of the structural parameters of collagen-based porous scaffolds: the influence of image processing and binarization.**

Summary:
Evaluation of structural parameters using micro-CT (CT - computerized tomography, computed tomography) is dependent on image processing prior to the actual analysis. However, the distortion caused by image processing is generally unknown. In our study, the micro-CT analysis of the basic structural parameters of model collagen scaffolds using different approaches and differences were evaluated. Our study demonstrates a significant dependence of the results obtained on image processing, and also offers an optimized approach to image processing.

Publication:
Bartoš M., Suchý T., Luňáčková J., Soukup, P. (2022): The micro-CT analysis of the structural parameters of collagen-based porous scaffolds: the influence of image processing and binarization. Microscopy and Microanalysis, Volume 29, 244 - 253.
DOI:doi.org/10.1093/micmic/ozac024

Illustration:



The raw data was binarized (GT-Global Threshold) and analyzed or further modified using despeckle (GT+DSP) or sweep (GT+SW) operations and subsequently analyzed. The second type of analysis was based on contrast enhancement (UN-Unsharp) and binarization (UN+GT), or further modified by despeckle (UN+GT+DSP) or sweep (UN+GT+SW) operations and subsequently analysed.

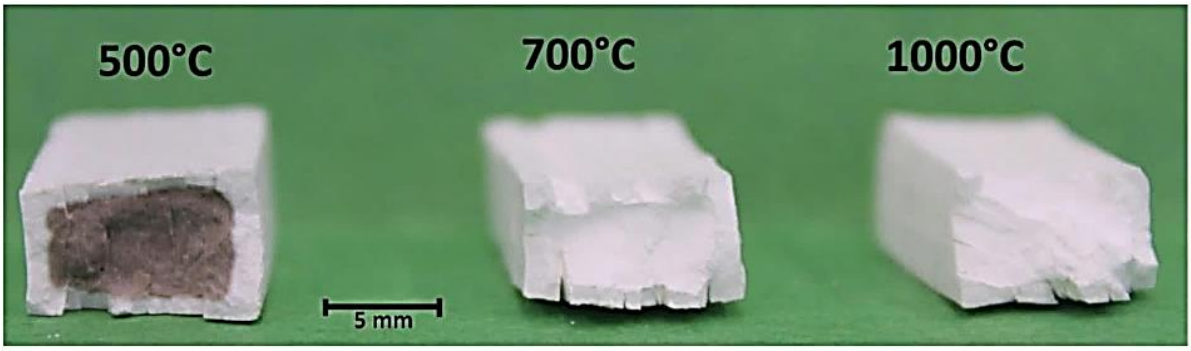
2) **Problems associated with the assessment of organic impurities in bioapatites isolated from animal sources: a review**

Summary:
This review provides a summary of recent studies that address problems relating to the purity of bioapatites isolated from animal sources. It is essential that the issue of the presence of organic impurities, especially peptides and proteins, following the isolation process be solved with respect to the expansion of the use of xenogeneous bones as a material suitable for the production of artificial replacements. Firstly, the study provides a review of both the various extraction procedures employed for the isolation of bioapatites from animal sources and the

characteristics of the extracted bioapatites. Particular attention is devoted to describing individual groups of analytical techniques that serve to prove the presence of proteins and peptides in the isolated apatite phase. Subsequently, an evaluation is provided of the effectivity.

Publication:
Šupová M. (2022): Problems associated with the assessment of organic impurities in bioapatites isolated from animal sources: a review. Journal of the Australian Ceramic Society 58 (1), 227–247. DOI: https://doi.org/10.1007/s41779-021-00678-y

Illustration:



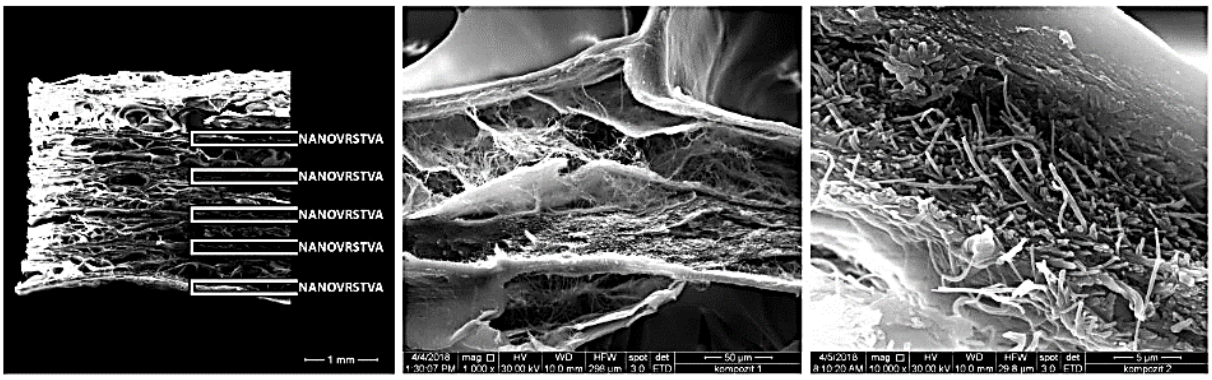
Bovine bone blocks prepared by alkaline hydrothermal treatment at various calcination temperatures. Sections of beef bone blocks that have undergone alkaline hydrothermal treatment followed by calcination at 500 °C, 700 °C and 1000 °C to constant weight.
As can be clearly seen, the inner part of the block at 500 °C has a dark greyish colour, which indicating the presence of organic impurities**.**

3) Problems associated with the assessment of organic impurities in bioapatites isolated from animal sources: a review

Summary:
The subject invention is a collagen composite comprising at least one layer of of highly porous collagen foam and at least one layer of collagen nanofibers. The composite is capable of controlled local release of active agents. Further subject matter of the invention is a method of preparing the collagen composite.

