



## 2 Resilience of hydrothermal systems against natural and anthropogenic disturbances. General and specific objectives of the RESILTHERM project

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The RESILTHERM project has the following general objectives:

★ to devise the complete hydro-geodynamic model of the thermal hydrostructure of Băile Herculane, by using the correlation of the groundwater chemistry and microbiological data with the geological structure mineralogy and with the values of the local hydrologic and climate parameters;

★ to define the reactive mass transport model which describes the geothermal system of Băile Herculane, in compliance with the geological, hydrological, climatic, chemical and microbiological constraints associated to groundwater flow regimes subject both to a normal behaviour, and to simulated stresses due to natural and anthropogenic disturbances;

★ to devise the conceptual model able to provide a generally-valid characterization of the thermal hydrostructures resilience under various scenarios of disturbing factors action.

The specific objectives of the RESILTHERM project are:

– to outline the groundwater hydrochemical regime characteristics in the site area, by using a single and coherent set of analysis methods, appropriate for the investigated groundwater type;

– to provide an advanced microbiological description of the thermal water discharges of Băile Herculane and to outline possible biogeochemical reactions;

– to establish the speciation of the elements, sulfur included, both in solution (the generation

of ion pairs, of complexes with inorganic and organic ligands, redox and ionic exchange processes), and by surface equilibria with respect to the particulate phases, including nanoparticles;

– developing a thermodynamic model with high internal consistency, dedicated to the computation of the activity coefficients in geofluids over the ranges of concentrations and temperatures which are characteristic to Băile Herculane area, by relying on the Pitzer model of the specific interaction of ions;

– numerical modeling of geo- and biogeochemical processes which are liable to explain the geofluids anomalous behaviour associated to the natural and anthropogenic disturbances.

– to prepare a groundwater resilience map by taking into account stress factors that are specific to the Băile Herculane area;

– to prepare a set of recommendations for exploiting the Herculane thermal water accumulation in such a way that its properties would not be altered.

The RESILTHERM project-team includes experts belonging to the academic community and whose competence is illustrated by the multitude of papers they have published in highly ranked scientific periodicals, this circumstance certifying that the scientific results to be obtained will be valuable, while having at the same time a direct applicability for an appropriate management of the thermal water resources. In terms of experimental facilities both involved

partners benefit of an appropriate set of investigation equipments, IT devices, transportation means and current-use instruments. Additional equipments stipulated for being procured in the project framework are required for increasing the processing velocity and for acquiring an advanced confidence of the experimental operations.

The project must solve, in scientific terms, a series of quite difficult, yet highly stimulating problems, such as:

- quantifying the effect that seismo-tectonic movements have on the groundwater chemistry variations, while also taking into account that similar composition changes could result from other types of processes as well;
- modeling the sulfur speciation in hydrothermal solutions, a task requiring conjoint efforts of both geochemical and microbiological nature, with fundamental research issues being involved;
- although having been already demonstrated, the outstandingly important part that nanoparticles carried by groundwater play in the reactive mass transfer is not easy to be actually outlined, both from a theoretical, and from a practical perspective;
- a phylogenetic study based on SSU rRNA gene library construction for bacteria and microorganisms, and a physiological study of different functional classes of organisms from hydrothermal groundwater at Băile Herculane.

#### **The novelty and the originality of the proposed project**

The absolute novelty of the RESILTHERM project derives from proposing to utilize the resilience concept in the case of deep hydrothermal structures. In this particular case, the disturbing factor cannot be invoked to be the climate change influence, as it is in the case of the water resource systems resilience evaluation, so that other specific stress factors have to be compulsorily considered. To our knowledge, such a problem has not been previously addressed, and

we did not find, in the appropriate scientific literature, any references to such a topic.

Another novel, and at the same time original feature is that different from the case of the water resource systems resilience assessment, for which parameters used in the evaluations are strictly of a hydrological nature, RESILTHERM additionally considers hydrochemical and microbiological parameters as well. At the same time, we emphasize once more that the project topic is the resilience of a particular type of hydrostructures, and not the ecological systems resilience.

#### **Expected results and the project end products**

The RESILTHERM project aims to develop, for the first time, a general applicability model for assessing the hydrothermal structures resilience, such a model being the main end product to be obtained. The complexity of the investigated phenomenon requires that an advanced study is conducted by means of a multidisciplinary approach. A series of issues which will be necessarily investigated in order to reach the specified goal of the project will provide research results that may be utilized in various contexts by the scientific community. In this respect, highly useful will prove to be: the substantiation of the connection existing between seismicity and the groundwater chemistry, the activity coefficients computation model, the methods for assessing the sulfur speciation in thermal waters, the microbiological inventory of the Băile Herculane thermal water accumulation, etc.

It will be possible that the performed study, as well as the large volume of acquired experimental data, shall be utilized in order to prepare practical applicability documents for the Băile Herculane thermal water accumulation, like, for instance, the resources/reserves re-assessment, updating the groundwater outlets pharmacodynamic study, establishing the sanitary protection areas, issues related to the geothermal potential utilization (domestic hot water preparation, district heating, electricity generation, etc.).