Assessment of Mozley C800 laboratory mineral separator for specialty metal indicator mineral exploration: Aley carbonatite, British Columbia, Canada

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Main Objectives:

- To refine customized indicator mineral and geochemical methodologies to explore for poorly exposed specialty metal deposits in the Canadian Cordillera.
- Assess heavy mineral separation by Mozley C800 Laboratory Mineral Separator with an emphasis on recovering Nb-bearing (pyrochlore and columbite-[Fe]) and rare earth element (REE)-bearing (monazite and REE-fluorocarbonates) minerals.
- Evaluate the advantages of automated methods (QEMSCAN) over hand picking for advanced mineralogical studies.
- The results of this study will form the basis to optimize indicator mineral methodologies to explore for carbonatite-hosted specialty metal deposits world-wide.

Project Outline

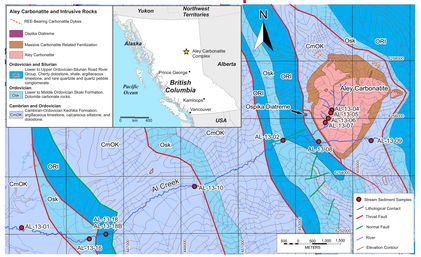
Limited exploration budgets and deposit andcommodity specific exploration necessitates a more focussed, customized approach.

Stage 1 (previous work) involved characterising the Aley carbonatite, stream-sediment sample collection, and orientation survey. This involved chemical analyses of the sediments and selection of an optimal size fraction for indicator mineral studies (Luck and Simandl 2014; Mackay and Simandl 2014).

Stage 2 (current study) involves evaluation of inexpensive and rapid methods to produce heavy-mineral concentrates for specialty metal-targeted exploration. An initial assessment of the Mozley C800 Laboratory Mineral Separator (referred to from here on as Mozley C800) is presented using synthetic standards (prepared for this purpose) and stream-sediments collected from the Aley carbonatite drainage area. Minerals with high densities and constituent Nb, Ta, and light rare earth elements (LREE; La, Ce, Pr, and Nd) were selected as potential indicator mineral candidates.

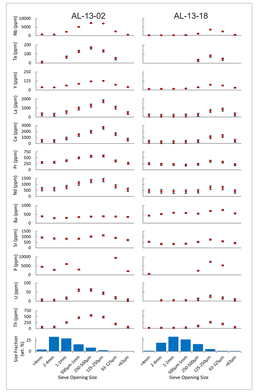
Stage 3 (proceeding concurrently with stage 2) will address customization of microscopic, SEM, QEMSCAN, and electron microprobe methods in advanced mineralogical studies.

Study Area, Local Geology, and Stream Sediment Sample Locations



The Aley Carbonatite (290 km north of Prince George, BC; inset map) outcrops over a 3-3.5 km diameter area. Measured+indicated resources are 286 million tonnes at 0.37% Nb_2O_5 (Taseko Mines Limited, 2013). The Aley Carbonatite intruded into platformal carbonate and siliciclastic rocks of the Kechika Formation, Skoki Formation and Road River Group. Twelve stream-sediment samples (locations denoted by red circles) were collected from the stream draining the Aley carbonatite. From Mackay et al. 2015; modified after Mäder (1986), Massey et al. (2005), McLeish (2013) and Mackay and Simandl (2014).

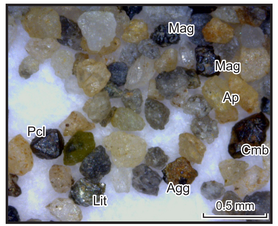
Stream Sediment Orientation Survey



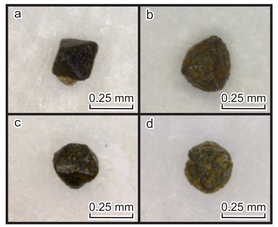
Concentration of potential carbonatite pathfinder elements for each size fraction of stream-sediment samples from the Aley area. The 125-250μm size fraction was selected for stage 2 and 3 geochemical and indicator mineral studies based on the distribution of material in the different size fractions and elemental concentrations (Nb, Ta, and LREE; La, Ce, Pr, Nd). Time permitting, the 63-125μm and 250-500μm size fractions would also be worthwhile for testing. From Mackay et al. 2015; modified from Mackay and Simandl 2014.