Publication:
Grus T., Suchý T., Šupová M., Chlup H., Hartinger J. (2022): Kolagenní kompozit pro řízené uvolňování aktivních látek a způsob jeho přípravy. Úřad průmyslového vlastnictví, Česká republika. Patent 309204. 2022-05-18.
https://isdv.upv.cz/doc/FullFiles/Patents/FullDocuments/309/309204.pdf

Illustration:
(comment on the other side)



The image on the left shows a highly porous composite foam prepared by sieving nanofibrous layers with collagen dispersion. The image in the middle illustrates the transition between fibers and the porous structure of the foam, the image on the far right shows a detail of the impregnation of the nanofibrous layer with the dispersion.

Further outcomes:

- Horný L., Roubalová, L., Kronek J., Chlup H., Adámek T., Blanková A., Petřivý Z., Suchý, T., Tichý P. (2022): Correlation between age, location, orientation, loading velocity and delamination strength in the human aorta. Journal of the Mechanical Behavior of Biomedical Materials 133, 105340.
DOI: doi.org/10.1016/j.jmbbm.2022.105340

- Machoň V., Bartoš M., Suchý T., Levorová J., Foltán R. (2022): Micro-computed tomography evaluation of bone architecture in various forms of unilateral condylar hyperplasia. Journal of Oral and Maxillofacial Surgery 52, 44–50.
DOI: doi.org/10.1016/j.ijom.2022.05.008

- Pazourková L., Martynková G.S., Šupová M. (2022): Ca-deficient hydroxyapatite synthesis on the bioapatite bovine bone substrate study. Materials Today: Proceedings 52, 227–231. DOI: doi.org/10.1016/j.matpr.2021.11.412

- Balík K., Jančová A., Křížková M., Lukšíček J., Sucharda Z., Žaloudková M. (2022): Zařízení na potahování vláken biodegradabilním polymerem. Užitný vzor, vlastník: Ústav struktury a mechaniky hornin AV ČR. Datum udělení užitného vzoru: 19.7.2022. Číslo vzoru: 36228. (asep-analytika.lib.cas.cz)

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The Department of the Structure and Properties of Materials continued the research of socially necessary technologies during the year**: (a)** the modelling of glass melting processes and the development of new melting facilities; **(b)** the monitoring of inhomogeneities in glass melts at high temperatures; **(c)** the vitrification of radioactive waste (experimental research and process modelling); **(d)** the preparation of infrared-permeable glasses (chalcogenide and heavy oxide glasses); **(e)** processing of biomass into useful products; **(f)** processing of waste cross-linked polyethylene and waste polyactide acid, and **(g)** preparation of advanced geopolymer materials and their applications, in particular for the restoration of monuments (the restoration of the original ceramic tiles in the Pilgrimage church of St. John of Nepomuk in Žďár nad Sázavou);

Main outcomes

1) Impact of melt flow on the process of glass melting

Summary:

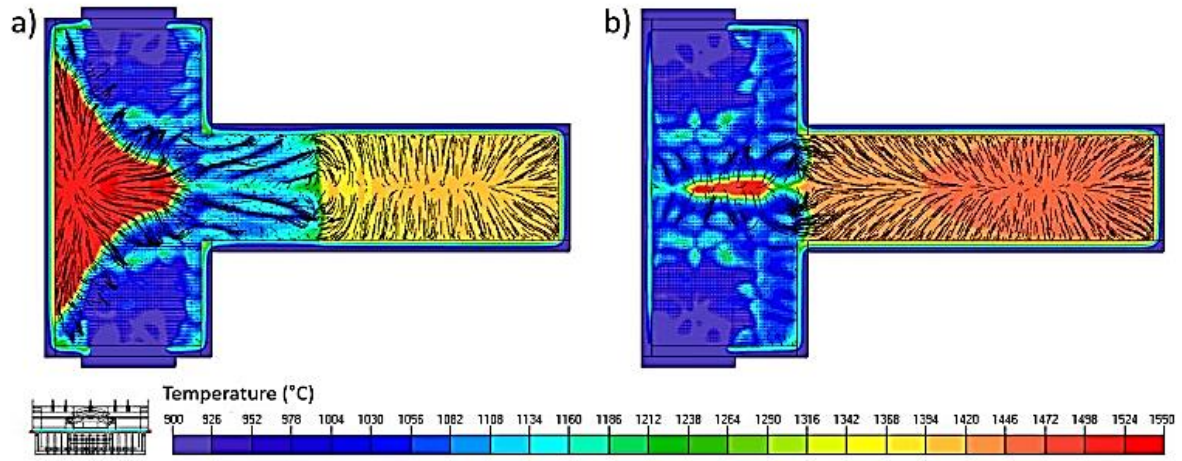
The space designed for glass melting was mathematically modelled in order to set the controlled flow of enamel and determine its effect on the performance of the plant. The conversion region of the melting space is rotated by gas vertical burners and heating electrodes, and the homogenization region is rotated by a central longitudinal row of electrodes to ensure efficient removal bubbles and sand dissolution. The conditions for optimum melt flow in the stem cover region have been defined. The influence of the energy distribution in the space as well as the shape and strain distribution on the kinetics of sand dissolution and bubble removal.

Publication:

Cincibusová P., Jebavá M., Tonarová V., Němec L. (2022): Impact of melt flow on the process of glass melting. Journal of Asian Ceramic Societies 10 (3), 621-637.
DOI: doi/full/10.1080/21870764.2022.2099102

Illustration:

The glass melting furnace: top view of the trunk boundary receding back in the homogenisation region in case of a change in the type of strain: **a)** central position sideways stemming, **(b)** stemming shifted to the front wall space.



