

Preface

Assignment of the project and its structuring

In the year 2000, specialists from the Czech Geological Survey and cooperating organisations launched a three-year project of science and research VaV 630/3/00 called “Complex geochemical research on interactions and migrations of organic and inorganic compounds in rocks and soils”. Dr. Tomáš Pačes was the person in charge of the project for the whole time. From the very beginning, the project was divided into two completely independent sub-tasks. The first one was designated as DÚ 01 “Ecological research on pollutant migration processes” and was conducted under the supervision of Pavel Müller in the Brno branch of the Czech Geological Survey and in the Department of Mineralogy, Petrology and Geochemistry of Masaryk University. It was focused on pollutant interactions with rocks and soils with pore permeability – with sediments.

Initial scope of the DÚ 01 Project Solution

Numerous works dealing with natural processes of interactions between liquid and solid phase refer to soils and infiltrated rain and groundwater. Experiments with soils ranged from monitoring of simple retentions of individual compounds to complex interactions under normal conditions and even under special circumstances. Sediments characterized by low contents of natural organic compounds (if compared to soils) were subjected to experiments in a significantly smaller extent. Sediments, however, form the subsoil and become substrates of soil horizons. At the same time, sediments represent an environment in which the most distinct movements of groundwater and partly also surface water take place.

Long durations of the present experiments with soils and sediments pose a substantial problem. Short spans of the accomplished experiments (maximum tens or hundreds of hours) thus enabled us to monitor and understand only initial stages of the whole process.

The interaction between elementary constituents of the environment – rocks and soils and the hydrosphere – is connected with compound redistribution and mutual influence of both reacting system components. The already very complex system of mutually affecting agents may become even more complicated, when an anthropogenic contamination appears. As a consequence of various spills, rocks and soils can be contaminated by inorganic and organic compounds – pollutants, which become a part of fluid migration.

The migration rate and the fate of organic and inorganic pollutants in natural environment are determined especially by interactions between carrier medium (water) and rocks and soils, with which they are in a direct contact. Pollutants may occur in various forms:

- in pore waters,
- bonded on exchange sites of clay minerals,
- associated with (occluded by/adsorbed on) dispersed Fe-Mn oxyhydroxides,
- as organometallic complexes adsorbed on the surface of clay minerals,
- coordinated in octahedral and tetrahedral positions of clay mineral structures,
- as ions bonded by strong bonds in the structure of insoluble or just slightly soluble mineral phases (refractory minerals, crystalline Fe-Mn oxyhydroxides etc.).

It is the form of occurrence, i.e., the character and the strength of the pollutant bond on its environment, what determines the extent of a risk to the ecosystem. The understanding of interaction processes between the water environment and sediments requires a combination of theoretical studies, laboratory experiments simulating natural conditions and application of computational modelling. The results acquired from theoretical modelling must be confronted with pollutant behaviour in natural systems.

In addition to actual chemical and geochemical interactions, migration and the subsequent fate of pollutants are determined by physical properties of rocks and soils, which affect the rate and mode of pollutant transport. From the viewpoint of incidence of various environments, which most often interact with pollutants, unconsolidated and slightly consolidated sediments are of high significance (in addition to soils and weathered rocks). The reference localities serving for monitoring of migration of dangerous pollutants were chosen among this particular sort of rocks (unsaturated and saturated zone with pore permeability), which are in direct contact with the atmosphere, surface and groundwater. The research in the scope of DÚ 01 proceeded in two major directions, E 01 and E 02:

- E 01: “Interactions between pollutants and rocks and soils” – theoretical research on a complex interaction system comprising the aforementioned type of environment and contaminating organic and inorganic compounds;
- E 02: “Migration of petroleum hydrocarbons in saturated and unsaturated zones” – applications of the developed methods on a particular locality, affected by a spill contamination.

Main research objectives within the scope of stage E 01

- The study of sorption characteristics of natural sorbents,
- investigation, modelling and prediction of sorption behaviour, migration and estimation of the fate of prior organic and inorganic pollutants in rocks and soils,
- investigation of interactions in a complex system: rock/soil – water – anthropogenic organic and inorganic pollutants (basic concepts of treatment of environmental problems in practice),
- verification and development of experimental methods used for the study and measurement of sorption parameters,
- evaluation of the influence of both organic and mineral geosorbent compositions (compositions of sorption system phases) on pollutant migration,
- appraisal of the specific role of natural geosorbent organic matter in sorption processes.

Main research objectives within the scope of stage E 02

- The description of migration, distribution and also possible degradation processes determining the fate of petroleum hydrocarbons (including volatile monoaromatic BTEX compounds – benzene, toluene, ethylbenzene and xylene) in rocks/soils (both in saturated and unsaturated zones),
- experimental verification of published data on the rates and ways of decomposition of prior organic pollutants in the natural environment,
- evaluation of main sources and types of possible hydrocarbon contamination resulting from industrial activity,
- investigation of the migration and fate of hydrocarbon contaminants in rocks and soils at the ELSTAV locality, affected by a spill contamination,
- support of ecological prevention and effective remediation of rocks and soils.

Results

The results acquired within the solution of this project are summarised in a set of five successive publications. The first four represent stage E 01; the last one covers stage E 02:

- Mineralogy, petrography and geochemistry of sediments used in pollutant sorption experiments (authors: Magdaléna Koubová – Josef Zeman – Pavel Müller)
- Adsorption of copper and cadmium from aqueous solution by various types of sediments under static and dynamic conditions (authors: Hana Müllerová – Ondřej Kruml – Karel Vybíhal – Josef Zeman – Pavel Müller)
- Characteristic of organic matter and contents of some ubiquitous hydrophobic organic pollutants in selected soils and sediments (authors: Zbyněk Boháček – Josef Bezděk – Miloslava Kovářová – Jaromír Hanák – Jan Toul – Pavel Müller)
- Sorption of hydrophobic organic pollutants on soils and sediments (authors: Jan Toul – Josef Bezděk – Miloslava Kovářová – Zbyněk Boháček – Jaromír Hanák – Ján Milička – Pavel Müller)
- Contamination by petroleum hydrocarbons and volatile organic compounds – Case study: ELSTAV BRNO (authors: František Konečný – Zbyněk Boháček – Pavel Müller – Miloslava Kovářová – Irena Sedláčková)

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Pavel Müller
Guest editor