Australian Strategic Materials

The Geology of the Toongi Rare Metal and Rare Earth Deposit

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Mines and Wines – Discoveries in the Tasminides

Orange NSW

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A Global Perspective to Set the Scene

Rare Metals and Rare Earths probably should be renamed Non-Rare Metals and Non-Rare Earths because they aren't rare.

In 2011 there were over 400 rare earth and rare metal projects in various stages of evaluation.

Currently there are at least 150, excluding lithium.

Development is driven by metallurgical process (technology), which in turn is governed by the host rock mineralogy and ore minerals. Location / infrasture are important.

China is dominant in production of many rare metal and rare earths.

USGS Global "advanced" rare earth projects by type ~2015 – excludes most heavy mineral sand (monazite) deposits

The Toongi Deposit is the focus for ASM's Dubbo Project

(and ASM's Critical Metals Business)

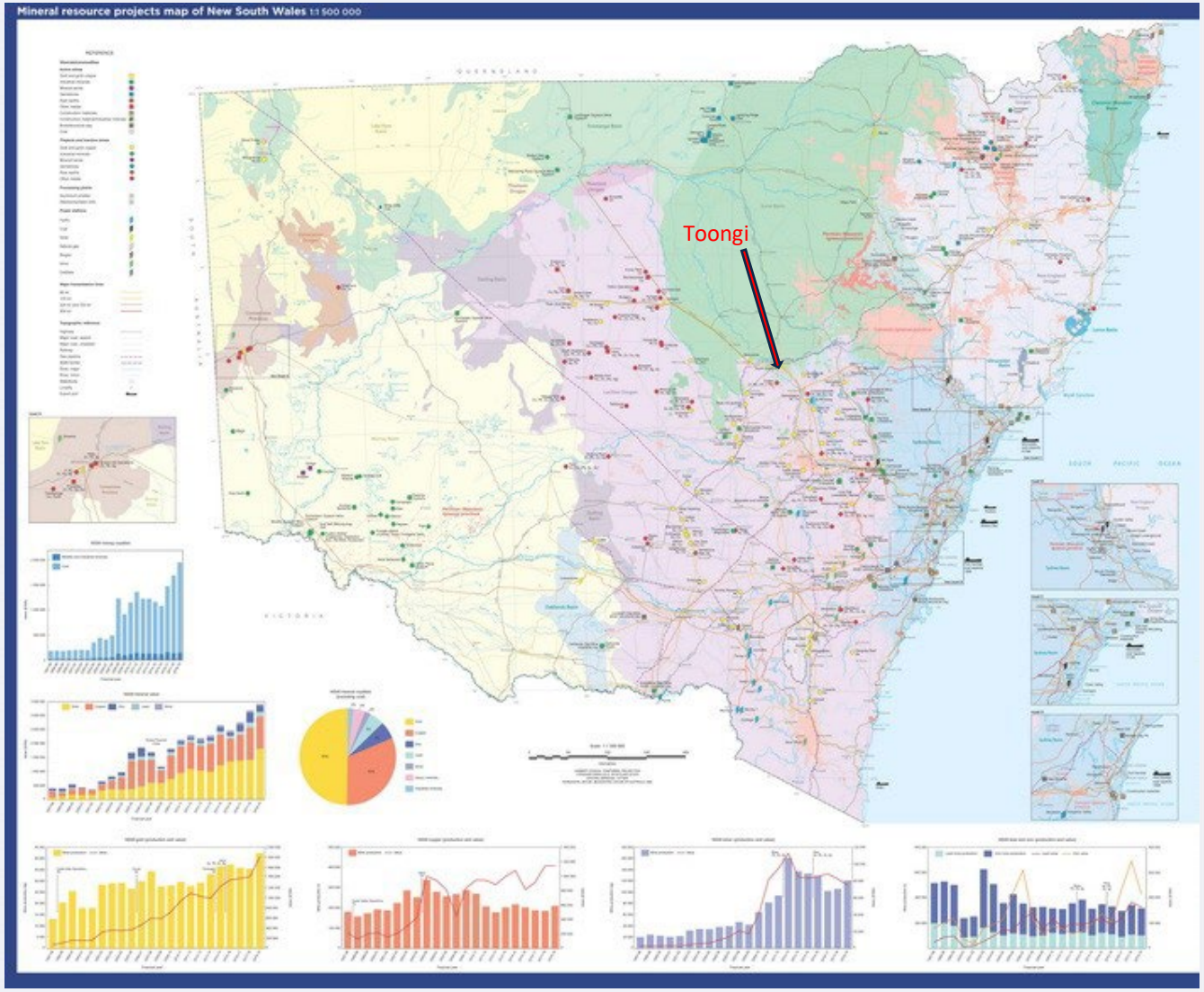
Toongi is located 25km south of Dubbo, at the northern edge of the exposed eastern Lachlan Orogen.

The deposit was originally discovered by the BMR (GA) in 1951 as a radiometric anomaly in a wide spaced regional aerial survey.

As part of a regional copper study in 1982, Geopeko located the trachyte outcrop and drilled 5 RC holes.

Alkane followed up the anomalous Nb, Y and U results and acquired an exploration licence in 1987.