2) Effect of sucrose on technetium and rhenium retention during vitrification of low-activity wastes

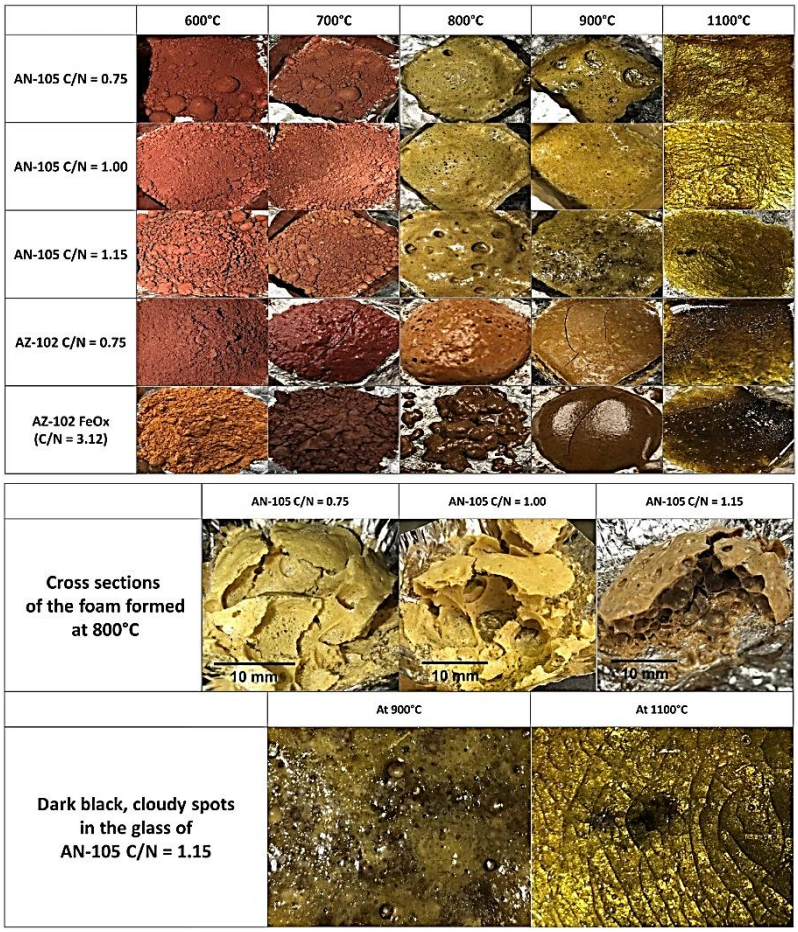
Summary:

Sucrose ($C_{12}H_{22}O_{11}$) has been used in low-activity waste (LAW) melter feeds containing large fractions of nitrates, nitrites, or both because it facilitates foam suppression and denitration. This study focused on the effect of sucrose in LAW feeds on technetium (Tc) and rhenium (Re) retention. The amount of sucrose added in feeds was varied to differentiate the carbon-to-nitrogen mole ratio (C/N ratio). The results show that larger sucrose addition (higher C/N ratio) enhances Tc and Re retention. Reducing conditions induced by sucrose decomposition and early chemical reactions between sucrose and $NaNO_3$/$NaNO_2$ are expected to increase Tc and Re retention. However, high sucrose addition decreased sulfur (S) retention slightly because sodium sulfate decomposes in reducing conditions at lower temperature. This early sulfate decomposition can affect Tc and Re retention partly because these species can be soluble in sulfate phases. This

correlation indicates that the decrease of sulfate phases in the glass by early decomposition can reduce the solubility of Tc and Re in the sulfate phases, which may increase Tc and Re retention in the glass. In addition, continuous gas evolution and vigorous foaming at the foaming temperature range of 700–900°C may influence Tc and Re retention process interrupting retention or facilitating volatilization.

Publication:
Lee S., Jin T., Rivers E., Kloužek J., Luksic S., Marcial J., George J., Dixon D.R., Eaton W.C., Kruger A.A. (2022): Effect of sucrose on technetium and rhenium retention during vitrification of low-activity wastes. Journal of Asian Ceramic Societies 105, 7321–7333. DOI: https://doi.org/10.1111/jace.18701

Illustration:
(A) Samples of AN-105 and AZ-102 during heat treatment; (B) cross-sectional images of the foam formed at 800°C in AN-105 feeds and dark black, cloudy spots in the glass of the AN-105 C/N = 1.15



3) Temperature sensing down to 4 K with erbium-doped tellurite glasses

Summary:
Two binary tellurite glasses within TeO_2–$PbCl_2$–WO_3 system with different concentrations of Er^{3+} ions were prepared by the conventional melt-quench technique and their optical properties were compared with emphasis on their potential use for temperature sensing starting from 4 K. Therefore, absorption and emission spectroscopy was used to determine the emission properties of Er^{3+} in the visible and near-infrared regions across a wide temperature range of 4-300 K. Photoluminescence emissions resulting from direct absorption or frequency up-conversion were

measured across a wide temperature range and their dependence on the concentration of erbium ions and on excitation power density were studied in detail. It was demonstrated that by optimizing concentration of erbium ions, the luminescence intensity ratio of suitably selected thermally coupled/uncoupled levels and their Stark sublevels can be used for the non-contact optical temperature sensing at cryogenic temperatures.

Publication:
Yatskiv R., Kostka P., Grym J., Zavadil J. (2022): Temperature sensing down to 4 K with erbium-doped tellurite glasses. Journal of Non-Crystalline Solids 575, 121183. DOI: https://doi.org/10.1016/j.jnoncrysol.2021.121183

4) **Application for invention: Method for producing industrial oil, technical paraffin and energy gas by low-temperature splitting of waste cross-linked polyethylene by defined heating in the presence of a catalyst**

Summary:
The present invention relates to a method for producing industrial oil, technical paraffin and energy gas from waste cross-linked polyethylene by a low-temperature pyrolysis under atmospheric pressure to a temperature of 400-450 °C under defined conditions and in the presence of a catalyst.

