Harvesting, storage and saving of energy using microporous minerals

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Given that up to 40% of energy demand in Europe (up to 80% in North America) is used in buildings, the R&D of sustainable technologies for heating and cooling of residential buildings is a key priority in many countries. Among the most promising technological solutions are the heat pumps, in particular those using adsorption (Adsorption Heat Pumps, AHP). The typical working cycle of these machines, encompassing three temperature levels, utilizes a low temperature heat source (e.g. solar or geothermal) to evaporate the working fluid (e.g. water) or activate (i.e. dehydrate) the adsorbing material. In the triggered thermodynamic cycle, heat is released to the environment at an intermediate temperature by the (exothermic) adsorption process by the fluid condensation, while the heat is taken form the environment at the highest T level during the endothermic desorption process.

Zeolites and related microporous minerals are among the most suited adsorbing materials both due to their efficiency and sustainability. The exothermic enthalpy of hydration, thermodynamically stabilizing the otherwise metastable anhydrous zeolite structure [1], explains the endothermic nature of the dehydration phenomenon in these minerals. Therefore, the H_2O desorption from zeolite at low T (e.g. T = 130-150°C from evacuated solar collectors) can be exploited to store heat which can be released to the environment during the next vapour adsorption. The thermal stability of several zeolite topologies [2] makes the ad/desorption cycle fully reversible. In AHPs and Solar Coolers, one evaporator and one condenser are connected to zeolite tanks which can be dehydrated at low T by solar or geothermal heat. Double tanks, cyclically operated in antiphase, allow to make use of both the release to (heating) and the subtraction from (cooling) the environment of the adsorption and condensation heat. Use of natural zeolites for solar cooling has been reported since 80-ties in USA for the chabazite from Bowie, and for chabazite and clinoptilolite in Italy [3].

Solar Heat Storage (SHS) systems can be designed by coupling the physisorption on zeolites to the chemisorption related to transformation between different hydration state(s) in crystalline phase(s) higher energy density (e.g. sulphates).

[1] Navrotsky *et al*. (2009) *Chemical Reviews*, **109**, 3887. [2] Cruciani (2006) *J Phys Chem Solids*. **67**, 1973. [3] Tchernev (2001) *MSA Rev. Miner. Geochem*, **45**, 589.

Sulfide Sites in the Arctic Ocean: Jan Mayen and Loki's Castle

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There is a growing consensus on the need of exploiting the resources of the ocean floors. High latitude oceans, and ocean floors, are not easy to study, for ovious reasons,.but the recent discoveries of hydrothermal vents in the Arctic Ocean openned new ground for exploration for metal resources. Jan Mayen and Loki's Castle on the Mohns Ridge are two known sites of interest [1].

The Jan Mayen hydrothermal field was discovered in 2005 at ≈71°N; it is located at water depths ranging from 550 to 700 m and the mesured temperatures reached 270°C. It is composed of two separate vent fields, set 5 km apart, named Trollveggen and Soria Moria, respectively. Host rocks tend to be alkaline basalts [2].

The Loki's Castle hydrothermal field was discovered in 2008 at ≈73.30°N, at a water depth of 2400m and with a maximum recorded temperature of 317°C. Host rocks are mainly MORB, although some ultramafic rocks are exposed nearby [3].

At both sites, ROV collected samples of chimney fragments and their surrounding deposits revealed pyrite, chalcopyrite and sphalerite as the main sulfides present. Jan Mayen's whole rock analyses for the chimney fragments depict maximum metal contents for Fe of 6.5wt%, for Zn 39.9wt% and for Cu 1wt%; while Loki's Castle samples contain a maximum of 31wt% Fe, 5.4wt% Zn and 2.4% Cu.

The dominant sulfide phase at Jan Mayen is sphalerite followed by pyrite, while at Loki's Castle pyrrhotite and pyrite predominate. Predominant non-sulfide phases at Jan Mayen are barite and silica, while Loki's non-sulfide phases are composed mainly of talc/serpentine and anhydrite.

	Fe (wt%)		**Zn (wt%)**		**Cu (wt%)**	
	Max	Avg	Max	Avg	Max	Avg
Jan Mayen	6.5	4.9	39.9	18.2	1.1	0.4
Loki's Castle	31	9.9	5.4	0.1	2.4	0.6

Samples from both these hydrothermal systems are currently being studied in order to understand their genesis, and better constrain their metal content and possible economic interest.

[1] Pedersen *et al*.(2010), AGU Monogr. Ser.,vol.**188**, 67 – 89.[2] Pedersen *et al.(*2005).AGU Fall Meeting,abst: **#OS21 C-01**. [3] Pedersen *et al*.(2010) Nat Commun, **1(8):** 126.

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