

REPORT 258



MINE WASTE SAMPLING AND CHARACTERISATION IN WESTERN AUSTRALIA: ELVERDTON TAILINGS

MIWATCH, SUSTAINABLE MINERALS INSTITUTE



Department of **Energy, Mines,**
Industry Regulation and Safety

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PERTH 2025



**Geological Survey of
Western Australia**

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A catalogue record for this book is available from the National Library of Australia

REFERENCE

The recommended reference for the whole publication is:

MIWATCH, Sustainable Minerals Institute 2025, Mine waste sampling and characterisation in Western Australia: Elverdton tailings: Geological Survey of Western Australia, Report 258, 227p.

ISBN 978-1-74168-058-4

ISSN 1834-2280

Grid references in this publication refer to the Geocentric Datum of Australia 1994 (GDA94). All locations are quoted to at least the nearest 100 m.



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Published 2025 by the Geological Survey of Western Australia

This Report is published in digital format (PDF) and is available online at <www.demirs.wa.gov.au/GSWApublications>.



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Cover image: Photo of the Elverdton tailings storage facility

Mine waste sampling and characterisation in Western Australia: Elverdton tailings

**Final Report for Western Australian Department of Mines, Industry Regulation
and Safety**

Reporting Date: 07/04/2025



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Executive Summary

A 'stream 1' (integrated geochemical and mineralogical) study was undertaken at the historical Elverdton mine site to explore for critical metal endowment of mined residues. The Elverdton site is located around 540 km south-east of Perth and 11 km south-east of Ravensthorpe. The mineralisation comprises Cu-bearing quartz veins hosted by a north trending shear zone within The Ravensthorpe Greenstone Belt, a calc-alkaline intrusive/extrusive complex. The Elverdton deposit was mined for copper, silver and gold between 1957 and 1971, with processing of ore from nearby Kundip taking place from 1988 to 1992. The tailings from these periods were deposited on site in two tailings storage facilities (TSFs), which are uncontained and subject to erosion. Current operations by tenement holder Paxton Enterprises Pty Ltd include the excavation of tailings for use as mineral soil conditioner.

Sampling of the two TSFs, the tailings fan, hardpans and salt forming on the tailings took place in October 2023. The Elverdton mine residue samples ($n = 71$) are enriched in the base/precious metals Cu, Pb, Au and Ag, the critical metals Te, Se, Bi, Mo, Co, Re, W, and the rare earth elements (REE), La and Ce. On average, significant enrichment is seen in Cu, Mo, U and Se at $> 10 \times$ crustal abundance, Au at $> 100 \times$ crustal abundance and Te at $> 1,000 \times$ crustal abundance.

In the TSF1 tailings, Cu contents range from 186-6,050 ppm, Au contents range up to 1 ppm, Co from 38-190 ppm, Ce from 65-421 ppm and La from 42-297 ppm. The tailings fan samples have a similar geochemical composition to the TSF1 samples. The TSF2 tailings are more enriched in Cu (1,020-6,500 ppm), Au (up to 1.4 ppm), Te (0.8-6.7 ppm) and Co (43-363 ppm). The hardpan samples are enriched in Au (0.4-1.6 ppm) and Se (1-6 ppm), and the salt samples are enriched in Cu (768-7,390 ppm), U (1.8-149 ppm) and Co (40-940 ppm).

The mineralogy of the tailings is dominated by quartz, chlorite, plagioclase, mica and amphibole. Sulphide minerals present include pyrite, pyrrhotite and chalcopyrite and trace amounts of bornite, molybdenite, tetrahedrite, covellite, chalcocite, sphalerite, galena, stannite, cobaltite and electrum. Secondary phases including jarosite, gypsum, iron oxide and hydroxide and schwertmannite are also abundant in the tailings and the hardpan samples. The salt sample contains a range of sulphate phases, including bloedite, hexahydrate, starkeyite and bassanite. The grain size and mineral chemistry of selected minerals are summarised in the following:

- Pyrite and pyrrhotite are fine grained, with $p80$ s of 5-35 μm , have high free surfaces of $>60 \%$ and are enriched in Cu (31-67,903 ppm) and Co (31-5,425 ppm).
- Chalcopyrite is fine grained, with $p80$ s of around 7-30 μm , and free surfaces of 45-71 %.
- Goethite and jarosite have $p80$ s of around 10-150 μm and free surfaces of 40-75 %. Goethite is enriched in Ti (1,398-6,746 ppm) and Cu (104-13,187 ppm). Jarosite is enriched in Cu (1,816-21,870 ppm), Pb (6.2-19,541 ppm) and Ti (311-12,490 ppm).
- Schwertmannite, Mg and Na-Mg sulphate grains have $p80$ s of around 6-30 μm . The Mg and Na-Mg sulphate grains have free surfaces of 75-100 %, while schwertmannite has free surfaces of 36-85 %. Schwertmannite is enriched in Cu (2,166-13,299 ppm), while Mg sulphate and Na-Mg are highly enriched in Cu (9,035-144,351 ppm), Mn (1,947-22,911 ppm), Ti (up to 19,389 ppm), Co (up to 14,857 ppm) and Ni (up to 8,351 ppm).
- The REEs are most enriched in garnet, with some high concentrations of Ce (1.2-74,375 ppm), La (0.7-50,107 ppm), Nd (0.5-18,282 ppm) and Pr (0.1-6,369 ppm). Garnet has variable grain sizes, with $p80$ s ranging from 20-75 μm , and free surfaces of 46-73 %.

The critical and strategic metals in the Elverdton tailings are hosted by multiple mineral phases, including primary sulphides and secondary sulphates. Further mineralogical and microanalytical work (e.g., SEM, EPMA) is recommended to better constrain metal deportment. If economic potential is identified, minerals processing test work (e.g., flotation or leaching) could be performed to investigate potential processing routes for the recovery of metals from the mined residues.

Acknowledgments

The following staff at the SMI are thanked for their assistance in project management: Kathleen Cato, Sherrie Palmer and Natasha Winters. Simon Johnson and Fawna Korhonen from the Geological Survey of Western Australia (GSWA) and Tara Read and Katrina Sachse from the Abandoned Mines Program (AMP) are thanked for project funding and administration (Department of Energy, Mines, Industry Regulation and Safety – DEMIRS). Kam Bhowany (previously SMI) is acknowledged for support in organising and managing fieldwork, sample logistics and analyses. Steven Batty, Deepika Venkataramani (GSWA), Katrina Sachse and Ebony Kershaw (AMP) are acknowledged for helping with sampling at the site. The tenement holder, Mark Williams of Paxton Enterprises Pty Ltd, is thanked for access to and sharing of information related to the site. The SMI and Queensland University of Technology staff are acknowledged for their sample preparation and analytical services. The authors acknowledge the instruments and expertise of Microscopy Australia (ROR: 042mm0k03) at Adelaide Microscopy, University of Adelaide, enabled by NCRIS, university, and state government support. The Resourcing Decarbonisation strategic program, directed by Assoc Prof Steven Micklethwaite, is thanked for funding support toward this research.

1. Introduction

1.1 Project background

Australia is well endowed in base and precious metals, but to date critical metals (e.g., Co, In, W, Ga, Ge) have not been the focus of the Australian mining industry. With increasing global pressure to utilise low-carbon technologies there is greater demand for critical metals to support this development, but through environmentally responsible sourcing of metals. The 2022 Australian Government Critical Minerals Prospectus includes a list of 25 metals (note- rare earth elements are considered as one category). Out of these, Australia is the amongst the top global producers for lithium (no. 2), tantalum (no. 1), vanadium (no. 2) and tungsten (no. 2). According to Western Australia's Battery and Critical Minerals Strategy 2024-2030, Western Australia aims to build an internationally competitive, ethical and value adding battery and critical minerals industry that enables global decarbonisation, economic diversification and delivers meaningful outcomes for regional communities. Western Australia is already a global player in the supply of critical metals, with a large number of upstream industry opportunities (exploration, mining, processing) and a wealth of critical metal deposits (Figure 1).

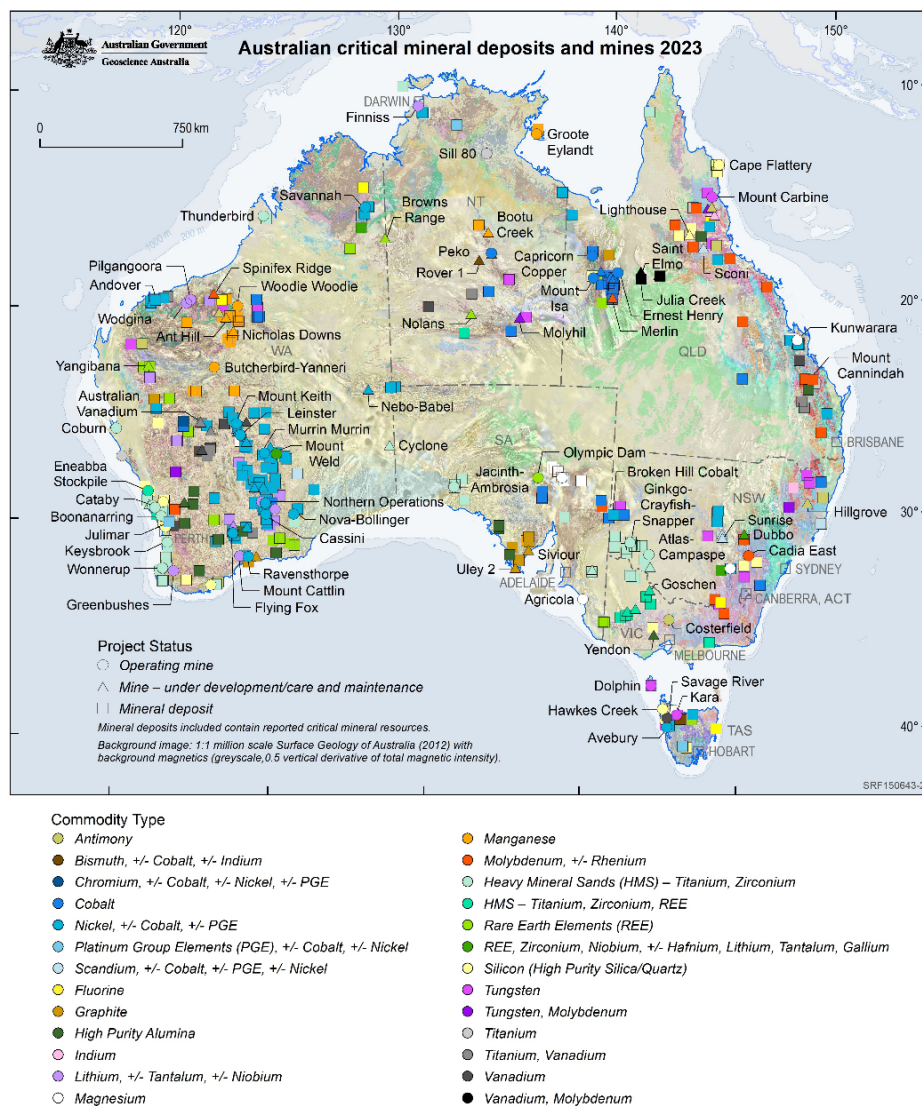


Figure 1. Australian critical mineral deposits and mines in 2023 (Geoscience Australia).

Western Australian has a long history of mining and therefore a legacy of abandoned mines and mined residues. Over 190,000 mine site features are catalogued in the Abandoned Mines Inventory (<https://www.wa.gov.au/organisation/resource-and-environmental-regulation/abandoned-mines-inventory>). The map in Figure 2 shows the locations of 1,500 documented abandoned mined residues in Western Australia, including ash dumps, leach pads, rock and soil dumps, tailings dumps and waste dumps. Mined residues occur extensively across Western Australia, originating from a range of commodities which may be associated with critical metals (e.g., Zn with In, Ge, Ga; Ni with Co). In the past, critical metals were not commonly recovered and as a result may have reported to the mine residues during mining and processing. Mine residues can be associated with significant environmental impacts due to heavy metal contents and acid and metalliferous drainage potential. Through assessing fertility there lies an opportunity for ‘economic rehabilitation’ of mine residue sites. The contents and mode of occurrence of critical metals in mine residues must be assessed to determine economic potential and metallurgical processing pathways for metal extraction.

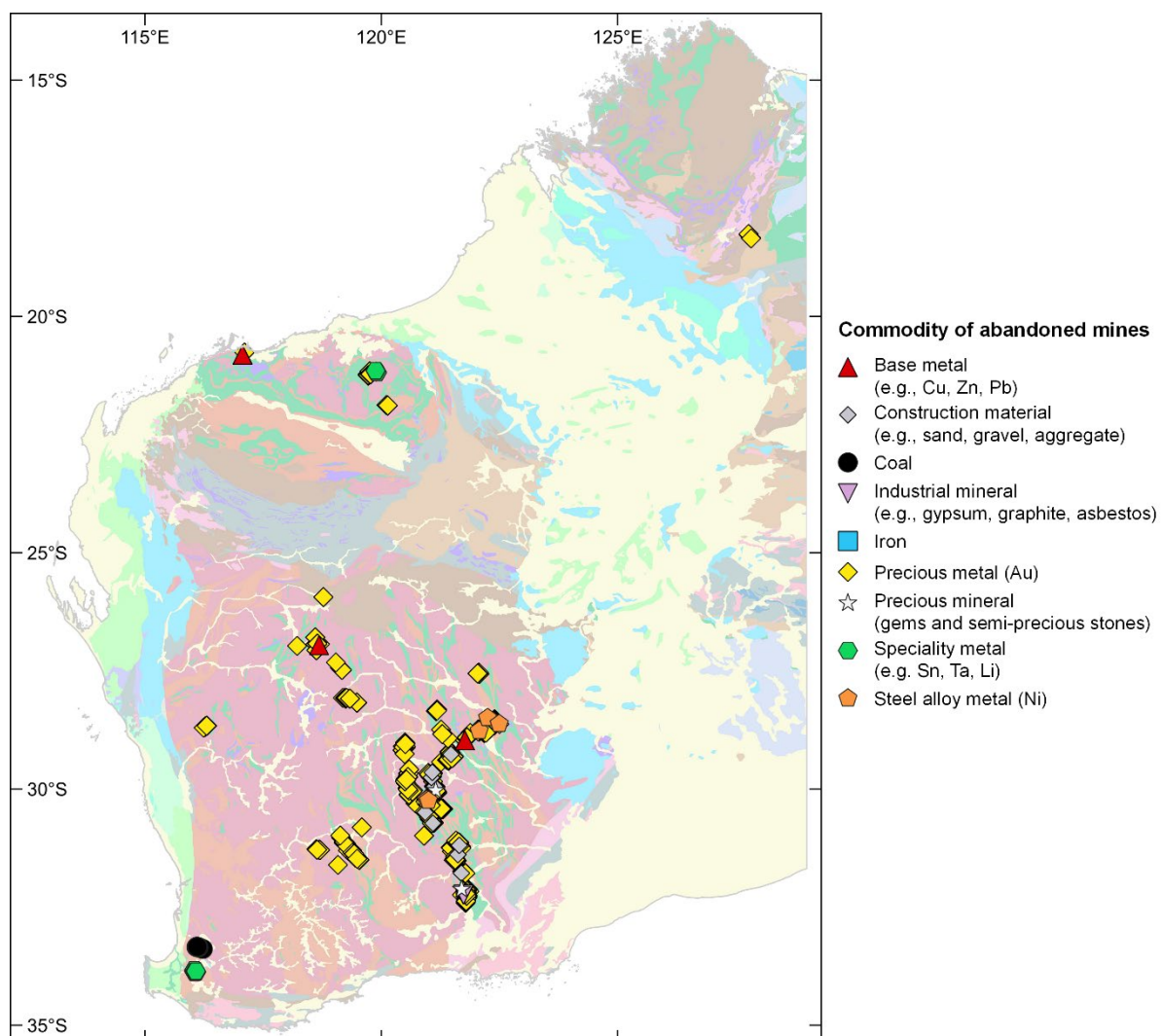


Figure 2. Abandoned mined residues (ash dump, leach pad, rock and soil dump, tailings dump, waste dump) and related commodities in Western Australia, compiled from the Abandoned Mines Inventory database (DEMIRS, <https://www.wa.gov.au/organisation/resource-and-environmental-regulation/abandoned-mines-inventory>). Only features with a listed commodity are shown (n = 1,503).