Publication:
Straka Pavel, Bičáková Olga, PV 2022-487, 21.11.2022, Industry property office of the Czech Republic, applicant Institute of Rock Structure and Mechanics of the CAS

Further outcomes:

- Marcial J., Kloužek J., Vernerová M., Ferkl P., Lee S., Cutforth D., Hrma P., Kruger A., Pokorný R. (2022): Effect of Al and Fe sources on conversion of high-level nuclear waste feed to glass. Journal of Nuclear Materials 559, 153423. DOI: doi.org/10.1016/j.jnucmat.2021.153423

- Marcial J., Luksic S., Kloužek J., Vernerová M., Cutforth D., Varga T., Hrma P., Kruger A., Pokorný R. (2022): In-situ x-ray and visual observation of foam morphology and behavior at the batch-melt interface during melting of simulated waste glass. Ceramics International. 48 (6), 7975–7985. DOI: doi.org/10.1016/j.ceramint.2021.11.344

- Marcial J., George J., Ferkl P., Pokorný R., Kissinger R., Crum J., Kloužek J., Hrma P., Kruger A. (2022): Elemental mapping and iron oxidation state measurement of synthetic low-activity waste feeds. Journal of Non-Crystalline Solids 591, 121725. DOI: doi.org/10.1016/j.jnoncrysol.2022.121725 (RVO 67985891)

- Rigby J., Dixon D., Cutforth D., Marcial J., Kloužek J., Pokorný R., Kruger A., Scrimshire A., Bell M., Bingham P. (2022): Melting behaviour of simulated radioactive waste as functions of different redox iron-bearing raw materials. Journal of Nuclear Materials 569, 153946. DOI: doi.org/10.1016/j.jnucmat.2022.153946

- Lee S., Jin T., Rivers E., Kloužek J., Luksic S., Marcial J., George J., Dixon D., Eaton W., Kruger A. (2022): Effect of sucrose on technetium and rhenium retention during vitrification of Low-activity wastes. Journal of the American Ceramic Society 105 (12), 7321-7333. DOI: doi.org/10.1111/jace.18701(RVO 67985891)

- Marcial J., Cicconi M., Pearce C., Kloužek J., Neeway J., Pokorný R., Vernerová

M., McCloy J., Nienhuis E., Sjoblom R., Weaver J., Hand R., Hrma P., Neuville D., Kruger A. (2022): Effect of network connectivity on behavior of synthetic Broborg Hillfort glasses. Journal of the American Ceramic Society 106, 1716–1731. DOI: doi.org/10.1111/jace.18778

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All scientific departments popularised the results of their activities, either in exhibitions, in the framework of the Week of Science of the CAS or in field panels or presentations to the public (see section 7).

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3. Research projects conducted by the Institute's scientific departments in 2022

Projects financed by the Grant Agency of the Czech Republic:

- Infrared transmissive glass based on heavy metal oxides.
- The mechanics of arterial delamination and crack propagation.
- The radiolytic alteration of organic matter in a uranium-bearing environments.
- The study of methods for the modification of the mechanical properties and collagen structures of collagen masses.
- The influence of post-genetic changes in granites on their resistance to weathering processes in historical buildings.
- Stress and hydraulic field-controlled weathering and erosion of granular rocks.
- Quaternary tectonic activity in West Bohemia and its relationship to volcanism.
- Microscopic anatomy of tree rings as a source of chronological information for the optimization of landslide hazard determination.
- Coseismic landslides in mountain ranges of active and stabilized accretionary wedges.

Projects financed by the Technology Agency of the Czech Republic:

- Interactive map of the seismic hazard in the Czech Republic.
- Natural seismicity as a tool in the research for geothermal energy sources.
- The geological environment and mineral resources.
- Geophysics, geotechnics, geomaterials, geothermal energy in practice. Subprojects:
    - The potential for the cracking of waste polyethylene into a mixture of hydrocarbons: the technological verification of a heat treatment method.
    - Validation of collagen dispersion processing technology for impregnation porous surfaces of implant anchoring parts.
    - The development of equipment for the coating of thin wires with biodegradable polymers from a solution.
    - Partially pyrolysed composites as a lightweight roofing material – the verification of climatic resistance and the optimisation of a suitable textile reinforcement material.

- Non-contact magnetoresistive 3D positioning system.
- A seismic beacon - a system for detecting temporal changes in the properties of rock masses.
- A system for the automated evaluation of network records.
- The optimisation of a system for the automated measurement, processing and interpretation of electro-resistance monitoring.

Projects financed by the Ministry of Education, Youth and Sports and the Ministry of Health:

- The preparation and characterisation of amorphous materials for infrared applications.
- Bioartificial cardiovascular patches and vascular replacements based on porcine collagen reinforced nano/microfibres remodelled via stem cells in bioreactors.
- Biomechanically defined absorbable materials for cardiovascular surgery.
- Delimitation of the zone of partial healing of zirconium fission tracks via the fission track and micro-Raman spectroscopy methods: the key to understanding thermochronological dating, the properties of zirconium-based materials and the thermal maturity of hydrocarbon source rocks.

Projects with foreign participation:

- Representation of the Czech Republic in the management of INQUA (International Union for Quaternary Research).
- The six-component continuous monitoring of seismic swarms and other earthquakes in the Long Valley Caldera area, California.

4. Cooperation with universities

With respect to university teaching activities during the year, the staff of the IRSM provided in the summer semester 369 hours in bachelor's and 205 hours in master's study programmes; in the winter semester 325 hours in bachelor's, 211 hours in master's and 14 hours in doctoral study programmes. The institute trained 10 doctoral students, 2 of them from abroad. The staff of the Institute worked as teachers and taught several courses and number of study programmes in various fields during the year, especially at the Charles University (Faculty of Science, Faculty of Mathematics and Physics and the Faculty of Medicine in Pilsen), the Czech Technical University in Prague (Faculty of Mechanical Engineering and the Faculty of Nuclear Sciences and Physical Engineering), the University of Chemical Technology (Faculty of Chemical Technology and Faculty of Environmental Technology), the Masaryk University in Brno (Faculty of Natural Sciences), the Mendel University in Brno, the University of Ostrava (Faculty of Natural Sciences) and the University of South Bohemia, České Budějovice (Faculty of Education), as well as at the Universidad Nacional de Cordóba Argentina - Faculdad de Ciencias Exactas, Físicas y Naturales.

Masaryk University in Brno (Faculty of Natural Sciences), Mendel University in Brno, University of Ostrava (Faculty of Natural Sciences), University of South Bohemia in České Budějovice (Faculty of Education) and Universidad Nacional de Cordóba Argentina - Faculdad de Ciencias Exactas, Físicas y Naturales. The Institute has two joint workplaces with universities, namely with the Faculty of Science of Charles University and the University of Chemical Technology in Prague.