After early encouraging results, Alkane embarked on a major evaluation program in 1998. It continues ……



GSNSW Regional Geology

Regional Geology

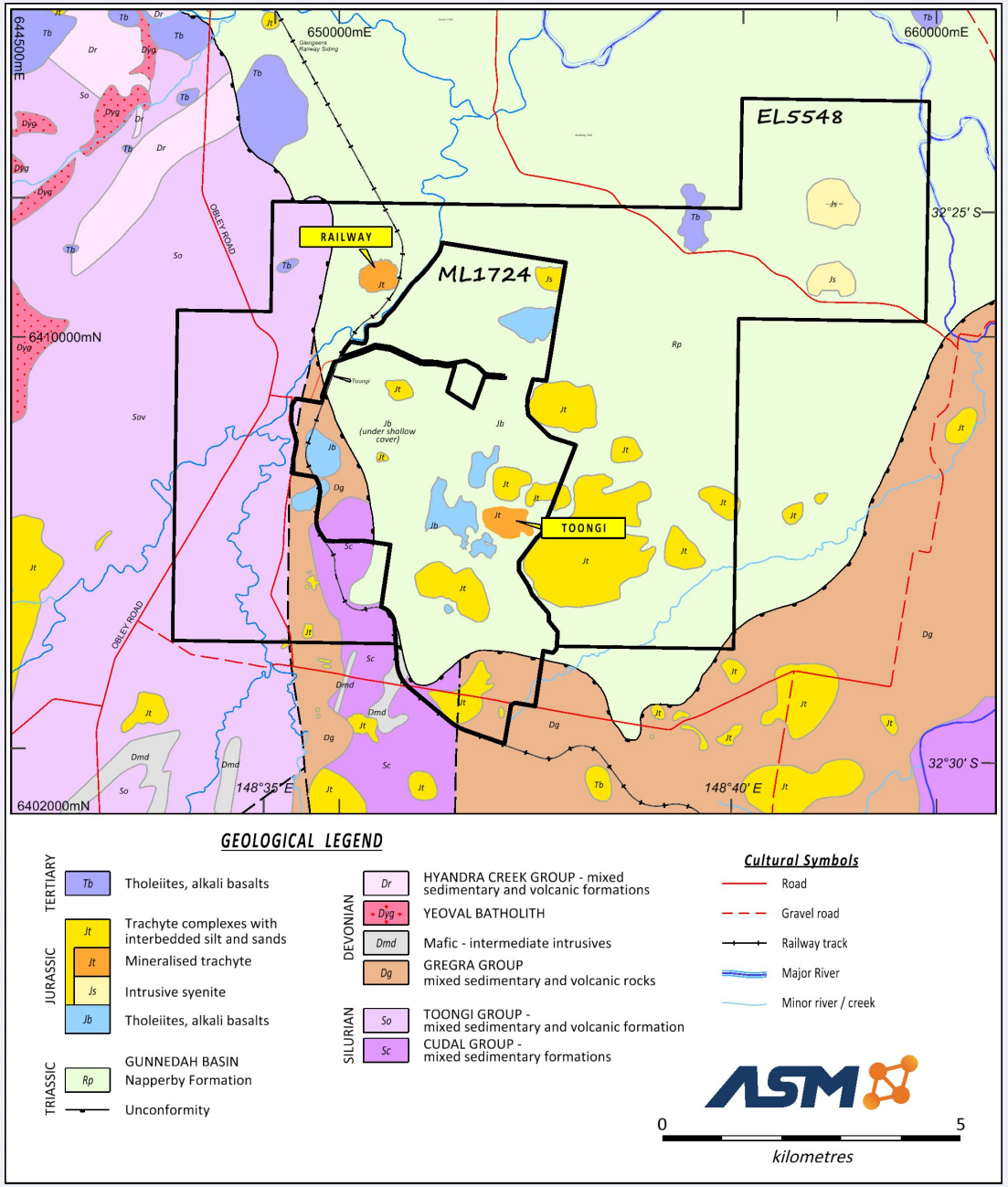
Toongi is part of the Mesozoic Eastern Australian Alkaline Volcanic event. There is a younger but spatially contemporaneous Cenozoic Alkaline Volcanic event.

The deposit is central to the Toongi Alkaline Magma Field (TAMF) which is spread over about 50km^2 and comprises a number of trachyte lava flows, pyroclastics and domal intrusive bodies.

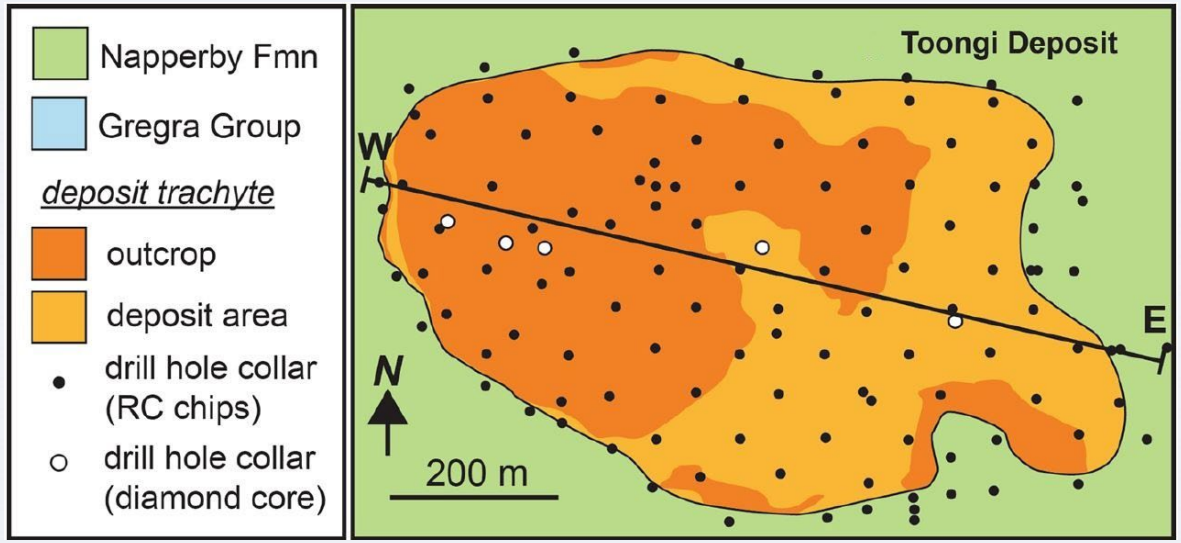
The TAMF lies at the boundary between the Permo-Triassic Gunnedah Basin to the north, and Late Cambrian to Carboniferous Lachlan Orogen to the south.