The Geological Survey of Western Australia (GSWA) recognises the great potential to explore mine residues in Western Australia for critical metals. This research, funded by the GSWA and the University of Queensland, will study two abandoned mine sites in Western Australia at ‘Stream 1’ level (integrated geochemical and mineralogical investigation). This report evaluates the critical metal fertility of the mine residues at the Elverdton site and provides recommendations for potential processing routes to recover critical metals.

1.2 Project aims and objectives

This research focusses on assessing the critical metal endowment of abandoned mine residues in Western Australia. Two sites operated by the Abandoned Mines Program were selected, as summarised in (Table 1). The aim of this particular study is to gain an understanding of the tenor and deportment of critical metals in the Elverdton mine tailings.

Table 1. Sites sampled in Western Australia.

Report no.	Site	Owner/ Operator	Deposit type	Residue type(s)	Ore target elements	Target critical metals	Samples (n)
1	Elverdton	Abandoned Mines Program / Paxton Enterprises Pty Ltd	Hydrothermal veins	Two tailings storage facilities and eroded tailings.	Cu, Au	Te, Se, Bi, Mo, Co, W, REE	71
2	Ellendale	Abandoned Mines Program	Lamprophyre diamond	E4 site: Tailings storage facility, waste rock E9 site: Light stock pile, tailings storage facility	Diamond	REE	140

To meet the objectives of the project several activities were undertaken, including:

1. Compilation of the relevant available information from public and confidential sources;
2. Targeted sampling of up to 2 sites (70-140 samples per site).
3. Multi-element geochemistry (4-acid digestion ICP-MS, lithium borate fusion ICP-MS / AES on all samples); and
4. Targeted mineral occurrences of selected representative tailings samples by XRD, MLA and LA-ICP-MS.

2. Deposit geology and mining history

The historic Elverdton mine site is located in the south of Western Australia, approximately 540 km south-east of Perth (Figure 3.A), in the Ravensthorpe area, around 11 km south-east of Ravensthorpe and 35 km north of Hopetoun (Figure 3.B). The Elverdton deposit was mined for copper and gold over several periods between 1899 and 1971, with further processing of nearby ores taking place from 1988 to 1992. The tailings from these periods were deposited on site in two tailings storage facilities (Figure 3.C). Background information on geology, mining history and mine residues is summarised in the following sections.

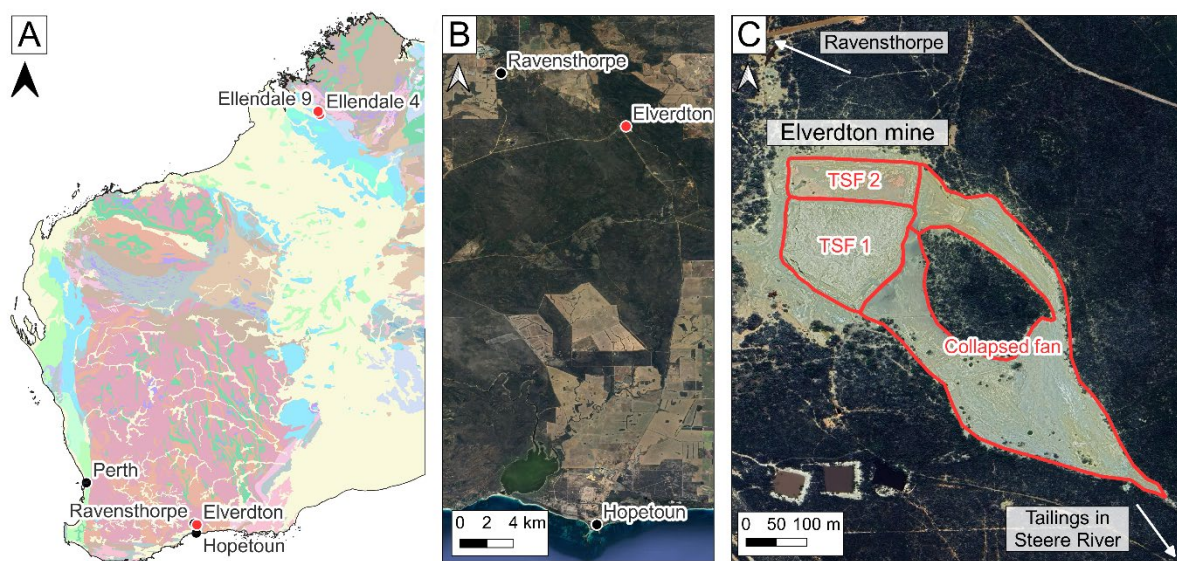


Figure 3. A. Location of the Elverdton site in Western Australia. B. Location of the Elverdton site in the Ravensthorpe area. C. The Elverdton tailings site, highlighting the uncontained tailings cells and the collapsed fan of tailings.

2.1 Regional and deposit geology

The Elverdton Cu-Au deposit is located in the Ravensthorpe greenstone belt, at the southern margin of the Yilgarn Craton (Figure 4). The Ravensthorpe greenstone belt is made up of three distinct tectonostratigraphic terranes: (1) in the east, the Carlingup Terrane (~2960 Ma) comprises metamorphosed komatiite, basalt, sediments, and acidic volcanics; (2) the central Ravensthorpe Terrane (~2990-2970 Ma) contains tonalite and andesitic volcanoclastic rocks; and (3) the Cocanarup greenstones mostly consist of strongly deformed metasedimentary rocks, as well as ultramafic and mafic rocks, and lies along the western margin of the greenstone belt (Figure 5). The Ravensthorpe Terrane and the Cocanarup greenstones were thrust eastward over the Carlingup Terrane, with the accreted terranes subsequently being deformed into a large-scale synform, plunging to the south (Witt, 1998, 1999).

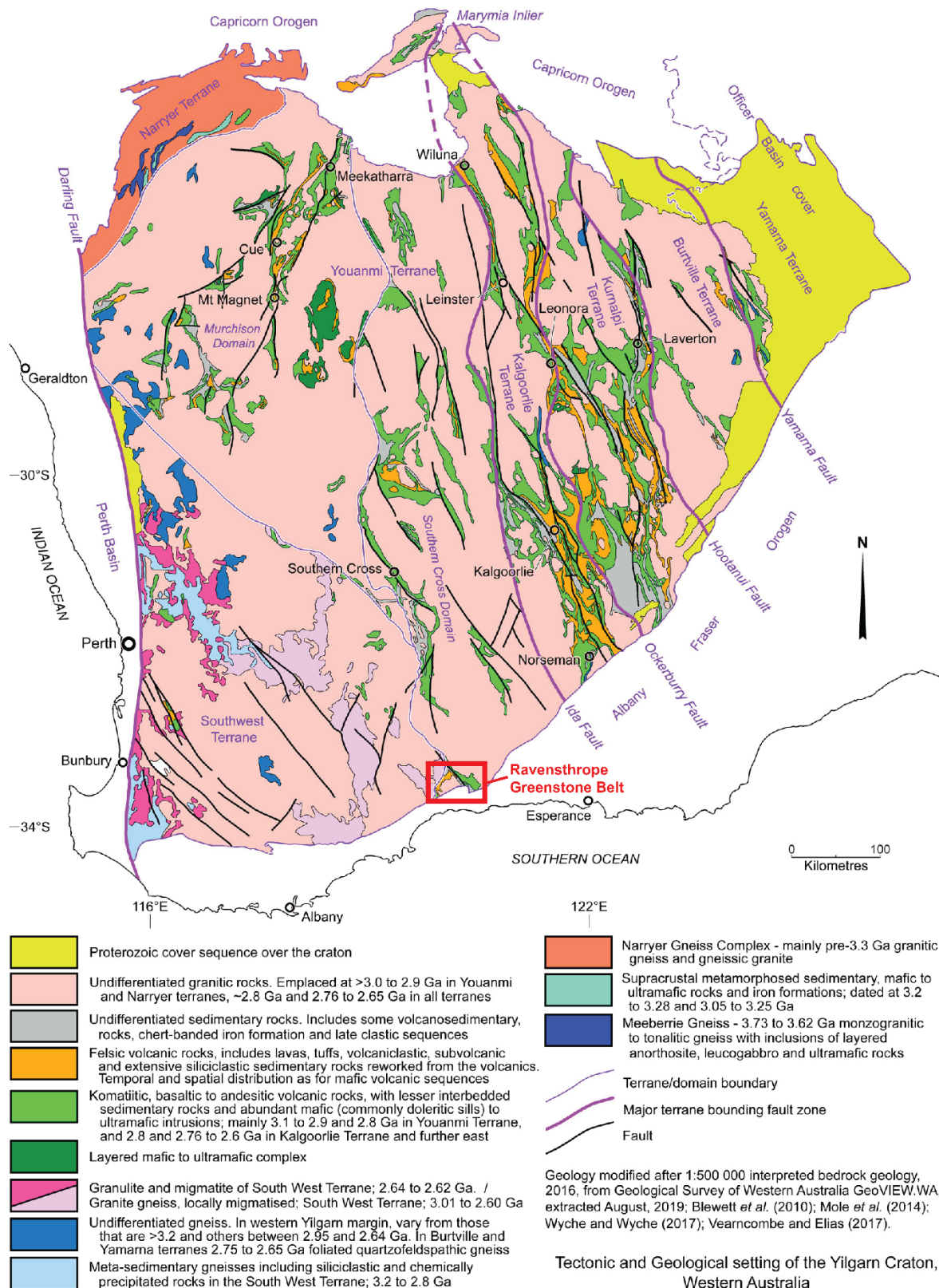


Figure 4. Regional geological map of the Yilgarn Craton, showing the location of Ravensthorpe Greenstone Belt at the southern margin of the Southern Cross Domain of the Youanmi Terrane. Adapted from portergeo.com.au/database.

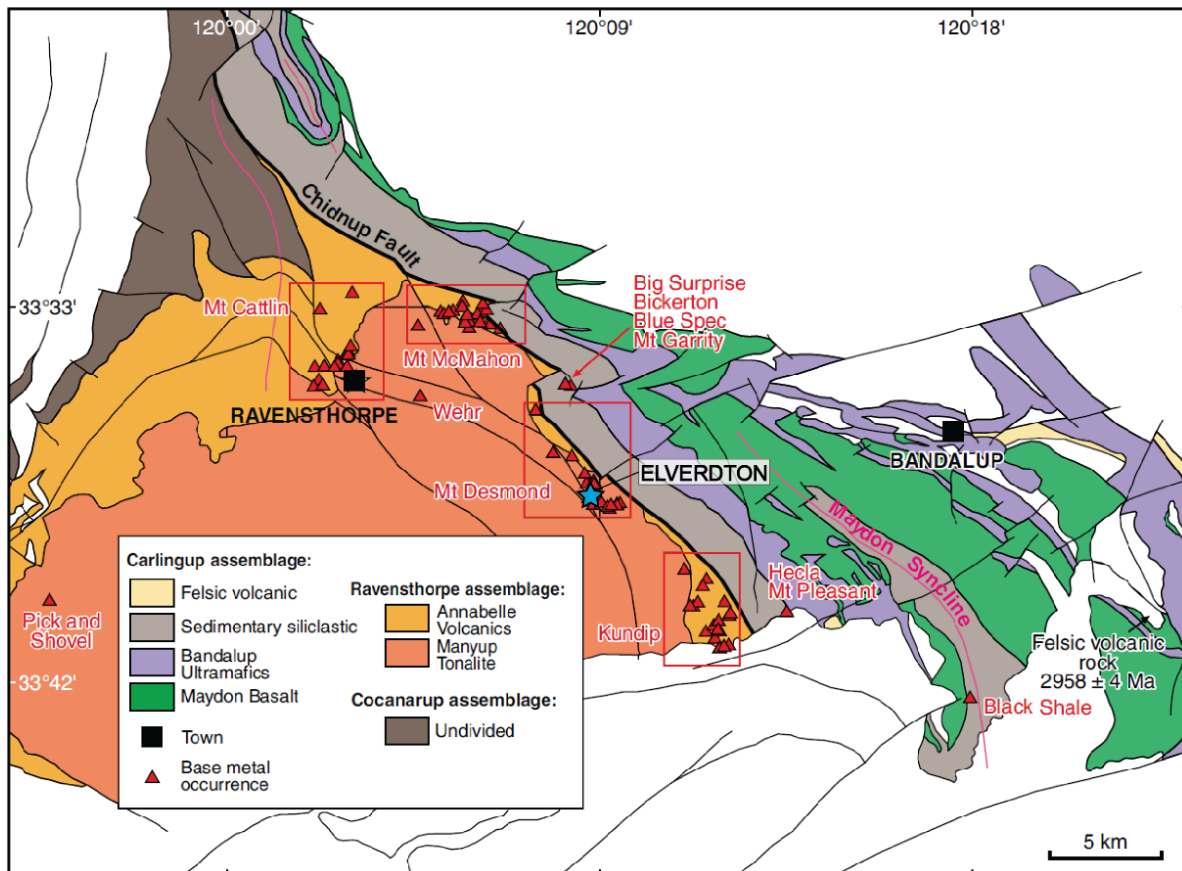


Figure 5. Geological map and mineral occurrences in the Ravensthorpe Greenstone Belt, and the location of the Elverdton deposit. Modified after Hollis et al. (2017). The location of the Elverdton site is shown by a pale blue star.

The majority of Cu-Au and Cu-Zn mineralisation in the Ravensthorpe greenstone belt is hosted by the Ravensthorpe Terrane, including the Elverdton deposit. Historically, almost half of Western Australia's copper production has come from the Ravensthorpe greenstone belt (Marston, 1979). Nickel sulphide deposits and massive to bedded pyrite mineralisation are hosted by the Carlingup Terrane. During accretion of the three terranes comprising the Ravensthorpe greenstone belt, tourmaline-rich pegmatites, containing Ta-Nb and Li, were intruded into active thrust faults. Remobilisation of base- and precious-metal mineralisation in the Ravensthorpe Terrane may also have taken place at this stage (Witt, 1998).

The Ravensthorpe Terrane is a low-K, calc-alkaline intrusive/extrusive complex that is similar to modern island arc associations and can be subdivided into the Annabelle Volcanics and the Manyutup Tonalite (Witt, 1998, 1999). The calc-alkaline complex has dated at circa 2907-2990 Ma, as determined by SHRIMP U-Pb in zircon geochronology (Savage et al., 1995). The Annabelle Volcanics comprises a sequence of metamorphosed, calc-alkaline volcanic rocks, dominated by volcanoclastics that are associated with minor lava flows. The Manyutup Tonalite Complex occupies the central part of the Ravensthorpe Terrane and Ravensthorpe greenstone belt (Figure 5). The composition of the Manyutup Tonalite varies diorite to granodiorite but the intrusion is mainly a coarse-grained, equigranular biotite-hornblende tonalite (Witt, 1998, 1999).

The Elverdton copper-gold deposit is hosted by a north to north-north-west trending shear zone, which dips steeply to the east, with a length of ~700 m and width of ~12 m. The shear zone contains Archaean metasediments and basic igneous rocks, including medium-grained biotite

granodiorite, fine-grained plagioclase-hornblende-chlorite-quartz rocks, metadolerite, metabasalt, quartz-plagioclase-biotite-chlorite-(hornblende) schist. Copper mineralisation occurs in Cu-bearing quartz veins, with an oxidised zone to a depth of around 26.5 m, comprising ferruginous copper carbonate (malachite, azurite, covellite) in a siliceous gangue. Below the oxidised zone, this assemblage transitions to a chalcopyrite-gold-pyrite-magnetite(-pyrrhotite-ilmenite)-quartz association downwards, with rare silver-bismuth tellurides. In the 1950s, average copper grades of between 2.5 to 5.0 % were reported over 30 m sections. Gold grade was seen to diminish with depth, most likely because of secondary enrichment, with gold being associated with siliceous ore rather than copper sulphide. Some slight radioactivity was detected at Elverdton, but was deemed un-economic (Low, 1963; Marston, 1979).