The Institute's staff participated during the year in 4 doctoral study boards, namely at the University of Chemical Technology in Prague, the Technical University of Ostrava and Charles University (Faculty of Science).

The implementation continues of the “Agreement on Mutual Cooperation concerning the Implementation of the Physics of the Earth and Planets doctoral study programme” concluded with the Faculty of Mathematics and Physics of Charles University involving both full-time and combined forms of study.

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5. Contractual services

Contracts:

1) Commissioned by: Devro, Ltd., Jilemnice
Contract: The preliminary analysis of collagen casing samples.
Summary: Technical report summarising the results of elemental analysis of eleven samples of collagen casings supplied.
Application: The optimisation of the technological processes at Devro.

2) Commissioned by: Devro, Ltd., Jilemnice
Contract: The analysis of collagen mass samples.
Summary: Technical report summarising the results of elemental analysis of five samples of collagen materials supplied.
Application: The optimisation of the technological processes at Devro.

3) Commissioned by: Devro, s.r.o., Jilemnice
Contract: The analysis of collagen mass and collagen casing samples.
Summary: Technical report including the results of determination of free and bound water, fat and amino acid content of sixteen samples of collagen masses and casing samples.
Application: The optimisation of the technological processes at Devro.

4) Commissioned by: Devro, s.r.o., Jilemnice
Contract: Chemical analysis of collagen materials and adhesives.
Summary: The technical report contains analyses of two samples of collagen masses and three adhesives. The samples were analysed for secondary structure of collagen, fat content and amino acid composition were determined and elemental analysis was performed.
Application: The optimisation of the technological processes at Devro.

5) Commissioned by: Devro, s.r.o., Jilemnice
Contract: Chemical analysis of collagen materials and adhesives II.
Summary: The technical report contains the results of the analysis of four samples of collagen materials and four samples of adhesives supplied. The collagen masses were isolated from adhesive tubes with the appropriate markings. The samples were subjected to infrared spectral analysis of the secondary structure of the collagen, the fat and hydroxyproline content was determined, electron microscopy image analysis was also performed on the samples processed by gentle drying to the critical point. In addition, the analysis was carried out of the amino acid composition of all eight samples.
Application: The optimisation of the technological processes at Devro.

6) Commissioned by: UJP Praha, a.s.
Contract: The pre-hydridation of Zr1Nb alloy samples.
Summary: The identification of the effect of absorbed hydrogen on the corrosion properties of the Zr alloy of a nuclear fuel coating tube involved the study of a set of 105 test samples with the required hydrogen concentrations of 1000, 600 and 300 ppm. The hydridation of the zirconium alloy was performed via the application of an original method developed by the IRSM employing sorption microbalances that makes use of the accuracy and sensitivity of the weighing system, the potential for its evacuation to high vacuum rates, the potential to vary the

temperature and pressure conditions and the ability to terminate hydridation once the required weight gain has been attained.
Application: The prediction of the corrosion behaviour of Zr alloy-coated tubes as the first protection layer for nuclear fuel.

7) Commissioned by: DIAMO state enterprise, uranium mining and processing plant.
Contract: The determination of the pore distribution in rocks.
Summary: The aim of the contract was to determine the distribution of pores in rocks in the meso-, macro- and coarse pore range with respect to 60 structurally intact samples of sedimentary rocks using the mercury porosimetry method. The results of the porosimetry analysis proved, based on the comparison of two analyses of each sample, the very good degree of homogeneity of the analysed sedimentary rocks. The porosity in 36 samples ranged on average up to 11%, with 12 samples exhibiting slightly lower values of, on average, around 8%. The highest porosities, up to 30%, were recorded for 12 samples. The results of the analysis clearly indicated the significance of the most frequently represented radius, which corresponded to the predominance of the size of the pores according to their classification in the analysed rocks. Samples with predominantly mesoporous, macroporous and coarsely porous characters were identified.
Application: The determination of the transport parameters of the Turonian and Cenomanian collector transition.

8) Commissioned by: Ředitelství silnic a dálnic ČR (The Czech Highways Authority)
Contract: I/9 Svor - verification of the extent of potential block-type slope deformation.
Summary: The extent of potential block-type slope deformation on the route of the planned I/9 Svor bypass was assessed for the Road and Motorway Directorate of the Czech Republic. The overall geomorphological, structural-tectonic and engineering-geological analysis of the slopes.
Application: Road constructions.

9) Commissioned by: Ředitelství silnic a dálnic ČR (The Czech Highways Authority)
Contract: Geophysical survey of the Starý Jičín site on the section D48 Bělotín - Rybí.
Summary: A geophysical survey of the Starý Jičín site on the D48 Bělotín - Rybí section was carried out and the results were evaluated. The extent of potential slope deformations on the route of the currently constructed D48 motorway (section Bělotín - Rybí) near Starý Jičín was assessed.
Application: Road constructions.

10) Commissioned by: ČEZ a.s.
Contract: Seismic risk calculations for the Dukovany and Temelín nuclear power plants
Summary: The project concerned the determination of probabilistic seismic hazard curves, uniform response spectra and seismic hazard disaggregation for the Dukovany and Temelín nuclear power plants. The calculations, which were summarised in the form of two reports, were made in preparation for an International Atomic Energy Agency (IAEA) mission planned for 2022.
Application: The safety of nuclear power plants.

11) Commissioned by: The Czech Radioactive Waste Repository Authority (SÚRAO).
Contract: The monitoring of the activity of the brittle structures of the Bukov URF and the Rožná mine - continuous monitoring and evaluation.
Summary: The parameters of brittle structures and brittle failure were measured and evaluated for the Bukov underground research facility and the Rožná Mine. The results were subsequently summarised in a technical report by Stemberk J., Briestenský M., Hartvich F., Fučík Z. (2021): The monitoring of the activity of brittle structures at the Bukov URF and the Rožná mine – continuous monitoring and evaluation 3. – MS SÚRAO, TZ 571/2021, 2021, 30 pages.
Application: The disposal of radioactive waste.

