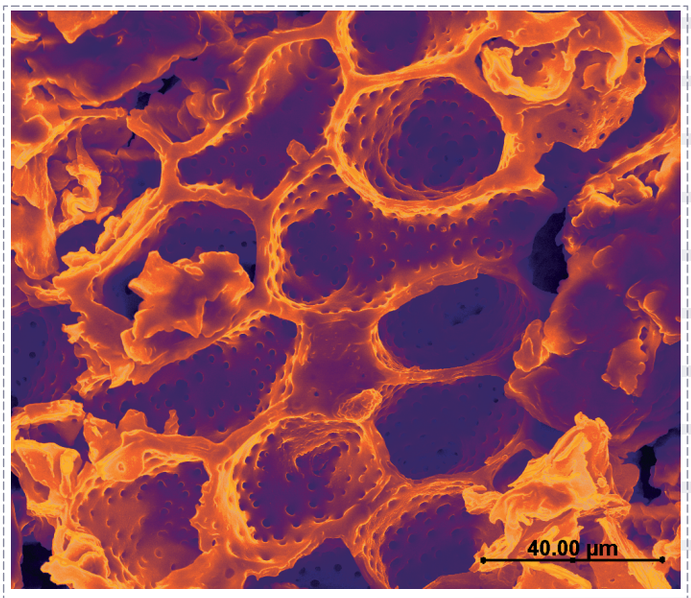
DEPARTMENT OF MATERIALS STRUCTURE AND PROPERTIES

INSTITUTE OF ROCK STRUCTURE AND MECHANICS
of the Czech Academy of Sciences

THEMATIC RESEARCH FOCUS

- **PROCESSING OF BIOMASS, WASTE PLASTICS AND COAL**
- **USE OF BIOASHES**
- **GEOPOLYMER COMPOSITES**
- **PHYSICAL METHODS OF RAW-MATERIAL PROCESSING**
- **INSTRUMENTAL ANALYSES AND MOLECULAR MODELLING**



SEM photomicrograph of biomass structure (apricot) seeds

MAIN RESEARCH SUBJECTS

The Department of Material Structure and Properties studies the relationships between structure and properties of inorganic and organic materials as well as methods for their preparation. It develops energy-efficient production processes and environmental technologies. Individual research fields with application potential are focused on alumino-silicate materials and geopolymers, carbonaceous products and metal materials with magnetic properties. A traditional field of research is the thermal processing of coal, biomass and waste plastics.

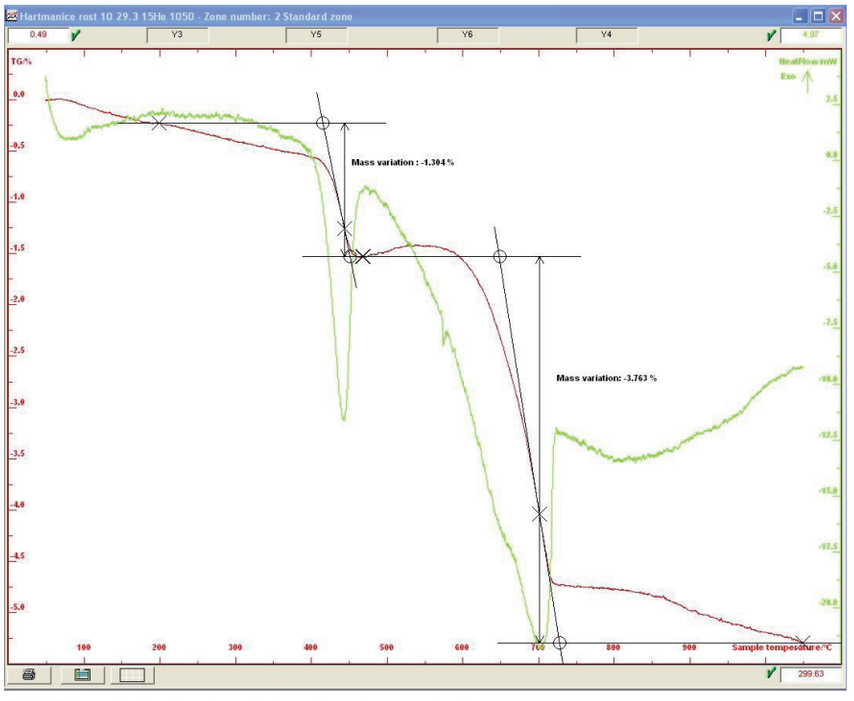
- **Chemistry and geopolymer technologies:** preparation of new geopolymer materials; use of bioashes from biomass combustion for the nutrient-enrichment of soils; material assessment of historical mortars and plasters for restoration purposes; research on the microstructure and the micromechanical properties of geopolymer composites.
- **Environmental technologies:** organic waste treatment; methods of co-gasification of coal with organic wastes for energy purposes; methods of hydrogen production from renewable sources. A new research direction is the preparation of catalysts for organic-waste thermal decomposition.
- **Magnetic materials:** creation of strong magnetic fields from rare-earth permanent magnets for various applications; construction of highly efficient filters and magnetic separators. The assembled magnetic filters and separators are used in technological lines of raw-material and ceramic-mass treatment industrial plants.