2.2 Mining history and current operations

Gold and copper mineralisation in the Ravensthorpe area was first discovered in 1899. Major periods of copper ore production occurred between 1901 - 1918 and 1957 – 1971, predominantly from eleven mines: Desmond, Elverdton, Flag, Harbour View, Hillsborough-Fairplay, Last Chance, Marion Martin, Mount Benson, Mount Cattlin, Mount Desmond and Surprise mines (Marston, 1979). The area produced 20,115 t of copper, 4,000 kg of gold and 2,580 kg of silver until mining operations ceased in 1971 (Witt, 1999).

Mining at Elverdton commenced in 1901, first exploiting the oxidised zone with open cut methods, and subsequently with underground mining to reach the sulphidic primary ore, with maximum depths of 150-200 m (Marston, 1979; Quartermaine, 1987). Ores were processed via hand picking and gravity concentration for gold, and bulk of the ores and concentrates were smelted locally in Ravensthorpe (Golder Associates, 2019; Marston, 1979).

During the latter period of mining (1957 - 1971), underground mining recommended, extending to a depth of 350 m (Golder Associates, 2019). A processing plant was established at Elverdton for the recovery of copper and coarse gold from low-grade sulphide ores (1.5-2.0 %), with a capacity of 10,000 t ore a week. The plant comprised jaw and cone crushers, ball mills, and cyclones to separate the fines, which then underwent froth flotation. Recoveries of around 89-95 % were achieved, the produce concentrates with around 19-25 % Cu, 12 g/t Au and 65 g/t Ag (Marston, 1979). According to Witt (1998), the Elverdton deposit produced 99.62 kg of Au and around 14,250 t of Cu. Tailings from mines around Ravensthorpe and Kundip were also transported to the Elverdton site for reprocessing to recover gold during this period (RHS, 2017).

From 1988 – 1992, gold prices increased and the Elverdton treatment plant was again utilised to recover gold from ores and tailings from nearby Kundip. The process involved flotation and potentially the use of cyanide. Tailings from this time were stored on top of TSF2 (Figure 3.C), which was first constructed and filled during the 1957 – 1971 mining period.

The Elverdton mine tenement was forfeited in 1992. In 1995 a mining lease (M74/102) was granted to the tenement holder Paxton Enterprises Pty Ltd, with current operations including the excavation of tailings for use as mineral soil conditioner.

2.3 Mined residues at Elverdton

The Elverdton site hosts two tailings storage facilities (TSF), as seen in Figure 3.C and Figure 6. There is estimated to be approximately 700,000-720,000 t of tailings at the Elverdton site, with the majority of the tailings materials being produced during the 1957-1971 mining period (DEMIRS, 2021; Golder Associates, 2019). The south TSF (TSF1) was developed first, followed by the north TSF (TSF2), which abuts the north face of TSF1. The TSFs were constructed by pumping the tailings slurry at around 60 % solids onto the surface and gradually increased the height as the tailings dried. Both TSFs contain tailings from Elverdton, while TSF2 is overlain by around 1 m of tailings from the 1988 – 1992 period of processing gold ores from Kundip (Golder Associates, 2019).

The two TSFs do not have engineered containment and are subject to ongoing uncontrolled erosion via wind and water. A large fan of eroded tailings is found to the southeast of the TSFs, and the tailings materials are deposited for several kilometres down the Steere River (Figure 6). Tailings discharge events are believed to have mostly occurred during 1957-1971 period; anecdotal information suggests that a collapse of around 100,000 t of tailings from TSF1 occurred in the 1960s following a series of storms events. The tailings fan is estimated to be 100,000 m², with a depth of 0.5-1.0 m, representing a loss of 50,000-100,000 m³ of tailings from the TSFs (Golder Associates, 2019).

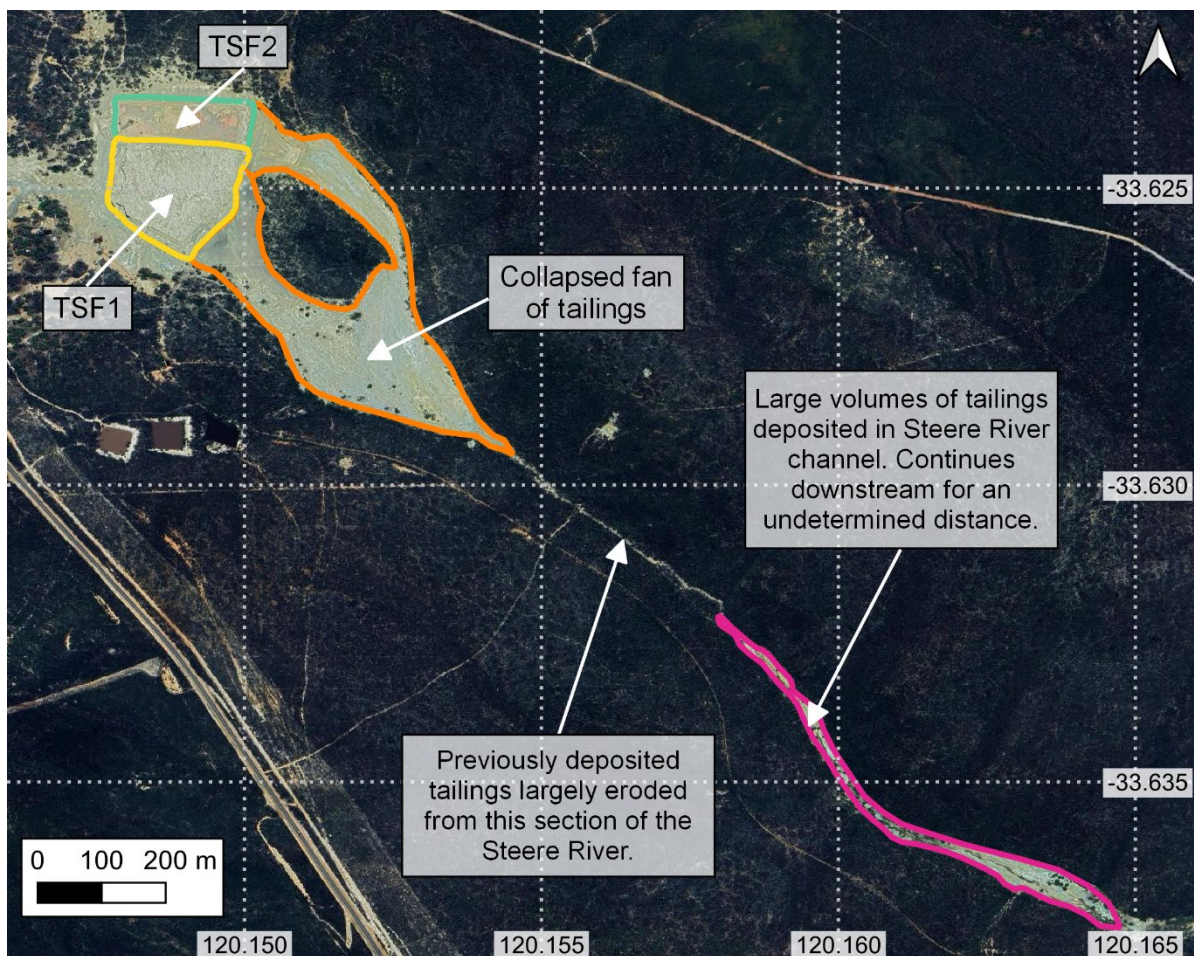


Figure 6. A map of the Elverdton site illustrating the mine residues present, including the south (TSF1) and north (SF2) tailings storage facilities, the collapsed fan of tailings, and the tailings in the Steere River.

Community concern around the erosion of the Elverdton tailings into the surrounding environment prompted preliminary studies of the site in 1999 and led to the installation of temporary control measures. These included timber pegging on the sides of the TSF1 and the construction of bunds, sediment ponds and sediments traps. The Elverdton site is now being monitored and investigated by the Abandoned Mines Program of the Department of Energy, Mines, Industry Regulation and Safety (for further information, see <https://www.dmp.wa.gov.au/Geological-Survey/Elverdton-29345.aspx>), and is classified as 'Possibly Contaminated – Investigation Required' according to the *Contaminated Sites Act 2003* (DEMIRS, 2021).

Photos of TSF1 can be seen in Figure 7, highlighting the key observations. The tailings in TSF1 are generally pale white-grey to brown, with clear layering observed in the profile, and a maximum height of around 9 m (Figure 7.A). Fine layering of fine-grained pale grey and coarser-grained pale brown tailings were observed at a smaller scale (Figure 7.B). In Figure 7.C-E, the erosion of the surface of TSF1 can be observed, with large gullies and buttes, which indicate that around 2 m of tailings has been eroded (Golder Associates, 2019). Figure 7.C also shows the formation of dark orange-brown hardpan layers on the tailings. The timber pegging of TSF1 can be observed on the slope of the tailings above TSF2, as seen in Figure 7.F.

In Figure 8, photos of TSF2 show the distinctive red colour of the tailings, in contrast to the paler grey-brown Elverdton tailings (Figure 8.A-D). Orange-brown hardpans have formed on the surface of the tailings and show some evidence of flowing and slumping (Figure 8.E-F). TSF2 is much smaller than TSF1, with a lower elevation (Figure 8.A,E), and shows less wind and water erosion than TSF1.

Photos of the tailings fan, as well as the tailings deposits in the Steere River, can be found in Figure 9. There is evidence of wind erosion and transport of the tailings, as seen by the dune-like deposit in Figure 9.A. The main material in the fan was likely deposited during storm events, and the vast extent of the fan can be seen in Figure 9.B-D. In Figure 9.E-G, the tailings deposited in the Steere River is shown, while Figure 9.G-H demonstrate the formation of white, orange, yellow and green efflorescent salts on the remaining tailings in the river channel.

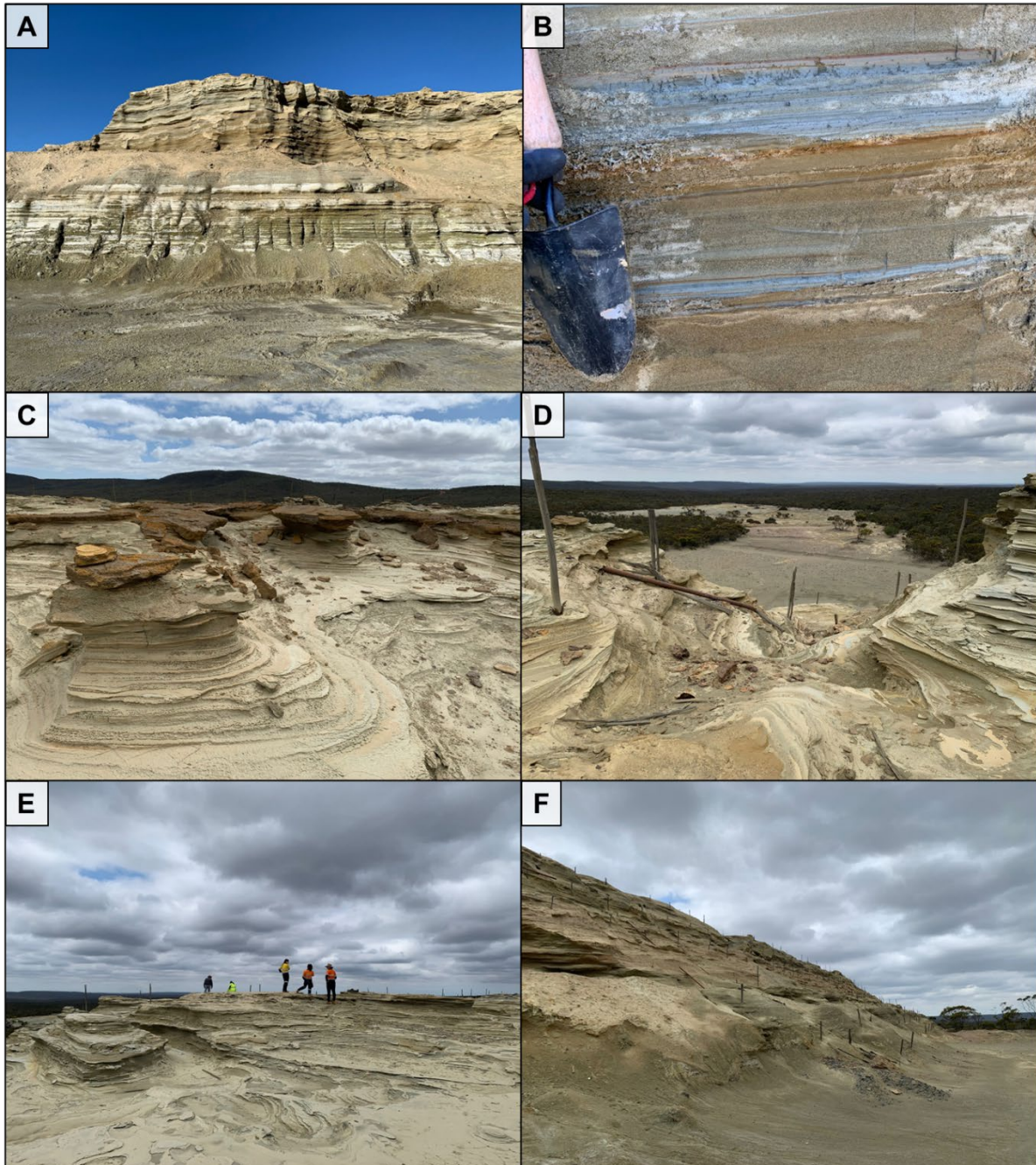


Figure 7. Photos taken of TSF1 at the Elverdton site. A) View of exposed tailings layers from top to bottom. B) A profile section of the tailings near the base of TSF, with clear interlayering of fine-grained pale grey tailings and coarser-grained, sand pale brown tailings. C) Top of TSF1, with erosion of tailings layers and formation of hardpans. D) Erosional gully from top of TSF1, leading down to fan of eroded tailings. E) Top of TSF1, with erosional features in layers of tailings. F) Dam wall with timber pegging to prevent continued erosion.

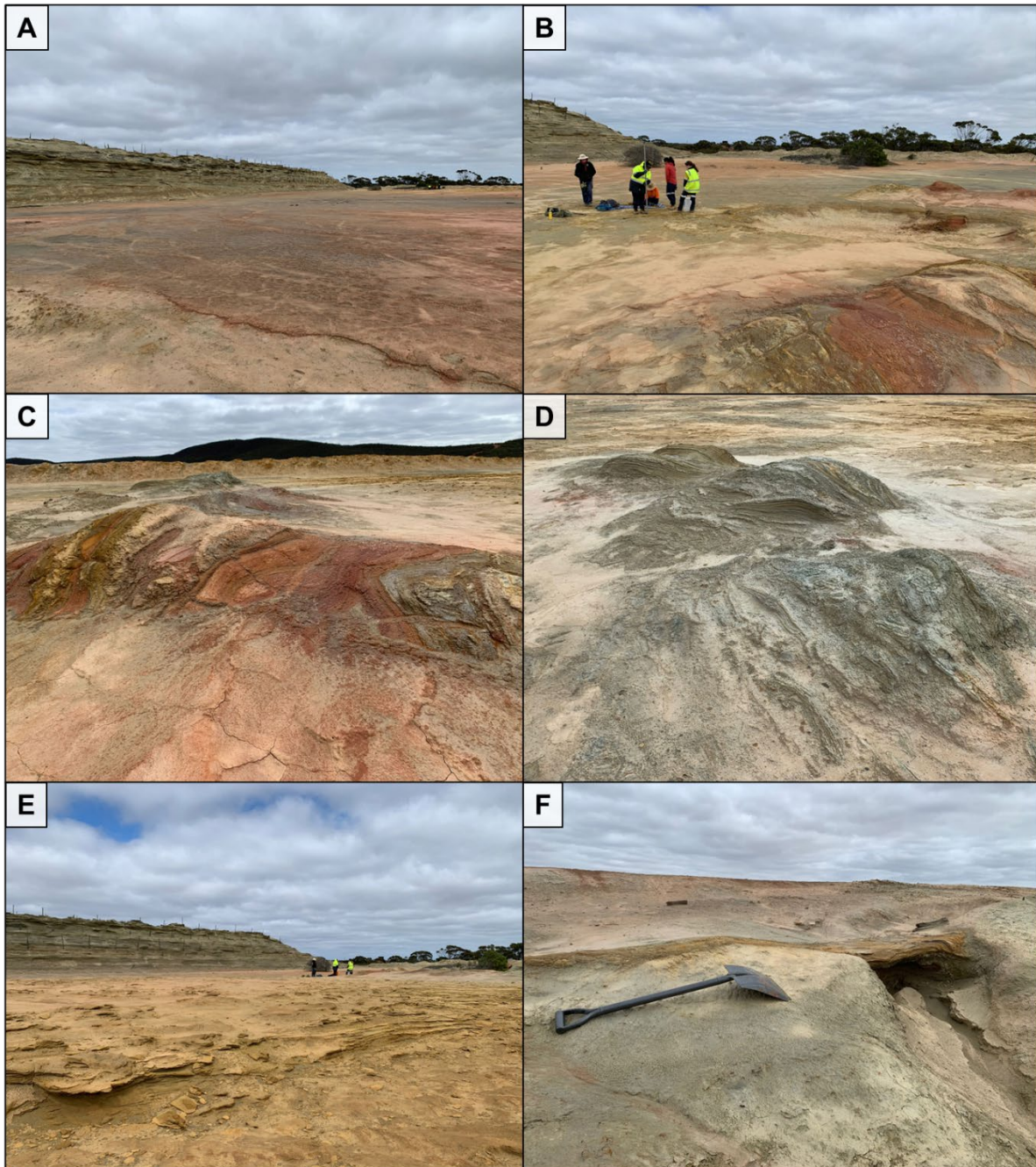


Figure 8. Photos taken of TSF2 at the Elverdton site. A) Surface of TSF2, with distinctive red colour. B) Team members from SMI and DEMIRS sampling on TSF2, with red colour of tailings visible. C) Excavated tailings with clear colour variations, from red to brown-orange to grey. D) Excavated tailings with grey colour, possibly older Elverdton tailings. E) Formation of hardpan layers in brown-orange tailings at the surface of TSF2. F) Formation of hardpan layers and flow features and gullies in tailings.