12) Commissioned by: The Czech Radioactive Waste Repository Authority (SÚRAO).

Contract: The monitoring of the seismic phenomena at the radioactive waste repository located in the Richard mine near Litoměřice
Summary: The results of long-term continuous seismic monitoring conducted at two seismic stations in the radioactive waste repository located in the Richard mine were presented and commented upon in the form of three reports compiled as a contribution towards ensuring the seismic safety of the repository.
Application: The seismic safety of the repository.

13) Commissioned by: Energoprůzkum Praha, spol. s r. o.
Contract: Monitoring of movement activity at two selected dislocations in the Skalka mine adit in 2022.
Summary: The results of the monitoring of physical activity at two selected dislocations in the Skalka mine adit were summarized and commented for the purpose of energy consulting.
Application: The Power engineering and energy advisory.

14) Commissioned by: The Vyšehrad National Cultural Monument organization
Contract: Stability monitoring of selected objects in the Vyšehrad National Cultural Summary: Monument: The stability of the objects of the national cultural monument Vyšehrad and The results of the monitoring were evaluated.
Application: Care of tangible heritage monuments.

15) Commissioned by: Karst Research Institute, Postojna, Slovenia
Contract: Evaluation of microposition measurements and creation of a database.
Summary: Within the framework of the research of karst formations, the measurements of micropositions were evaluated and a database of the obtained data was created.
Application: The research of karst formations.

Expertise:

1) Commissioned by: The Czech Highways Authority.
Expertise: The Safety monitoring of the D8 highway

2) Commissioned by: The Nature Conservation Agency of the Czech Republic (NCA), Protected Land Scape Area Broumovsko, East Bohemia Regional Branch
Expertise: Assessment of the Krápníky rock formation in the Teplice Rocks and evaluation safety measures.

3) Commissioned by: The Adršpach Technical Services, s.r.o.
Expertise: Assessment of the stability of rock blocks and proposal of remedial measures: The Television Tower area, The Adršpach-Teplice rock town.

4) Commissioned by: The River Basin Elbe organisation
Expertise: Experimental geophysical measurements of sediment thicknesses on selected profiles on the Elbe River by electrical resistivity tomography. (MaSEL project - Mapping of sediment quality in the Elbe reservoirs of the Czech Elbe).

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6. International cooperation

The Institute participated during the year in 13 international projects, 8 bilateral scientific cooperation agreements with foreign partners and cooperated with an International Advisory Board. The Institute's staff participated in 8 international scientific organizations, in three cases in official management positions.

International projects:

1) Batch-to-Glass Conversion and Chemical Durability of Glass for Vitrification of Low Activity Waste (Battelle Energy Alliance, LLC, Idaho, USA, Contract No. 206349, 2018-2022)

2) Mathematical Modeling and Experimental Evaluation of Melter Cold Cap for Nuclear Waste Vitrification (Battelle Energy Alliance, LLC, Idaho, USA, Contract No. 166789, 2016-2022)

3) Analysis of Foaming – Critical Batch-to-Glass Conversion Process. (The Ministry of Education, Youth and Sports of the Czech Republic, Programme Inter-Excellence – Inter-Action, USA, contract no. LTAUSA18075, 2019 – 2022)

4) Preparation and characterisation of disordered materials for application in infrared spectra (EU project – Danube region, Project No. 8X20053, program Mobility, cooperation of Czech rep., Slovak rep., France and Serbia, 2020-2022)

5) Full-color tunable emission of lanthanide-doped monolithic glasses upon single beam irradiation for laser-based volumetric displays (CZ-Turkey project, TÜBITAK- 21-11, 2021-2022)

6) Radiolytical alteration of the organic matter in coal and rocks enriched in radioactive minerals.

7) Environmental application of organic petrology

8) The evaluation of self-heating on coals of different rank via optical microscopy

9) Identification of Dispersed Organic Matter

10) Natural Seismicity as a Prospecting and Monitoring tool for geothermal energy extraction

11) Research and Development project about seismic hazard and ground motion

12) Understanding Active Deformation of the Adriatic Plate and its Margins

13) Six-component continuous monitoring of seismic swarms and other earthquakes in the region of Long Valley Caldera, California (The Ministry of Education, Youth and Sports, Programme Inter-Excellence, contract no. MSMT-37785/2019-2)

14) Earthquake-triggered landslides in recently-active and stabilized accretionary wedges (International project GACR/MOST TW 22-24206J, 2022-2024).

Official positions in the membership of international organisations:

1) Doc. Ing. Jaroslav Kloužek, CSc.: International Commission on Glass, Technical Committee No. 18 – Glass melting. Chairperson, term of office: 2016 – 2023.

2) RNDr. Petra Štěpančíková, Ph.D: International Union for Quaternary Research, Commission on Terrestrial Processes, Deposits, and History. Vice president, term of office: 2019 – 2023.

Bilateral cooperation with foreign partners:

1) Instituto Geofísico del Peru
Theme: The monitoring of tectonic movements.

2) Instituto Nacional de Investigación en Glaciares y Ecosistemas de las Montaña (Peru).
Theme: The evaluation of the danger of slope movements around the village of Rampac Grande, Cordillera Negra, Peru.

3) Instytut Geofizyki Polskiej Akademii Nauk.
Theme: The research of tectonic movements and slope deformations in the Svalbard archipelago.

4) Uniwersytet Wroclawski.
Theme: The research of the structural-geological conditions and construction of the Broumov/ Góry Stolowe table mountains; arctic and permafrost research.

5) Naturhistorisches Museum Wien.
Theme: The research of active tectonics in caves in the Eastern Alps.

6) Johannes-Guttenberg Universität Mainz.
Theme: The radiometric dating of active tectonics in karst caves.

7) University of Memphis.
Theme: The research of local seismicity.

