Ion Microprobe Analysis of 18O/16O in Authigenic and Detrital Quartz in the St Peter Sandstone

C. M. Graham, J. Valley, B. Winter and S. Kearns

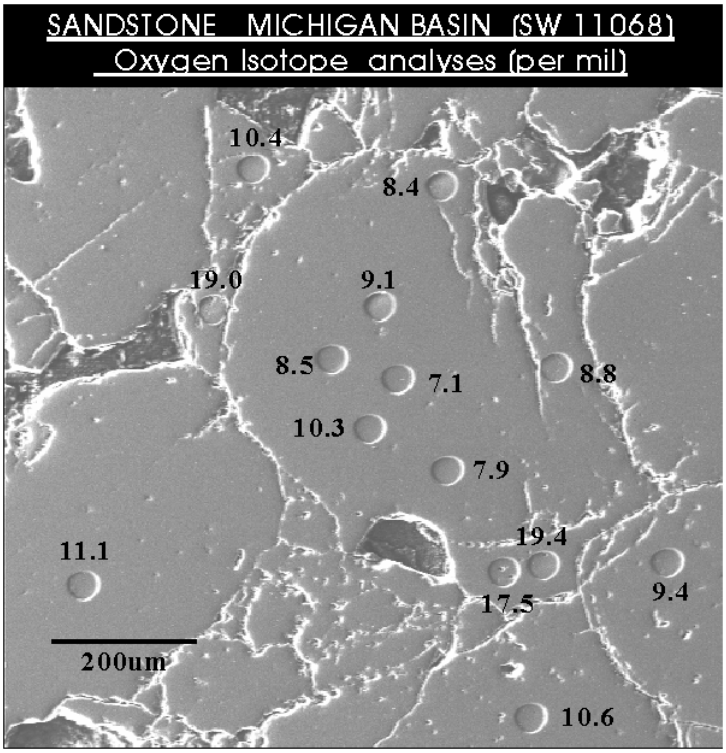
Introduction

Quartz cementation in sandstones may lead to dramatic reduction in permeabilities and formation of diagenetic seals in hydrocarbon reservoir rocks. The oxygen isotopic compositions of authigenic quartz cements in sandstones provide an important monitor of the temperatures, compositions and origins of pore-occluding fluids during diagenesis. If temperatures of quartz formation can be independently constrained from fluid inclusion measurements or thermal models of basin formation, then sources and pathways of cement-forming fluids may in principle be identified.

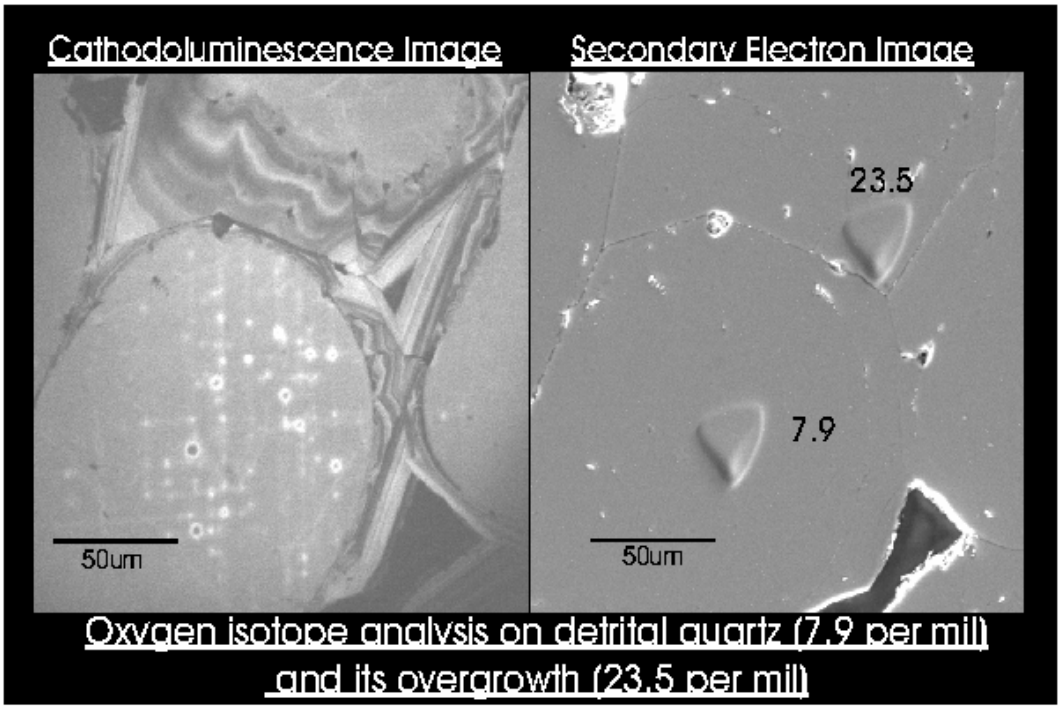
In this study we have applied recently-developed ion microprobe techniques in a micro-analytical study of 18O in authigenic and detrital quartz in four samples of St Peter Sandstones from northern US Midwest, in order to establish their diagenetic histories.