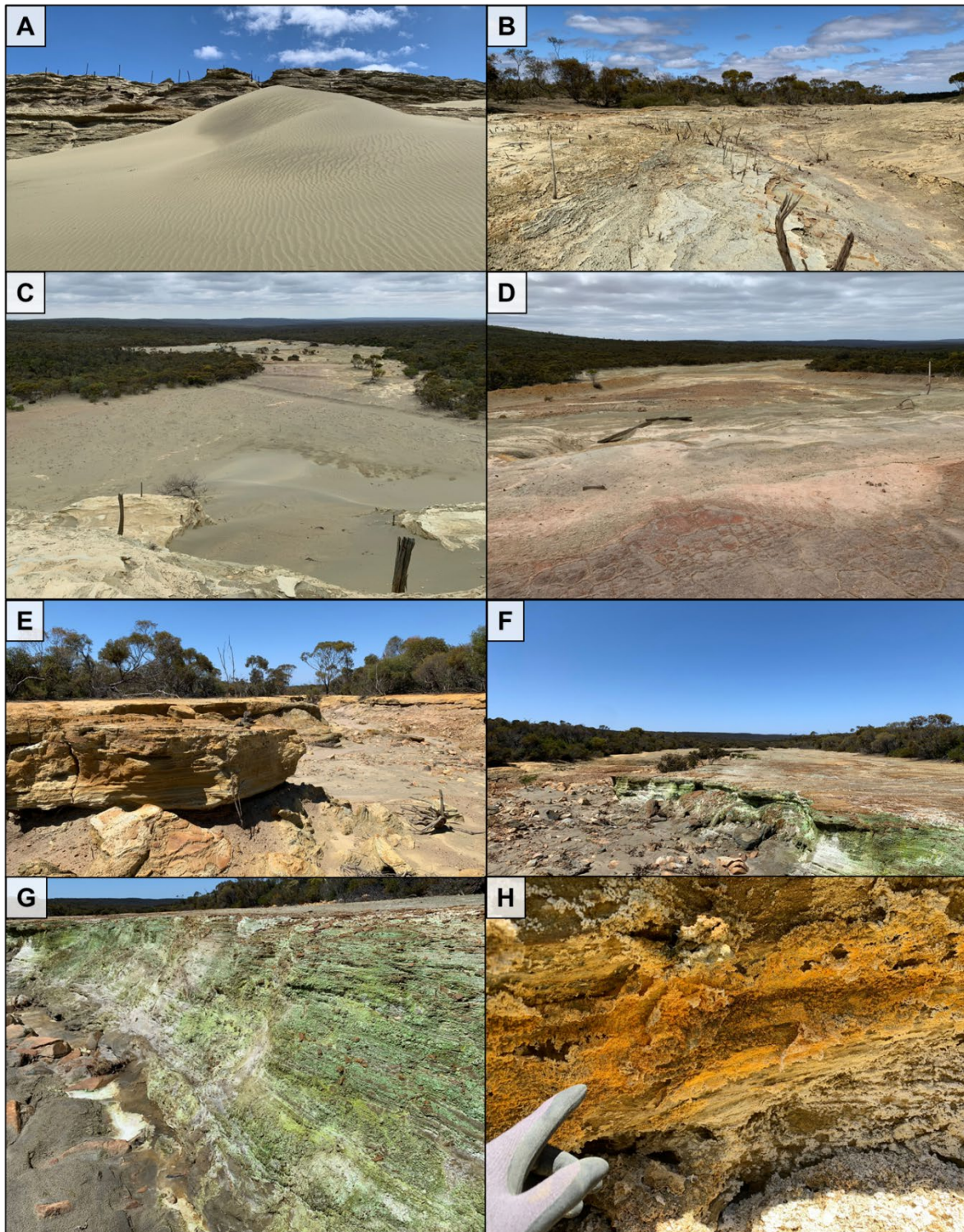


Figure 9. Photos taken of the eroded tailings fan at the Elverdton site and tailings in the Steere River. A) Large dune-like deposit of coarse, wind-blown tailings at the east side of TSF1. B) Tailings deposited in the fan of eroded material, showing erosional gullies and the remains of plants that were covered by the fan. C) The view of the tailings fan from TSF1. D) The view of the sediment trap and tailings fan from TSF2. E) Tailings deposited in the Steere River, partially eroded away. F) A wide section of the Steere River valley, showing the deposition of large volumes of tailings. G) The formation of white, green and yellow efflorescent salts on the tailings in the Steere River. H) The formation of orange-red efflorescent salts on the tailings in the Steere River.

3. Materials and methods

3.1 Sample collection

A sampling campaign to the Elverdton tailings site took place in October 2023. The sampling targeted the tailings contained in the two TSFs as well as the fan of collapsed material and the tailings deposited in the adjacent Steere River. Hardpans and efflorescent salts formed on the tailings were also sampled to aid understanding of metal remobilisation processes occurring at the site. Sample locations shown in Figure 10 and summarised in Table 2.

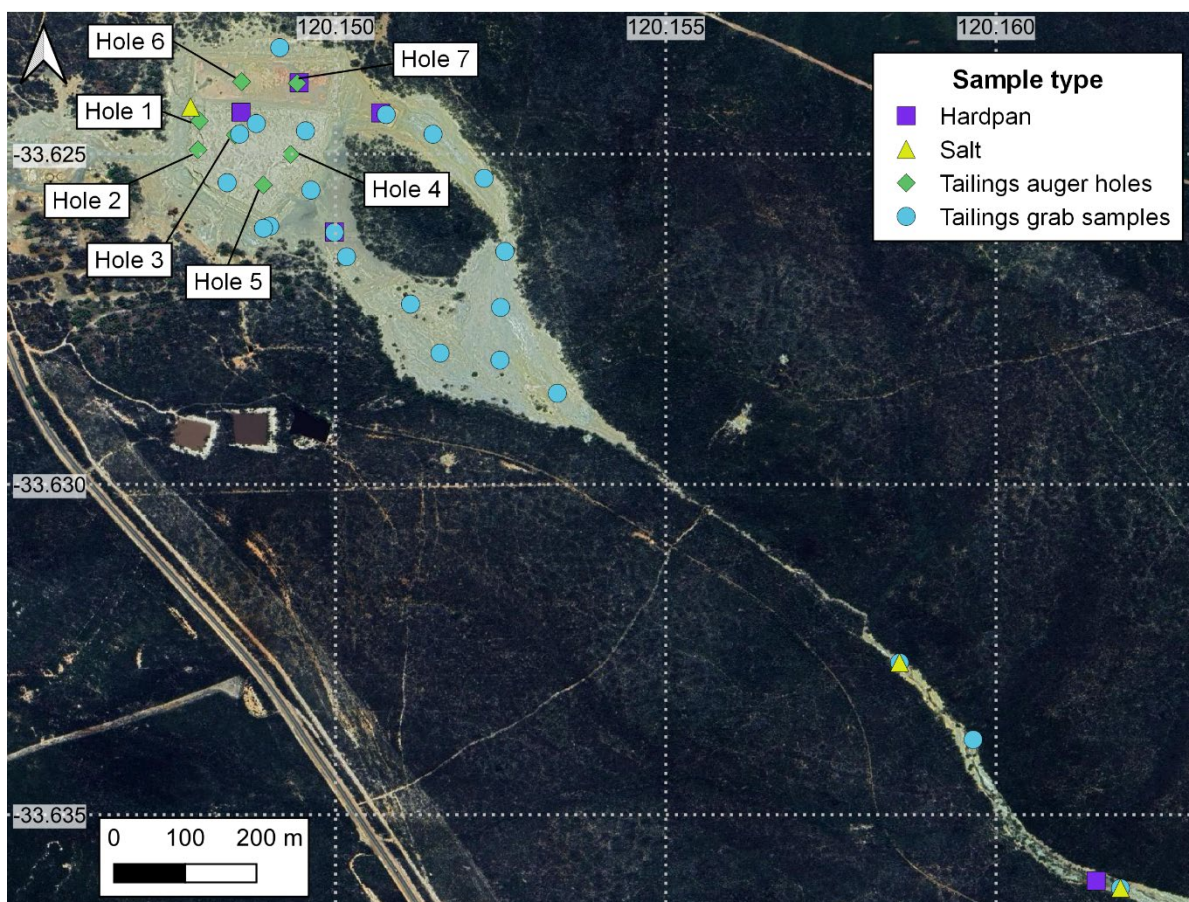


Figure 10. Map of the Elverdton site showing the sampled locations.

Tailings samples from the TSFs were collected using a hand auger. In total, seven auger holes were completed; five in the larger TSF1 and two in TSF2 (Figure 10). Two auger holes were placed on a lower tier of the tailings where they have been partially excavated, on the west flank of TSF1, to access the deeper tailings. Depths of up to 8 m were reached from the top of TSF1, and 4.4 m on the lower tier, to the base of the tailings (Table 2). Sampling of TSF2 reached a maximum depth of 1.6 m due to water saturation of the tailings meaning that augering could not continue. According to Golder Associates (2019), the tailings on TSF2 from the latter stage of processing for gold were around 1 m deep and therefore the older underlying Elverdton tailings in TSF2 may have been sampled.

Table 2. Summary of samples collected at the Elverdton site.

Hole/Sample number	Sample type	No. samples	Depth reached (m)
Hole 1	Tailings	6	3.0
Hole 2	Tailings	6	4.3
Hole 3	Tailings	10	8.0
Hole 4	Tailings	6	6.0
Hole 5	Tailings	6	5.0
Hole 6	Tailings	3	1.5
Hole 7	Tailings	4	1.6
GS_01 -> GS_08, GS_22 -> GS_24	Tailings, salt and hardpan from TSF 1 and TSF2	11	
GS_09 -> GS_21	Tailings and hardpan in fan of collapsed tailings	13	0.3-1.3 m
GS_25 -> GS_30	Tailings, salt and hardpan along Steere River channel	6	
Total Samples		71	

The augered tailings were logged, with facies defined based on particle size and colour, and samples collected from each of the defined facies. A total of 41 samples were collected from the auger holes (Table 2). Examples of auger holes from TSF1 and TSF2 can be seen in Figure 11.A-B. Clear differences in the colour of the tailings can be observed. The Elverdton tailings in TSF1 having a pale grey-brown colour, becoming darker as water content increases with depth, while the tailings in TSF2 have a distinct red colour in the upper metre before transitioning to darker Elverdton tailings, in accordance with Golder Associates (2019). In Appendix A, photos and logs of all seven auger holes can be found.

Additional grab samples were collected across TSF1 (Figure 10, Table 2), including four of the upper profile of tailings that had largely been eroded and could not be sampled with augering, as seen in Figure 11.C. Three grab samples were collected from around the base of TSF1, which was not accessible with augering, on the east and south sides (Figure 11.D). Eleven samples were collected in the tailings fan by hand augering through the depth of the fan (0.3-1.3 m), homogenising the tailings material and collecting a subsample by coning and quartering (Figure 11.E). Hardpans were sampled in several locations across the site and down the Steere River ($n = 5$, Figure 11.F), as well as efflorescent salt samples ($n = 3$, Figure 11.G), with the locations seen in Figure 10. Furthermore, three samples of tailings were collected from the deposits in the Steere River, with some tailings still appearing to be very fresh (Figure 11.H). A total of 30 grab samples of tailings, hardpans and salt were collected, for a total of 71 samples across the site with the 41 auger samples (Table 2).

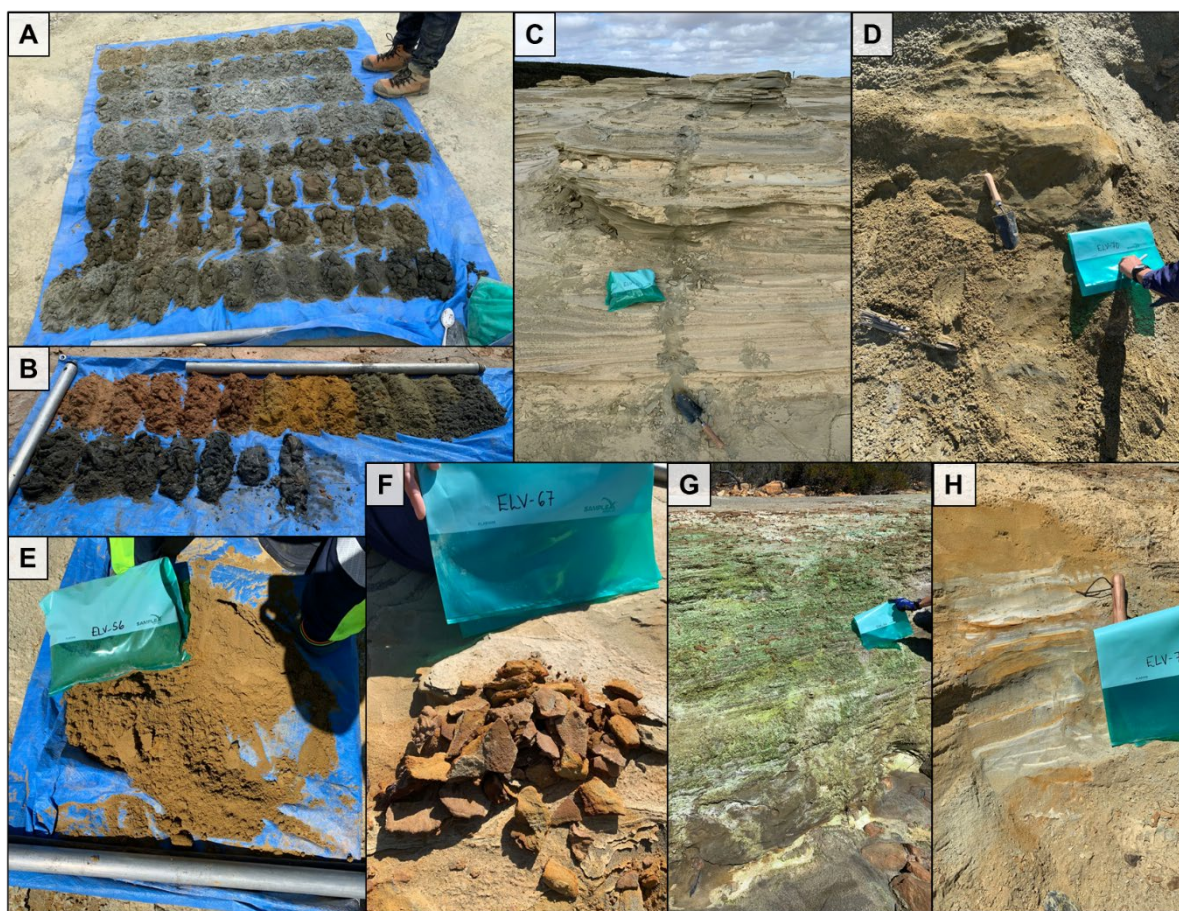


Figure 11. Photos taken during sampling of the mine residue types at the Elverdton site. A) Tailings from auger hole 3 on TSF1, reaching depth of 8 m. B) Tailings from auger hole 7 on TSF2, reaching depth of 1.6 m. C) Grab sampling of the remaining upper layers of tailings on TSF1. D) Grab sampling of lower layers of tailings exposed at the base of TSF1. E) Pile of tailings sampled with the auger from the tailings fan, after coning and quartering. F) Sampling of hardpan materials forming on the tailings. G) Grab sampling of efflorescent salts formed on the tailings in the Steere River. H) Grab sampling of relatively fresh tailings, with clear layering visible, deposited in the Steere River.

