Assessment of Mozley and Wilfley shaking tables for concentrating carbonatite indicator minerals, Aley carbonatite, British Columbia, Canada

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TGI 4 Ore Systems

Objectives

One of the main objectives of the Specialty Metals component of the Targeted Geoscience Initiative 4 (TGI-4) is to develop simple, inexpensive methods to explore for rare-earth element (REE) and niobium (Nb) ± tantalum (Ta) deposits described in Mackay and Simandl (2014a) and Simandl (2014). The main purpose of this study is to determine if Mozley and Wilfley tables can concentrate carbonatite indicator minerals (Table 1) to a degree that additional processing is not required for quantitative assessment using Quantitative Evaluation of Minerals by Scanning electron microscopy (QEMSCAN®). Expensive and labour intensive mineral picking is eliminated from indicator mineral surveys.

Potential carbonatite indicator minerals

Table 1: Potential carbonatite indicator minerals. Expected ranges in pathfinder element content (Wt. %). Modified from Mackay et al. (2015a).

Mineral	Chemical Formula	Density (g/cm³)	Nb_2O_5	Ta_2O_5	TREO
Pyrochlore	$(Ca,Na)_2(Nb,Ti,Ta)_2O_6(O,OH,F)$	4.2–6.4	34.2–86.8	0–4.3	2.6-6.0
Columbite-(Fe)	$(Fe,Mn)(Ta,Nb)_2O_6$	5.3–7.3	46.8–81.2	0–31.2	n.a.
Fersmite	$(Ca,Ce,Na)(Nb,Ta,Ti)_2(O,OH,F)_6$	4.69–4.79	66.0–70.1	0–16.9	4.8
Monazite	$(Ce,La,Nd,Th)PO_4$	4.8–5.5	n.a.	n.a.	59.2
Zircon	$ZrSiO_4$	4.6–4.7	n.a.	n.a.	0.1–4.4
Bastnaesite	$Ce(CO_3)F$	4.95–5.00	n.a.	n.a.	73.6–78.1
Synchysite	$Ca(Ce,La)(CO_3)_2F$	3.90–4.15	n.a.	n.a.	47.8
Apatite	$Ca_5(PO_4)_3(OH,F,Cl)$	3.16–3.22	n.a.	n.a.	0.5–5.5
Barite	$BaSO_4$	4.48	n.a.	n.a.	n.a.
Celestine	$SrSO_4$	3.9–4.0	n.a.	n.a.	n.a.
Magnetite	Fe_3O_4	5.1–5.2	n.a.	n.a.	n.a.
Arfvedsonite	$Na_3[(Fe,Mg)_4Fe]Si_8O_{22}(OH)_2$	3.44-3.45	n.a.	n.a.	n.a.
Richterite	$Na(Ca,Na)(Mg,Fe)_5(Si_8O_{22})(OH)_2$	3.09	n.a.	n.a.	n.a.
Aegerine	$NaFeSi_2O_6$	5.50–5.54	n.a.	n.a.	n.a.
Perovskite	CaTiO3	4.0-4.3	n.a.	n.a.	n.a.

n.a. = not applicable

Aley Carbonatite

The Aley carbonatite is located 290 km north of Prince George, British Columbia (Figure 1), and outcrops over a 3 x 3.5 km area (Mäder, 1986; McLeish, 2013). It was selected as a case study location because it is the most important Nb-deposit in the Canadian Cordillera with a measured plus indicated resource of 286 million tonnes at 0.37% Nb_2O_5, with a cut-off grade of 0.20% Nb_2O_5 (Jones et al. 2014). It is hosted by greenschist facies metasediments. The main body of the Aley carbonatite is dolomitic with volumetrically minor calcite carbonatite, surrounded by fenitised country rock (Mäder, 1986; McLeish 2013).

