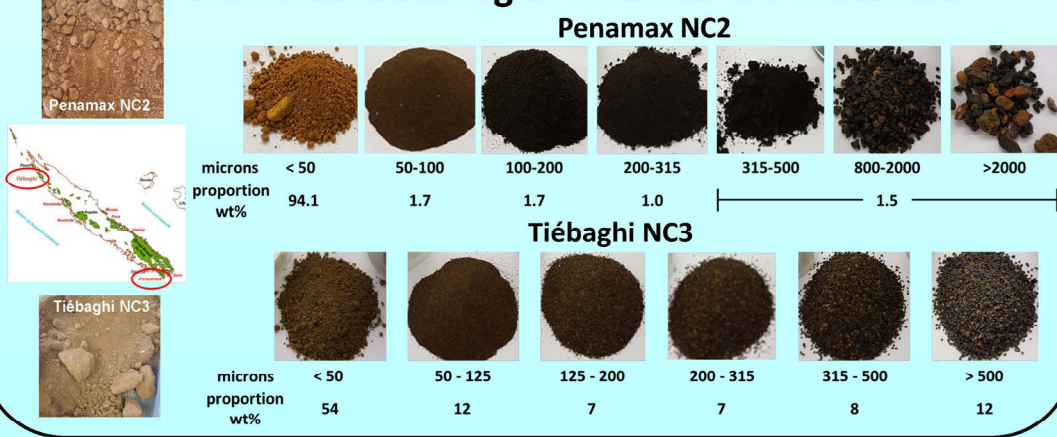


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Gravimetric sieving of limonite raw materials



Limonites from laterite deposits are often discarded as low grade Ni and Co mine waste. However, these resources are volumetrically enormous.

New Caledonia limonites from Penamax and Tiébaghi contain up to 22,000 and 48,000 tonnes Co respectively.

With a view to enhancing their bioleach potential, we have studied the mineral and chemical properties of a suite of size fraction separates from these two limonites.

Density separation



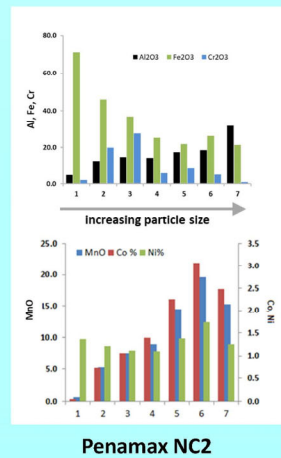
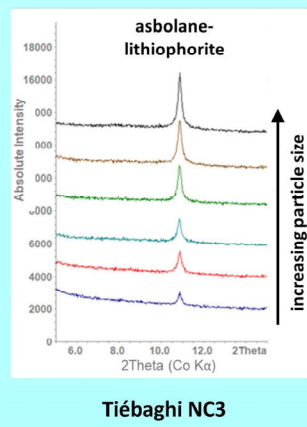
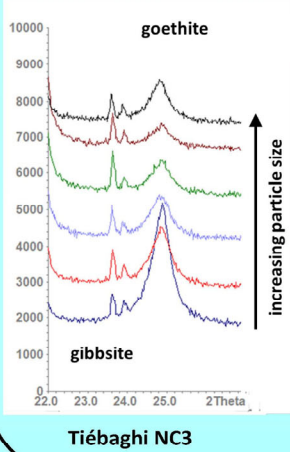
100-400 microns

Mozley Table density separation was performed on NC2 to produce an Mn oxide concentrate with a grainsize of 100-400 µm

Bulk mineralogy

X-ray diffraction shows that goethite dominates the mineralogy in the smallest size fraction and is reduced in all other size fractions (left).

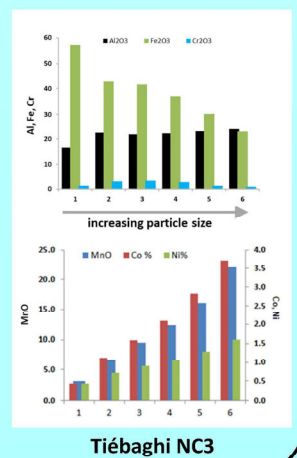
Mn oxyhydroxide minerals are enriched in the larger size fractions (right).



Bulk chemistry

In NC2 and NC3, Co and Mn increase and Fe decreases in abundance as the particle size increases. Ni does not vary significantly for NC2 but increases with particle size in NC3.

The Co-Mn correlation reflects Co being hosted by Mn oxyhydroxides. This is also true for most of the Ni in NC3, but significant Ni is also present in Fe oxyhydroxides in NC2.

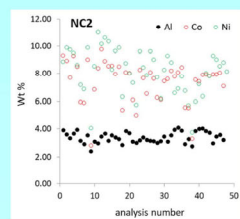


Quantitative mineralogy

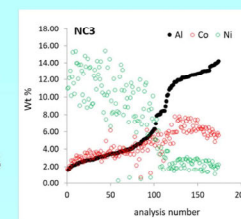
Relative modal proportions of the main minerals in NC2 (left) and NC3 (right) were quantified using an Automated Mineral Analyser.

