OVERVIEW:

The scientific activity of the Department in 2001 can be summarised as follows.

In the Environmental Physics Laboratory gas chromatography methods are being developed mainly for atmospheric investigations and hydrological applications. A method for measuring the SF_6 contents in water for determining the age of young groundwaters is well advanced. Reconnaissance measurements performed in two aquifers yielded a reasonable agreement with the ages obtained from the tritium method. A proper determination of trace gases dissolved in water requires the measurement of the so-called "excess air" resulting from the excessive dissolution of air bubbles at the groundwater table. For this purpose, a new method of analysing the concentrations of argon and neon in water was developed. The separation of argon from oxygen in gas samples, extracted from water, carried out with the help of the catalyst of NiO type. Neon is determined with the aid of a pulse discharge helium detector (type PI-2D, VALCO Ltd) doped with neon. The initial results are promising. Atmospheric investigations were continued by measurements of the concentrations of F-11, F-12, F-113, $CHCl_3$, $CHCCl_3$, CCl_4, and SF_6 in the Kraków area. Incidentally, high concentrations of SF_6 are observed. The air flow trajectories available in the BADC Trajectory Service (http://cirrus.badc.rl.ac.uk/trajectory/) were used in an attempt to identify the emission source of these high SF_6 concentrations. So far only the north-west direction was identified. Hydrogeological investigations of the origin and ages of different interesting groundwater systems by environmental isotope methods were also continued, and the origin of chemically unique mineral water in Krynica Spa has been identified as related to dehydration of clay minerals in burial diagenesis.

The Natural Radioactivity Laboratory has been involved in interdisciplinary projects on the measurements of radon concentration in soil gas in areas of different geological structures, in collaboration with the Institute of Geological Sciences of Polish Academy of Sciences. The geological fault system which surrounds the „Las Wolski" horst is covered with loess overburden. An evident increase in radon concentration in the upper loess layer is observed over the fault position. This may have important environmental implications. Several samples of soil taken from those areas were analysed for the concentration of natural isotopes (U, Th, and K). Natural radioactivity measurements in various samples (soils, rocks, raw, and building materials, etc.) have been carried out using low background spectrometers (with NaI(Tl) and HPGe detectors). The results are used in the data base of the Polish Central Laboratory of Radiological Protection and were presented at the III Nat. Conf. on Radiochemistry and Nuclear Chemistry. The increasing interest in radon environmental research bears fruit of some co-operation with various institutions in Poland and Central Europe. We took part in the national inter-comparison concerning the methodology of „radon-in-water" measurements. The results are to be published. A joint project „The Radon Centre – Non-Governmental International Scientific Network" has been started in co-operation with the Central Mining Institute in Katowice. The main goals are to prepare and execute joint research projects and programmes, and to disseminate and put into practice the results of research activities of particular Network members.

Neutron methods are an important part of nuclear geophysics and are also used in medical modalities. Investigations of the neutron transport parameters require usually the detection and/or calculation of spatial, time, and energy distributions of fast, epithermal and thermal neutrons, and of the accompanying γ radiation. The research has been directed into several aspects:

- Basic theoretical and experimental investigation for the thermal neutron transport:
  a) the temperature behaviour of the pulsed parameters in a hydrogenous moderator,
  b) diffusion cooling in small two-region systems containing substances of different types of energy characteristics of thermal neutron scattering.
- Calculations of the radiation field and energy deposition in the water beam dump for the TESLA electron-positron collider for the DESY facility, using the FLUKA Monte Carlo code;
- Monte Carlo study for designing a BNCT facility at the Polish research nuclear reactor MARIA;
- Theoretical determination of the apparent neutron parameters of rocks in the complex borehole geometry (slowing-down, migration, and diffusion lengths);
- Modelling of properties of the well logging tool sensitive to the contents of Si, Cu, Fe (using Monte Carlo method);
- Modelling of a prototype geophysical tool designed for a borehole neutron absorption cross section measurement with a two detector system (thermal-epithermal).

The benchmark MC calculations for geophysical applications are verified by experiments on the Polish geophysical calibration facility in Zielona Góra. The neutron experiments are carried on at the pulsed 14 MeV neutron generator, additionally equipped last year with a thermostatic sample chamber (0 – 70 °C).

The research carried on in the Department corresponds to its formal structure. The wide range of subjects entailed the succeeding division into laboratories. The Laboratory of Physics and Modelling of Radiation Transport (P&MRT) came into being in 1975 under the leadership of Prof. Jerzy Łoskiewicz. The research carried on in the P&MRT Laboratory comprised numerical methods of calculation of particle transport problems, laboratory experiments solving the problems of gamma and neutron transport in media, and problems of natural radioactivity in environment. These main subjects have been developed and have grown up becoming more and more independent. In 2001 the Scientific Council of the Institute resolved to reorganise the P&MRT Lab. The new Laboratory of Natural Radioactivity (NR Lab) arose in the middle of 2001. The NR Laboratory has taken over those parts of scientific output of the previous Lab, which are adequate to its designation. The remaining part of the P&MRT Laboratory group has been merged with the Laboratory of Neutron Transport Physics (NTP). This fusion reinforced the NTP Laboratory which carries on the theoretical, numerical and experimental research for the neutron and radiation transport physics.

Assoc. Professor Urszula Woźnicka

REPORTS ON RESEARCH:

Geological and Isotopic Evidence of Diagenetic Waters in the Polish Flysch Carpathians

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The origin of CO_2-rich chloride waters in the Polish flysch Carpathians is the subject of controversies even when isotope data are considered. Earlier studies showed that they contain a non-meteoric component, with isotopic composition characteristic for dehydration waters released in metamorphic processes, i.e., $\delta^{18}O \cong +6.5‰$ and $\delta^{2}H \cong -25‰$. However, the present study and comparison with other known occurrences of waters having similar isotopic composition suggests that they mainly result from the transformation of smectites to illities during the burial diagenesis of flysch sediments. These waters are characterised by high chloride contents (up to about 14 g/L), which differ in different regions, and remain difficult to explain as the $\delta^{18}O$ and $\delta^{2}H$ values are slightly scattered and do not show any distinct contribution of marine water. It is shown that such waters are also characterised by high ratios of Na^+/Cl^- and B/Cl^-, which can be useful in their identification. Particularly interesting waters occur in the four deepest wells of the Krynica Spa, which undoubtedly contain a non-meteoric chloride component. Their positions on $\delta^{18}O$-$\delta^{2}H$ diagrams are scattered to the left from a typical mixing line of meteoric waters with dehydration waters, which makes it difficult to determine their origin. However, they can be regarded as containing different percentages of a dehydration component because their Cl^--$\delta^{2}H$ relation is linear and similar to typical mixing lines of dehydration waters with meteoric waters. The non-typical positions of these waters on the $\delta^{18}O$-$\delta^{2}H$ diagram can be explained by isotopic shifts of $\delta^{18}O$ from a typical mixing line to more negative values, supposedly caused by isotopic exchange of oxygen between CO_2 and water. In that process, small volumes of water are involved, as deduced from very slow flow rates in rocks of a low porosity, and large amount of CO_2, as deduced from very high pressures measured at well heads, and an eruption of CO_2, which occurred during drilling one of the wells.