# BIOGEOCHEMICAL ANALYSIS

## for greenfields exploration

### Spinifex as a vector to LCT Pegmatites

**LabWest Technical Note 4** **June 2017**

As the focus of greenfields exploration in Australia moves to areas of deep sedimentary cover, surface signals are sought that can be interpreted to deduce features of the underlying basement.

Biogeochemistry – the sampling and chemical analysis of vegetation – is rapidly becoming the geochemical technique of choice in many areas of deep cover, whether standalone or in combination with other approaches.

The demonstrated ability of various species to collect and concentrate metallic traces from depths of 100 metres or more, the relatively easy access and low impact of sampling, and sensitivity of the technique has led to interest by many explorers, resulting in several discoveries of note. Exploration efforts for gold, base metals, rare-earth elements, uranium and now lithium are increasingly benefiting from biogeochemistry.

Mulga, Eucalypts, Mitchell Grass, Spinifex and other widespread species have been successfully utilised in the Australian outback, and this Technical Note focusses on the emerging use of Spinifex as vector to detecting covered LCT Pegmatites.

The geochemical signals being sought are often faint, so all stages of sample handling and data generation must be meticulous to give the best signal-to-noise ratio possible. LabWest works with leading biogeochemists to develop techniques to ensure these exacting standards are met - the result is our capabilities in this field are second to none.

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Minerals Analysis Pty Ltd

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Figure 1. Abundant spinifex in typical, poorly exposed granite and gneiss terranes of the Pilbara

# Spinifex Biogeochemistry

## A NEW TECHNIQUE FOR LCT PEGMATITE EXPLORATION IN THE PILBARA

Lithium, a very reactive lithophile element, is concentrated in fluids-volatiles during magmatic differentiation of fertile granitic systems. Like boron, lithium is readily absorbed by clay minerals during weathering. This partitioning is important, as clays are a major component of the sedimentary protoliths that melt to form S-type granites. The main hard rock source of lithium is from LCT (**L**ithium-**C**esium-**T**antalum) pegmatites that evolve during crystallisation of S-type granitic magmas. LCT pegmatites are difficult to image using geophysical techniques because of their chemistry and mineralogy, and thus, chemical vectors have proven to be particularly useful in exploration. Spinifex biogeochemistry has recently been shown to have significant application for lithium exploration in Australia, particularly in the poorly outcropping LCT pegmatite prospective gneissic and granitic terranes of the East Pilbara (Figure 1).

### SPINIFEX AS A SAMPLING MEDIUM

Spinifex (*Triodia* sp.) is a widespread xerophytic (adapted to dry conditions) species in Australia, occurring in almost two thirds of the continent, much of which is poorly exposed (Figure 1). It provides a low cost and low impact geochemical sampling medium for exploration, where rocks are obscured by a veneer of transported cover. This is because spinifex roots penetrate to the water table, *commonly deeper than 100m*, where, the presence of humic acid and an extensive bacteria web facilitates metal dissolution. Liberated metals diffuse through the root system, allowing geochemical anomalies to be detected by analysis of green fronds in concentrations ranging from ppm to ppt (see for example Collerson, 2016).

### ANALYTICAL CAPABILITIES

Trace elemental concentrations in biogeochemical media are generally present at ppb-levels and, to increase sensitivity, concentrations have traditionally been increased to ppm-levels by controlled ashing prior to analysis. However, improvements in digestion techniques and ICP-Mass Spectrometry have led to greater sensitivity and lowered detection limits, enabling biogeochemical analysis to extend to ppt levels, and eliminating the need for ashing. To maintain the abundances of volatile alkali metals (lithium, sodium, potassium, rubidium and cesium) during sample processing, LabWest has developed a microwave digestion technique for spinifex and other biogeochemical sampling media, that preserves alkali metal and in particular Li, Cs and Ta anomalism.

### SIMPSON DESERT STUDY

In a study funded by the Queensland Government, biogeochemical data for spinifex has recently allowed the identification of basement chemical anomalism and lithological variability in the Simpson Desert. The spinifex biogeochemical vectors suggested the existence of several obscured mineral systems (Collerson, 2014). This ultimately allowed discovery of an entirely new Silurian to Devonian mineral province in Australia; the Diamantina Alkaline Province, a plume track that extends for ~2000 km across New South Wales, south western Queensland and into the Northern Territory (Collerson, 2015 & 2016). The province is highly prospective for niobium, scandium and the heavy rare earth elements as well as copper, nickel and the platinum group elements.

