Application of K/Ar and Rb/Sr geochronology to constrain the timing of sedimentary deposition and diagenesis: preliminary results from Western Australian basins

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Abstract

Isotopic and geochemical studies are important tools to understand depositional histories as well as fluid flow and diagenetic histories with implications for both exploration and reservoir management. Isotopic age and geochemical tracing data have the potential to yield important information about the origin of hydrocarbons, the timing of fluid flow and related diagenetic events, the nature and distribution of potential formation damage, and the timing of faulting and deformation. Authigenic illite and glauconite in sandstones contain potassium and are therefore suitable for age determination using the potassium–argon (K/Ar) geochronometer. Diagenetic illite is of interest for the petroleum industry because it can provide a K-Ar date constraining a heating and/or fluid flow event within a sedimentary basin. Glauconitic clays are iron-rich, 2:1 dioctahedral clay minerals with variable potassium content in interlayer sites. Dating of these K-bearing minerals, using the K/Ar and Rb/Sr isotopic systems, offers the prospect of establishing the absolute timing of depositional and/or diagenetic events.

The radiogenic isotope systematics of sedimentary rocks are complex due to the intimate mixture of minerals of different origins such as protoliths, detrital phases as well as authigenic minerals, often making it problematic to provide unambiguous ages. Special sample preparation techniques involving freeze thaw disaggregation to avoid overcrushing and extensive size separation to reduce the amount of detrital phases can address these issues. Progressive size reduction down to submicron size fractions (<0.2 mm) increases the proportion of authigenic clay phases in the clay component and minimizes contamination and suggest that the most reliable isotopic ages for authigenic clay minerals are obtained for the finest size fractions. The validity and importance of the assumptions involved in K/Ar dating of authigenic illite and glaucony (e.g. contamination, closed system behaviour, excess Ar) must be carefully addressed and the sample material characterized using a wide range of tools comprising XRD, SEM, particle granulometry as well as TEM.

Preliminary results of two pilot studies applying isotopic dating of authigenic illite and glauconite in Western Australian basins demonstrate the potential of K/Ar geochronology. Petrographic investigations of the Ordovician Acacia Sandstone from the southern Canning Basin reveal illite as an abundant authigenic phase that causes significant reduction in permeability and porosity. The authigenic illite has a filamentous pore bridging morphology with crystallinity values consistent with high-grade diagenesis. Preliminary K/Ar dates on illite separates (<2 mm) from 2 wells (Salanum 1, Acacia 1) yield apparent ages ranging around the Early Carboniferous (Tournaisian). The presently limited data do not allow an unequivocal interpretation, but they could indicate post-depositional thermal pulses and/or diagenetic events. In the second pilot study, glaucony-bearing core samples of the Mardie Greensand of the offshore Barrow Sub-basin were investigated. Because of their widespread occurrence in marine sediments of the basins on the North West Shelf, isotopic dating of glauconitic clays could be valuable in establishing the chronostratigraphy of these basins where other tools, such as biostratigraphy are sometimes ambiguous. Glauconitic clays were abundant in all samples with the majority aggregated into faecal pellets in the 100 to 500 mm grain size range, that form part of the grain framework of the sediments. In some samples the glaucony grains exhibit distinct, Al-enriched, paler green rinds surrounding dark green Fe-rich cores. Preliminary K/Ar and Rb/Sr dates for glaucony clay-size fractions reveals two group of ages, (1) dates that are older than the time of deposition due to inheritance from older K-feldspar contaminants and (2) dates that are younger than deposition which could indicate a

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diagenetic overprint. Conventional K-Ar was applied in this context as a screening tool to select appropriate samples for further ^{40}Ar-^{39}Ar investigations.

Future efforts to resolve the ambiguities inherent in the dating of glauconitic clays will address both contaminants and possible heterogeneity in the glauconitic clay population itself. Application of recently developed, in-situ UVLAMP ^{40}Ar-^{39}Ar dating and micro-encapsulation, will allow quantification of the effects of heterogeneity. The combination of new technologies will permit more geologic significance to be attached to the results of future isotopic studies of glauconitic clays from the NW shelf.