Lithium-rich pegmatites of the Bynoe Field

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The Bynoe Pegmatite Field, located just 15 km south of Darwin (Figure 1), has been a small but busy Sn-Ta production hub in the Northern Territory for over 100 years; however, it was not until mid-2016 that its credentials as a potentially world-class lithium district were recognised. A number of explorers are now active in the field and are quickly realising this potential, a necessity given the competitors in Western Australia have had a head start!

The prospectivity of the field was touched on by the forward-thinking Northern Territory Geological Survey geologists (Ahmad 1995, Frater 2005) who recognised the favourable granite geochemistry and documented the historic Sn-Ta production. The Bynoe pegmatites are of a special type – ‘LCT’ (lithium-caesium-tantalum) – that evolved from the S-type Two Sisters Granite ca 1850 Ma. This granite is exposed to the southwest of the field (Figure 1). It was emplaced under conditions favourable for the development and injection of volatile-rich structurally-controlled pegmatite dykes into the overlying turbiditic Burrell Creek Formation. The relative homogeneity of this host formation appears to have been critical in confining the fertile magmatic fluids.

The pegmatites range from narrow ‘veins’ to broad lozenge-shaped bodies up to 500 m long and 60 m wide, generally trending north-northeast, parallel to regional fabric. They are expressed at surface as highly weathered clay-quartz (smectite-kaolinite) saprolite, close to the Cenozoic weathering surface that is now being slowly exhumed (Figure 2). There is no sign of the lithium-bearing mineral spodumene at the 100-odd historic prospects, but there are local occurrences of the Li-phosphate mineral amblygonite and Li-bearing micas that were recognised during the main phase of Sn-Ta exploitation in the 1980s. The simple explanation is that spodumene is a variety of pyroxene that has little resistance to weathering and alteration. The initial soil, rock chip and RAB sampling that Core Exploration Ltd undertook in early 2016 gave little away, just as it had for Altura Ltd in the late 2000s. Geochemical trends are evident, but these are orders of magnitude lower than what would be expected for ore-grade mineralisation. It was not until deep reverse circulation and diamond core drilling took place that the true nature of the pegmatites was revealed – grades averaging 1.6% Li\textsubscript{2}O over 30 m true width.

In drill core, the fresh pegmatite is composed of extremely coarse spodumene (20–30%), quartz, albite, microcline and muscovite (in decreasing order of abundance), along with accessory ambygonite, apatite, cassiterite, ilmenite, rutile, and rare cordulite, tantalite, tourmaline (elbaite), fluorite, topaz and beryl (see Figure 3 and Figure 4). Spodumene is intergrown with the other minerals but overall is late in the paragenetic sequence. At some prospects it contains numerous spherical quartz inclusions, while at others it forms inclusion-free optically-continuous crystals more than 10 cm long. It has a diagnostic red-pink UV fluorescence (Figure 3).

Unlike many of the classic pegmatites of Dakota, the Bynoe versions are not strongly zoned, apart from a narrow (1–2 m) quartz-mica-albite wall facies (Figure 3). Internally there are subtle textural and mineralogical changes towards

\begin{figure}[h]
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\includegraphics[width=\textwidth]{figure1.png}
\caption{Bynoe Pegmatite Field – LCT pegmatites are the mass of small blue dots (from Frater 2005).}
\end{figure}

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the core of the pegmatite body, but the overall lithium content is remarkably consistent. In addition, very little lepidolite, a typical Li-bearing mineral in many pegmatite fields around the world, has been recognised thus far.

Banded facies consistent with rapid late crystallisation is recognised in the Bynoe pegmatites. There is also minimal late-stage alteration or deformation of the pegmatite and host rocks. Andalusite and garnet form at the very periphery of the larger bodies, but otherwise the host is uniformly greenschist grade. These various characteristics appear to relate to the parental granite evolution in which a hydrous phase was not significant.

What could prevent the Bynoe field reaching its full potential is the weathering profile. All of the 100-odd historic mines and prospects were found by surface prospecting; given the limited exposure of bedrock in the district, there could be 100s more as a mere one metre of laterite is enough to have concealed them from the old timers and
various forms of modern surface exploration, like remote sensing and soil geochemistry. New discoveries will need to come from innovative exploration techniques (largely geophysical) in what is largely a geophysically amorphous terrain. In addition, there are mapped pegmatites that the old timers ignored due to low Sn and Ta grades; we now know that the best pegmatite yet drilled, in terms of lithium grade and mineralogical quality (Grants prospect), contains negligible Ta in fresh pegmatite.

The distinct advantage of the Bynoe field is its proximity to Darwin with its regional infrastructure, such as roads and port, and stable workforce. The pegmatite quality is also now being recognised – simple mineralogy, coarse texture, high grade – these features allow options for low-cost concentrate production or direct shipping. The modest size and strip-ratio of the pegmatites that are currently drilled may not be a limiting factor for acceptable annual production rates in a diverse supply chain, and where the customer values a premium product. A larger longer-term operation obviously hinges on the discovery of a large coherent pegmatite body or a series of proximal smaller bodies (for which there remains numerous untested targets such as Zola and Ringwood prospects). Moreover, there is also untested potential for broad pegmatite cupolas and greisen-associated lithium in the Two Sisters Granite hanging wall.

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References