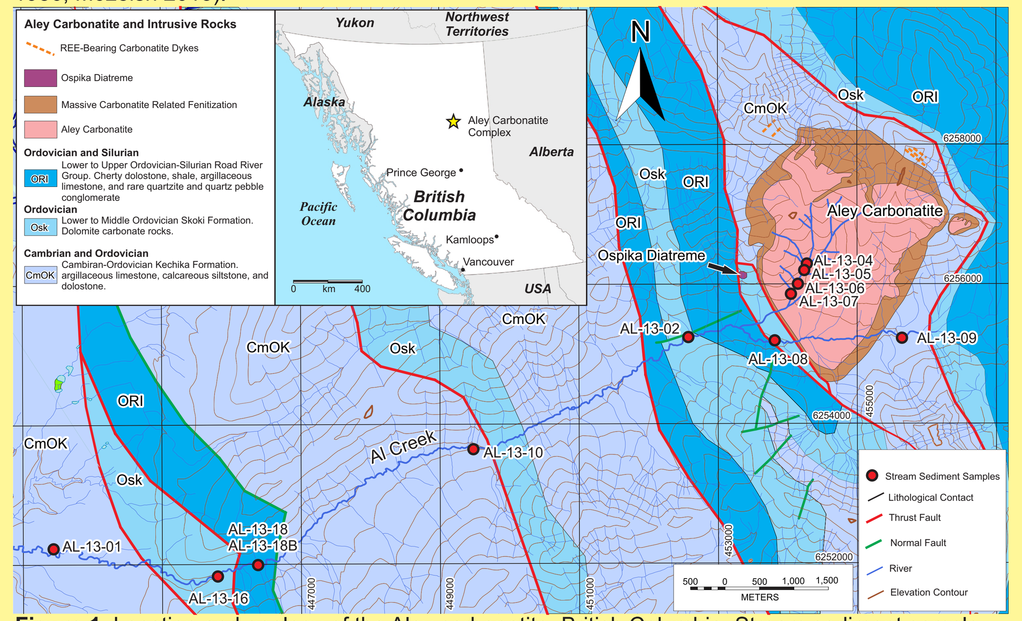

Figure 1. Location and geology of the Aley carbonatite, British Columbia. Stream sediment sample locations are denoted by red circles. Modified after Pride (1983), Mäder (1986), Massey et al. (2005), McLeish (2013) and Mackay and Simandl (2014b).

Mozley C800 laboratory mineral seperator

The Mozley C800 (Figure 2) is a light and compact alternative to most other shaker tables and gravity concentrators used by metallurgists. It performs density sorting of grains using side to side (stroke) and front to back (throw) motions. During processing, material is separated into concentrate (high density), middlings (mixed), and tailings (low density). Information regarding the Mozley C800 concentrator presented here is derived from Mackay et al. (2015b).

Figure 2. The operating procedure is simple once optimal conditions for sample processing are identified. Dry sieved (125–250 µm size fraction) samples weighing ~75 g are poured from a beaker onto the table and wetted at the wash water pipe (copper tube). A spray bottle is used to remove all material from the beaker. Water is supplied by the wash water pipe and the irrigation pipes (two white plastic tubes with water outlets at regular intervals). The direction of water flow is denoted by black arrows. Tailings separate first, moving longitudinally down the trough in the direction of water flow and are collected at the end of the table. The v-profile tray, best suited for coarse grain sizes (100 µm–2 mm), was used for this study. The Mozley C800 set up parameters were: 1.75° longitudinal slope; 70 rpm table speed; 6.35 cm amplitude (throw and stroke); and 1.6 L/min water flow rate.

Once the selected time interval (15-minutes in this case) is reached, the table and water are turned off. The division of sediment into concentrate, middlings and tailings is visually discernable by shape and colour of the material stream (Figure 3). Tailings, middlings and concentrate are separated and washed into separate containers.

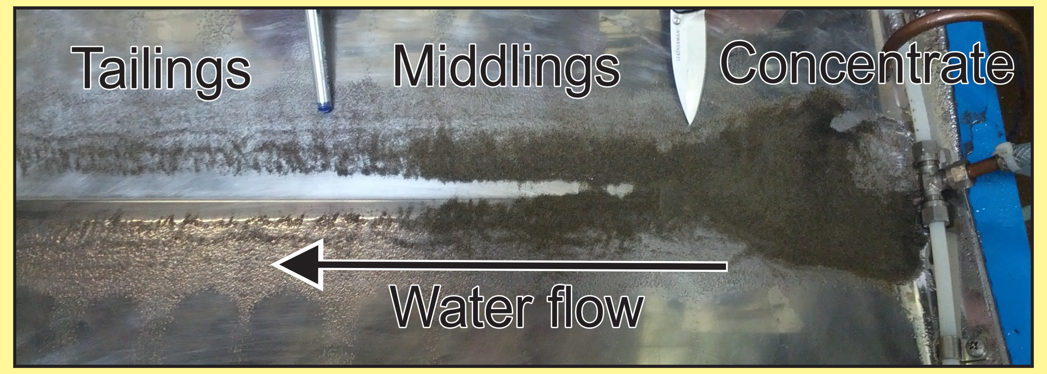

Figure 3. View of the surface of the Mozley C800 laboratory mineral separator table after a completed run. Sample material is separated into concentrate, middlings and tailings based on pattern and colour of the material stream.

