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Mineralogy and Petrology of Basement Granites of the Cooper Basin, Central Australia

Jaco van Zyl (1), Massimo Gasparon (2), and Tonguc Uysal (3)

(1) Geothermal Energy Centre of Excelence, University of Queensland, Brisbane, Australia(j.vanzyl@uq.edu.au), (2) Geothermal Energy Centre of Excelence, University of Queensland, Brisbane, Australia(m.gasparon@uq.edu.au), (3) Geothermal Energy Centre of Excelence, University of Queensland, Brisbane, Australia(t.uysal@uq.edu.au

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Although the Australian continent is tectonically relatively stable in comparison with other continental settings, the radiogenic heat production within the Australian continental crust is significantly high. One region with particularly elevated heat production is the Cooper Basin. The Cooper basin is an intra-cratonic basin that contains Late Carboniferous to middle Triassic sedimentary rocks which is mainly comprised of non marine sediments.

The Cooper Basin overlies granites which have intruded the Warburton Basin Sediments. The Cooper basin in turn is overlain by the Eromanga Basin. This paper focuses on four deep wells in which granites have been intersected. The aim of this study is to characterize the mineralogy and petrology of the granites to further the understanding of heat production.

Ten petrographic thin-sections were made from the granites and sampled at different depths in the four geothermal wells. Eight (Big Lake-3507; McLeod-1-3745.2, 3745.9, 3748.3; Moomba-1 2847.75, 2848.7, 2851, 2847.4) of the ten samples exhibit minor to strong alteration, with the other two remaining samples (Jolokia-1 4905 and Moomba-1 2857.4) showing only slight alteration. The predominant mineral in the altered samples is quartz, and a highly birefringent clay mineral (illite from EPMA and XRD) with minor oxides (Goethite, Rutile) sulphides (Galena, Pyrite) and REE-rich silicates (Thorite, Zircon) and phosphates (Apatite, Monazite and Xenotime). The sections exhibiting minor alteration contain plagioclase and K-feldspar in varying stages of decomposition. These feldspars contain varying amounts of illite crystallites.

The only altered mineral in the two slightly altered samples is biotite. In Jolokia 1- 4905 the biotite has been completely replaced by a Fe-bearing illite. In Moomba 1- 2857.4 the biotite is only in the early stages of alteration, with the alteration product being Fe-chlorite.
Considering all the thin sections, three textures were identified based on mineralogy and grain size. The first texture is the primary granite texture, which is evident in the low alteration samples and is also observed in the altered samples through the large grain size of some quartz grains (> 2mm). The primary quartz in these samples is highly fractured with extensive undulose extinction and planar deformation features. The second texture is an intermediate pseudomorphic texture after the alteration of biotite into a larger, more crystalline illite. This texture is characterized by the clay minerals having a grain size between 200 μm and 1 mm. The third texture is the more pervasive alteration. This is exhibited by the finely (< 100μm) inter-grown clay minerals and associated fine-grained quartz.

In addition to the petrology, the illite crystallinity values were measured in the granites and the overlying sediments. They broadly indicate that temperatures during the hydrothermal process in the granite ranged from 250[U+F0B0]C (in Moomba 1 and Big Lake 1) to 350[U+F0B0]C (in McLeod 1 and Jolokia 1). The crystallinity of the illite in the sedimentary rocks is lower in comparison to those in the granite samples. Together with the occurrence of chlorite and kaolinite in the sediments, this indicates that the sediments and the underlying granite were subjected to different fluid chemistries and temperature regimes.

Thin section optical microscopy also shows that the granites have been severely fractured, and that the fracturing was accompanied by significant hydrothermal alteration. Fracturing in the granite occurs mostly as irregular micro-fractures and veining, as well as planar micro-deformation structures in quartz. This indicates that the granite has been subjected to a significantly high stress regime of an unknown origin with subsequent hydrothermal fluid circulation. Hydrothermal alteration mineralogy consists of largely a single phyllosilicate phase (illite). In many cases, all feldspars and micas in the granite have been completely altered to illite.