### LCT PEGMATITES IN THE PILBARA

Following the success of the Simpson Desert study, the possible use of spinifex biogeochemistry as an exploration vector for LCT pegmatites in the Pilbara region was evaluated in a reconnaissance programme. Exploration for LCT pegmatites is difficult in the region because these targets have no magnetic or gravity response, and radiometric response is masked by cover.

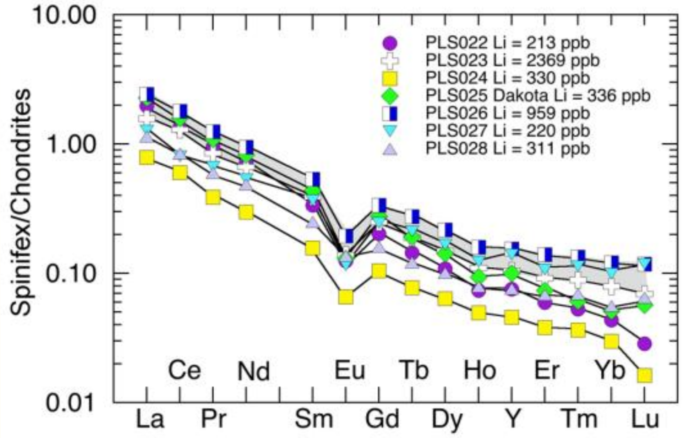


**Figure 2:** Chondrite normalized REE data showing spinifex data from the Pilbara. Shaded field shows Li-bearing spinifex. Smooth REE patterns reflect quality of the low-level analytical data

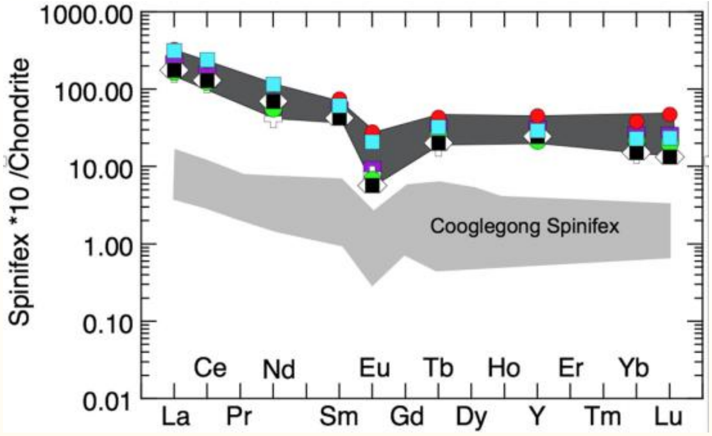


**Figure 3:** Chondrite normalized REE data comparing Cooglegong spinifex with the REE patterns of pegmatites from the Cooglegong granite.

Samples from East Pilbara were analysed using LabWest's MSA digest with determination by ICP-Mass Spectrometry and Emission Spectrometry. Representative data for seven of the samples are given in Table 1, and illustrate the sensitivity of the technique.

The smooth chondrite-normalised rare-earth element (REE) patterns exhibited in the results (Figure 2) also demonstrate the quality of the spinifex trace element data. These mimic the chondrite normalised REE patterns for the country rock samples from the same location (Figure 3) and it is thus apparent that spinifex does not fractionate REEs during plant growth, but preserves essentially unfractionated chondritic ratios.

Excellent recovery of the alkali metals and high field-strength elements (HFSE) in this technique allow regional variation in the obscured basement to be established. Data shown in Table 1 demonstrates the response of selected elements — in particular the LCT indicators Li, Cs, Rb and Ta — in spinifex samples from the east Pilbara. The Y/Ho and Zr/Hf ratios obtained exhibit charge-and- radius-controlled (CHARAC) behaviour, further supporting the conclusion that spinifex uptake of these elements also essentially preserves chondritic ratios (c.f., Bau, 1996).

This is also shown in Figure 4, which compares chondrite normalised REE data for lithium-bearing Pilbara spinifex samples with REE data for LCT pegmatite and their source granites from the Pinilla de Fermoselle pegmatite belt in Zamora Province (Roda-Robles et al., 2012). Importantly, the Pilbara spinifex exhibits virtually the same degree of LREE to HREE fractionation as the Zamora samples, including the presence of similar negative Eu-anomalies, inferring that Spinifex biogeochemistry provides an excellent vector for LCT pegmatite exploration where outcrops are limited.