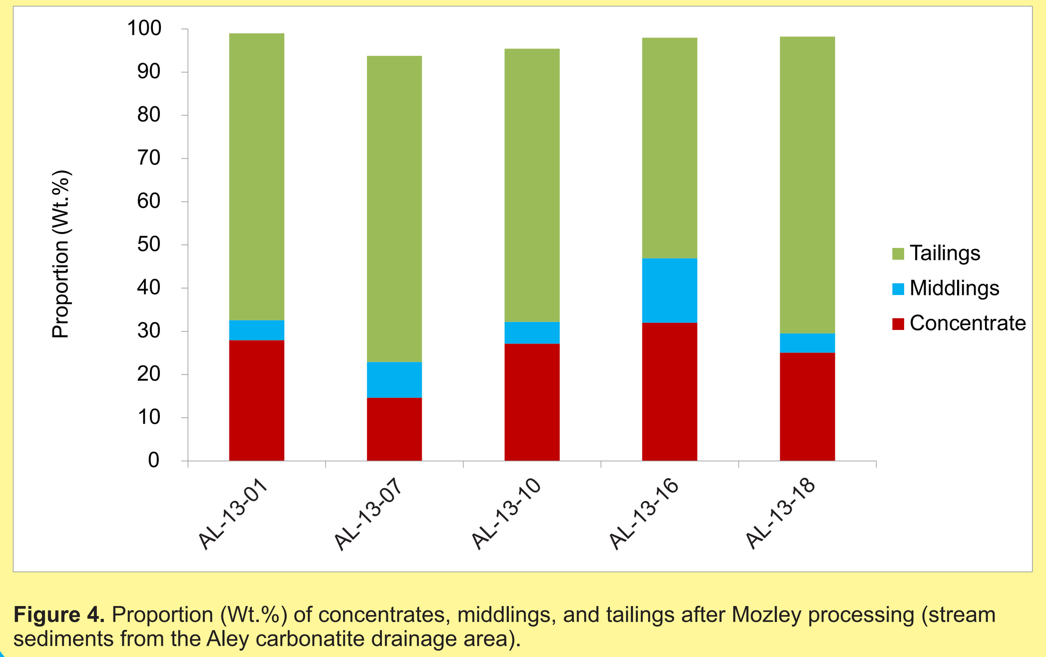

Figure 4. Proportion (Wt.%) of concentrates, middlings, and tailings after Mozley processing (stream sediments from the Aley carbonatite drainage area).

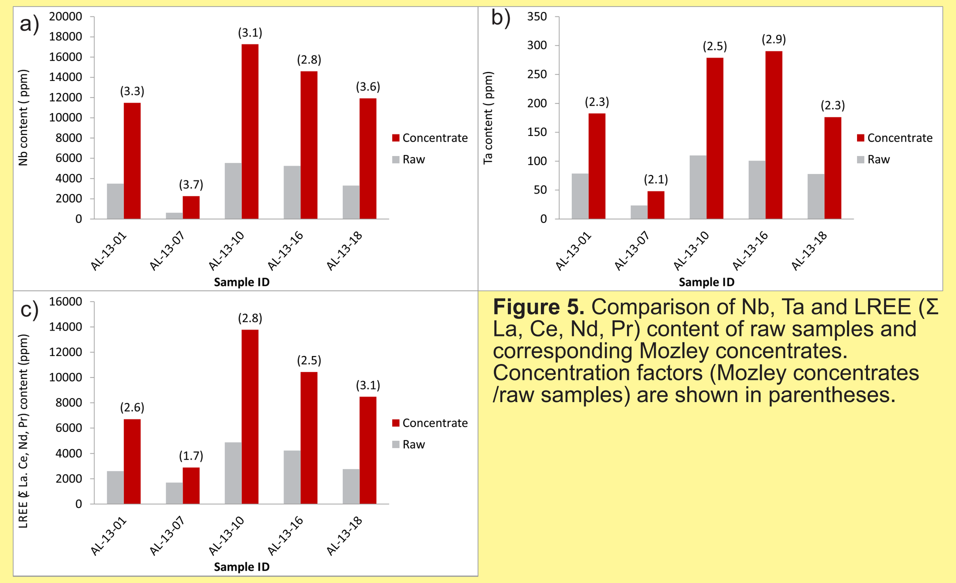

Figure 5. Comparison of Nb, Ta and LREE (Σ La, Ce, Nd, Pr) content of raw samples and corresponding Mozley concentrates. Concentration factors (Mozley concentrates /raw samples) are shown in parentheses.

