Timing of Illite Authigenesis within a Tight Gas Reservoir, Onshore Taranaki Basin, New Zealand

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The onshore Taranaki Cardiff Field is a large four-way dip anticlinal structure with an original estimated volume of gas-in-place for the main reservoir (K3E) between 200 BCF and 1 TCF. The discovery well (Cardiff-1) was plugged and abandoned after failing to produce commercial quantities of hydrocarbons due to low sandstone permeability. Recent drilling of the K3E reservoir in a second well (Cardiff-2/2A) by operator Austral Pacific has to date not resulted in the original predicted flow rates.

Petrographic studies of conventional cores through the sandstone reservoir at Cardiff-1 suggest that low permeabilities are largely the result of common, widespread authigenic illite. The timing of illitisation has been constrained by K-Ar dating of the <2 micron illite fraction and suggests precipitation in the Early Pliocene (c. 4.5Ma).

The timing of illite authigenesis is consistent with a rapid burial event where temperatures in the reservoir reached c. 130°C due primarily to burial depths approaching 5 km. This event postdates the onset of quartz cementation (as suggested by fluid inclusion analyses) and modelled oil migration from underlying Cretaceous coaly source rocks.

It is suggested that most of the authigenic illite formed by illitisation of earlier formed authigenic kaolinite with potassium sourced by K-feldspar dissolution. The acidity to drive these reactions could have been derived from CO_2 in aqueous solution, with CO_2 expelled from intraformational coaly source rocks. An Early Pliocene illite age is roughly coincident with the modelled very early thermogenic maturation of intraformational late Eocene coals and supports this interpretation.

Timing of Illite Authigenesis and Oil-Gas Charging Histories of Sandstone Reservoirs within the Tarim Basin, China

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The Tarim Basin, China, comprises several sandstone reservoirs. The oil and gas charging histories of the selected reservoirs will be discussed based on K-Ar dating of authigenic illites. The ages of authigenic illites of Lower Silurian bituminous sandstones in the Central uplift area range between 383 to 235 Ma, indicating that the Silurian ancient oil pools were formed during the late Caledonian-late Hercynian. The ages of authigenic illites of the Upper Devonian Donghe sandstones range between 264 to 231 Ma, indicating that the Donghe sandstone hydrocarbon accumulations were mainly formed in the late Hercynian. The ages of authigenic illites of the Lower Jurassic Yangxia Group sandstones in the Yinan-2 gas field, Kuqa depression, range between 28 to 24 Ma, indicating that oil and gas charging started within the Miocene. The ages of authigenic illites of Lower Cretaceous sandstones in the Akemomu gas field, Kashi sag, Southwest depression, range between 23 to 19 Ma, indicating that there might be some ancient oil pools or migration of oil and gas within this area. The illites of Paleogene sandstones in the Dina 2 gas reservoir, Kuqa depression, have a mainly detrital origin and can not be used for studying the timing of oil and gas charging. The ages of authigenic illites of the underlying Cretaceous sandstones in Dina-201 well range between 25 to 15 Ma, indicating that oil-gas charging in this reservoir most probably started within the Miocene.

Thermochronology and Landscape Evolution in the Basin Hinterland - Understanding Sediment Supply into Deep-Basin Environments

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Understanding the sources of sediment supply and how these have changed through time provide key insights into the evolution of basins and the hydrocarbon systems they contain. In the past, information about the source of sedimentary material has mostly been gleaned from the nature of the sediments themselves. Such materials, however, provide access to only part of the overall continuum from erosion of source material through to deposition of the ultimate products of this cycle. The application of low-temperature thermochronology to rocks from the basin hinterland can now provide powerful new insights into the evolution of the land surface itself, and hence into the nature of the sediments derived from it. Thermochronology by the fission-track and (U-Th)/He methods applied to apatites from outcropping basement samples can be used to reconstruct temperature histories from large areas over durations of up to hundreds of Ma. The past temperatures revealed can often be taken as a proxy for palaeodepth below an evolving land-surface, especially for the low-temperature environment of the upper few kilometres (<~120°C). Thermochronology in this low-temperature zone can therefore provide a unique record about rock movements towards the surface, and hence about the evolution of the land-surface itself, the emergence and destruction of topography, and the development of drainage. In this way, regional scale thermochronology of basement areas can provide new reconstructions of sediment supply at various stages of basin history. Initial applications of this approach to basins on the NW and SE margins of Australia are extremely promising.

Can Apatite (U-Th)/He Dating Provide Useful Thermal History Information in Sedimentary Basins?

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Numerous studies have illustrated the potential of apatite (U-Th)/He dating for refining thermal history solutions derived from AFTA (apatite fission track analysis) and VR (vitrinite reflectance) data in hydrocarbon exploration settings, particularly at lower temperatures.

Initial studies showed a high degree of consistency between AFTA and apatite (U-Th)/He dating, but increasing evidence contradicts this simple picture, revealing apatite (U-Th)/He ages which are often much older than expected on the basis of AFTA. Use of thermochronologic data in hydrocarbon exploration demands accuracy in the systematics of the processes involved, and therefore it is vital that the cause of any inconsistencies between different techniques should be identified and eliminated.

This inconsistency between AFTA and (U-Th)/He becomes particularly pronounced in samples giving Mesozoic or Paleozoic ages, although low uranium apatites provide more consistent data. Results from a setting where AFTA and (U-Th)/He data in high and low uranium apatites can be compared reveal that (U-Th)/He ages in high uranium apatites are clearly anomalous, retaining He at temperatures where accepted diffusion systematics suggest all He should be lost.

We conclude that the inconsistencies between AFTA and apatite (U-Th)/He dating arise because of a change in the helium retentivity of apatite as the accumulated radiation dose within the crystal lattice increases. We find that published He diffusion systematics apply only to "low-dose" apatites, and their use in extracting thermal history information from apatites giving fission track ages are older than ~50 Ma can be justified only if the uranium content is < ~2 ppm.

Probing Fault Zone Heterogeneity on The Nojima Fault: Constraints from Zircon Fission-track Analysis of Borehole And Trench Samples

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We summarize our recent results of the zircon fission-track (FT) thermochronologic analysis of the Nojima fault, which was activated during the 1995 Kobe earthquake (Hyogoken-Nanbu earthquake; M7.2). Rock samples were collected from the University Group 500 m (UG-500) borehole, Geological Survey of Japan 750 m (GSJ-750) borehole, the fault trench at Hirabayashi, and nearby outcrops. In the two boreholes that penetrate the fault at depth, zircon FTs were partially annealed in the samples nearby the fault. The age of onset of cooling from the zircon partial annealing zone (ZPAZ) was estimated by the inverse modeling of FT data using the Monte Trax program; i.e., ~4 Ma within ~3 m (in the hanging wall only) from the fault plane in the UG-500, and ~31-38 Ma within ~25 m from the fault in the GSJ-750. On the basis of one-dimensional heat conduction modeling as well as the general positive correlation between the FT annealing and deformation/alteration of borehole rocks, those cooling ages in both boreholes probably represent ancient thermal overprints by heat dispersion or transfer via fluids in the fault zone. Based on the calculation of in-situ heat dispersion, it is likely that the thermal overprints were caused by migration of hot fluids along the fault zone from deep crustal interior. For the fault trench samples, zircon FTs of the 2 – 10 mm thick pseudotachylyte layer were totally annealed and subsequently cooled through ZPAZ at ~56 Ma, which is interpreted as the time of (final stage) of pseudotachylyte formation.