The chemistry that we know well is the chemistry of "normal conditions". People in the twenty-first century know many rules and theories that allow to receive huge amounts of useful materials, but in an open flask a chemist is not able to produce for example diamonds. The limitation is to carry out the processes at room temperature and atmospheric pressure. Such conditions are rare, even on the scale of our Earth or the Solar System. The pressure around us is equal to 0.1 MPa, much higher than the pressure in space and at the same time much lower than that in the depths of planets or stars. The temperature in the Earth's core is estimated to be several thousand of Celsius degrees, and the pressure is millions of times greater than the atmospheric pressure. So, the question arises: Are the "journeys" to another planet or to the inside of our Earth possible? The answer is "yes". Further, it turns out, that there is no need to buy a very expensive and complicated devices of huge dimensions to simulate such conditions. All you need is a small device that fits in your hand - a diamond-anvil cell (DAC). It is based on a very simple principle. The sample is squeezed between two diamonds and the reached pressure can be comparable to that inside the Earth. Such squeezed substances can be also heated with a laser up to thousands of Celsius degrees.

The natural sense of DAC research is the reproduction of conditions observed inside the Earth or other planets. Many minerals and mineral resources, including oil and natural gas, are formed and located deep under the surface of the Earth at high pressure, where their physical properties are different than those observed at atmospheric pressure. The results of such experiments are therefore of great practical importance in geology, seismology or astronomy.

The project will include structural studies of the simplest aliphatic hydrocarbons and their derivatives at extreme conditions. These compounds are gases or low-boiling liquids at normal conditions, so their high-pressure investigations also involve the development of the methodology of loading such substances into the high-pressure chamber. High-pressure crystallization allow to search for new polymorphs of simple and extremely important chemical compounds, such as *e.g.* vinyl chloride or ethylene used in huge amounts in polymerization processes, butene isomers obtained in the processing of oil or freons of old and new generation. Polymorphic forms are crystals composed of the same chemical molecules but they differ in their mutual positions in the structure. The consequence of such a different arrangement is the change of physical properties. Based on the analysis of the nature of intermolecular interactions, which are the main cohesion forces of molecules in the crystal, the mechanisms of discovered phase transitions at high pressure will be explained. The main aims of the project will therefore be to describe the role of particular types of intermolecular interactions in molecular association and crystal formation, to determine new structures of important and simple compounds, to determine the conditions for the formation of new crystalline forms and to improve the method of loading gases and low-boiling point liquids to the high-pressure chamber.

This type of investigations may lead to various benefits, such as: obtaining better drugs (more bioavailable polymorphs), more efficient extraction of gases and energetical liquids from geological deposits, or obtaining high-density polymers. Therefore, obtained results will not only have a general meaning, but will also help to effectively prevent the impact of freons to environment, understand the causes of gas condensation and freezing of liquids. Owing to structural data, it will also be possible to explain the binding of gas molecules to the various types of ground, for example in slate rocks.