Kaolin minerals: Tracking meteoric alteration with an example from Offshore Western Australia

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Geological concentrations of kaolin family minerals illustrate mineral stabilization pathways which are the footprint of low total dissolved solids fluids, typically meteoric water. Although meteoric waters range in isotopic composition due to latitude and orography, the fundamentals of weathering processes create low temperature kaolinite in a variety of basins. Kaolinites will convert to dickite at higher temperatures, yet do so in a way that often preserves their low temperature δ18O signal even if deuterium is exchanged.

Carnarvon Basin gas field reservoirs beneath the intra-Jurassic unconformity contain significant quantities of authigenic kaolin pore fillings and grain replacements. Petrography and geohistory data indicate that the kaolins formed as a result of meteoric throughput during early Jurassic uplift, yet they are the dickite polytype. The kaolins are of interest because they retard quartz cementation.

Siderite cement is patchy and precipitated early, often preserving sandstone intergranular volumes (IGV) of up to 36%. All textural observations illustrate that the siderite was precipitated at low temperatures. Siderite δ18O ranges from -11.94 to -14.3 ‰ VPDB and so it follows that the original meteoric water is constrained to -12 +/- 3‰ VSMOW.

Plate reconstructions show that this isotopically depleted water is reasonable for the position of the Carnarvon Basin drainage. Using this water, kaolin precipitation is constrained at 10°C to 50°C for measured values of 10.2 to 13.2 ‰ δ18O VSMOW. When southerly Jurassic drift (25S to 45S) and early Jurassic uplift are considered, the precipitation temperature is constrained to the lower end of the range.