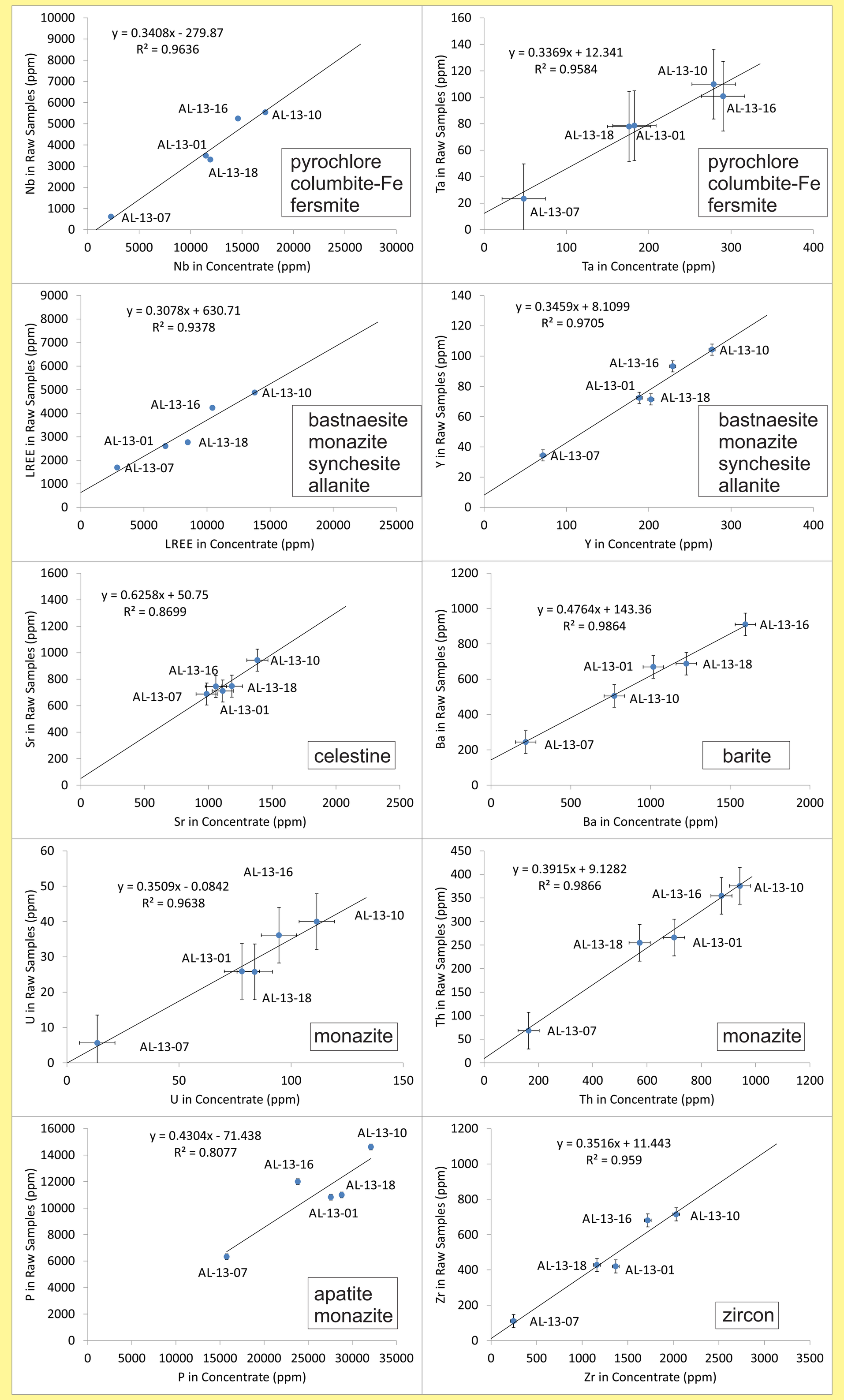

Figure 6. Comparison of Nb, Ta, LREE (Σ La, Ce, Pr, Nd), Y, Sr, Ba, U, Th, P, and Zr content (determined by pXRF) of the 125-250µm fraction from before and after Mozley C800 separator processing. High coefficients of determination (R^2) for most pathfinder elements indicate that processing consistently concentrated corresponding carbonatite indicator minerals (shown in boxes). Error bars (2σ) are based on repeated portable X-ray fluorescence analyses of standards as described in Luck and Simandl (2014).

Wilfley Shaking Table #13

Mineral concentrators such as the The Mine & Smelter Supply Co Wilfley shaking table #13 used in this study are a common tool in mining and exploration activities. Wilfley shaking tables separate silt and sand sized material by mineral density. Simple to calibrate and maintain, it processes a continous feed of material. Informaiton regarding the Wilfley concentrator presented here is derived from Mackay et al. (2015a).

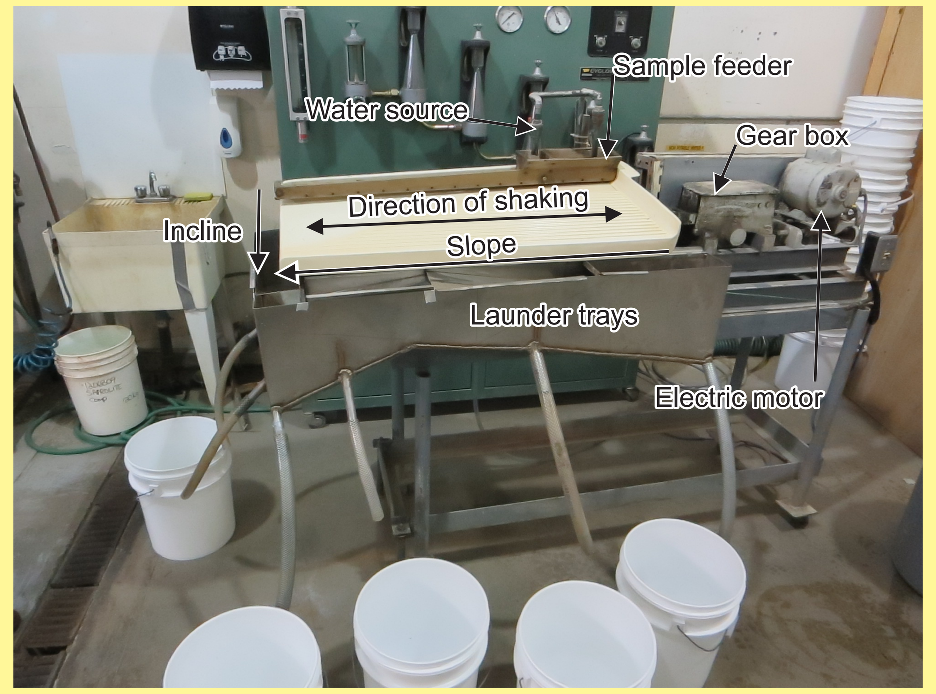

Figure 7. Dry sieved (125–250µm size fraction) stream sediment samples varying from 380-940g were mixed into a slurry with water and gradually washed into the sample feeder (Figure 7). Material moves with the direction of shaking across the table surface and diagonally down the table slope. The table was set with an 8° incline, 3° slope, 10mm stroke, and table speed of 250 rpm for all samples from Aley. Water flow was kept constant for all samples at 18 L/min based on optimization using synthetic standards.