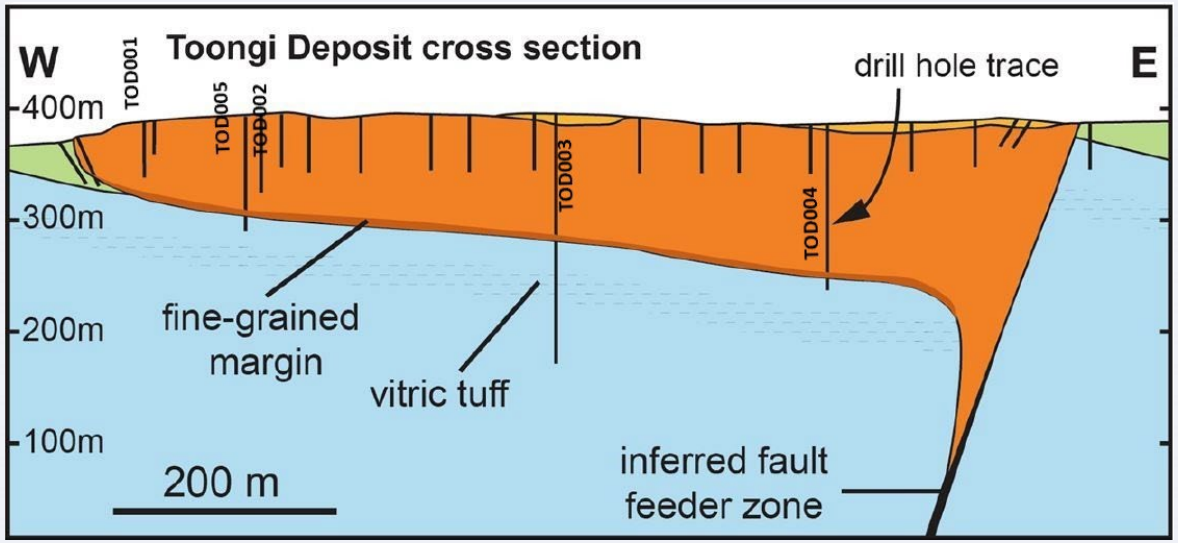
Only the Toongi deposit and nearby Railway occurrence are known to contain elevated rare metals and rare earths.

Toongi has been dated at ~190my (early Jurassic) by GSNSW.



