Ancient seawater salinity retained as fluid inclusions in hydrothermal quartz from the 2.2 Ga Ongeluk Formation, South Africa

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Hydrothermal quartz retaining ancient seawater

Seawater salinity is a critically important component for limiting the concentrations of other cations. The analyses of fluid inclusions in hydrothermal quartz precipitated during seafloor hydrothermal alteration are useful for estimating the salinity of ancient seawater [1]. We performed PIXE [2] and microthermometric analyses on the fluid inclusions in hydrothermal quartz from the 2.2 Ga Ongeluk Formation, which consists mainly of submarine volcanics [3].

Results and estimation of 2.2 Ga seawater salinity

These fluid inclusions were individually analyzed with microthermometry and PIXE to obtain concentrations of Cl, Na, K, Ca, Mn, Fe, Cu, Zn, Br, and other elements. The results show bimodal salinity distributions for the primary (high-salinity) and secondary (relatively low-salinity) fluid inclusions. For the primary inclusions, a wide Na/Ca variation was identified. Furthermore, a wide variation in transition metal concentrations in the Na-rich primary inclusions. The primary compositional variations can be explained by three-endmember mixing processes among seawater, Ca-rich hydrothermal fluid affected by albitization (Ca-Na exchange reaction) and transition metal-rich hydrothermal fluid probably affected by high temperature water/rock reactions. These reactions are similar to those observed in modern subseafloor hydrothermal systems. The estimated seawater salinity is approximately six times greater than the modern value, indicating a secular fluctuation of seawater salinity through Earth history.

[1] Weiershäuser et al. (2005) *Precam. Res.,* **138**, 89–123. [2] Kurosawa et al. (2008) *Nucl. Instrum. Methods Phys. Res. B,* **266**, 3633–3642. [3] Gutzmer et al. (2003) *Chem. Geol.* **201**, 37–53.