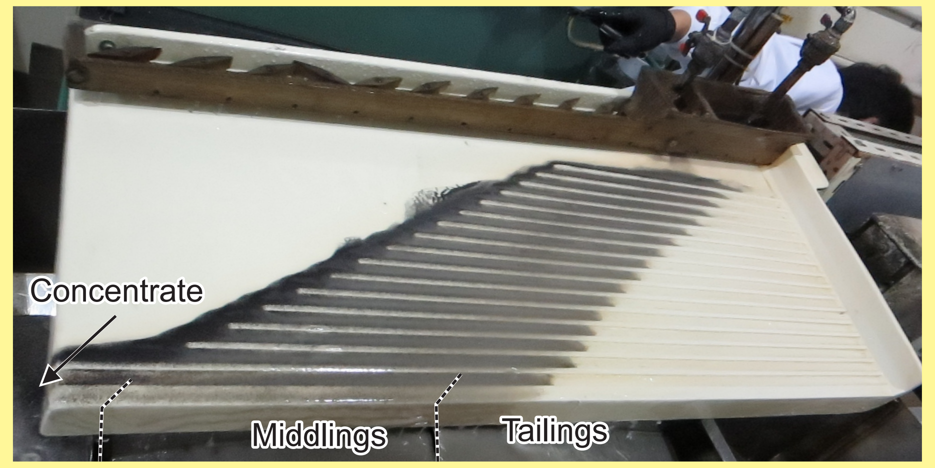

Figure 8. Close-up of the Wilfley table. Heavy minerals (black) are separated from middlings and tailings as material moves from the top-right to bottom-left. Denser material (concentrate) is carried farthest left along the table ridges while the least dense material is washed off the bottom of the table. Launder trays are positioned to collect the concentrate, middlings, and tailings. Suspended particles are allowed to settle and excess water is decanted from concentrates, middlings, and tailings.

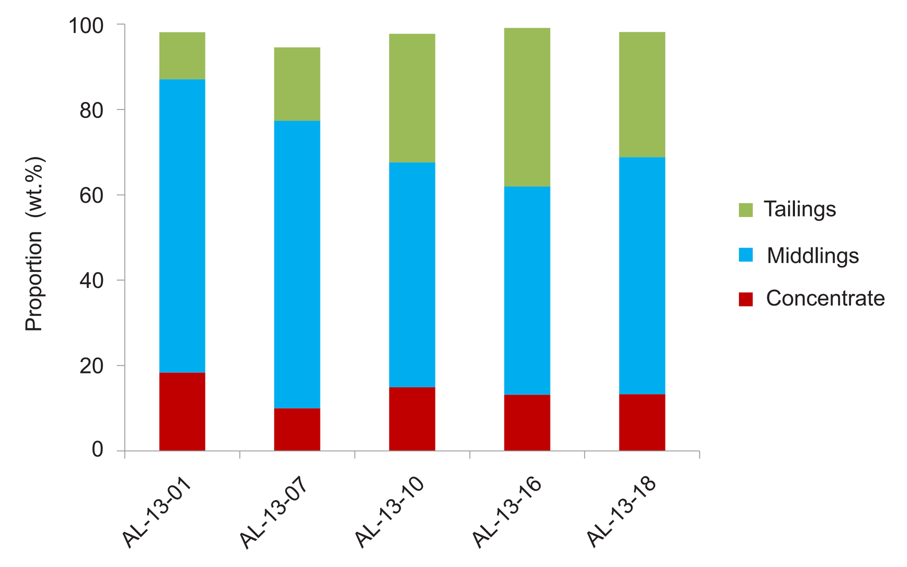

Figure 9. Proportion (Wt.%) of concentrates, middlings, and tailings after Wilfley table processing (stream sediments from the Aley carbonatite drainage area).