Potential Indicator Minerals

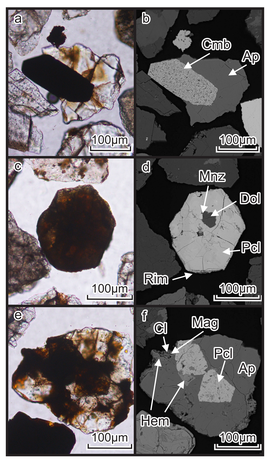
Potential indicator minerals for carbonatite-hosted specialty metal desposits include pyrochlore (4.20-6.40 g/cm^3), columbite-(Fe) (5.30-7.30 g/cm^3), fersmite (4.69-4.79 g/cm^3), monazite (4.80-5.50 g/cm^3) and REE-fluorocarbonates such as bastnaesite (4.95-5.00 g/cm^3) and synchysite (3.90-4.15 g/cm^3). These minerals have similar or higher densities than magnetite (5.10-5.20 g/cm^3) in the synthetic standards used for initial optimization of Mozley C800 operating conditions.



(Left) Mozley C800 heavy mineral concentrate (sample AL-13-16) containing apatite (Ap), pyrochlore (Pcl), columbite-(Fe) (Cmb), and magnetite (Mag). Lithic fragments (Lit), and grain aggregates (Agg) are also present. Pyrochlore is identified by its distinctive octahedral crystal habit. Optical identification can be difficult in highly weathered grains. A magnet can be used to separate magnetite from columbite-(Fe) and other non-magnetic minerals.



a) Fresh (unweathered) euhedral, dark brown and **b)** subhedral, strongly weathered pyrochlore grains from stream sediments sampled directly over the deposit (sample AL-13-04). **c)** Subhedral, slightly weathered and **d)** strongly weathered pyrochlore grains from downstream (8.8km; sample AL-13-16) of the Aley carbonatite.

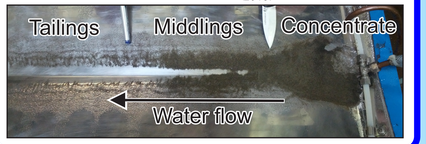


a) Euhedral columbite-(Fe) partially surrounded by apatite (polished grain mount in plane polarized light; ppl). **b)** The columbite-(Fe) grain shows irregular texture characteristic for the Aley carbonatite (back scatter electron; BSE). Composite grains containing two or more mineral phases are common. **c)** Euhedral pyrochlore grain (ppl). **d)** The pyrochlore is highly fractured and contains dolomite (Dol) and minor monazite (Mnz) inclusions (BSE). The grain also has a minor weathered rim of Nb and Fe oxide material. **e)** An anhedral apatite grain (ppl image) **f)** with subhedral pyrochlore and hematite inclusions. The apatite has an alteration (weathered) rim of hematite (Hem), magnetite and minor chlorite (Cl) (BSE).

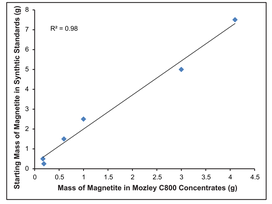
Processing Procedure

(Left) A sample being poured onto a Mozley C800. Water is supplied to the v-profile tray by the wash water pipe and the irrigation pipes. Arrows denote the direction of water flow. Duration of processing varied during operating condition optimization to suit deposit characteristics and sample size. Other operating parameters were kept constant for all samples. From Mackay et al. 2015.

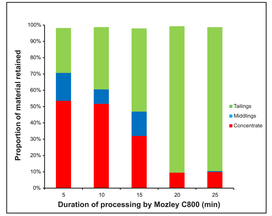
(Below) Separated concentrate (high density), middlings (medium density), and tailings (low density). Concentrate narrows to where the middlings start. Separation of middlings from tailings is marked by a decrease in the spatial density of grains. From Mackay et al. 2015.



