

Subsurface gas geochemistry and its implication to possible gas hydrates in the Qinghai-Tibet permafrost

ZHENGQUAN LU^{1*}, BIHAO WU¹, ZHU RAO²,
YOUHAI ZHU¹, XURONG LUO¹ AND RUIMEI BAI¹

¹Institute of Mineral Resources, Chinese Academy of Geological Sciences, Beijing 100037, China

(*correspondence: luzhq@vip.sina.com)

²National Research Center for Geoanalysis, Beijing 100037, China (raozhu99@sohu.com)

Field investigation shows that gases from lower atmosphere, cold vent, subsurface ice and sediment are mainly composed of hydrocarbons. Their gas geochemistry indicates that gases from subsurface sediment can be expressed in a mixture of 91.13% CH₄ + 6.54% C₂H₆ + 2.33% C₃H₈ if hydrocarbons are normalized. Similarly the composition of gases from subsurface ice can be characterized by 96.38% CH₄ + 2.93% C₂H₆ + 0.69% C₃H₈; the composition of gases from cold vent is almost 100% CH₄ or 99.20% CH₄ + 0.80% C₂H₆ and that of gases from low atmosphere is 100% CH₄. These gases from varied media appear anomalous in some locations. Theoretically if under appropriate temperature and pressure conditions hydrocarbons could be formed into gas hydrate. Hence these anomalous gases could be the result of dissociation of gas hydrate due to environmental change in the permafrost.

Given the existence of heavy hydrocarbons, the phenomenon of gas variation from varied media, and the development of active faults or fractures [1], these anomalous gases could also be partly derived from the deep layer in the course of faulting activities, or partly from the shallow layer under the transformation of organic matter, or partly from the relic gas reservoir in the glacier displacement process [2]. If these gases have a common source and potentially form gas hydrate in the permafrost, the source could be indicated by two cases: one from subsurface ice and the other from cold vent. Based on such gas compositions, together with the mean annual surface temperature, thermal gradients above and below the base of permafrost, possible gas hydrates are modelled. The minimal permafrost thickness necessarily for gas hydrate to occur is 50.57 and 134.41m respectively in the two cases. In possible gas hydrates the upper occurrence depth is ~67m to ~186m; the lower depth is ~244m to ~1000m; the thickness is ~145m to ~935m.

[1] Wu *et al.* (2005) *Geoscience* (in Chinese) **19**, 165-175.

[2] Lu *et al.* (2007) *Geological Bulletin of China* (in Chinese) **26**, 1029-1040.

Organic matter diagenesis, methane oxidation and their relation to ikaite precipitation in Antarctic sediments

ZUNLI LU^{1*}, RICHARD D. PANCOST²,
ALFRED AQUILINA² AND ROSALIND E.M. RICKABY¹

¹Department of Earth Sciences, University of Oxford, Parks Road, Oxford OX1 3PR, UK

(*correspondence: Zunli.Lu@earth.ox.ac.uk)

²The Organic Geochemistry Unit, Bristol Biogeochemistry Research Centre, School of Chemistry, University of Bristol, Bristol BS8 1TS, UK (R.D.Pancost@bristol.ac.uk)

Ikaite is a calcium carbonate hexahydrate (CaCO₃•6H₂O) considered to be stable only at low temperatures. It has been used as an indicator of near freezing bottom water, and the hydration water contained in the crystals has been suggested to be a potential record of ice volume[1]. We determined the chemistry of two sediment cores collected by U.S. Antarctica Program cruise NBP0703, containing large euhedral ikaite crystals in the Antarctica Peninsula region (Bransfield Strait and Firth of Tay). Strong organic matter degradation and anaerobic oxidation of methane (AOM) in both cores results in rapid consumption of sulfate and large variations in δ¹³C_{DIC} at relatively shallow depths (< 2m). A rapid build-up of DIC is accompanied by a sharp decrease in dissolved Ca concentrations around the SMTZ, presumably due to precipitation of authigenic calcium carbonate, including ikaite. Organic matter diagenesis and AOM both affect the DIC and pH of the pore water, which controls the saturation state of the ikaite. Here we investigate the role of these two processes in ikaite precipitation using pore water data[2], archaeal biomarkers[3] and a 1D solute transport reaction model[4] to simulate these processes and investigate relative contributions of organic matter degradation and AOM to DIC accumulation. Saturated and unsaturated PMI (pentamethylcosane), among the most widespread archaeal lipids, are abundant in all samples and their concentrations increase across the SMTZ. The biomarker abundance and isotopic compositions will be compared with other marginal settings to constrain the AOM rates at our ikaite sites.

[1] Rickaby *et al.* (2006) *Geology* **34**(6), 497-500. [2] Lu Z. *et al.* (submitted) *EPSL*. [3] Pancost (2001) *Geochimica Et Cosmochimica Acta* **65** (10), 1611-1627. [4] Wallmann *et al.* (2008) *Geochimica Et Cosmochimica Acta* **72** (12), 2895-2918.