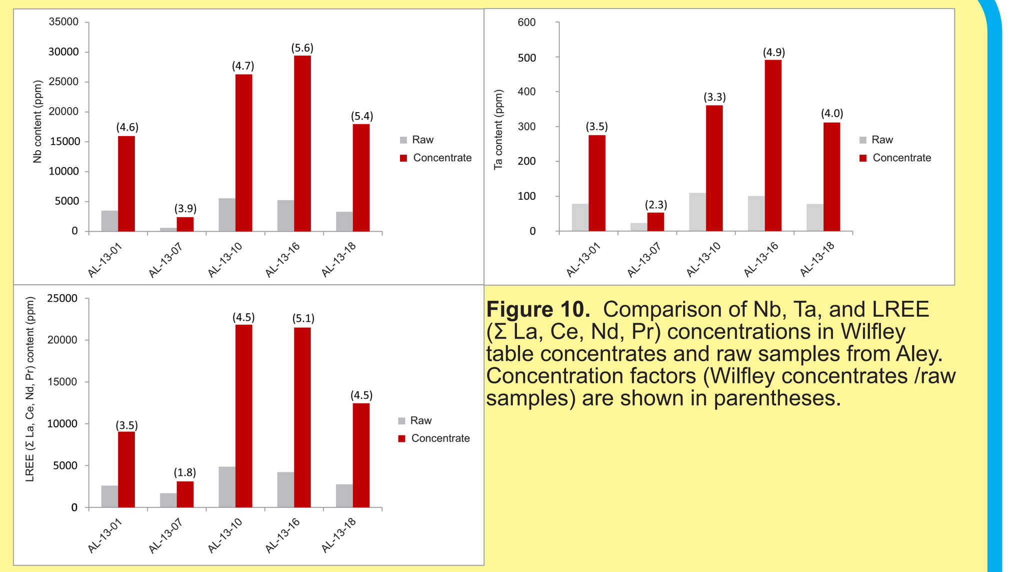

Figure 10. Comparison of Nb, Ta, and LREE (Σ La, Ce, Nd, Pr) concentrations in Wilfley table concentrates and raw samples from Aley. Concentration factors (Wilfley concentrates /raw samples) are shown in parentheses.