**Table 1:** REE, Tin, Selected REE, High Field Strength Element and Alkali Metal abundances, Rb/K , Cs/K ratios as well as Y/Ho and Zr/Hf Ratios in Spinifex Samples from the East Pilbara

| | K ppm | Rb ppb | Cs ppb | Li ppb | Zr ppb | Ta ppb | Nb ppb | Sn ppb | Rb/K x $10^{-3}$ | Cs/K x $10^{-5}$ | Ho ppb | Y ppb | Zr ppb | Hf ppb | Y/Ho | Zr/Hf |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DL | 5 | 5 | 0.5 | 5 | 1 | 0.1 | 1 | 10 | | | 0.1 | 0.5 | 1 | 0.5 | | |
| #1 | 4064 | 4578 | 52.7 | 213 | 194 | 8 | 25 | 21 | 1.13 | 1.30 | 4.0 | 118.5 | 194 | 8.1 | 29.6 | 24.0 |
| #2 | 3017 | 5883 | 273.1 | 2369 | 226 | 1.2 | 48 | 21 | 1.95 | 9.05 | 6.0 | 163.8 | 226 | 7.8 | 27.3 | 29.0 |
| #3 | 4166 | 6495 | 34.3 | 330 | 99 | 0.8 | 23 | < 10 | 1.56 | 0.82 | 2.7 | 71.7 | 99 | 3.4 | 26.6 | 29.1 |
| #4 | 1944 | 5866 | 57.6 | 336 | 116 | 0.4 | 22 | 16 | 3.02 | 2.96 | 5.1 | 156.7 | 116 | 4.3 | 30.7 | 27.0 |
| #5 | 4371 | 5869 | 162.6 | 958 | 237 | 0.2 | 73 | 33 | 1.34 | 3.72 | 8.7 | 242.4 | 237 | 7.8 | 27.9 | 30.4 |
| #6 | 2533 | 2261 | 31.7 | 220 | 122 | < 0.1 | 92 | 14 | 0.89 | 1.25 | 6.7 | 219.1 | 122 | 5.2 | 32.7 | 23.5 |
| #7 | 1085 | 818 | 27.4 | 311 | 158 | 1.6 | 28 | 17 | 0.75 | 2.53 | 4.3 | 119.5 | 158 | 5.9 | 27.8 | 26.8 |

# Spinifex Biogeochemistry

## SUMMARY

The low cost and low environmental impact of sampling spinifex increase its desirability as a geochemical exploration vector.

Work to date on spinifex using LabWest indicates that:

1. The microwave digestion protocol is effective in ensuring alkali metals are not lost during analysis of spinifex plants
2. Near chondritic Y/Ho and Zr/Hf ratios indicate that spinifex does not appear to fractionate the REEs, or the high field strength elements, during plant growth
3. REE concentrations ranging from ~1000 ppb to less than 1 ppb generate smooth chondrite normalised patterns that mimic patterns in lithologies on which the spinifex is growing
4. Spinifex values for LCT indicators (Li, Cs, Rb and Ta) reflect underlying basement lithological variation
5. Spinifex biogeochemistry provides an excellent vector for LCT pegmatite exploration where outcrops are limited

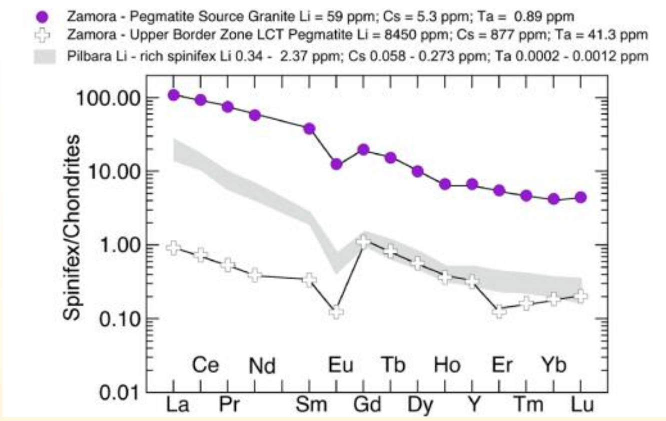


**Figure 4:** Figure comparing Pilbara Li-bearing spinifex field with data for the Zamora LCT pegmatite and its source granite from Roda-Robles et al., (2012).

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