Toongi Geology

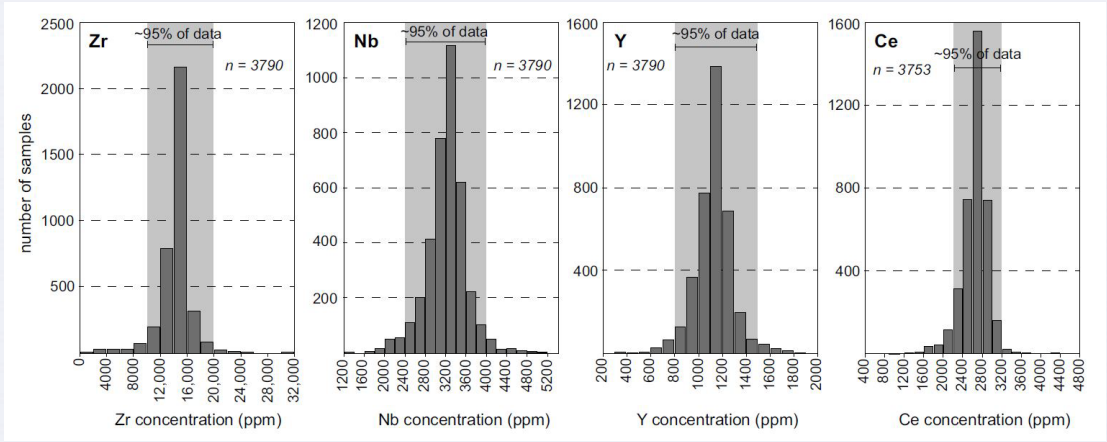




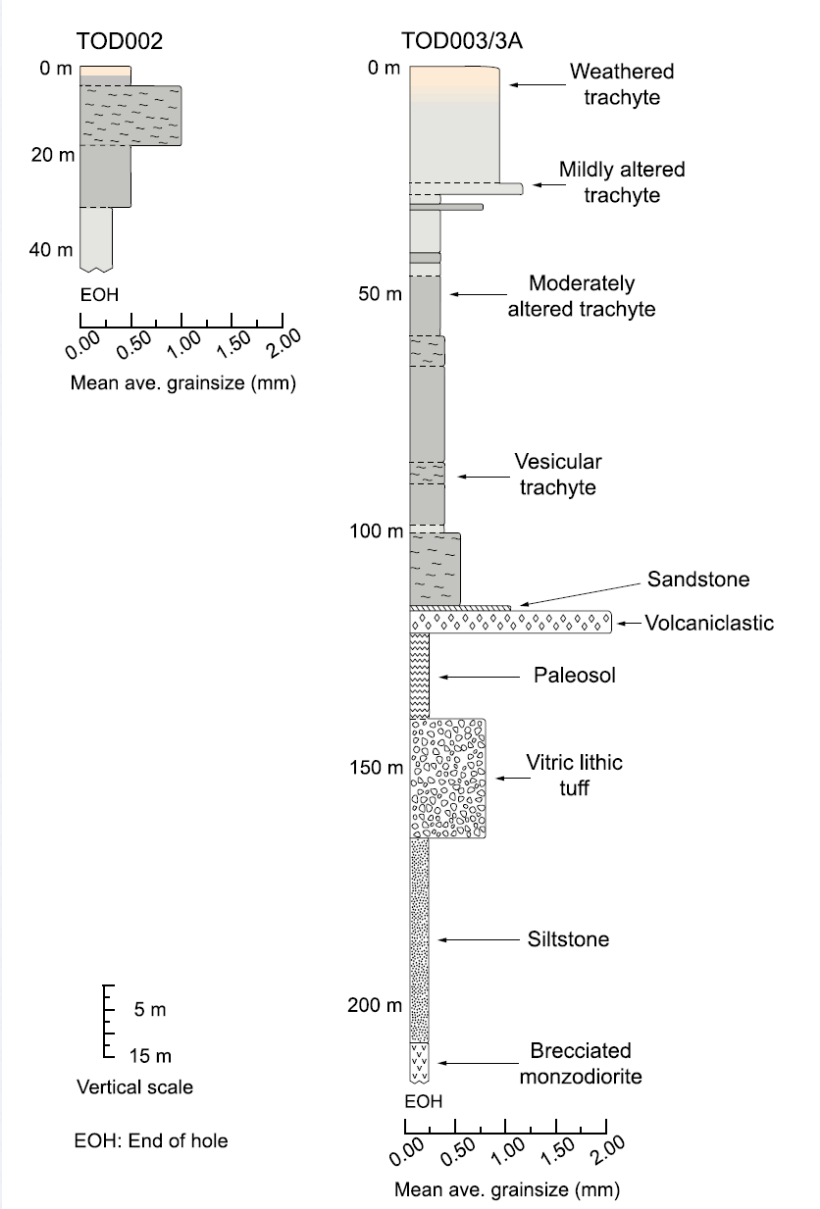
122 RC and 5 core, largely vertical holes, tested the deposit on 50m by 100m staggered drill pattern to define the resources over the 850m by 450m outcrop.

The RC drilling averages 50m in depth to provide an initial 40 year open pit life. Three core holes penetrated to the base of the body determine any mineralogical or grade variations, and demonstrate the lopolith(laccolith) shape.

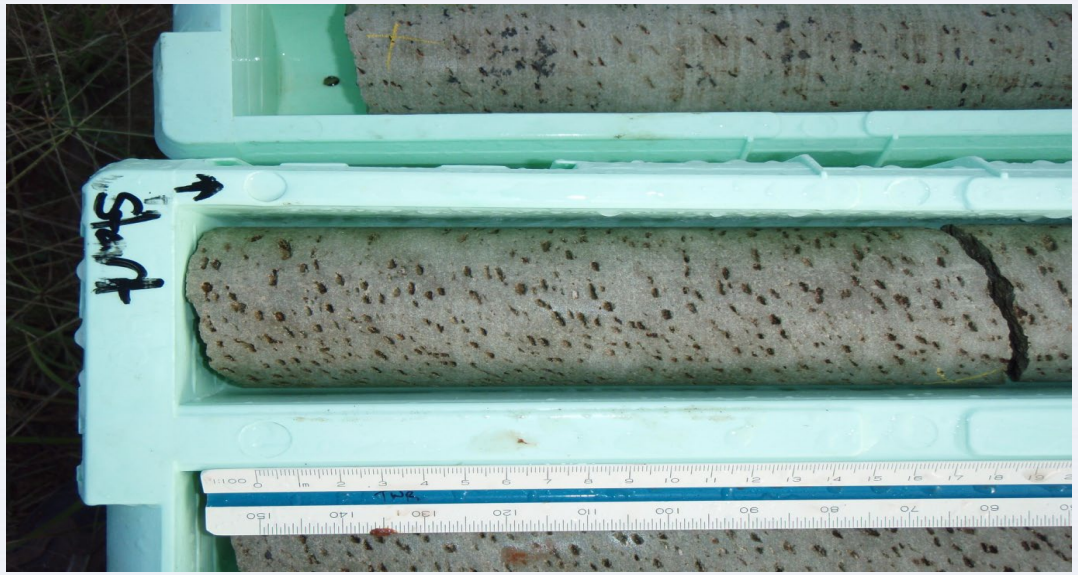
Remarkable grade continuity both laterally and at depth