KEY RESEARCH EQUIPMENT

- Spectro, Kleve X-ray fluorescence analyzer for elemental analysis of solid and liquid materials.
- Agilent 6890N gas chromatographs with FID and TCD detection for gaseous-mixture analysis.
- SETARAM Setsys Evolution 18 thermal analyzer.
- Perkin-Elmer thermal analyzer.
- TERI-MOM thermal analyzer.
  The analyzers are used to characterize polymers, coal, norganic-substances and biomass decomposition reactions. The analyses are performed in both inert and oxidizing atmosphere.
- Automatic fusion machine for XRF analysis.
- Labio GC-UV spectrometer.
- CECIL CE-7500 UV-VIS double-beam spectrometer.
- CILAS 920 laser particle-size analyzer with a range of 0.7 – 400 µm.

Heat-treatment furnace with fixed bed and cracking module

- Stationary- and moving-bed furnaces with continuous monitoring of gas components, volume of gases generated, pressure and temperature.
- Material-firing furnace, a material-strength testing machine, friction mills, a vibration screen grader, a jaw crusher, a vibration mill, a disintegrator, a programmable drying oven with a maximum temperature of 300 °C.



DSC/TG analysis of grate ash from burning wood chips

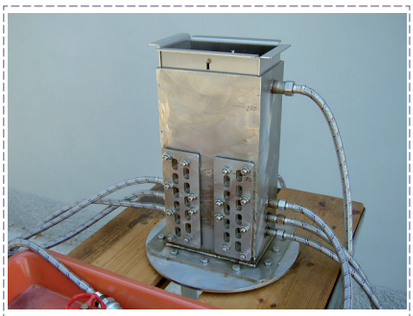
Thermal analyser SETARAM Setsys Evolution No. 18 working in both inert and oxidizing atmospheres

ACHIEVEMENTS

Magnetic filters and separators for raw-material and ceramic-mass treatment

Žežulka V., Pištora J., Lesňák M., Straka P., Ciprian D., Foukal J.: I*ntensity distribution of strong magnetic fields created by opposing linear Halbach assemblies of permanent magnets,* Journal of Magnetism and Magnetic Materials, Vol. 345, 2013, 7–12.

Žežulka V., Straka P., Soukup V.: *Method of forming magne ic blocks and equipment for carrying out that method.* No.: US 7,796,001 B2, US Patent and Trademark Office, 2010.



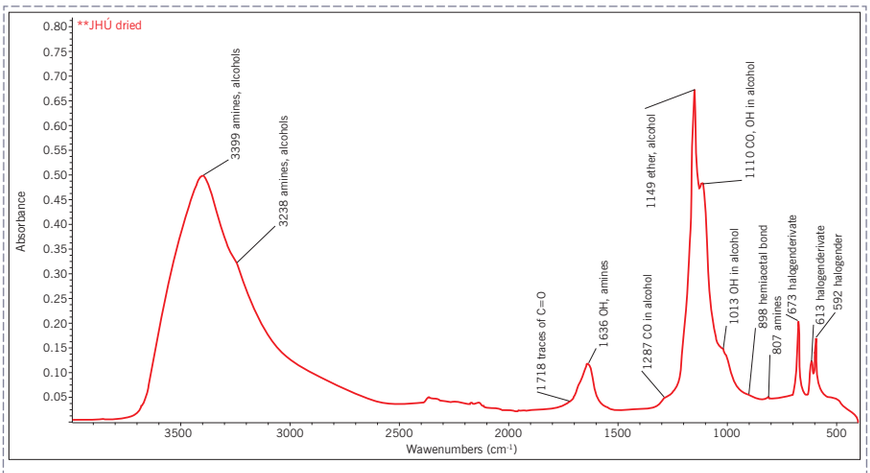
Equipment for assembling large magnetic blocks from magnetic plates

Environmental technologies

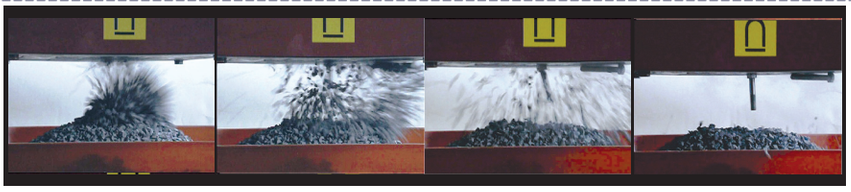
Straka P., Bučko Z.: *Co-gasification of lignite/waste-tyre mixture in a moving bed.* Fuel Processing Technology, Vol. 90, 2009, 1202–1206.