Analyses & Results

Analyses were made using a 20um primary Cs+ beam and samples were charge neutralised with a normal-incidence electron flood gun. High energy (350eV) negative secondary ions were analysed at low mass resolution with a typical internal precision of about 0.9per mil for a 30-minute analysis: this precision is consistent with theoretical counting statistics.



The power of the ion microprobe technique in providing high spatial resolution oxygen isotope analysis in relation to detailed textural images is shown in the paired Cathodoluminescence and electron images.



The results for the four samples studied are shown in histograms which illustrate

- The clear isotopic distinction between authigenic and detrital quartz in all samples.
- The wide range of oxygen isotopic compositions of authigenic quartz in Arch cements compared to Basin cements.
- The large differences in isotopic compositions of Arch and Basin cements.

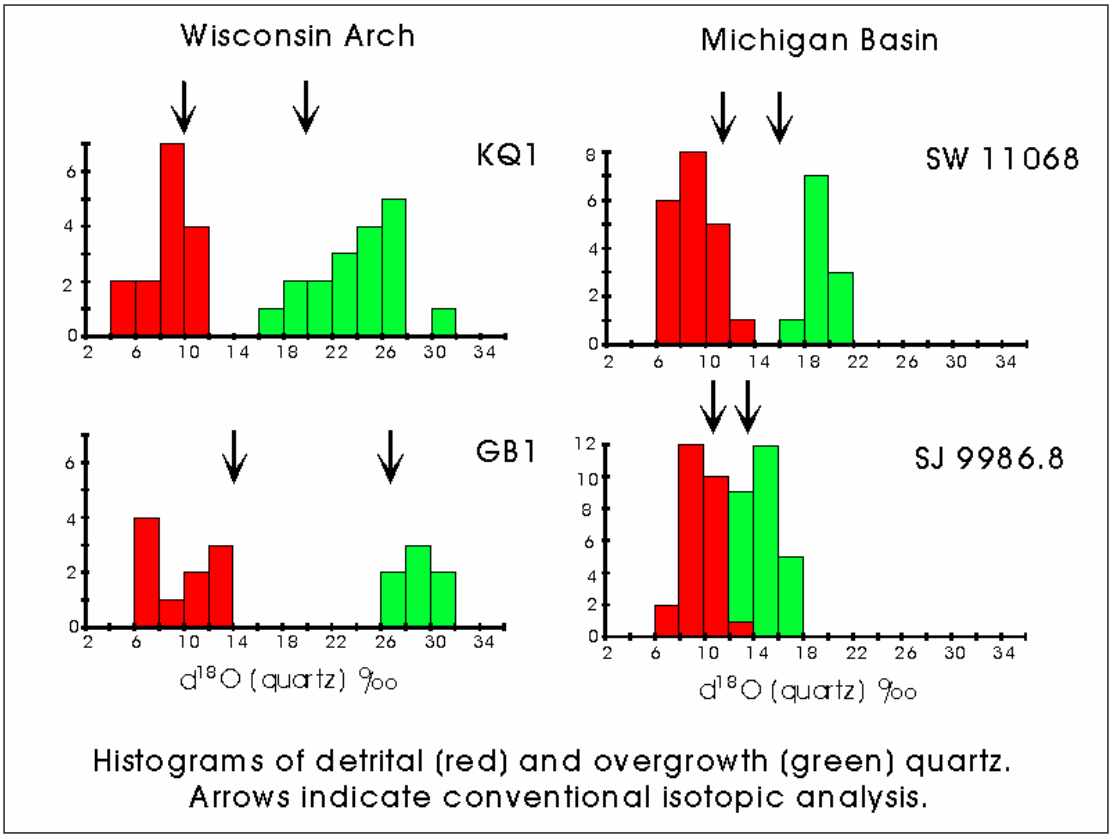
Conclusions

18O-enriched quartz overgrowths in sandstones from the Wisconsin Arch show complex CL zonation and reflect one of two possible processes:

1. Meteoric waters mixing with upwelling basinal fluids, and quartz precipitating at low temperatures.
2. Or higher temperature quartz precipitation during episodic gravity-driven upwelling of warm basinal fluids (of comparable isotopic composition to Michigan Basin fluids) from the Illinois Basin, related to evolution of Mississippi Valley type Pb-Zn ore-forming fluids.

Quartz overgrowths in Michigan Basin sandstones, which derived their silica locally by pressure solution, are thought to have precipitated continuously over a range of temperatures from hot basinal fluids of restricted isotopic composition and circulation. Detrital quartz shows significant intra-grain and

inter-grain isotopic variation (5-13per mil) but no significant inter-sample variation, consistent with a uniform source of granitoid and metamorphic quartz in space and time.



Histograms of detrital (red) and overgrowth (green) quartz.
Arrows indicate conventional isotopic analysis.