3.2 Sample preparation

The samples were sent directly to Australian Laboratory Services (ALS) Geochemistry in Brisbane for analysis. Sample preparation at ALS depends on the sample material (pulp, chips and rock). Wet samples are dried for at least 24 hours in oven at 60 °C. Rock chips and rock samples are coarse crushed to 70% passing 2 mm, with 250 g of the material split and pulverised to 85% passing 75 µm. Barren material (quartz) is used to clean the crusher and pulveriser after each sample, to avoid contamination of the samples. Data quality was assured by inserting relevant certified reference materials, OREAS 601c, at a rate of 1:15.

3.3 Geochemical assay

The prepared pulps were submitted to 4 different analytical streams. For ME-MS61 analysis, 0.25 g of pulps were digested in a combination of 4 acids, namely HCl (hydrochloric acid), HNO₃ (nitric acid), HF (hydrofluoric acid) and HClO₄ (perchloric acid). The solutions were then analysed using ICP-

AES/MS. Fused beads were prepared from 2 g of the pulps mixed with lithium borate flux, with the bead then dissolved in acid prior to analysis by ICP-MS (ME-MS81). Pulps (~30 g for better results) were pressed and analysed for the determination of Si, Ti and Zr by pXRF. Furthermore, gold contents were analysed with method Au-AA25, which involves fire assay and atomic absorption spectroscopy. All geochemical assay was conducted in Brisbane, with Table 3 summarising the elements and the detection limits for each of the analytical suites used.

Table 3. Analytical suites used and their limit of detection ranges (ALS Global).

ME-MS61	Analyte	Ag (ppm)	Al (%)	As (ppm)	Ba (ppm)	Be (ppm)	Bi (ppm)	Ca (%)	Cd (ppm)	Ce (ppm)	Co (ppm)	Cr (ppm)	Cs (ppm)
	Lower LOD	0.01	0.01	0.2	10	0.05	0.01	0.01	0.02	0.01	0.1	1	0.05
	Upper LOD	100	50	10000	10000	10000	10000	50	1000	500	10000	10000	500
	Analyte	Cu (ppm)	Fe (%)	Ga (ppm)	Ge (ppm)	Hf (ppm)	In (ppm)	K (%)	La (ppm)	Li (ppm)	Mg (%)	Mn (ppm)	Mo (ppm)
	Lower LOD	0.2	0.01	0.05	0.05	0.1	0.005	0.01	0.5	0.2	0.01	5	0.05
	Upper LOD	10000	50	10000	500	500	500	10	10000	10000	50	100000	10000
	Analyte	Na (%)	Nb (ppm)	Ni (ppm)	P (ppm)	Pb (ppm)	Rb (ppm)	Re (ppm)	S (%)	Sb (ppm)	Sc (ppm)	Se (ppm)	Sn (ppm)
	Lower LOD	0.01	0.1	0.2	10	0.5	0.1	0.002	0.01	0.05	0.1	1	0.2
	Upper LOD	10	500	10000	10000	10000	10000	50	10	10000	10000	1000	500
	Analyte	Sr (ppm)	Ta (ppm)	Te (ppm)	Th (ppm)	Ti (%)	Tl (ppm)	U (ppm)	V (ppm)	W (ppm)	Y (ppm)	Zn (ppm)	Zr (ppm)
	Lower LOD	0.2	0.05	0.05	0.01	0.005	0.02	0.1	1	0.1	0.1	2	0.5
	Upper LOD	10000	100	500	10000	10	10000	10000	10000	10000	500	10000	500

ME-MS81	Analyte	Ba (ppm)	Ce (ppm)	Cr (ppm)	Cs (ppm)	Dy (ppm)	Er (ppm)	Eu (ppm)	Ga (ppm)	Gd (ppm)	Hf (ppm)	Ho (ppm)	La (ppm)
	Lower LOD	0.5	0.1	10	0.01	0.05	0.03	0.02	0.1	0.05	0.1	0.01	0.1
	Upper LOD	10000	10000	10000	10000	1000	1000	1000	1000	1000	1000	1000	10000
	Analyte	Lu (ppm)	Nb (ppm)	Nd (ppm)	Pr (ppm)	Rb (ppm)	Sm (ppm)	Sn (ppm)	Sr (ppm)	Ta (ppm)	Tb (ppm)	Th (ppm)	Tm (ppm)
	Lower LOD	0.01	0.1	0.1	0.02	0.2	0.03	1	0.1	0.1	0.01	0.05	0.01
	Upper LOD	1000	2500	10000	1000	10000	1000	10000	10000	2500	1000	1000	1000
	Analyte	U (ppm)	V (ppm)	W (ppm)	Y (ppm)	Yb (ppm)	Zr (ppm)						
	Lower LOD	0.05	5	1	0.1	0.03	2						
	Upper LOD	1000	10000	10000	10000	1000	10000						

pXRF-34	Analyte	Si (%)	Ti (%)	Zr
	Lower LOD	0.5	0.1	5 ppm
	Upper LOD	47	60	5%

AU-AA25	Analyte	Au (ppm)
	Lower LOD	0.01
	Upper LOD	100

3.4 X-Ray diffractometry (XRD)

On receipt of the preliminary geochemical assay data, 10 samples with the highest Cu, Co, Bi, Au, Ag, As, Mo, Se, Te and Re were chosen for mineralogy and mineral chemistry studies. This was performed by XRD at the Queensland University of Technology (QUT) Central Analytical Research Facility (CARF) laboratories. Using a representative sub-sample of coarse reject materials recovered from ALS Global, each sub-sample was accurately weighed and specimens prepared for XRD by the addition of a corundum (Al₂O₃) internal standard at 20 wt. %. The specimens were micronised in a McCrone mill using zirconia beads and ethanol, then dried in an oven overnight at 40 °C. The resultant homogenous powders were back-pressed into sample holders.

A small portion of the crushed samples was also dispersed in water. After sonication (5 min) and settling for 5 min, the fine fraction (nominally < 5 µm in suspension) was transferred via pipette to a low background plate and allowed to settle and dry. This preparation is used to concentrate the fine (clay dominant) fraction and aids identification of the clays present. This means ratios of the clays and other phases present in this extract may vary from the bulk sample: the fine fraction result is qualitative. The air-dried slides were further treated in an ethylene glycol atmosphere (60 °C) for several hours, then immediately re-examined.

Step scanned X-ray diffraction patterns were collected for an hour per sample using a PANalytical X'Pert Pro powder diffractometer and cobalt K α radiation operating in Bragg-Brentano geometry. The collected data was analysed using JADE (V2010, Materials Data Inc.), EVA (V5, Bruker) and X'Pert Highscore Plus (V4, PANalytical) with various reference databases (PDF4+, AMCSD, COD) for phase identification. Rietveld refinement was performed using TOPAS (V6, Bruker). The known addition of corundum facilitated the reporting of absolute phase abundances for the modelled phases. The sum of the absolute abundances was subtracted from 100 wt. % to obtain a residual (called non-diffracting/unidentified, also known as “amorphous”). The residual represents the unexplained portion of the pattern: it may be non-diffracting content but will also contain unidentified phases and the error from poorly modelled phases.

3.5 Mineral liberation analysis (MLA)

Automated mineralogy tools such as the mineral liberation analyser (MLA), Quantitative Evaluation of Minerals by SCANNing electron microscopy (QEMSCAN) and the Tescan TIMA uniquely combine back scattered electron (BSE) image analysis, X-ray mineral identification and advanced imaging and pattern recognition analysis to produce classified mineralogy outputs (Parbhakar-Fox and Lottermoser, 2015). Primary applications of these technologies have been to collect modal mineralogy data through point counting methods, and to characterise target mineral phases in terms of their size, shape, liberation characteristics and mineral associations. The ten samples selected for mineralogical analysis were analysed with MLA with the aim of understanding the characteristics of sulphide minerals and secondary phases (e.g., jarosite), as these potentially host the critical metals of interest.

The selected samples ($n = 10$) were analysed at the Sustainable Minerals Institute, University of Queensland JKMRC MLA lab. As there was a wide range of particle sizes present, MLA samples were prepared using the vertical mounting method. For this type of mount the sample is mixed in a mould with graphite and epoxy, cured then sectioned and remounted in the standard 30 mm round mould as shown in the image (Figure 12). Once the vertical mount has cured the surface is then ground back and polished to give a high-quality finish prior to carbon coating.

The XBSE measurement mode (which uses a combination of backscattered electrons and X-rays to identify phases present in the sample) was used to provide information of the relative abundance of the minerals in the sample and identify potential hosts of key elements.

Due to a wide range of particle sizes, measurements were undertaken using two approaches: the first without setting a minimum particle size and setting the maximum particles measured to 50,000 (this method can be used for modal mineralogy but did not measure the full sample section); the second measurement was done to image to the full particle section and capture the coarse particles (for this measurement a minimum particle size was set to exclude fine particulates, this measurement should not be used for modal mineralogy). A site-specific mineral reference library was developed for these samples. All results were processed in-house using Dataview software.

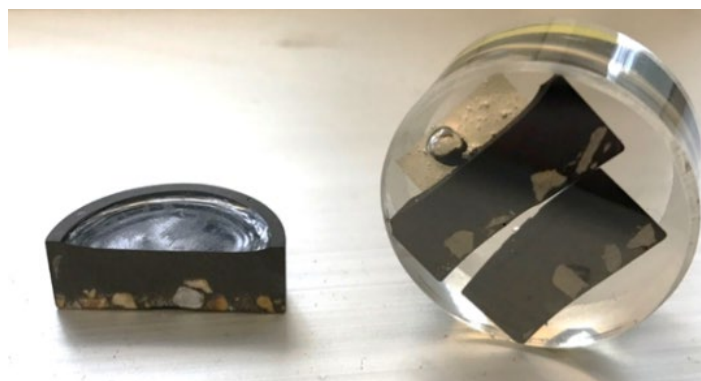


Figure 12. Example of MLA mount.

3.6 Laser ablation ICP-MS (LA-ICP-MS)

Laser ablation analyses were performed at the University of Adelaide analytical laboratories, using a RESOLUTION laser platform, equipped with a Coherent COMPex Pro 193 nm excimer laser and Lauren Technic S155 large format sample cell, coupled to an Agilent 7700 quadrupole ICP-MS.

Many element isotopes were measured to capture the trace element contents of the targeted minerals and to reveal minerals other than the target that might be ablated during analysis, e.g., as mineral inclusions or in minerals adjacent to the target. For each spot analysis, the background signal was recorded for 30 seconds, then the laser was turned on and the targeted mineral ablated while the ICP-MS collects data for each element for ~60 seconds.

During spot analysis, the material analysed is typically dominated by the targeted mineral. Element signals that show no changes, gradual smooth changes, or changes consistent with chemical zonation are interpreted to be chemically bound into the target mineral structure. However, lasering through evenly distributed 'invisible' micro-inclusions may also show no or gradual changes in the signal and are therefore indistinguishable from 'true' chemical substitution into the mineral structure. Both types of occurrences are referred to as refractory. Elements that have signals with discrete, sharp changes in the laser signal, and can sometimes reach a sufficient level to dilute target major element signals are interpreted as being hosted in mineral inclusions or in minerals adjacent to the target. To calculate concentrations, the average of the signal over the time interval of interest was calibrated against reference standards.

The laser spot size used for the mineral grains was 20 μm , while 50 μm was used for STDGL3 and GSD-1G primary standard glasses, and size-matched 20 μm spots were used on Peru Pyrite secondary standards for pyrite chemistry calculations. Data reduction was performed using the LADR software package (Norris Scientific). In total, there were 20 laser ablation spot analyses in pyrite, 24 in pyrrhotite, 18 in chalcopyrite, 48 in iron oxide, 22 in goethite, 39 in jarosite, 21 in schwertmannite, 17 in Mg sulphate and 11 in Na-Mg sulphate. For the measurements of REEs in garnet, apatite and iron oxide, standards NIST612, GSD-1G, BCR-2G and BHVO-2G were used. Laser spot sizes of 24 μm were used for mineral grains, and 50 μm for the standards. There were 16 laser ablation spots analysed in apatite, 12 in garnet and 33 in iron oxide.

4. Results

4.1 Geochemistry

The bulk geochemical dataset presented herein is a combination of all analytical methods used. The full geochemical results and quality assurance and quality control (QAQC) from ALS are provided in Appendix B. It should be noted that rare earth elements (REEs) were analysed in both, however ME-MS81 analyses are reported as REEs may not be totally soluble using ME-MS61 as certified in Appendix B. In Appendix C, the QAQC results from the OREAS 601c standards are presented, where the results indicate that the geochemical assay measurements are accurate and reliable.

A spider diagram is presented in Figure 13 to investigate which elements are enriched relative to average crustal abundance. The Elverdton mine residue samples are enriched in the base and precious metals Cu, Pb, Au and Ag. The samples are also enriched in a range of critical metals, as defined by Australian Government (2024), including Te, Se, Bi, Mo, Co, Re, W, and the REEs, La and Ce (Figure 13). On average, significant enrichment is seen in Cu, Mo, U and Se at > 10 x crustal abundance, Au at > 100 x crustal abundance and Te at > 1,000 x crustal abundance.

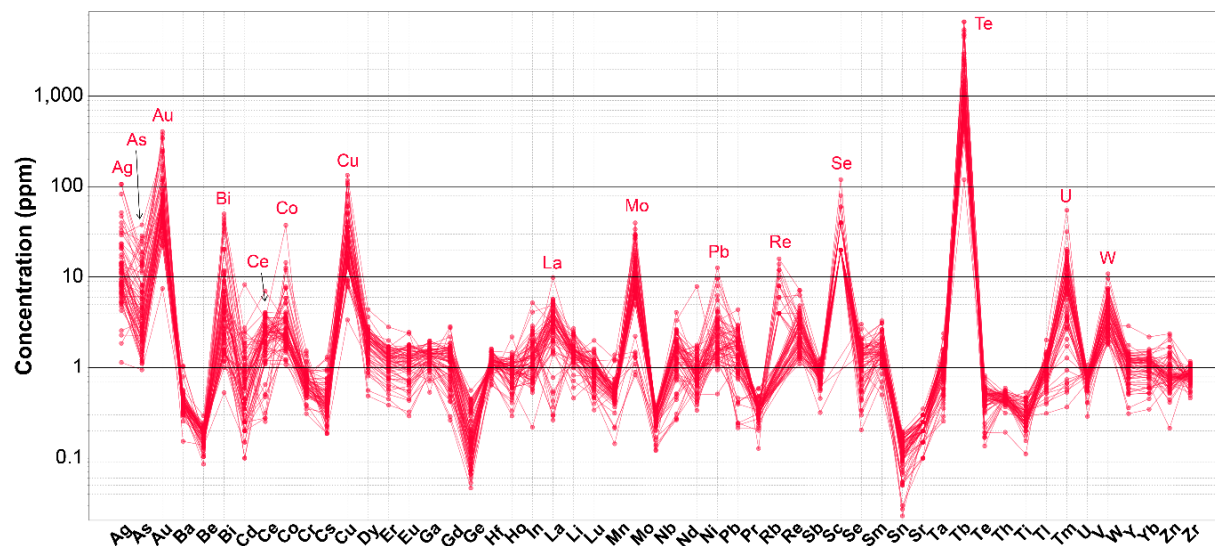


Figure 13. Spider plot of the geochemical assays of the samples from Elverdton (n = 71).