Straka P.: *Study of the Catalytic Effect of Magnetite in the Gasification of Chars from the Lignite/Rubber Mixtures.* Gasification: Chemistry, Processes and Applications. Monograph, New York: Nova Science Publishers, Ed.: M. D. Baker, 2012, 315–327.

Straka P., Náhunková J., Žaloudková M.: *Analysis of unburned carbon in industrial ashes from biomass combustion by thermogravimetric method using Boudouard reaction.* Thermochimica Acta, Vol. 575, 2014, 188-194.



The FTIR spectrum of the leachate of the industrial ash from biomass combustion



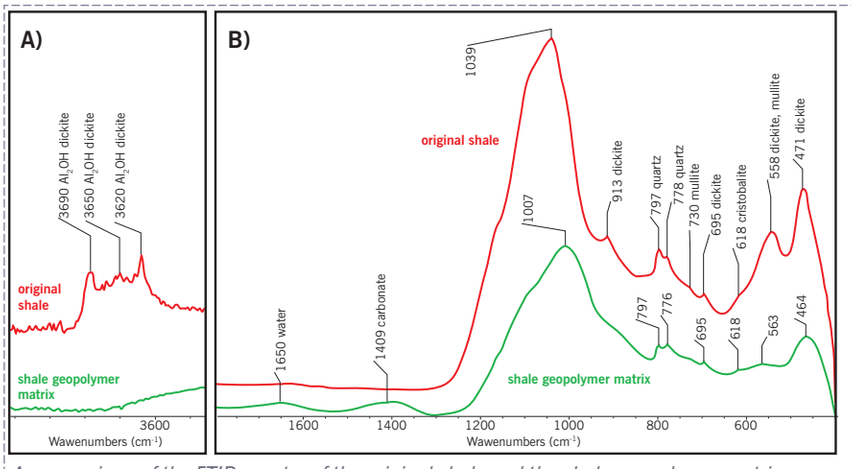
Successive phases in the attraction of steel screws from beneath an 80-90 mm layer of crushed stone from a distance ca 200 mm towards the surface of the suspended magnetic circuit.

Material characterization

Hanzlíček T., Perná I., Ertl Z.: *The influence of temperature and composition on modeled mortars.* International Journal of Architectural Heritage, Vol. 6, No. 4, 2012, 359–372.

Hanzlíček T., Perná I., Brus J.: *27Al Magic Angle Spinning – Nuclear Magnetic Resonance (MAS-NMR) Analyses Applied to Historical Mortars.* International Journal of Architectural Heritage, Vol. 7, No. 2, 2012, 153–164.

Perná I., Hanzlíček T., Šupová M.: *The identification of geopolymer affinity in specific cases of clay materials.* Applied Clay Science, Vol. 102, 2014, 213-219.



A comparison of the FTIR spectra of the original shale and the shale geopolymer matrix

Waste-material utilization

Perná I., Hanzlíček T.: *The solidification of aluminum production waste in geopolymer matrix.* Reference: Journal of Cleaner Production, Vol. 84, 2014, 657-662.

Hanzlíček T., - Perná I.: *Thermal resistance of foamed fluidized bed ashes.* Acta Geodynamica et Geomaterialia, Vol. 162, No. 2, 2011, 115-122.

Szákova J., Ochecová P., Hanzlíček T., Perná I., Tlustoš P.: *Variability of Total and Mobile Element Contents in the Ash after Biomass Combustion.* Chemical Papers, Vol. 67 Issue 11, 2013, 1376-1385.

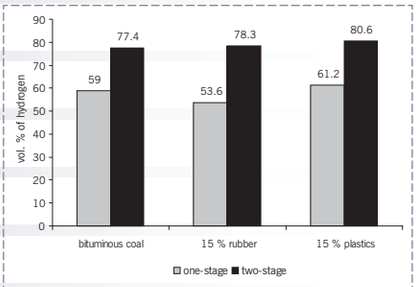
A solid product from a foamed and non-foamed geopolymer containing a high amount of aluminum-production waste

Hydrogen production

Bičáková O., Straka P.: *Production of hydrogen from renewable resources and its effectiveness.* International Journal of Hydrogen Energy, Vol. 37, Issue 16, 2012, 11563–11578.

Straka P., Bičáková O.: *Hydrogen-rich gas as a product of two-stage co-gasification of lignite/waste plastics mixtures.* International Journal of Hydrogen Energy, Vol. 39, Issue 21, 2014, 10987–10995.

