

## Pb-U-Th isotopic evolution of the D'Orbigny angrite

E. JAGOUTZ<sup>1</sup>, R. JOTTER<sup>1</sup>, A. KUBNY<sup>1</sup>, M. E. VARELA<sup>2</sup>,  
R. ZARTMAN<sup>1</sup>, G. KURAT<sup>3</sup>

<sup>1</sup>Max-Planck-Institut für Chemie, Postfach 3060, D-55020  
Mainz, Germany (jagoutz@mpch-mainz.mpg.de)

<sup>2</sup>CONICET-UNS, Departamento de Geología, San Juan 670  
(8000) Argentina, (evarela@criba.edu.ar)

<sup>3</sup>Naturhistorisches Museum, Postfach 417, A-1014, Vienna,  
Austria, (gero.kurat@univie.ac.at)

In order to understand the early evolution of our solar system high resolution dating of meteorites is necessary. Since most of the meteorite classes were formed in the first 50 Ma (1%) of our solar system's history, high precision dating is necessary. In particular, relative dating using extinct isotopes like the Mn-Cr system hinges on an absolute calibration. Only the Pb-Pb system can serve this purpose, but few such high precision Pb-Pb ages have been reported (1-3). Some of them have been reported with an age precision of 0,01%, which requires a measurement precision of 0.03% for the <sup>206</sup>Pb/<sup>207</sup>Pb ratio--reached only by using the faraday collector and a tight control of the mass fractionation.

In the D'Orbigny meteorite for which we have obtained Pb-Pb ages, such a high precision has not yet been achieved because the Pb concentration in the dated pyroxene is extremely low (between 7 and 17 ppb). Four pure mineral separates of clean pyroxenes (of about 15 mg each) yielded only 100 to 250 pg of Pb that was too little to run on the faraday collector. Instead, measurement was made with an ion counter giving a typical error for the <sup>206</sup>Pb/<sup>207</sup>Pb ratio of 0,1 to 0,2 % and translating into an age error of 2 to 4 my.

D'Orbigny is the sixth angrite to be identified and the largest of this rare meteorite class. Until now high-precision Pb-Pb data only has existed only for Angra dos Reis and LEW 86010 (1). Two of the D'Orbigny pyroxenes are from the groundmass and the other two are idiomorphic and grew inside druses-like cavities. The latter are considered to be 100% pure while the former may contain some inclusions. Also, we analysed one sample of anorthite, which had a Pb isotopic composition close to that of terrestrial Pb, and may be dominated by terrestrial Pb.

The Pb-Pb age of the two matrix pyroxenes are  $4549 \pm 2$  Ma and  $4557 \pm 2$  Ma; however, the U-Pb ages are distinctly discordant for the younger pyroxenes. The druses pyroxenes gave Pb-Pb age of  $4555.4 \pm 1.9$  Ma and  $4556 \pm 4$  Ma, with <sup>206</sup>Pb/<sup>204</sup>Pb ratios of 522 and ~2000, respectively. Furthermore, the U-Pb ages for both these pyroxenes are, within the uncertainties of the correction parameters, concordant, as is a Th-Pb age for the second analysis. Unfortunately, the relatively large error of its Pb-Pb age reflects the small amount of Pb on the filament.

### References

- 1) Lugmair and Galer (1992) GCA 56, 1673-1694. 2) Göpel et al. (1994) EPSL 121 153. 3) Amelin Y. et al. (2002) LPSC XXXIII 1151.

## Including stagnant zones in order to model overlapping redox processes occurring in a shallow sandy aquifer

RASMUS JAKOBSEN

Environment and Resources DTU, Technical University of  
Denmark, Building 204, 2800 Kgs. Lyngby, Denmark

Partial equilibrium was used by Jakobsen and Postma (1999) to model a sequence of redox processes in a shallow aquifer using the 1-D transport capability of PHREEQC (Parkhurst and Appelo, 1999). Partial equilibrium implies overall kinetic control, due to slow breakdown of complex organic matter, while the anaerobic terminal electron accepting processes (TEAP's) are determined and controlled by the thermodynamics of the system. The TEAP's approach equilibrium showing small (negative) Gibbs energies that are close to constant for a given process in a given system.

The model in Jakobsen and Postma (1999) did not simulate the observed H<sub>2</sub> levels, due to the assumption of equilibrium, and could not fully simulate the observed overlap of sulfate reduction and methanogenesis. If a minimum energy yield, rather than true equilibrium, is used for the different TEAP's, there is no increase in the simulated overlap, but reasonable H<sub>2</sub> levels are obtained, though the modelled H<sub>2</sub> span is too wide, with values that are too high in the methanogenic zone. This corresponds to the apparent lack of available energy for methanogenesis if the observed concentrations of H<sub>2</sub> are used for calculating the available energy. This, and the lack of overlap in the model, indicate the presence of stagnant zones featuring more reduced conditions, next to zones with active groundwater flow.

Stagnant zones are readily included in PHREEQC, and the current model features stagnant zones in which the organic matter is added, leading to high H<sub>2</sub> concentrations and methanogenic conditions in these. H<sub>2</sub> and methane diffuse into the zones with flowing water where oxidation by sulfate or Fe-oxides may take place. If the oxidation of methane is controlled by the same K-value used for methanogenesis it would imply an energy loss for the microorganisms, which is not realistic. Furthermore the model fails to simulate the overlap of sulfate reduction and methanogenesis. Therefore it is necessary to implement a method in which both methanogenesis and methane oxidation are controlled by thermodynamics, but only occur if energy is gained from the process. The current version of the model is able to simulate the observed overlap of the redox processes, and the match to the observed H<sub>2</sub> concentrations is improved.

### References

- Jakobsen R. and Postma D. (1999) Redox zoning, rates of sulfate reduction and interactions with Fe-reduction and methanogenesis in a shallow sandy aquifer, Rømø, Denmark, *Geochim. Cosmochim. Acta* 63, 137-151.
- Parkhurst D.L. and Appelo C.A.J. (1999) User's guide to PHREEQC (Version 2) US Geol. Surv. Water Resour. Inv. Rep., 99-4259.