Trachyte – TOD003



Morris 2013



Vesicular trachyte

Trachyte flow in contact with oxidised silty sediments at base

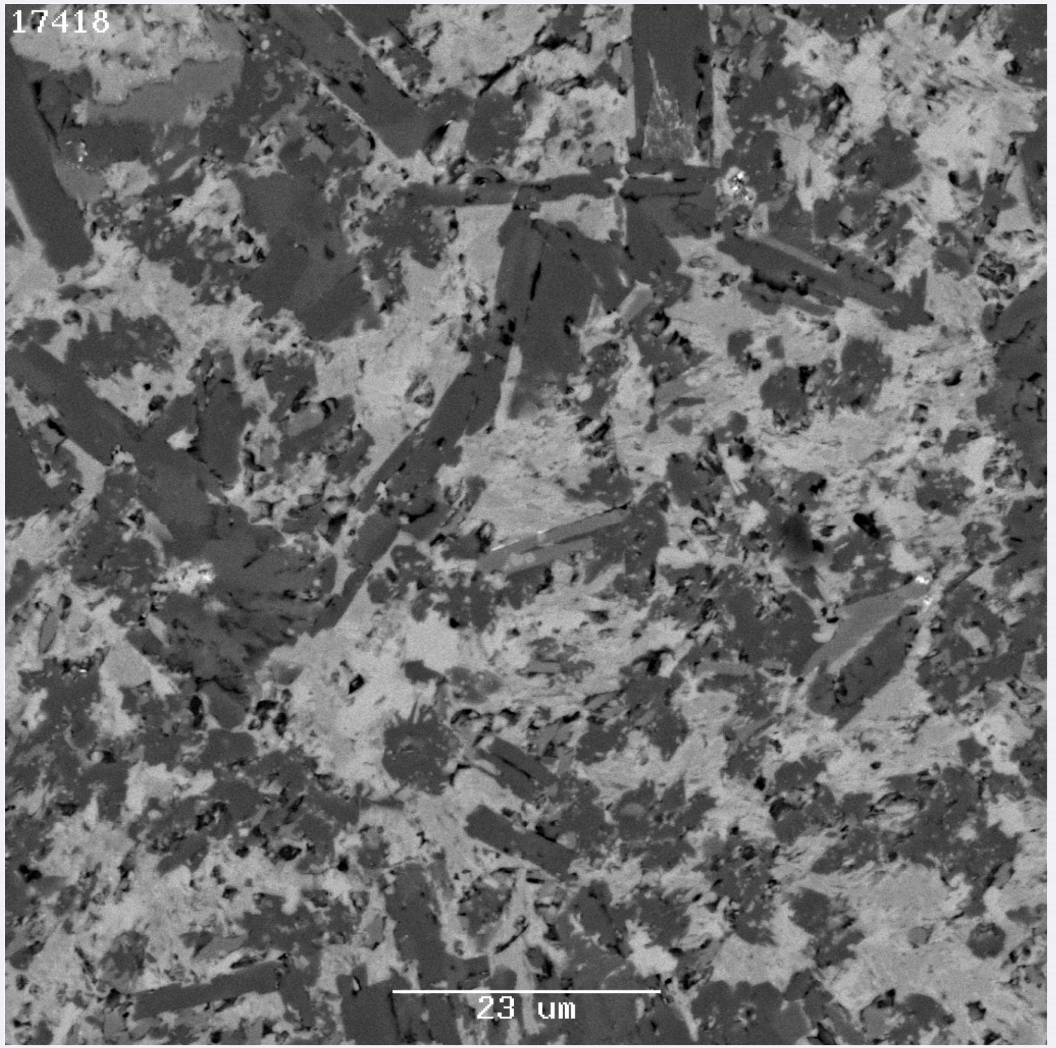
Trachyte Petrology

- K-feldspar - partly sericitised ~30 - 40%
- Albite (sodic feldspar) ~30 - 40%
- Aegirine (sodic clinopyroxene) ~15 - 20%

- Minor calcite, siderite, quartz, rhodocrosite

Weathering down to ~15 metres depth.
No impact on mineral assemblage.

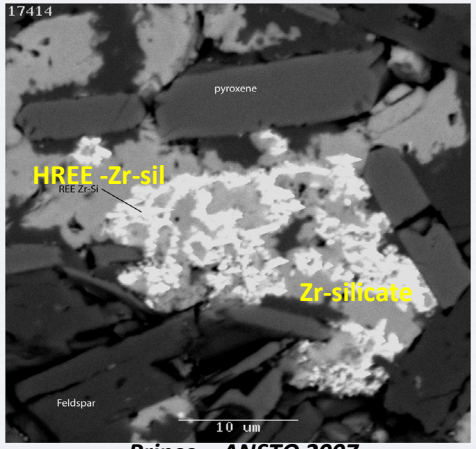
Major chemistry: 61.7% SiO_2; 12.5% Al_2O_3; 7.03% Fe_2O_3;
0.85% CaO; 6.55% Na_2O; 4.48% K_2O; 0.31% MgO; 0.51% MnO;
0.05% P_2O_5; 0.12% TiO_2; 2.54% LOI. 3.33% ore elements



