

The main scientific aim of this project is determine and explain the mechanisms of generation, migration and mixing processes of hydrocarbon (CH_4 , C_2H_6 , C_3H_8 , $n\text{C}_4\text{H}_{10}$, $i\text{C}_4\text{H}_{10}$) and non-hydrocarbon (N_2 , CO_2 , He, Ne, Ar, Xe, Kr) components of natural gases which ran in geological past and also run in the present time within the Earth's geospheres, on inorganic way in the upper mantle and lithosphere, and organic and inorganic ways in Palaeozoic-Cenozoic sedimentary cover. Noble gases, molecular nitrogen (N_2) and carbon dioxide were generated within the upper mantle and lithosphere and differences of stable Ne, He, Ar, Xe and Kr isotope compositions, and stable N and C isotope composition of inorganic molecular nitrogen and carbon dioxide in lithosphere and the upper mantle are connected with different geochemical and geothermal conditions within these Earth's geospheres. Hydrocarbon gases, carbon dioxide and molecular nitrogen are generated during organic processes within the sedimentary rocks. Methane and carbon dioxide and small volume of ethane and propane can be generated during microbial (fermentation and/or carbon dioxide reduction) processes. Gaseous (CH_4 , C_2H_6 , C_3H_8 , $n\text{C}_4\text{H}_{10}$, $i\text{C}_4\text{H}_{10}$) hydrocarbons, carbon dioxide and molecular nitrogen can be generated during low- and high-temperature thermogenic processes of destruction of coals and/or organic matter dispersed in claystone-mudstone complex. Molecular nitrogen also originated during the thermal decomposition of NH_4 -rich clay minerals (mainly illites). All these genetic types of gases will be identified based on stable C, H, N, Ne, He, Ar, Xe and Kr isotope compositions of individual gas components. After generation, different genetic types of gases within the upper mantle, lithosphere and sedimentary rocks underwent migration and mixing with each other. These processes can caused secondary isotopic fractionation, which can be resolved based on stable isotope studies of individual gases. For determining these mechanisms, first time in the World, we plan to use a full set of stable C, H and N isotope analyses in our Organic Geochemistry Laboratory at the AGH University of Science and Technology in Kraków, and noble gases isotope analyses in the Isotopic Laboratory at the Tokyo University. We plan to compare the isotopic composition of natural gases and hydrous pyrolysis gases referred to the results of geochemical analyses of initial coals and dispersed organic matter and after hydrous pyrolysis, and to geological and geothermal settings of the Upper Palaeozoic strata of the Upper Silesian and Lublin basins and Miocene strata of Carpathian Foredeep. It should be noted that in 2013 the first in Europe, and the fourth in the World, set of installations for hydrous pyrolysis experiments was constructed in the AGH thanks to cooperation with U.S. Geological Survey in Denver. Hydrous pyrolysis is a time consuming and costly experimental method but it better simulates natural petroleum generation processes than both closed- and open-system anhydrous pyrolysis because water is always present in the natural geological systems. Poland does not have any scientific centre equipped with instruments for noble gases analyses, therefore, the noble gases concentrations and their isotopic composition will be measured at the Tokyo University, which is one of few World's research centres conducting analyses of isotopic composition of all noble gases. Other analytical research of molecular and isotopic ($^{12,13}\text{C}$, $^1,^2\text{H}$, and $^{14,15}\text{N}$) compositions of natural gases, and geochemical analyses of organic matter (i.e., stable C isotope composition of extracted bitumens, their fractions and kerogen, biomarker distribution and elementary composition of organic matter), and hydrous pyrolysis experiments will be carried out in Organic Geochemistry Laboratory at the AGH University of Science and Technology. This laboratory is one on the best in Europe equipped (e.g. a Rock-Eval 6 Turbo apparatus; two Finnigan Delta V Plus and Finnigan Delta Plus mass spectrometers, a Hewlett Packard 5890 series II GC; GC-MS method – an Agilent 7890A GC equipped with an Agilent 7683B automatic sampler coupled with a 5975C mass selective detector; GC-MS-MS method – an Agilent 7990A GC with triple quadrupole QQQ detector; a Kerogenatron apparatus for kerogen separation and a Carlo Erba EA 1108 instrument for elemental analysis). Although great progress has been made over the last twenty years in understanding of the mechanisms of generation, migration and mixing processes of hydrocarbon and non-hydrocarbon components of natural gas within the upper mantle, lithosphere and sedimentary cover, still the most fundamental questions remain unsolved. The universal aspect of this project will be the better understanding of the mechanisms of mentioned above processes, on examples of natural gases accumulated in Devonian and Carboniferous strata of Upper Silesian and Lublin basins and Miocene strata of the Carpathian Foredeep.