Material	Mineral	Proportion (<50µm)	Proportion (>315µm)
NC2	Mn oxyhydroxides	0.36 wt%	34 wt%
	Fe oxyhydroxides	86 wt%	22 wt%
NC3	Mn oxyhydroxides	3.7 wt%	67 wt%
	Fe oxyhydroxides	72 wt%	12 wt%

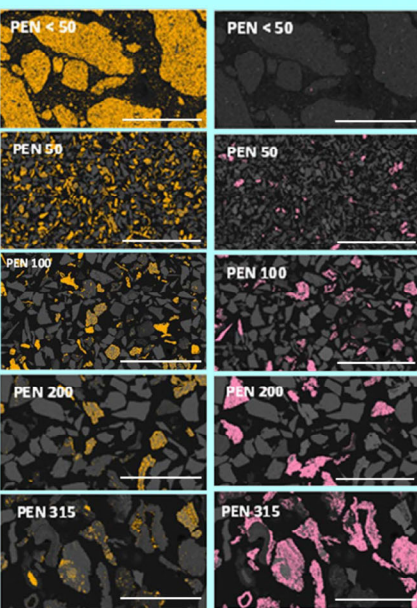
Mn oxyhydroxide chemistry



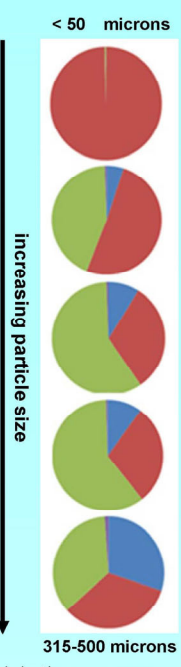
In NC3 (right) Al₂O₃ varies from 2 to 15 wt%. In these Mn oxyhydroxides Co increases and Ni decreases with Al content.



Fe oxyhydroxide Mn oxyhydroxide

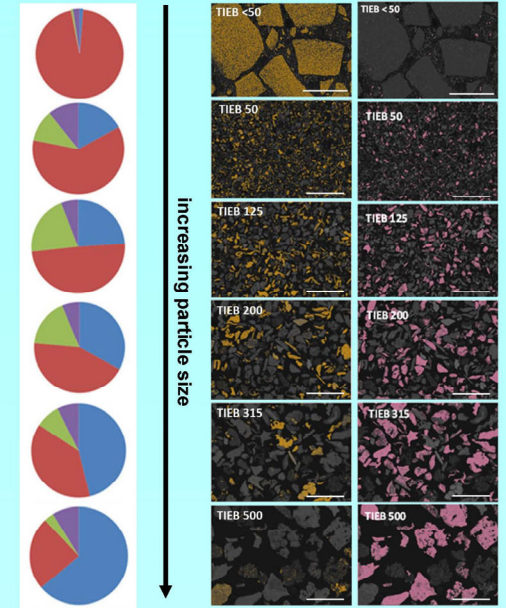


Backscatter electron images from an Automated Mineral Analyser. Scale bar = 1 mm

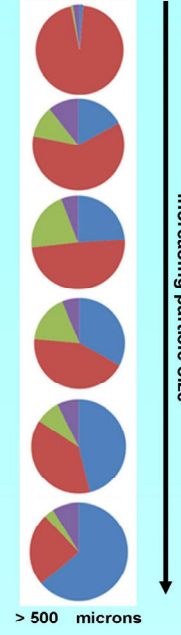


315-500 microns

Fe oxyhydroxide Mn oxyhydroxide



Backscatter electron images from an Automated Mineral Analyser. Scale bar = 1 mm

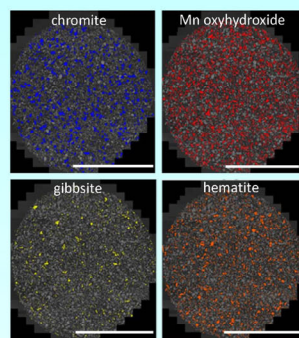


Mn oxide concentrate

Mn oxyhydroxide, hematite, chromite and gibbsite dominate the oxide concentrate.

	SiO ₂ %	Al ₂ O ₃ %	Fe ₂ O ₃ %	MgO %	Cr ₂ O ₃ %	MnO %	Co %	Ni %	Cu ppm	Zn ppm
Mn concentrate	1.50	15.0	34.7	3.03	18.55	12.0	1.70	1.65	190	890
NC2 bulk	2.15	5.50	69.6	0.47	2.95	1.19	0.16	1.35	56	437

Compared to the bulk, Co and Mn are 10 times more enriched in the concentrate. Ni is 20% more abundant and Fe is 50% reduced.



Scale bar = 10 mm

Conclusions

- Mn oxyhydroxides are 95 (NC2) and 18 (NC3) times more abundant in the largest size fraction compared to the smallest.
- Co and Mn are 10 times more enriched and Fe is 50% reduced in the Mn oxide concentrate compared to the bulk NC2 limonite.
- Combining the Mn oxide concentrate and >400µm fractions gives a sample with 2.4 wt% Co that is viable for industrial scale bioleaching.
- Subsequent bioleach solutions are 12 times more concentrated in Co than for bulk NC2, increasing the viability of Co recovery from solution.

Acknowledgement

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