

## Highly saline Palaeoproterozoic seawater inferred from fluid inclusions in 2.4 Ga Ongeluk Formation

TAKUYA SAITOU<sup>1\*</sup>, TAKAZO SHIBUYA<sup>2</sup>,  
TSUYOSHI KOMIYA<sup>1</sup>, KOUKI KITAJIMA<sup>3</sup>,  
SHINJI YAMAMOTO<sup>1</sup>, MANABU NISHIZAWA<sup>1</sup>,  
YUICHIRO UENO<sup>1</sup> AND SHIGENORI MARUYAMA<sup>1</sup>

<sup>1</sup>Tokyo Institute of Technology, Tokyo 152-8551, Japan  
(\*saitou.t.ac@m.titech.ac.jp)

<sup>2</sup>Japan Agency for Marine-Earth Science and Technology,  
Yokosuka 237-0061, Japan

<sup>3</sup>The University of Tokyo, Tokyo 164-8639, Japan

We present microthermometry of fluid inclusions in hydrothermally precipitated quartz in 2.4 Ga Ongeluk Formation, Kaapvaal Craton, South Africa. The studied lavas probably erupted during Palaeoproterozoic Snowball Earth event [1, 2], thus is prime target to obtain the information of seawater composition during the snowball period. The quartz crystals fill drainage cavities of pillowed basaltic lava and were probably precipitated soon after eruption under seawater [3]. The primary fluid inclusions show final melting temperatures from -31.4°C to -3.6°C for ice and from -48.3°C to -22.0°C for hydrohalite. Their homogenization temperatures range from 74.9°C to 160°C. These results indicate that the fluid composition can be assumed as a NaCl-CaCl<sub>2</sub>-H<sub>2</sub>O system. Thus, the salinity of fluid inclusion can be calculated from its melting point. We found that the fluids show various NaCl/CaCl<sub>2</sub> ratio (0.1 – 16.8 molar ratio). This variation is consistent with albitization of igneous plagioclase (Ca/Na exchange reaction), which commonly occur in seafloor alteration processes. Hence, the fluid may record altered 2.4 Ga seawater. Based on the extrapolation of this albitization trend, we conclude that the salinity of the 2.4 Ga seawater would have been at least two times higher than that of modern seawater. The estimated salinity is higher than previous estimate of the early seawater based on total amount of continental salt deposits [4], thus requires some sort of concentration process. The high salinity could be expected, if the Ongeluk ocean was quantitatively frozen. Thus our result is consistent with the “hard” snowball scenario.

[1] Evans *et al.* (1997) *Nature* **386** 262-266. [2] Kopp *et al.* (2005) *PNAS* **102** 11131-11136. [3] Gutzmer *et al.* (2003) *Chem. Geol.* **201** 37-53. [4] Knauth (1998) *Nature* **395** 554-555.

## Distribution of trace metals in petroleums of different maturity levels

CS. SAJGO<sup>1\*</sup>, S.D. OLSEN<sup>2</sup> AND J. FEKETE<sup>1</sup>

<sup>1</sup>Institute for Geochemical Res., Hung. Acad. Sci., Budaörsi út  
45, Budapest, H-1112, Hungary

(\*correspondence: sajgo@geochem.hu,  
feketej@geochem.hu)

<sup>2</sup>Rogaland Research, Post Box 8046 4068 Stavanger, Norway  
(Samuel.D.Olsen@rf.no)

A set of trace metals (V, Ni, Co, Fe, Zn, and Mo, As, Hg) in a suite of oil samples (studied and classified on the basis of biomarker data) from Hungary [1] was analysed by ICP-MS [2]. The carbon isotopic composition of the C<sub>15+</sub> saturate and aromatic hydrocarbon fractions were also measured.

### Discussion of Results

The stability of biomarkers and some metal complexes have shown similar thermal dependence. The median values of determined trace elements are displayed in Table Ia and Ib grouped in maturity ranked oils [1].

**Table Ia:** Maturity sensitive trace metals in maturity groups (ppb)

	ranking of oils	Co	V	Ni	Mo
LtM	least-mature	111	425	11140	32,0
LM	low-mature	62	431	3229	13,0
MM	moderate mature	15	111	1236	1,6
M	mature	7	32	581	3,0
VM	very-mature	2	4	13	0,4

**Table Ib:** Trace metals in maturity groups (ppb)

	Fe	Zn	As	Hg	∑ of Ia+Ib
LtM	7145	116	222	845	27395
LM	6605	213	134	1150	15385
MM	13430	687	230	626	16833
M	2783	482	56	545	4548
VM	64	6	47	70	977

The metals (associated with the polar components and asphaltenes) in Table IA demonstrate direct maturity dependence [3]. The maturity dependence of metals in Table Ib are more complicated, partly governed by source facies and migration effects (picked up during migration) [4]. The evaluation of carbon isotopic data is also difficult because of the overlapping maturation and organic facies effects.

[1] Sajgo (2000) *Org. Geochem* **31**, 1301-1323. [2] Olsen *et al.* (1995) *Analyst* **120**, 1379-1390. [3] Lewan and Maynard (1982) *GCA* **46**, 2547-2560. [4] Punanova *et al.* (1988) *Geokhimiya* **No. 9**, 1360-1366.