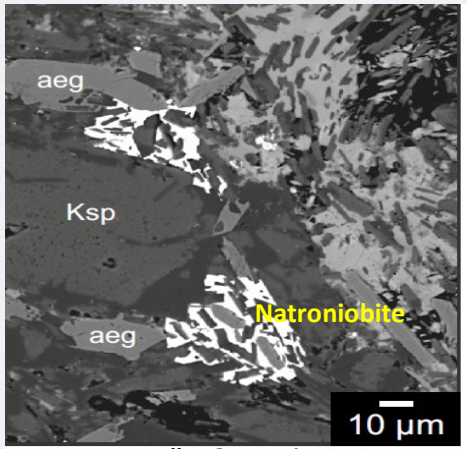
Prince – ANSTO 2007

Ore Mineralogy

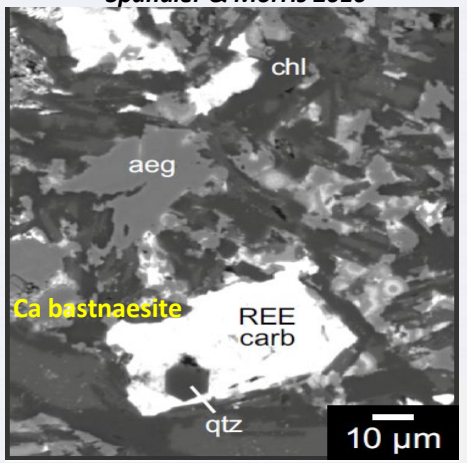
Zirconium Heavy REs	eudialyte group	$ZrSiO_4$ ± Ca, Y, HREE, H_2O +?U	< 2µm - 50µm
Niobium/ Tantalum	natroniobite	$NaNbO_3$ + Ta + ?Th also $NbFeSiO_4$	< 30µm
Rare Earths	calcian basnaesite	$Ca(REE)(CO_3)F$	< 100µm
	rare Sr minerals	$Sr(REE)(CO_3)H_2O$	



Prince – ANSTO 2007



Spandler & Morris 2016



Spandler & Morris 2016

Mineral Resources and Ore Reserves

Dubbo Project – Mineral Resources

Resource Category	Tonnes (Mt)	ZrO_2 (%)	HfO_2 (%)	Nb_2O_5 (%)	Ta_2O_5 (%)	Y_2O_3 (%)	TREO* (%)
Measured	42.81	1.89	0.04	0.45	0.03	0.14	0.74
Inferred	32.37	1.90	0.04	0.44	0.03	0.14	0.74
Total	75.18	1.89	0.04	0.44	0.03	0.14	0.74

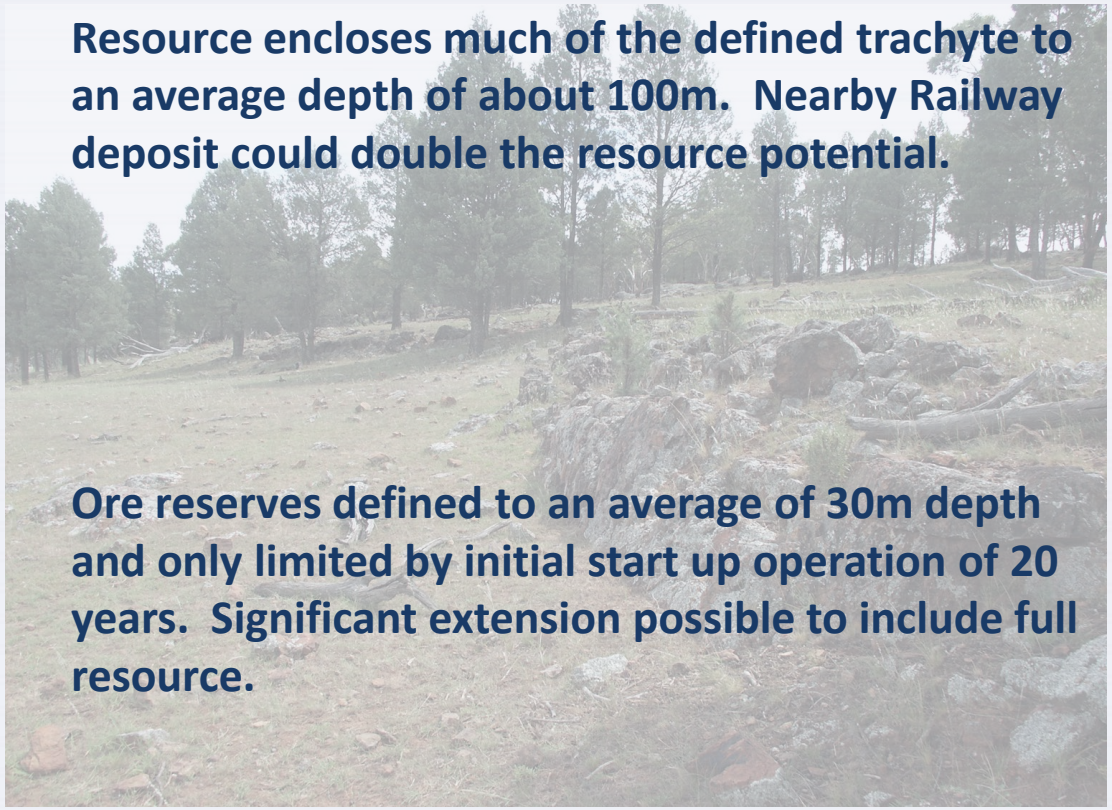
*TREO% is the sum of all rare earth oxides excluding ZrO_2, HfO_2, Nb_2O_3, Ta_2O_5, Y_2O_3,