Kříž V., Bičáková O.: *Hydrogen from the two-stage pyrolysis of bituminous coal/waste plastics mixtures.* International Journal of Hydrogen Energy, Vol. 36, Issue 15, 2011, 9014–9022.



The dependence of the hydrogen content on the type of the additive from one-stage and two-stage co-pyrolyses with bituminous coal

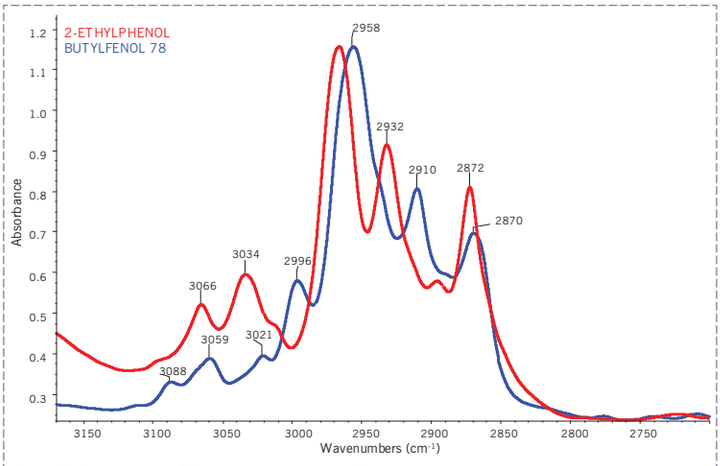
MAIN COLLABORATING PARTNERS

- Institute of Chemical Technology (Prague, CZ)
- Technical University – VŠB (Ostrava, CZ)
- Czech University of Life Sciences (Prague, CZ)
- Faculty of Mathematics and Physics Charles University (Prague, CZ)
- University of Pardubice – Jan Perner Transport Faculty (Pardubice, CZ)
- Czech Technical Univertity (Prague, CZ)
- Czech Development Agency (Prague, CZ)
- IQStructures s. r. o. (Řež, CZ)
- Bohemian Oil, s. r. o. (Prague, CZ)
- Université de Picardie, (France)
- Slovenian National Building and Civil Engineering Institute (ZAG), (Slovenia)
- Institute of Science and Technology for Ceramics in Bologna (CNR-ISTEC), (Italy)
- Faculty of Mechanical Engineering of the Slovak University of Technology, (Bratislava, Slovakia)

Theoretical organic chemistry and molecular modelling

Straka P., Buryan P.: *A Study of the Behavior of Alkyl Side Chains Phenols and Arenes in Polar and Non-polar GC Stationary Phases.* American Journal of Analytical Chemistry, Vol. 2, No. 3, 2011, 324-331.

Straka P., Novotná M., Buryan P., Bičáková O.: *The Cyclization of Alkyl Side Chains of Naphthalenes: the GC/Potential Energies/FTIR.* American Journal of Analytical Chemistry, Vol. 5, No. 14, 2014, 957-968.



The FTIR spectra of 2-ethyl phenol and 2-butyl phenol in spectral regions of 1680-1530 cm^{-1}

Restoration of historical monuments

Hanzlíček T., Steinerová M., Straka P., Perná I., Siegl P., Švarcová T.: *Reinforcement of the terracotta sculpture by geopolymer composite.* Materials & Design, Vol. 30, 2009, 3229–3234.

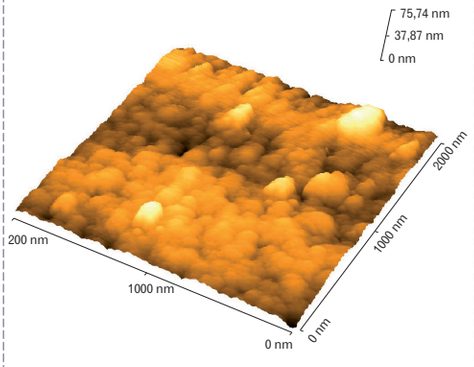
Hanzlíček T., Perná I., Ertl Z., Miller S.M.: *Pre-Portland cements and geopolymers.* Acta Geodynamika Geomaterialia, Vol. 165, No. 1, 2012, 57-62.

Geopolymer properties

Steinerová M., Schweigstillová J.: *Porous microstructure of the interfacial transition zone in geopolymer composites.* Ceramics - Silikáty. Vol. 57, No. 4, 2013, 328-335.

Steinerová M.: *Mechanical properties of geopolymer mortars in relation to their porous structure.* Ceramics - Silikáty. Vol. 55, No. 4, 2011, 362-372.

Highly damedged baroque statue was repaired by inner ribs



Geopolymer matrix – AFM image Surface of the geopolymer matrix based on meta-kaolinite shows its naturally created structure of clusters with a size of tens of nanometers

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