Optimization of Operating Conditions

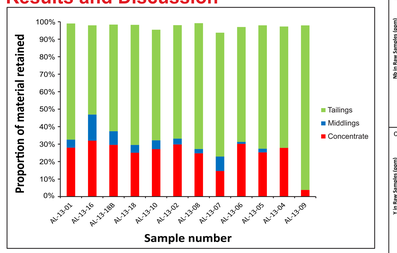


Synthetic standards (75g) were used to test operating parameters. They were made predominantly of quartz with 0.33 to 10 wt. % each of magnetite, garnet, and fluorite. The excellent correlation (R^2=0.98) between magnetite in synthetic standards and in Mozley C800 concentrates indicates consistent concentration. Magnetite concentration increased by 5.5 to 228.2 times. From Mackay et al. 2015.

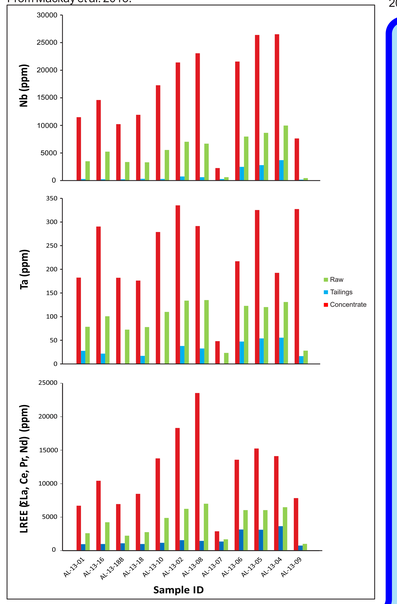


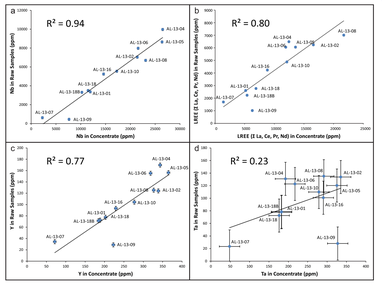
The proportion of concentrate for five identical sub-samples (~75g) of AL-13-16 decreased with increasing processing time. All other parameters were kept constant. The 15 minute time interval was selected for the remaining samples; this time is a compromise which ensures adequate concentration of heavy minerals, minimizing loss to tailings. From Mackay et al. 2015.

Results and Discussion



(Above) Most stream-sediment samples (~75g) show 24.7-32.0% of material retained in concentrate, consistent with the natural sample used during optimization. Sample AL-13-09 (sampled upstream of the carbonatite) shows noticeably lower proportions of retained concentrate (3.8%). (Below) Mozley C800 concentrates show large average increases in the concentration of Nb (4.3 times), Ta (3.1 times), and LREE (3.1 times) relative to raw (unprocessed) samples. Samples are ordered by their geographic location from west to east (see map). The decreasing carbonatite signature with increasing distance downstream is preserved. From Mackay et al. 2015.





(Above) Excellent correlation, based on high coefficients of determination (R^2), of **(a)** Nb (R^2=0.94), **(b)** LREE (R^2=0.86) and moderate correlation of **(c)** Y (R^2=0.77) in raw samples and Mozley C800 concentrates indicates consistent and effective concentration of pyrochlore, columbite-(Fe), magnetite, monazite, and REE-fluorcarbonates. The low coefficient of determination (**d**; R^2=0.23) between Ta concentrations in raw samples and Mozley C800 concentrates is likely due to concentrations near the detection limit. From Mackay et al. 2015.

Conclusions

- Mozley C800 Laboratory Mineral Separator is a compact, simple instrument with operating conditions that can be optimized for drainage-, deposit-, or commodity-specific conditions.
- Mozley C800 increased concentrations of Nb (average factor of 4.3), Ta (average factor of 3.1), and LREE (average factor of 3.1) from stream-sediment samples.
- Pyrochlore, columbite-Fe, monazite and REE-bearing fluorocarbonates were consistently concentrated.
- Based on chemical analyses, a predictable relationship between indicator mineral counts in raw stream-sediment samples and concentrates should be expected.
- These findings justify stage 3 of this project which involves microscopic, SEM (QEMSCAN), and electron microprobe methodology to reduce or eliminate the need for hand-picking indicator minerals.

Acknowledgements:

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