Re-Os geochronology of black shales from the Neoproterozoic Doushantuo Formation, Yangtze platform, South China

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Re-Os geochronometer is a useful tool in dating organic-rich sedimentary rocks like black shale. Precise Re-Os chronology also provides constraints on temporal variation in Os isotopic composition of seawater, which reflects the relative dominance of radiogenic Os from weathering of upper continental crust and unradiogenic Os from alteration of oceanic crust or dissolution of cosmic dust.

In this study, we carried out Re-Os isotopic analysis of black shale samples from the fossil-bearing Miaohe member (Doushantuo Formation IV) at Jiulongwan section and from Doushantuo Formation II at Baiguoyuan section in Three Gorge area, South China. A Re-Os isochron age of 593±17 Ma (MSWD=1.0) with initial Os ratio of 0.88±0.13 for the basal Miaohe Member was obtained by using a CrO_3-H_2SO_4 dissolution technique. This age falls in the range of precise U-Pb zircon ages of 551 Ma from the top and 635 Ma near the base of the Doushantuo Formation, respectively. The minimum age difference of ~25 Ma between the base of the Miaohe member and the 551 Ma old tuff on the top of the Miaohe member means very low sedimentation rates during black shale deposition (< 0.5 m/Ma). By the same technique, samples from Doushantuo Formation II at Baiguoyuan section only gave an imprecise age of 582±58 Ma (MSWD=1.8) with an initial Os of 0.54±0.05, which is comparable to the initial Os (0.62±0.03) for the 608 Ma Ediacaran Old Fort Point Formation in western Canada (Kendall *et al*. 2004). The increase in initial Os ratio from 0.54 for the lower Doushantuo Formation to 0.88 for the upper Doushantuo Formation is consistent with the secular increase of $^{87}Sr/^{86}Sr$ in the late Neoproterozoic ocean, and may result from enhanced continental weathering rates during the Ediacaran due to continental convergence of East and West Gondwana and subsequently the formation of a Transgondwana Supermountain.

Recent advances in kinetics of water-rock interaction and applications to geological carbon sequestration

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Recent laboratory experiments, field, and modelling studies on the kinetics of water-rock interactions have shown that the rates of dissolution and precipitation reactions are strongly inter-dependent or coupled [e.g., 1, 2, 3]. Numerous laboratory experiments have measured the dissolution rates at conditions far from equilibrium. However, reactions in batch and column experiments and in the field proceed in the near equilibrium region because of the low solubility of aluminosilicates. In the near equilibrium region, the Gibbs free energy term in the rate equations reduce the overall reaction rates. In the case of feldspar dissolution, slow clay precipitation effectively reduces feldspar dissolution rates by orders of magnitude. The implication is that a reaction network is operating, and a system geochemistry approach is necessary for studies of kinetics in geological systems.

When water-rock interaction theories are applied to geological carbon sequestration, the rate of fluid flow also plays a significant role on reaction rates. Recently, we conducted multi-phase reactive flow and transport modelling to simulate large scale CO_2 injection (a million tons per year for 100 years) into Mt. Simon sandstone, a major deep saline reservoir in the Midwest of USA [4]. The results indicate that most of the injected CO_2 remains within a radius of 2500 m lateral distribution. Four major trapping mechanisms and their spatial and temporal variations are evaluated in our simulations: hydrodynamic, solubility, residual, and mineral trapping. In our model, the replenishing water continues to dissolve CO_2 long after the injection, which results in total dissolution of hydrodynamically trapped CO_2 at the end of 10,000 years. In contrast, most previous models neglected the regional flow after injection and hence artificially limited the extent of geochemical reactions as if in a batch system. Consequently, a supercritical CO_2 plume (hydrodynamic trapping) would persist after 10,000 years.

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