Dubbo Project – Ore Reserves

Reserve Category	Tonnes (Mt)	ZrO_2 (%)	HfO_2 (%)	Nb_2O_5 (%)	Ta_2O_5 (%)	Y_2O_3 (%)	TREO* (%)
Proved	18.90	1.85	0.04	0.440	0.029	0.136	0.735
Total	18.90	1.85	0.04	0.440	0.029	0.136	0.735

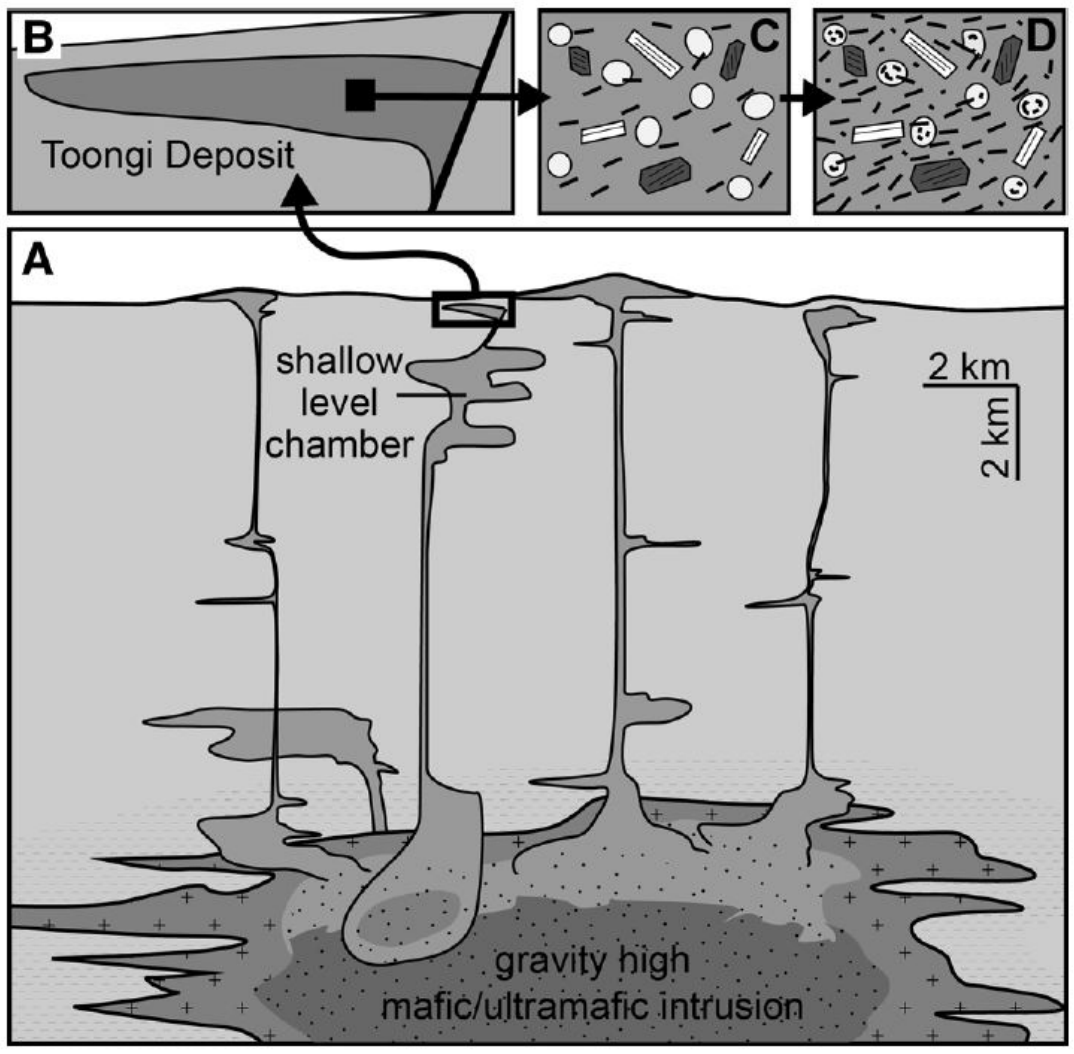
*TREO% is the sum of all rare earth oxides excluding ZrO_2, HfO_2, Nb_2O_3, Ta_2O_5, Y_2O_3,

Note: Full details including Competent Person statements are included in the Company's annual governance statement in the Annual Report released to the ASX on 7 October 2020 - the Company confirms that all material assumptions and technical parameters underpinning the estimated Mineral Resources and Ore Reserves, as disclosed continue to apply and have not materially changed



Background - western margin of trachyte outcrop

Evolution of Toongi Trachyte (Spandler & Morris 2016)