The contents of the enriched critical and strategic metals in the Elverdton samples are shown per residue type in Figure 14. The contents of the REEs are plotted in Figure 15, demonstrating that La and Ce are present in elevated abundances but the other REEs are not enriched compared to crustal abundance. The summary statistics of the enriched elements are provided in Table 4. On average, TSF2 has higher contents than TSF1 of most of the enriched elements, with the exception of Mo, U, W, La, Ce and Pb (Figure 14, Figure 15). The tailings fan samples are close in composition to the TSF1 samples. The hardpan samples appear to have preferential enrichment of Au and Se, while the salt composition is highly variable and enriched in Cu, U, As and Co. The contents of Fe and S are also provided in Table 4, showing that there is a significantly higher S content in TSF2 than TSF1, but similar Fe contents. Further analysis of the geochemical results is presented in two main sections: analysis of the tailings, including the samples in TSF1, TSF2, the tailings facies and the tailings fan, and analysis of the hardpan and salt samples. Following this, the element correlations and spatial distributions will be discussed.

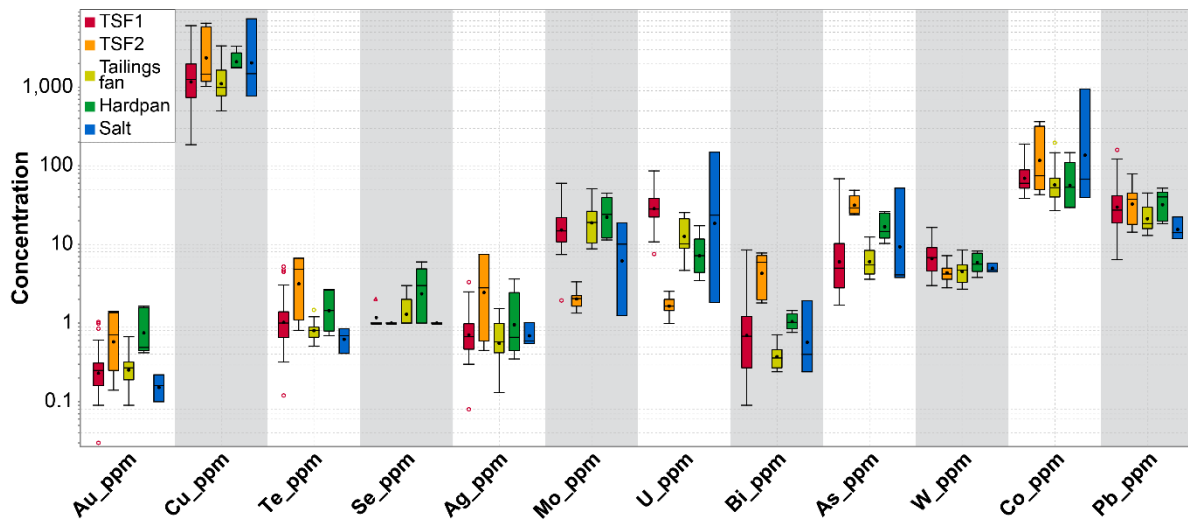


Figure 14. Box plot for enriched critical and strategic elements in the Elverdton samples, categorised based on the material type: TSF1 (n = 41), TSF2 (n = 7), tailings fan (n = 15), hardpan (n = 5), salt (n = 3).

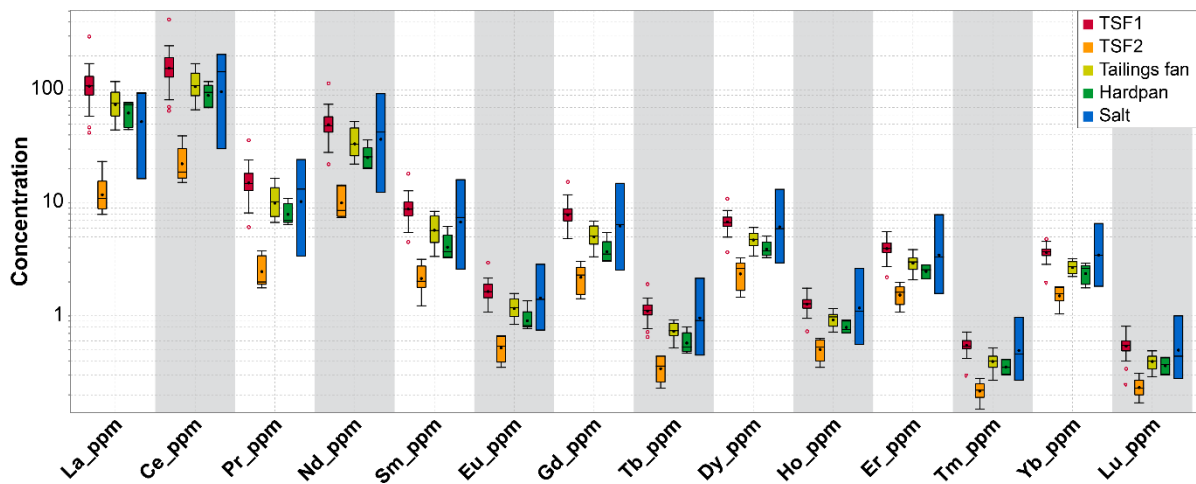


Figure 15. Box plot for REEs in the Elverdton samples, categorised based on the material type: TSF1 (n = 41), TSF2 (n = 7), tailings fan (n = 15), hardpan (n = 5), salt (n = 3).

Table 4. Summary of bulk geochemistry for selected elements of interest (ppm). C.A indicates the average crustal abundance values of elements in ppm (Rumble, 2021). BDL = below detection limit.

	Au	Cu	Te	Se	Ag	Mo	U	Bi
C.A.	0.004	25	0.001	0.05	0.08	1.5	1.8	0.17
Whole dataset (n = 71)								
Minimum	0.0	186	0.1	1.0	0.1	1.2	1.0	0.1
Maximum	1.6	7,390	6.7	6.0	7.5	60	149	8.5
Average	0.4	1,714	1.5	1.4	1.2	17	24	1.4
Median	0.3	1,315	0.9	1.0	0.7	14	22	0.7
TSF1 samples (n = 41)								
Minimum	BDL	186	0.1	1.0	0.1	1.9	7.6	0.1
Maximum	1.0	6,050	5.2	2.0	3.3	60	86	8.5
Average	0.3	1,481	1.3	1.2	0.9	18	31	1.3
Median	0.3	1,250	1.0	1.0	0.7	15	28	0.7
TSF2 samples (n = 7)								
Minimum	0.1	1,020	0.8	1.0	0.5	1.3	1.0	1.8
Maximum	1.4	6,500	6.7	1.0	7.5	3.3	2.5	7.8
Average	0.8	3,096	4.1	1.0	3.8	2.1	1.7	4.9
Median	0.7	1,455	4.8	1.0	2.8	2.1	1.6	5.9
Tailings fan samples (n = 15)								
Minimum	0.1	497	0.5	1.0	0.1	8.8	4.7	0.2
Maximum	0.7	3,340	1.5	3.0	1.5	51	25	0.7
Average	0.3	1,258	0.8	1.4	0.7	22	14	0.4
Median	0.3	987	0.8	1.0	0.6	19	10	0.4
Hardpan samples (n = 5)								
Minimum	0.4	1,745	0.7	1.0	0.4	11	3.5	0.8
Maximum	1.6	3,320	2.7	6.0	3.6	45	17	1.4
Average	0.9	2,168	1.7	3.0	1.4	25	8.3	1.1
Median	0.5	1,775	1.4	3.0	0.7	24	7.2	1.0
Salt samples (n = 3)								
Minimum	0.1	768	0.4	1.0	0.6	1.2	1.8	0.2
Maximum	0.2	7,390	0.9	1.0	1.0	19	149	1.9
Average	0.2	3,213	0.6	1.0	0.7	10	58	0.9
Median	0.2	1,480	0.7	1.0	0.6	10	24	0.4

Table 4 - Continued - Summary of bulk geochemistry for selected elements of interest (ppm). C.A indicates the average crustal abundance values of elements in ppm (Rumble, 2021).

	As	W	Co	Pb	Re	La	Ce	Fe (%)	S (%)
C.A.	1.8	1.5	25	12.5	0.0026	34	60	6.3	0.042
Whole dataset (n = 71)									
Minimum	1.7	2.7	27	6	0.002	7.9	15	2.3	0.1
Maximum	68	16	940	159	0.008	297	421	16.9	5.9
Average	12	6.3	94	34	0.004	91	133	8.2	0.9
Median	6.4	5.5	59	24	0.004	93	139	7.7	0.4
TSF1 samples (n = 41)									
Minimum	1.7	3.0	38	6	0.002	42	65	2.3	0.1
Maximum	68	16	190	159	0.008	297	421	11.4	2.0
Average	9.8	7.2	75	38	0.004	115	166	7.7	0.4
Median	5.0	6.8	60	27	0.003	109	155	7.4	0.3
TSF2 samples (n = 7)									
Minimum	24	2.8	43	14	0.004	7.9	15	7.5	0.3
Maximum	49	7.2	363	79	0.007	23	39	12.0	5.9
Average	33	4.5	172	37	0.006	13	24	9.9	3.1
Median	29	4.2	74	38	0.006	11	19	10.6	2.7
Tailings fan samples (n = 15)									
Minimum	3.6	2.7	27	13	0.002	44	67	5.0	0.1
Maximum	12	8.5	196	45	0.004	119	171	10.8	2.4
Average	6.6	4.8	67	23	0.003	77	111	7.7	0.8
Median	5.5	4.7	53	18	0.003	76	110	7.1	0.6
Hardpan samples (n = 5)									
Minimum	10	3.8	29	18	0.002	45	70	7.9	0.3
Maximum	26	8.2	147	52	0.002	78	119	16.9	2.5
Average	18	6.1	68	35	0.002	64	91	12.8	1.7
Median	15	5.6	53	40	0.002	74	95	13.5	2.0
Salt samples (n = 3)									
Minimum	3.8	4.5	40	12	0.006	16	30	3.5	0.3
Maximum	52	5.8	940	22	0.006	94	206	7.7	0.6
Average	20	5.0	349	16	0.006	68	127	6.1	0.4
Median	4.1	4.7	67	14	0.006	93	145	7.0	0.4

4.1.1 Tailings analysis

The geochemistry of the different tailings types will be compared in this section. In Figure 16, the contents of the most enriched elements in the tailings are plotted for each sample. It can be seen that the samples from TSF2 generally have higher contents of most elements in comparison to TSF1 and the tailings fan samples, with the exception of Mo and U. TSF2 is known to contain tailings originating from Elverdton as well as Kundip Au ores, which may explain the difference in chemical composition. The material in the tailings fan appears to be mainly derived from the Elverdton tailings, with a chemical signature very similar to that of TSF1. The geochemical results for TSF1, TSF2, the tailings facies and the tailings fan will be discussed in the following subsections.

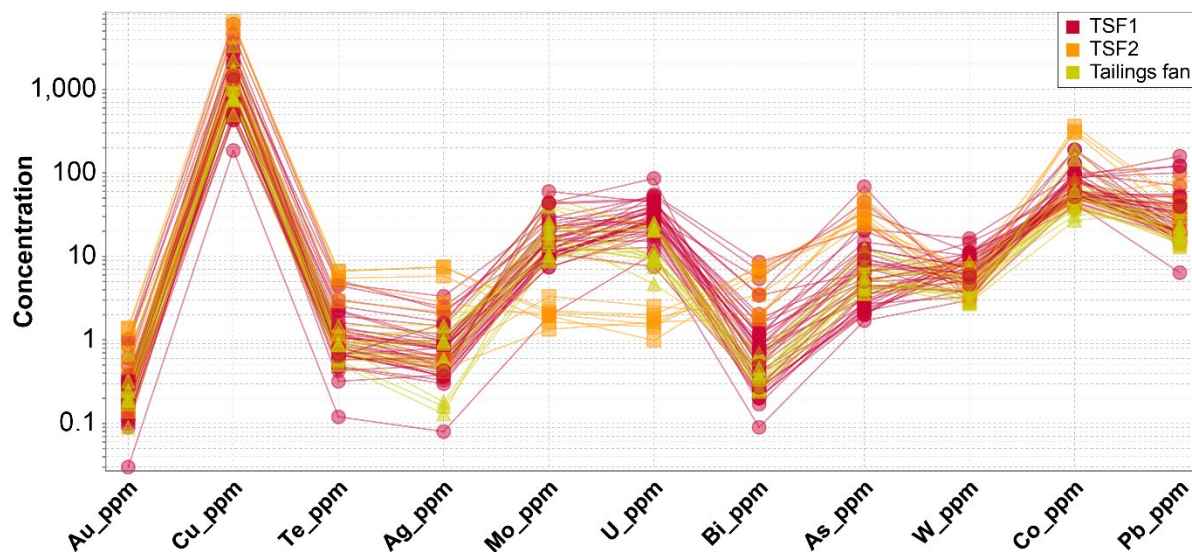


Figure 16. Concentrations of the most enriched elements in the tailings, in the TSF1 (n = 41), TSF2 (n = 7), tailings fan (n = 15) samples.

4.1.1.1 TSF1

As can be seen in Figure 14 and Figure 16, there is a wide spread in values for most geochemical variables of the TSF1 samples. This may be attributed to the larger number of samples (n = 41) compared to TSF2 (n = 7) and the tailings fan (n = 15), and the larger depth coverage of the samples, representing tailings from different parts of the ore body through the mining history. To investigate this further, the geochemical composition of TSF1 will be assessed with 2 m depth intervals, with a boxplot by depth shown in Figure 17. It should be noted that the depth intervals are somewhat estimated due to the variable topography of TSF1, resulting from erosion. The lower tier of TSF1 was assumed to be 4 m below the top surface, and so 4 m was added to the depths of the two auger holes on this tier. The grab samples taken at the top of TSF1 were given a depth of 0 m, and those taken at the base were given a depth of 9 m.

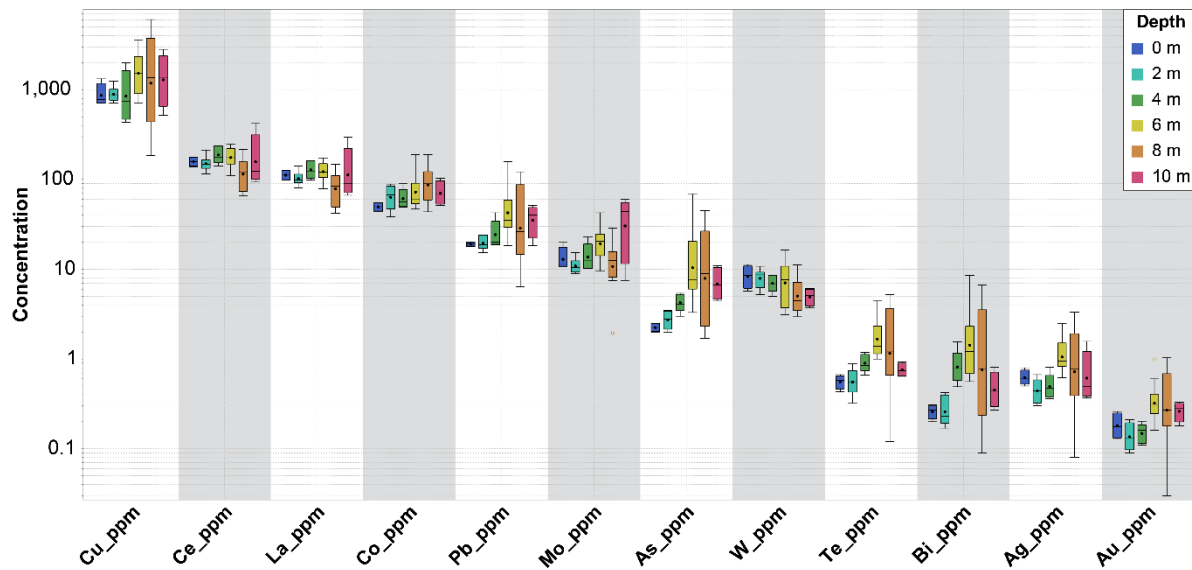


Figure 17. Box plot for enriched critical and strategic elements in TSF1, categorised by estimated depth intervals: 0 m (at surface, n = 4), 2 m (n = 13), 4 m (n = 5), 6 m (n = 14), 8 m (n = 8), 10 m (n = 4).