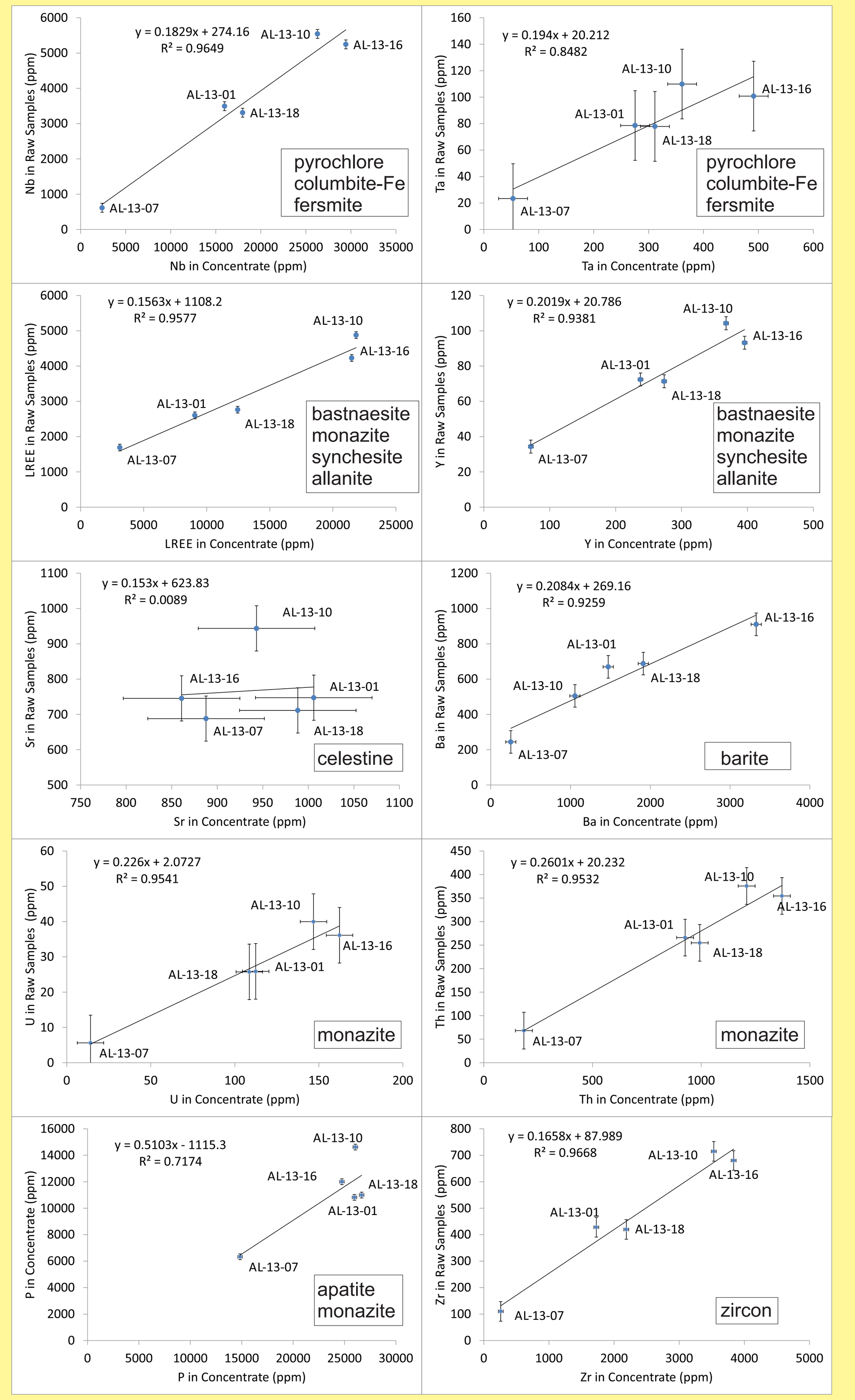

Figure 11. Comparison of Nb, Ta, LREE (Σ La, Ce, Pr, Nd), Y, Sr, Ba, U, Th, P, and Zr content (determined by pXRF) in Wilfley table concentrates and raw samples. High coefficients of determination (R^2) for most pathfinder elements indicate that processing consistently concentrated corresponding indicator minerals (shown in boxes). Error bars (2σ) are based on repeated portable X-ray fluorescence analyses of standards as described in Luck and Simandl (2014).

Comparison

Table 2: Comparison of concentration factors for Mozley and Wilfley shaker tables

	Mozley C800			Wilfley #13		
	Min	Mean	Max	Min	Mean	Max
Nb	2.8	3.3	3.7	3.9	4.8	5.6
Ta	2.1	2.4	2.9	2.3	3.6	4.9
LREE	1.7	2.5	3.1	1.8	3.9	5.1
Y	2.1	2.5	2.8	2.1	3.4	4.2
Zr	2.2	2.7	3.3	2.4	4.4	5.6
P	2.0	2.4	2.6	1.8	2.2	2.4
Th	2.2	2.5	2.6	2.7	3.4	3.9
U	2.4	2.8	3.3	2.5	3.8	4.5
Ba	0.9	1.5	1.8	1.0	2.4	3.7
Sr	1.4	1.5	1.6	1.0	1.2	1.4
Fe	1.7	2.3	2.7	1.7	3.5	4.6

Table 3: Comparison of coefficients of determination (R^2) for elemental abundances in mineral concentrates and raw samples

	Mozley C800	Wilfley #13
Nb	0.96	0.96
Ta	0.96	0.85
LREE	0.94	0.96
Y	0.97	0.94
Zr	0.96	0.97
P	0.99	0.93
Th	0.96	0.95
U	0.99	0.95
Ba	0.91	0.71
Sr	0.87	0.01
Fe	0.97	0.97

Table 4: Comparison of Mozley C800 Laboratory Mineral Separator and Wilfley Shaking Table #13 performance and applicability to Aley-style carbonatite-hosted Nb-deposits

Seperator	Mozley C800 (Mackay et al. 2015a)	Wilfley #13 (Mackay et al. 2015b)
Dimensions (portability)	Approx. 1.2m x 1m x 1m; pick-up truck transportable; designed to be moved (field or laboratory based)	Approx. 2.0m x 0.75m x 1.25m; commonly a stationary set up (laboratory based; 475mm x 1016mm table size*)
