Krzysztof Kaliński

The Institute of Geological Sciences works to put analytical methods to use in geological research

By Thought and Spectrometer

TERESA MADEYSKA
Institute of Geological Sciences
Polish Academy of Sciences
tmadeysk@twarda.pan.pl

Geologists' traditional motto – *mente et malleo*, or "by thought and hammer" – remains apt in modern times even though the hammer has been increasingly displaced by state-of-the-art equipment

The Department of Geological Sciences of the Polish Academy of Sciences was founded on 3 January 1956, as a unit integrating existing research centers in Kraków, Warsaw, and Wrocław, thereby partially inheriting the legacy of the Polish Academy of Arts and Sciences (PAU). The initiative to establish the center was spearheaded by the eminent Polish Professors Jan Samsonowicz, Roman Kozłowski and Stefan Zbigniew Różycki. In June 1979 the Department was transformed into the current Institute of Geological Sciences of the Polish Academy of Sciences, now under the direction of Prof. Teresa Madeyska.

The institution has been authorized to confer the degree of PhD (doctorate) since 1960, and the degree of DSc (habilitation) since 1987. By the end of 2005, the scientific council had conferred doctorate degrees to 123 individuals, 14 DSc candidates had earned degrees, and 10 scientists had been granted professorships.

Towards GeoLab

The institute carries out methodological research on the geochemistry of isotopes, mineralogy and micropaleontology, and conducts studies aimed at identifying the age and

origin of rocks and minerals, tracing the evolution of selected fragments of the earth's crust, reconstructing ancient sedimentary environments, and also assaying the human economy's impact on the natural environment.

The Institute particularly strives to employ a wide range of state-of-the-art methods and to thoroughly harness its laboratory apparatus, especially spectrometers, which permit geochemical isotope methods to be applied to geological research. The Institute's most prized resources are a VG SECTOR 54 Thermal Ionization Mass Spectrometer (TIMS), a Finnigan MAT Delta+ gas spectrometer (operated jointly with the Institute of Paleobiology, Polish Academy of Sciences), an alfa OCTET PC spectrometer, an MS-20 spectrometer, modern x-ray diffractometers, and an electron microscope with an x-ray microanalyzer. Owing to a subsidy from the Fund for the Development of Science awarded to a consortium of several research institutions in 2005, this array of equipment will soon come to include an MC-ICPMS spectrometer as well. The TIMS laboratory, a clean-room chemistry lab, and the MC-ICPMS investment project that is now underway have been consolidated to create an environmental laboratory dubbed GeoLab, able to serve several institutions.

The Institute puts existing isotope geochemistry methods to considerable use in geological research, and also further perfects how they are applied to various rocks, fossils, and underground waters. Measurements of radioactive and stable isotope ratios of various elements are used in studying many rocks, in dating geological processes, and also in petrological research. Isotopes of strontium, stable isotopes of carbon and oxygen, and isotopes of sulfur are used in stratigraphy, reconstructing sedimentary environments and climate variability, and tracing the diagenetic transformations of rocks and minerals. Research into the origin of underground waters, in turn, uses the isotope ratios of hydrogen, oxygen, sulfur, and nitrogen.

Clays, microlife, and faults

At present, one of the most important lines of research that is proving decisive for the Institute's stature in world science involves methodological studies on the mineralogy of phyllosilicates (sheet sillicates), particularly clay minerals. The properties, genesis, and transformations of these minerals are studied using x-ray, chemical, thermal, and isotope methods, infrared spectrometry, and high-definition electron microscopy. The Institute's staff members have authored or coauthored a range of mineralogical research methods and techniques, developed in cooperation with leading laboratories in France, Spain, the UK and the US. The research topics being pursued include investigating the impact of preparation techniques on clay minerals' properties that are important for the production of nanomaterials.

The Institute also excels at micropaleontology research. Fossils and remnants of such organisms as foraminifers, dinocysts, spores, acritarchs, radiolarians, calpionellids, diatoms, and cladoceras are useful in working out the stratigraphy of selected segments of the Paleozoic, Mesozoic, and Cenozoic and in reconstructing paleoecological conditions. New methods are also being developed in this field. Attempts at numerically modeling the morphogenetic processes evident in foraminifer skeletons (known as "tests") are yielding interesting results.

Research aimed at reconstructing the processes taking place in lithosphere plate collision zones is being pursued not only in Poland, but also in neighboring Central European countries, in the polar regions, and in other parts of the world, such as Vietnam and China. Such efforts integrate studies of a tectonic, petrological, mineralogical, geochemical, geochronological, and geophysical nature. Research focusing on the rocks of the Earth's crust, paying particular attention to ultra-high-pressure metamorphism and the melting of magmas in the lower lithosphere and asthenosphere, lays the groundwork for reconstructing rock migration patterns between the crust and the upper mantle, and also helps explain the genesis of the Earth's large igneous provinces (the remains of gigantic eruptions of lava that sometimes took place in the Earth's history).

The Institute's stature in the world science is boosted by its research on clay minerals

Tectonic processes are also reconstructed in sedimentary rocks using field studies, mineralogical and isotope techniques, analogous modeling, and also paleomagnetic methods (in cooperation with other centers).

Applied science

The institute lays particular emphasis on research that responds to the current needs of the economy and society. This category includes work on reconstructing sedimentary environments and on stratigraphic interpretation, especially as concerns the Carboniferous period. The results of such research are being harnessed in practice in the coal mining sector, in the regional correlation of deposit layers. They have also been recently applied to riverine delta sediments based on examples from Poland and the US; here the Institute has been working together with the petroleum industry.

Another important line of research involves reconstructing changes in the natural environment, in particular climate changes, based on the profiles of lake- and cave-bottom sediments and eolic (wind-borne) sediments. The aims of such research include tracing the history of the environmental changes that have occurred due to human impact. Moreover, pollution sources are being identified using isotope analyses of lead in soils and nitrogen in waters. ■