Ore-forming, base and precious metals enriched in the Elverdton TSF1 tailings, relative to average crustal abundance, include Cu, Pb, Ag and Au (Table 4, Figure 13, Figure 14 and Figure 16). Copper ranges from 186-6,050 ppm (average: 1,481 ppm, median: 1,250 ppm). Variations in Cu content can be observed with depth, with similar values from 0-4 m (average: ~900-1,000 ppm) and increasing with depths 6-8 m (average: ~1,500-2,000 ppm) (Figure 17). The Pb values are fairly low and range from 6-159 ppm (average: 38 ppm, median: 27 ppm), and tend to increase with depth from ~20 ppm at surface to 40-50 ppm at 6-10 m. Silver values are also fairly low, ranging from 0.1-3.3 ppm (average: 0.9 ppm, median: 0.7 ppm), while the Au contents range up to 1 ppm (average and median: 0.3 ppm). Both the Ag and Au contents tend to increase with depth, having the highest values at around 6-8 m depth, at ~1.9 ppm Ag and 0.4 ppm Au.

The TSF1 tailings are also enriched in the critical metals Te, Bi, Mo, As, Co, W, La and Ce (Table 4, Figure 13-Figure 16). Tellurium ranges from 0.1-5.2 ppm (average: 1.3 ppm, median: 1.0 ppm), while Bi values range from 0.1-8.5 ppm (average: 1.3 ppm, median: 0.7 ppm). The Mo contents range from 1.9-60 ppm (average: 18 ppm, median: 15 ppm) and As ranges from 1.7-68 ppm (average: 9.8 ppm, median: 5.0 ppm). All of these elements tend to increase with depth, with maximum values generally reached at 6-10 m (Figure 17). The Co values range from 38-190 ppm (average: 75 ppm, median: 60 ppm), tending to increase slightly with depth.

Tungsten ranges from 3-16 ppm (average: 7.2 ppm, median: 6.8 ppm) and is the only element that tends to decrease with depth, from around 9 ppm at the surface down to 5 ppm at the base. The REEs Ce and La occur at ranges of 65-421 ppm and 42-297 ppm, respectively (average Ce: 166 ppm, median Ce: 155 ppm, average La: 115 ppm, median La: 109 ppm). The REEs do not show a clear trend with depth.

4.1.1.2 TSF2

Based on the available samples, the TSF2 tailings has higher contents than TSF1 of most of the enriched elements. However, the tailings in TSF2 had high water contents and samples at depths greater than around 1.6 m could not be collected. It is thought that below around 1 m depth, the tailings transition from the younger Kundip gold ore tailings to the Elverdton tailings (Golder Associates, 2019). Although based on a small number of samples, a box plot showing the range of the TSF2 samples by 0.5 m depth intervals is plotted in Figure 18, to investigate whether any variations with depth can be observed and any evidence of the underlying Elverdton tailings can be seen.

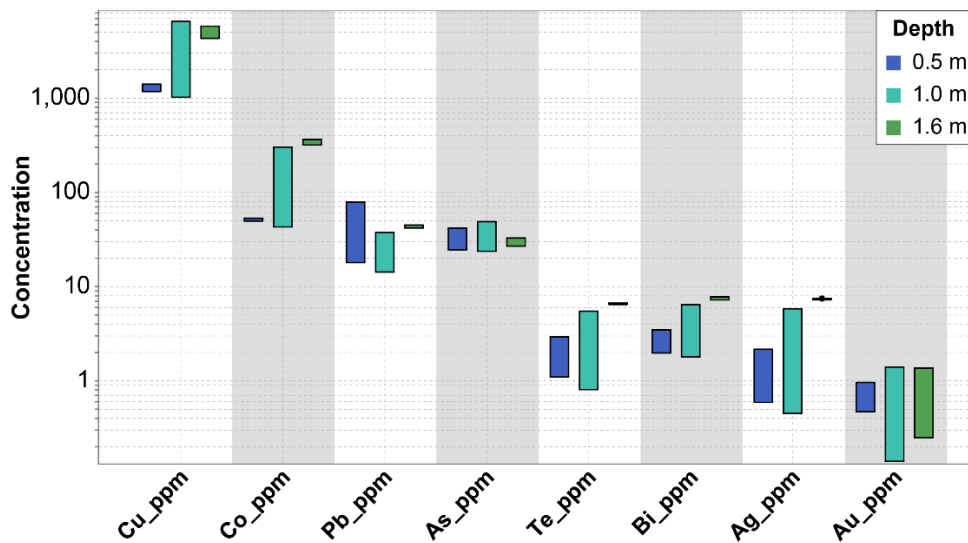


Figure 18. Box plot for enriched critical and strategic elements in TSF2, categorised by depth intervals: 0.5 m (n = 2), 1.0 m (n = 3), 1.6 m (n = 2).

The Elverdton TSF2 tailings are enriched in Cu, Pb, Ag and Au, relative to average crustal abundance (Table 4, Figure 13, Figure 14 and Figure 16). Copper ranges from 1,020-6,500 ppm (average: 3,096 ppm, median: 1,455 ppm). Based on the 0.5 m depth intervals (Figure 18), Cu content appears to increase with depth, from around 1,300 up to 5,000 ppm. The Pb values are fairly low and range from 14-79 ppm (average: 37 ppm, median: 38 ppm), and do not vary significantly with depth. Silver contents range from 0.5-7.5 ppm (average: 3.8 ppm, median: 2.8 ppm) and the Au contents range up to 1.4 ppm (average: 0.8 ppm, median: 0.7 ppm). The Ag contents tend to increase with depth, from around 1.4-7.5 ppm, while the Au content is fairly constant with depth.

The TSF2 tailings are enriched in the critical metals Te, Bi, As and Co (Table 4, Figure 13, Figure 14 and Figure 16). Tellurium ranges from 0.8-6.7 ppm (average: 4.1 ppm, median: 4.8 ppm), while Bi contents range from 1.8-7.9 ppm (average: 4.9 ppm, median: 5.9 ppm). The As values range from 24-49 ppm (average: 33 ppm, median: 29 ppm) and the Co contents range from 43-363 ppm (average: 172 ppm, median: 74 ppm). The contents of Te, Bi and Co appear to increase with depth, from around 2.0 up to 6.7 ppm Te, 2.7 up to 7.5 ppm Bi, and 50 up to 340 ppm Co (Figure 18). The As content does not vary significantly with depth.

4.1.1.3 Tailings facies

As previously mentioned, during sampling the tailings were logged and facies were defined based on particle size and colour. The facies were later refined and correlated across the auger holes. In total, six facies have been assigned, with four in TSF1 and two in TSF2, a detailed Table 5.

Table 5. Summary and description of the tailings facies.

Facies	Description	n	TSF
A	Fine to medium sand, pale brown-grey to red-orange, some hardpan, oxidised tailings	5	TSF1
B	Interlayering of blue-black to pink-brown clay and pale to dark brown-grey sand, clay dominant	9	TSF1
C	Interlayering of blue-black to pink-brown clay and pale to dark brown-grey sand, sand dominant	13	TSF1
D	Pale blue-grey to white sand, interlayering with dark blue-grey to brown clay	7	TSF1
E	Red clay, some sand content; occasionally oxidised	4	TSF2
F	Black-blue clay and fine sand, grading to blue-grey sand	3	TSF2

The geochemical results of the tailings facies will be presented briefly herein. Box plots of the enriched strategic and critical metals in the tailings facies are shown in Figure 19, where some variability can be observed. As previously stated, the TSF2 samples generally have higher average concentrations most enriched strategic and critical metals, while the TSF1 samples are more enriched in Mo, U, W and REEs (Figure 14, Figure 15). This can be seen with the facies in TSF2, particularly facies F, which is most enriched in Au, Cu, Te, Ag, Bi and Co. Facies F may represent the Elverdton tailings in TSF2, underlying the distinctive red-coloured Kundip tailings (facies E), but is significantly more enriched than the other Elverdton tailings facies.

The TSF1 facies have similar contents of Ce, La, Mo, U and W, while facies B is more enriched in the other strategic and critical metals than the other facies. This suggests that these metals may be more concentrated in the fine grain size fractions, with facies B being clay-dominated and facies C and D being sand-dominated. The facies A samples are near-surface samples where tailings are at least partially oxidised, and the lower metal contents of facies A may be related to leaching of metals in this zone.

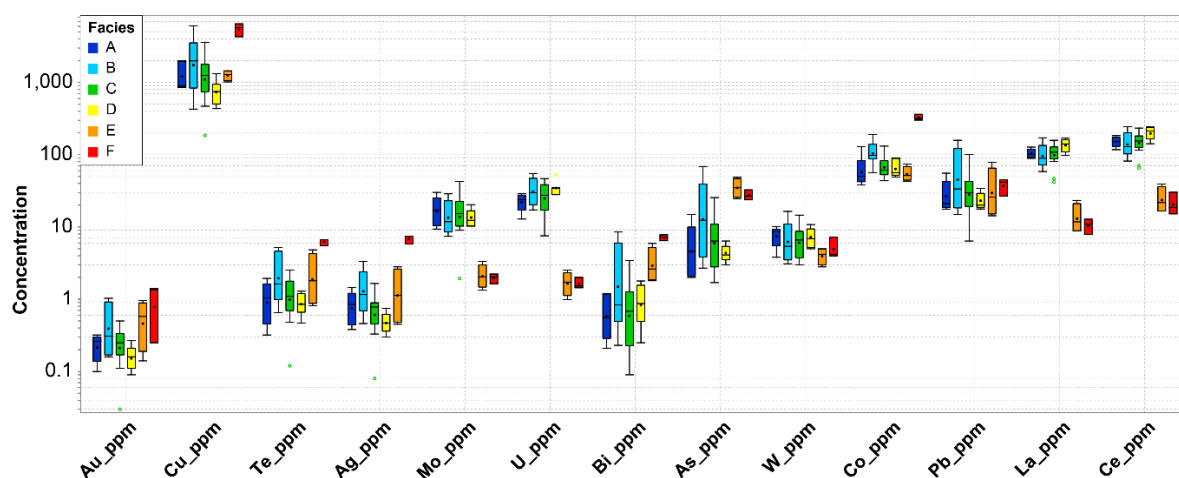


Figure 19. Box plot for enriched critical and strategic elements in the auger tailings samples, categorised by facies: A (n = 54), B (n = 9), C (n = 13), D (n = 7), E (n = 4), F (n = 3).

4.1.1.4 Tailings in fan

Fifteen tailings samples were collected across the tailings fan formed from the erosion of the TSFs (Figure 10). In general, the tailings fan samples have a very similar geochemical composition to the TSF1 samples and are likely to be mostly derived from these tailings. Some variations can be seen, with higher Se contents in the tailings fan and slightly lower values of many of the other elements (Figure 14).

The tailings fan samples are enriched in Cu, Pb, Ag and Au relative to average crustal abundance (Table 4, Figure 13, Figure 14 and Figure 16). The concentrations of the enriched elements in the tailings fan samples are also plotted in Figure 20. Copper ranges from 497-3,340 ppm (average: 1,258 ppm, median: 987 ppm). The Pb and Ag values are fairly low, with Pb ranging from 13-45 ppm (average: 23 ppm, median: 18 ppm) and Ag ranging from 0.1-1.5 ppm (average: 0.7 ppm, median: 0.6 ppm). The Au contents range up to 0.7 ppm (average and median: 0.3 ppm).

The tailings fan samples are also enriched in the critical metals Te, Se, Mo, As, W, Co and Bi, to varying degrees (Table 4, Figure 13-Figure 16 and Figure 20). Tellurium ranges from 0.5-1.5 ppm (average: 1.3 ppm, median: 1.0 ppm), while Bi values range from 0.1-8.5 ppm (average and median: 0.8 ppm). The Se contents range from 1-3 ppm (average: 1.4 ppm, median: 1.0 ppm) and Mo ranges from 8.8 ppm-51 ppm (average: 22 ppm, median: 19 ppm). Arsenic values range from 3.6-12 ppm (average: 6.6 ppm, median: 5.5 ppm) and W ranges from 2.7-8.5 ppm (average: 4.8 ppm, median: 4.7 ppm). Cobalt has the highest concentrations of the critical metals, ranging from 27-196 ppm (average: 67 ppm, median: 53 ppm).

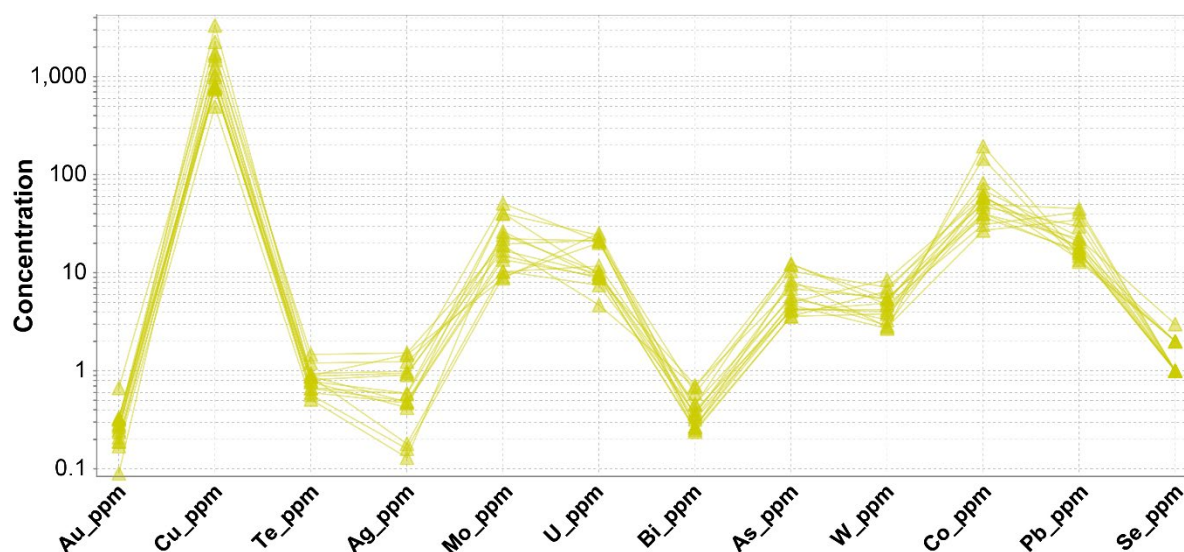


Figure 20. Concentrations of the most enriched elements in the tailings fan (n = 15) samples.

To investigate the variations in tailings chemistry with distance from TSF, bivariate plots of selected elements against distance are plotted in Figure 21. Some elements tend to increase further along the fan, with high values in the tailings deposited in the Steere River channel, including Cu, Co and Te (Figure 21.A-C). The trend is most apparent with the Co contents. In contrast, other elements, such as Mo, Pb and Ce, are higher and more variable nearer to the TSFs, and have significantly lower contents in the samples from the Steere River (Figure 21.D-F). These variations are likely influenced by the element mobility and the depositional processes occurring during the erosion and re-deposition of the tailings in the fan.