8) Uniwersytet Wroclawski – Wydzial Nauk o Ziemi i Ksztaltowania Srodowiska. Agreement of co-operation: Joint research projects concerning research fields stated in the agreement; Exchange of academic staff and students; Joint publications and exchange of scientific and didactic materials; Organisation of joint scientific conferences and workshops

International Advisory Board of the IRSM (IAB)

In October 2022, members of the International Advisory Board visited the Institute.
The Board was informed about the activities of the Institute and the individual various research activities of each departments. The members of the Board also attended the demonstration of fieldwork in Prague castle and at the end of the visit provided recommendations for further improvements activities of the IRSM.

Members of the IAB:

- **Prof. Dr. Kimon Christanis**
University of Patras, Department of Geology
University Campus, GR-265.04 Rio-Patras, Greece

- **Prof. Dr. Manfred Joswig**
Stuttgart University, Institut für Geophysik
Goethestr. 25, D-40237 Düsseldorf, Germany

- **Dr. Yann Klinger**
Institut de Physique du Globe – CNRS, Tectonic Lab. at IPGP
Université de Paris 1, rue Jussieu 75238 Paris cedex 05, France

- **Dr. Rouwen Lehné**
Hessisches Landesamt für Umwelt und Geologie (HLNUG)
Dezernat G1 – Geologische Grundlagen, Rheingaustr. 186, 65203 Wiesbaden, Germany

- **Prof. Vladimir Yudin**
Institute of macromolecular compounds RAS
199004 Saint-Petersburg, Bolshoy pr. 31, Russia

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7. Popularisation and public education activities

1) Exhibition: Unstable subsoil - Landslides, lives and perspectives. Museum of the City of Ústí nad Labem, IRSM; J. E. Purkyně University in Ústí nad Labem, 23 November 2021 – 3 April 2022.

2) Presentation: Possibilities of processing brown coal into germanium. Laboratory of Thermal Processes, Department of Material Structure and Properties of the IRSM: 26 January, 31 May, 5 August, 27 September, 12 October 2022

3) Presentation: Processing of waste organic materials. Laboratory of Thermal Processes, Department of Material Structure and Properties of the IRSM, 1 February, 1 September, 19 October, 23 November, 20 December 2022

4) Presentation: Activities for practice, magnetic materials. Laboratory of Environmental Technologies, Department of Material Structure and Properties of the IRSM. 17 January, 23 February, 12 April, 14 June, 6 December 2022

5) Presentation: Geopolymery ve stavebnictví, silikátové technologie. Laboratory of Geopolymers, Department of Material Structure and Properties of the IRSM 30 March, 22 December 2022

6) Science fair Prague: the use of waste inorganic and organic materials, demonstrations of raw materials and presentations of types of waste organic materials and the use of products derived from these wastes. PVA Expo Praha, Letňany, 2 - 4 June 2022

7) The Week of the Czech Academy of Sciences: Preparation of new geopolymeric materials and their use in restoration of monuments; processing of different types of waste organic materials and possibilities to convert these wastes into useful products in practice. Experiments and explanations on the teaching of the theory of pores, porous materials, natural resources and the cleaning of pollutants from the environment, natural sources and, removal of pollutants from the environment. 3 - 4 November 2022.

8) Presentation: Monitoring of active fault movements. Interpretation of educational panels on the monitoring of active fault movements in selected accessible caves (Turold, Mladečské, Zbrašovské, Výpustek, Bozkovské caves). October 2022

9) Seminar Biomaterials and their surfaces: basic issues of biomaterials and the current state of research and development and production of prosthetics or artificial replacements in the Czech Republic. Department of Composite and Carbon Materials. 13 – 16 September 2022

8. Network monitoring

Monitoring 1
Monitoring network: SlopeNet:
Monitoring of slope deformations, landslides and rock falls.
Operator: IRSM, RENS programme.
Activities: the geophysical and geotechnical monitoring of slope deformations with co-responsibility for monitoring.

Monitoring 2
Monitoring network: Network EU TecNet:
The 3D monitoring of tectonic structures in the EU.
Operator: IRSM, Czech/Geo programme.
Activities: device readings, service and data evaluation.

Monitoring 3
Monitoring network: Czech Regional Seismic Network:
Earthquake monitoring in Europe and worldwide.
Operators: Institute of Geophysics AS CR, IRSM, Institute of Geonics AS CR, Institute of Earth Physics, Masaryk university and the Charles University Faculty of Mathematics and Physics, Czech/Geo programme.
Activities: basic scientific earthquake research infrastructure, especially concerning long-term seismicity research in Europe and worldwide.

Monitoring 4
Monitoring network: MKNET:
Earthquake monitoring in the Lesser Carpathians.
Operators: IRSM, the Earth Science Institute of the Slovak Academy of Sciences, Progseis s.r.o., Czech/Geo programme.
Activities: the continuous recording and evaluation of detailed research data on selected seismically active areas.

Monitoring 5
Monitoring network: REYKJANET:
The monitoring of earthquakes in Iceland.
Operators: Institute of Geophysics AS CR and IRSM, Czech/Geo programme
Activities: detailed long-term international research in a seismically active area of Iceland.

Monitoring 6
Monitoring network: Landslides, rockfalls and ground currents as recorded in the media since 2011: The emergence and reactivation of slope deformations in the Czech Republic.
Operator: IRSM, NASA programme.
Activities: determination of the location and the time of occurrence of landslides, and the damage they cause.

Monitoring 7
Monitoring network: TecNet:
The monitoring of slow movements along tectonic faults.
Operator: IRSM, Czech/Geo programme.
Activities: the tracking of seismic tectonic movements along faults.

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9. Published periodicals

1) **Acta Geodynamica et Geomaterialia**, Vol. 19, Nos. 1–4, 2022, ISSN 1214-9705 (Print); 2336-4351 (On-line). Impact-factor journal published on a quarterly basis. Database monitoring: Science Citation Index Expanded; Journal Citation Reports/Science Edition.

2) **Ceramics-Silicates**, Vol. 66, Nos. 1–4, 2022, ISSN 0862-5468 (Print); ISSN 1804-5847 (On-line). Impact-factor journal published on a quarterly basis. Database monitoring: Science Citation Index; Materials Science Citation Index; the Engineering Index (Published by Engineering Information Inc.).

IV. Evaluation of other activities

The Institute has no other activities. For the evaluation of other activities, see Section III, point 5.