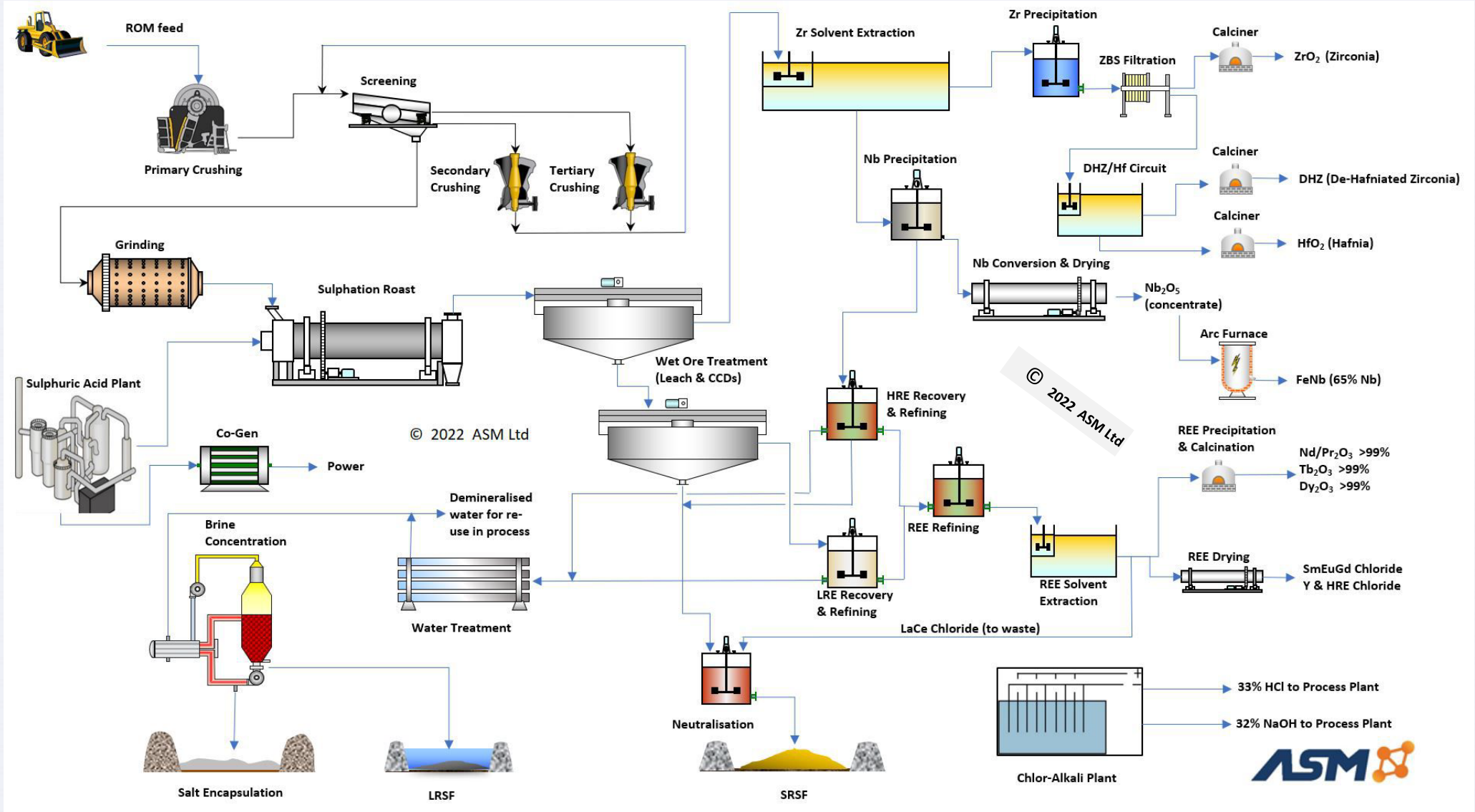
Schematic upper crustal section of the magmatic evolution of the TAMF.

The large mafic/ultramafic intrusion at ~ 10km is inferred from regional gravity data.

Most TAMF bodies were formed from magma that underwent deep fractionation, whereas Toongi is interpreted to have formed after extensive magma fractionation at shallow crustal levels.

The Toongi magma may have also undergone liquid unmixing to form immiscible blebs rich in rare metal, Na silicate liquid (white blebs in C), that subsequently entrained fine crystals of matrix felspar and aegirine to form snowball EGM (D).

Development – the 2021 Flow Sheet



Products

Zirconia and zirconium chemicals

De-hafniated zirconia

Hafnia

Ferro-niobium

Neodymium-praseodymium oxide

Terbium oxide

Dysprosium oxide

Samarium-europium-gadolinium chloride

Yttrium-heavy rare earth (Ho-Er-Tm-Yb-Lu) chloride

Critical Metals for Advanced Technologies

Zr Zirconium

- Ceramics - refractories; SOFCs
- Nuclear and speciality alloys
- Thermal barrier coatings (turbines)
- Hydrogen fuel cells
- Chemicals
- Fibre optical connectors/amplifiers

Hf Hafnium

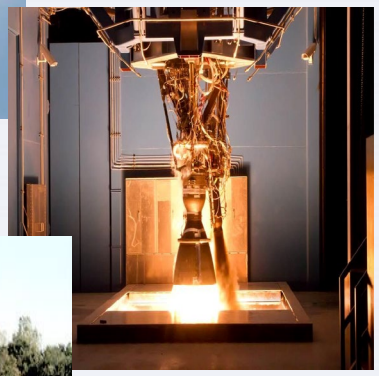
- Aerospace alloys (high temperature)
- Super alloys
- Nuclear control rods
- Plasma cutting tips
- Semiconductors
- Ferroelectric data storage devices
- Thermoelectric applications

Nb Niobium

- Various steel alloying applications
- Improves strength / reduces weight increasing fuel efficiency in transport applications
- Superalloys; incl rocket nozzles
- Electrodes in Li-ion batteries
- Superconductors

REE Rare Earths

- NdFeB permanent magnets
- Catalysts
- Phosphors
- EV, general auto and wind generators; robotics
- Special alloys
- UV Glass



Thank You

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