Level of training and operator attentiveness needed to operate	High	Moderate
Use of synthetic standards for optimizing operating conditions	Recommended	Recommended
Recommended sample size (based on manufacturer's specifications)	50-100g	N/A; but 8.6-65.0 kg in 0.25-1mm size fraction of till samples have been used (example from McClenaghan 2011)
Sample size successfully tested (125-250 µm fraction)	75g (90-100g sample may be preferred for low indicator mineral counts)	380-940g
Grain size (based on manufacturer's specifications)	100 µm - 2 mm (v-profile tray) <100 µm (flat tray)	<2 mm
Cleaning	Short cleanup (5 min)	Long cleanup (20 min)
Risk of contamination	Low; minimal material traps	High; several potential material traps
Approximate water usage (based on optimized parameters)	1.6 L/min (15 min/sample) 24L/sample	18 L/min (approx. 5min/sample; dependant on sample size) 90L/sample
Processing time per sample	15 min; samples < 100g	5 min; samples < 1000g

N/A = not available
*Smaller and larger table sizes available on the market

Conclusions

- Both Mozley C800 and Wilfley #13 effectively concentrate carbonatite indicator minerals in stream sediments
- Both tables produce concentrates with a predictable relationship to raw samples
- The Mozley C800 is more suitable for small initial sample weight (75 - 100 g) while the Wilfley #13 is more suitable for larger sample weights (> 380 g)
- Risk of contamination is lower and clean-up is easier with the Mozley C800 table

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