*Title*: **Geological sequestration of carbon dioxide** (L1)

*Keywords*: sites, techniques, enhanced energy recovery methods, influence of/on permeabilities, of/on mechanical properties, effects of existing and/or induced geological heterogeneities, induced microseismicity

*Subject*: The reduction of the emissions of carbon dioxide in the atmosphere is a concern for populations, states and companies. As long as carbon dioxide emissions are unavoidable in the next decades, a lesser evil consists in storing the produced gas. Among the proposed solutions, Carbon Capture and Storage consists in storing carbon dioxide in rock formations such as depleted oil and gas fields, coal veins and deep saline aquifers. However, injection of supercritical carbon dioxide in deep saline aquifers strongly modifies the geological, chemical and mechanical equilibria. Water drying increases ionic precipitation, clogs the existing pore network but the stress-induced concentrations may create a new fracture network. Outputs from the In Salah test field are a good starting point.

*Title*: **Geothermy at great depth with carbon dioxide as the working fluid** (L2)

*Keywords*: carbon dioxide, transport properties, solubility, reaction-diffusion, gas-liquid-rock interactions

*Subject*: Deep geothermy aims at producing electricity by circulating a fluid a great depth in favorable reservoirs. As a pre-requisite, the permeability of the rock should be enhanced. The standard working fluid is brine, a mixture of water and salts. Instead of water, carbon dioxide has been proposed as a heat transmission fluid. Next to its advantages in the production procedure, the proposal would also result in carbon sequestration. In fact, the larger compressibility and lower density of carbon dioxide are expected to increase the buoyancy forces and decreases the cost induced by the pumping system. On the other hand, the chemical interactions of carbon dioxide with the rock formation at high temperature have to be considered in the short and long ranges.

*Title*: **Enhancement of Geothermal Systems** (L3)

*Keywords*: porous network, rock stimulation, hydraulic fracturing, chemical enhancement

*Subject*: Deep geothermy aims at producing electricity by circulating a fluid a great depth in favorable reservoirs. At variance with hydrothermal reservoirs, as a pre-requisite, the permeability of the Hot Dry Rock reservoirs should be enhanced. The standard method to stimulate the rock formation is by application of hydraulic pressurisation over a height of uncased well. Different forms of explosives have been attempted at times.

Chemical enhancement is another option. Depending on the nature of the host rock, different acids and chelatants have been tested to dissolve minerals and minimize the induce pore clogging. The outputs of the test fields performed at Soultz-sous-Forêts may be used as a starting point.

*Title*: **Methane hydrates : a potential energy source** (L4)

*Keywords*: hydrate, dissociation, depressurization, thermal injection, chemical softening

*Subject:* Gas hydrates are solid crystalline compounds, looking like ice, formed when natural gas components,e.g. methane, ethane, hydrogen sulfide, carbon dioxide, occupy lattice positions in the water structure. The gas is not chemically bound to water. Methane hydrates are presently viewed as a potential energy source for the 21st century as a large amount of methane gas is trapped in seafloor reservoirs. Hydrates form under specific thermodynamic conditions, namely high pressures (a few MPa) and low temperatures (0 to 5°C), and hydrate bearing sediments (HBS) are found below deep oceanic sediments, and in the pergelisol of polar regions. Production presents major technological challenges. There are several problems to be solved during the production of natural gas from hydrate bearing sediments. These mainly relate to (1) the search and exploration of high quality deposits containing methane hydrates, (2) investigation of methods for the safe and economic viability of the production of the gas, and (3) consequences of the effects of gas production on the environment. The third item includes ground deformation due to the extraction of methane hydrate and the leakage of gas. When gas is extracted from the marine sediments, extensive subsurface deformations may lead to seabed catastrophic slides, and ensuing tsunamis.

*Title*: **Geological fluid injection: induced microseismicity and other misfortunes** (L5)

*Keywords*: fault, failure criterion, pressure,

*Subject:* Increased seismic events subsequent to the injection of reservoir fluids need to be distinguished from natural seismicity. Mitigating and controlling induced seismicity is a key challenge in future large-scale applications of geothermal energy, IEA (2011), and waste water disposals, Zoback (2010), (2012). Several geothermal projects, in Switzerland and Germany, have experienced unexpected levels of induced seismicity during drilling, stimulation or subsequent circulation leading to cancel the projects or requiring reduced production. Mitigation asks for an understanding of the mechanical causes of the seismic events, which may imply to abandon a geologically risky reservoir, or to modify the injection scheme either in space or in time, or to modify the stimulation technique if enhanced recovery is necessary. The observations from several test fields, Basel, Soultz-sous-Forêts, Salton Sea and Coso, are a starting point.