V. Information on measures to remedy management deficiencies and the report on how the said measures imposed in the previous year have been implemented

The IRSM had no management deficiencies in 2022 or in the previous year.

VI. Financial information on items that are significant in terms of the assessment of the economic situation of the Institute that may affect its future development

The main source of the Institute´s income is the state budget, so there are no facts that would be significant in terms of assessing the economic position of the institution and that could affect its development. In 2022, the Institute operated according to the approved budget; detailed financial statements are annexed to this final report. As can be seen from the auditor's report, the audit of the financial statements did not reveal any deficiencies. See the financial statement - Profit and loss statement 2022.

VII. Envisaged development of the Institute’s activities

The scientific activities of the IRSM will continue to develop in accordance with global research trends, with an emphasis on publishing and teaching and popularisation activities. With respect to scientific research and the enhancement thereof, the Institute will continue to recruit from the doctoral study programmes mentioned previously in this report. The certification of the Institute’s researchers will continue aimed at enhancing the quality of their work. The performance of researchers will be rewarded by increases in remuneration and the adjustment of working hours. The Institute’s equipment will be expanded, updated and developed on a continuous basis and the staff will be provided with the appropriate training.

VIII. Environmental protection activities

In response to the needs of society as a whole, the assessment of alternative fuels will continue and the Institute will continue to be involved in developing plastic and municipal waste treatment methods, the treatment and transformation of sludge from wastewater treatment plants into fertilisers and the advancement of radioactive waste disposal technologies. A further significant contribution comprises the development of a municipal waste processing method in cooperation with two industrial companies. Conditions are in place for IRSM employees to recycle their waste and hazardous waste is disposed of ecologically by authorised companies. Pest control is performed on a yearly basis.

IX. Further sections of the Annual Report: Profit and loss statement 2022

Institute of Rock Structure and Mechanics of the CAS, V Holešovičkách 94/41, 182 09 Prague 8, Czech republic

Profit and loss statement

ID number 67985891	**Balance as at 31. 12. 2022** (in Czech Crowns, the comma separates two decimal places)	According to Decree No. 504/2002 Coll.

Item		Row	Activities		
Number	Designation		Main activity	Supplementary activy	Total
A	***A. Expenses***				
A.I	**I. Consumed purchases and purchased services**	**002**	**24 574 128,98**	**1 544 540,89**	**26 118 669,87**
A.I.1	1.Consumption of material, energy and other non-inventory items	003	9 535 271,58	419 527,24	9 954 798,82
A.I.3	3. Repairs and maintenance	005	2 030 838,74	9 900,00	2 040 738,74
A.I.4	4. Travel expenses	006	3 126 795,63	472 991,27	3 599 786,90
A.I.5	5. Representation costs	007	102 442,01	1720,00	104 162,01
A.I.6	6. Other services	008	9 778 781,02	640 402,38	10 419 183,40
A.II	**II. Changes in inventories by their own actrvities and activation**	**009**	**-419 390,84**	**0**	**-419 390,84**
A.II.8	8. Activation of material, goods and interior services	011	**-419 390,84**	0	**-419 390,84**
A.III	**III. Total personnel expenses**	**013**	**67 420 788,25**	**2 029 457,00**	**69 450 245,25**
A.III.10	10. Wages and salaries	014	49 616 421,00	1 497 138,00	51 113 559,00
A.III.11	11. Statutory social insurance	015	16 238 114,25	502 583,00	16 740 697,25
A.III.13	13. Statutory social expenses	017	1 566 253,00	29 736,00	1 595 989,00
A.IV	**IV. Total taxes and fees**	**019**	**38 940,00**	**0**	**38 940,00**
A.IV.15	**15. Taxes and fees**	**020**	**38 940,00**	**0**	**38 940,00**
A.V	**V. Total other expenses**	**021**	**2 930 800,23**	**1 405 434,04**	**4 336 234,27**
A.V.16	16 Contractual fines, delay interests, other fines and penalties	022	5 525,88	0	5 525,88
A.V.19	19. Exchange rate losses	025	86 056,23	0	86 056,23
A.V.22	22. Other expenses	028	2 839 218,12	1 405 434,04	4 244 652,16
A.VI	**VI. Total depreciation expenses, sold assets, addition and utilization to reserves and adjustments**	**029**	**15 514 929,51**		**15 514 929,51**
A.VI.23	23. Depreciation expenses of fixed assets	030	15 162 204,93	0	15 162 204,93
A.VI.24	24. Sold fixed assets	031	731 339,48	0	731 339,48
A.VI.27	27. Addition and utilization to reserves and adjustments	034	-378 614,90	0	-378 614,90
A.VIII	**VIII. Total income tax**	**037**	**263 060,00**	0	**263 060,00**
A.VIII.29	29. Income tax	038	263 060,00	0	263 060,00
	Total expenses	**039**	**110 323 256,13**	**4 979 431,93**	**115 302 688,06**
B	***B. Revenues***				
B.I	**I. Total operating grants**	**041**	**91 327 769,20**	**0**	**91 327 769,20**
B.I.1	1. Operating grants	042	91 327 769,20	0	91 327 769,20
B.III	**III. Revenues of own services and merchandise**	**047**	**407 385,83**	**5 737 826,17**	**6 145 212,00**
B.IV	**IV. Total other revenues**	**048**	**18 750 961,70**	**0**	**18 750 961,70**
B.IV.7	7. Interest income	051	135 922,13	0	135 922,13
B.IV.8	8. Exchange rate gains	052	21 886,21	0	21 886,21
B.IV.9	9. Settlement of funds	053	686 091,01	0	686 091,01
B.IV.10	10. Other revenues	054	17 907 062,35	0	17 907 062,35
	Total revenues	**061**	**110 486 116,73**	**5 737 826,17**	**116 223 942,90**
C	**C. Profit / Loss before tax**	**062**	**425 920,60**	**758 394,24**	**1 184 314,84**
D	**D. Profit / Loss after tax**	**063**	**162 860,60**	**758 394,24**	**921 254,84**

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