Constraints on sedimentation rates from uranium diffusion

ANNA M. CRUSE^{1*}, STANLEY T. PAXTON² AND MICHAEL G. AUFILL³

¹Oklahoma State University, Boone Pickens School of Geology (*correspondence: anna.cruse@okstate.edu) Stillwater, OK 74078

²USGS Oklahoma Water Science Center, Oklahoma City, OK 73116 (spaxton@usgs.gov)

³Newfield Exploration, Tulsa, OK 74172 (maufill@newfield.com)

Uranium is a redox-sensitive element that is known to be enriched in black shales deposited in anoxic environments. While details of the reaction mechanisms by which uranium is ultimately preserved in rocks remain the subject of study, it is clear that a major factor controlling uranium accumulation is its diffusion across the sediment-water interface. Thus, box models of uranium diffusion can be used to constrain sedimentation rates in the rock record.

We measured uranium, TOC, δ^{13} C and other metal concentrations in several outcrops and cores of the Devonian Woodford Shale in southern Oklahoma. Assuming the slowest sedimentation rates, model results indicate that the highest observed uranium concentrations could be fixed in the sediments in less than 6,000 years.



However, considering the preserved thickness of outcrops today, the amount of time accounted for by this model is an order of magnitude less than that constrained by biostratigraphy. These results may indicate that more complicated biogeochemical models are required to properly constrain sediment input rates. More intriguing is the possibility that this discrepancy points to previously unrecognized nonconformities in the rock record.

The role of NaCl and CO₂ on the upper critical end point in SiO₂-H₂O: Insights from solubility experiments

M.F. CRUZ*, C.E. MANNING AND J.D. HUNT

Dept. of Earth and Space Sciences, University of California, Los Angeles, CA 90095, USA (*correspondence: miguelx9@gmail.com)

Silica is a major dissolved constituent of H2O-rich crustal fluids [1]; however these fluids commonly possess elevated concentrations of NaCl and/or CO2, and the effect of these components has received less attention [2]. For example, the hydrothermal melting point of quartz, and the position of the upper critical end point (UCEP) in the SiO₂-H₂O system [3, 4] should vary with the concentrations of these components. To constrain this behavior, we investigated the solubility of quartz in the systems NaCl-H2O and CO2-H2O at 900-1000°C and 15-20 kbar using hydrothermal piston-cylinder methods, with reagent NaCl and silver oxalate as NaCl and CO₂ sources, respectively [2, 5]. Results with NaCl show a steep initial decline in XSiO₂ vs. XNaCl with a slope of -1.44. At higher salinities, the slope levels to -0.58. In the CO₂-H₂O system, preliminary results suggest a similarly dramatic initial decline. To compare the two systems, XNaCl and XCO₂ data were converted to water activities using models from [6] and [7] respectively. Previous studies at lower PT have shown that solubilities are consistently lower in CO₂-H₂O than in NaCl-H₂O for a given water activity; this behavior is observed at higher PT as well. Coupling data from this study with those of previous and related studies [2, 4, 5, 8], our results require that NaCl and CO₂ shift the UCEP of SiO₂-H₂O to higher T and P. Because NaCl lowers silica solubility, it must raise the UCEP to higher temperature and/or pressure. Additionally, because CO₂ decreases silica solubility to an even greater extent than NaCl, this must indicate a greater shift in the UCEP to higher temperature and/or pressure with addition of CO₂.

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