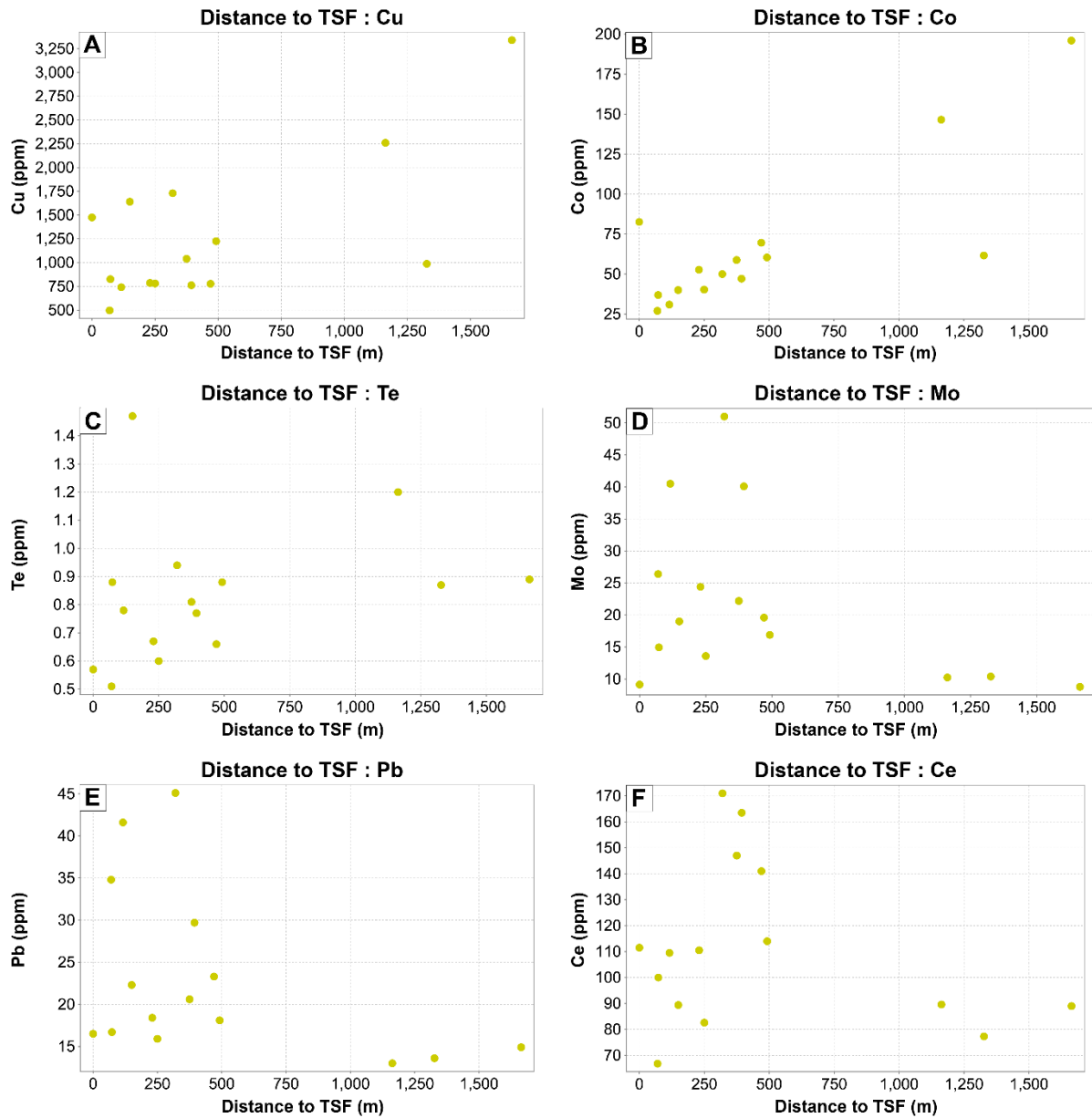


Figure 21. Bivariate plots of selected geochemical variables in the Elverdton tailings fan (n = 15), against the distance to the TSF which increases along the tailings fan and the Steere River; Distance to TSF (m) vs: A. Cu (ppm); B. Co (ppm); C. Te (ppm); D. Mo (ppm); E. Pb (ppm); F. Ce (ppm).

4.1.2 Hardpan and salt analysis

Hardpans are formed in the oxidation zone of tailings through the reactions of sulphide minerals and the accumulation of secondary phases (e.g., iron oxides and oxyhydroxides, gypsum, and sulphate phases), creating a margin of cemented and agglomerated grains with low porosity (e.g., Elghali et al., 2019; Graupner et al., 2007). Such secondary phases may preferentially host large amounts of metals, such as Fe, Cu, Zn, Pb and As, higher than that of the fresh tailings (e.g., Lottermoser and Ashley, 2006; Parviainen, 2009). Hardpans were found in various locations across the TSFs and the eroded tailings fan (Figure 7.C, Figure 8.E-F, Figure 10, Figure 11.F), and were sampled to investigate their metal contents. The salt samples comprise secondary efflorescent salts (Figure 9.G-H, Figure 10, Figure 11.G) that form in semi-arid to arid conditions, through sulphide oxidation reactions. Efflorescent salts formed on tailings are commonly found to be enriched in metals such as Cu, Pb, Zn, As, Co, Ni, Mn and Fe (Loredo-Jasso et al., 2021; Maya et al., 2015; Nieva et al., 2021; Rodríguez-Pacheco et al., 2022).

The hardpan and salt samples have variable compositions, with some elements enriched and some depleted relative to the tailings samples (Figure 14). The geochemical results for the hardpan and salt sample are presented with a line graph, as seen in Figure 22. The summary statistics are provided in Table 4. Although the mean and median values are provided in Table 4, only the range of values will be discussed herein due to the low number of hardpan and salt samples collected.

The hardpan samples are enriched in Te, Bi and As relative to TSF1, and Au and Se compared to all tailings samples (Figure 14, Figure 22, Table 4). The Te values range from 0.7-2.7 ppm, while the Bi contents range from 0.8-1.4 ppm and As ranges from 10-26 ppm. The Au and Se contents range from 0.4-1.6 ppm and 1-6 ppm, respectively, with the maximum Au and Se values seen at Elverdton. Furthermore, contents of up to 3,320 ppm Cu and 147 ppm Co occur in the hardpans.

The salt samples are enriched in As relative to TSF1, and Cu, Co and U compared to all tailings samples (Figure 14, Figure 22, Table 4). The As values range from 4-52 ppm, while the Cu contents range from 768-7,390 ppm, the highest Cu concentration from the Elverdton samples. The Co contents range from 40 up to 940 ppm and the U contents range from 1.8-149 ppm, with the maximum Co and U contents at Elverdton. The salt samples have low contents of Au, ranging from 0.1-0.2 ppm, and Ag, ranging from 0.6-1.0 ppm.

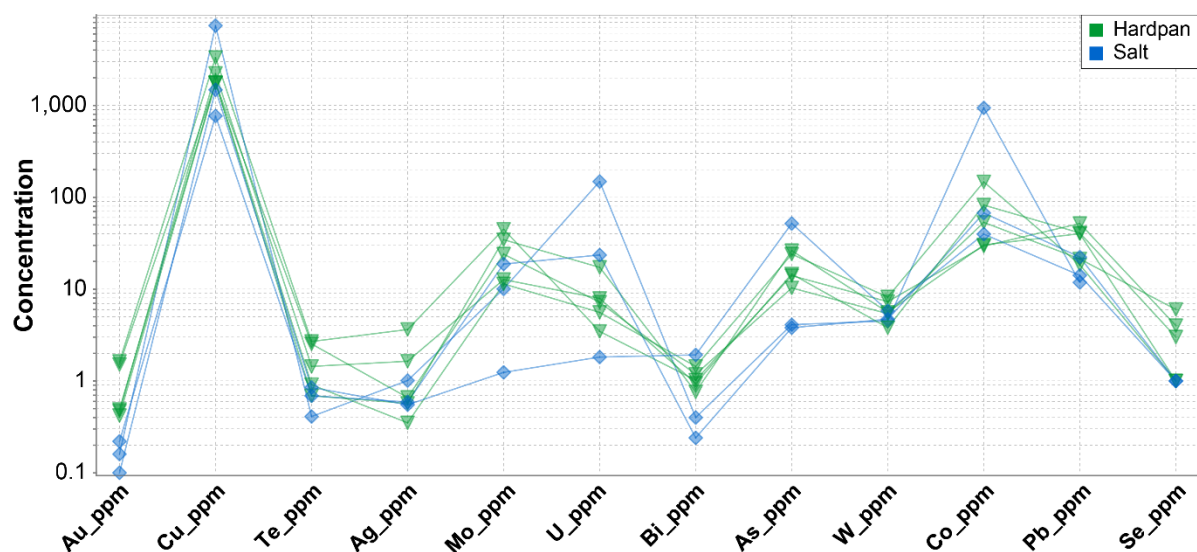


Figure 22. Concentrations of the most enriched elements in the hardpan (n = 5) and salt (n = 3) samples.

4.1.3 Spatial distribution

Maps illustrating the spatial distribution of the enriched base and precious metals Cu, Pb, Au and Ag are provided in Figure 23 to Figure 26. Further maps of the spatial distribution of the critical metals Te, Bi, As, Co, Mo, W, Ce and La are shown in Figure 27 to Figure 34. The maps aim to highlight the spatial variations in the contents of these elements across the site, in TSF1, TSF2, the tailings fan, and differences between the tailings, hardpan and salt samples.

The spatial distributions of Cu, Pb, Bi and Co are similar, with the highest values usually seen in TSF2, and in the north and west parts of TSF1 (Figure 23, Figure 24, Figure 28, Figure 30). Copper and Co are particularly high in the salt samples at base of TSF1. Gold, Ag and Te are higher in TSF2 in general, with some moderate values in the north west of TSF1, but high values also occur in hardpans at the top of TSF1 and in the tailings fan sediment trap to the east of TSF2 (Figure 25, Figure 26). The highest As values occur in the auger holes on the west edge of TSF1 and in TSF2, with a significant As content also found in a salt sample in the Steere River.

Molybdenum, W, Ce and La follow different spatial distributions, typically being more enriched in TSF1 with much lower values in TSF2 (Figure 31 to Figure 34). The Mo values are also much higher and more variable across the tailings fan, whereas the other elements have lower contents in the tailings fan. Tungsten, Ce and La also show some moderate values in the tailings fan.

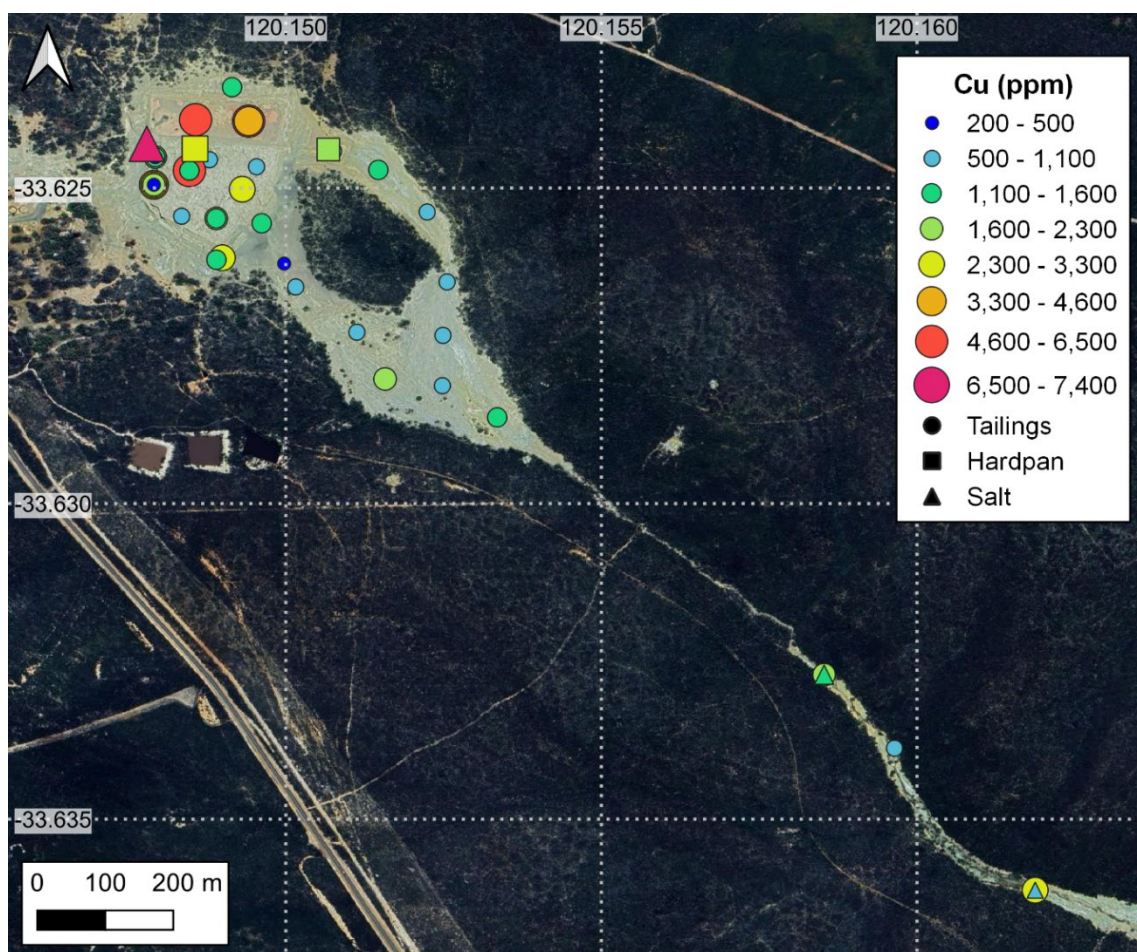


Figure 23. Spatial distribution of Cu (ppm) in the Elverdton samples. Satellite image from Google Earth.

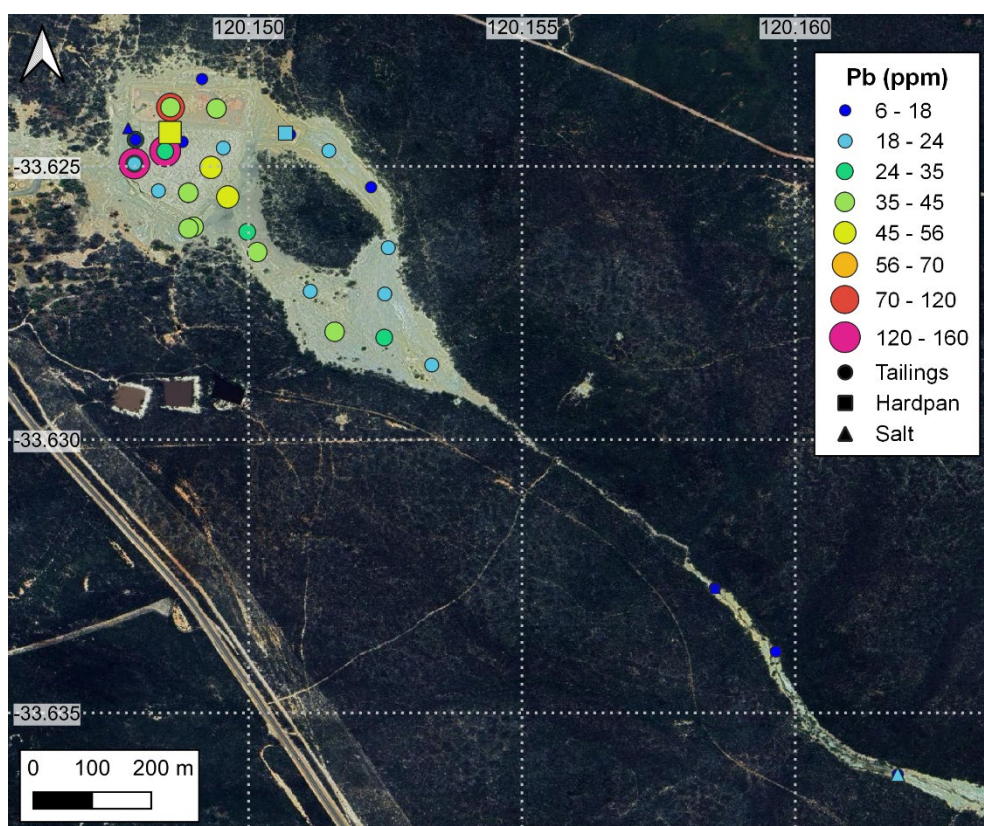


Figure 24. Spatial distribution of Pb (ppm) in the Elverdton samples. Satellite image from Google Earth.

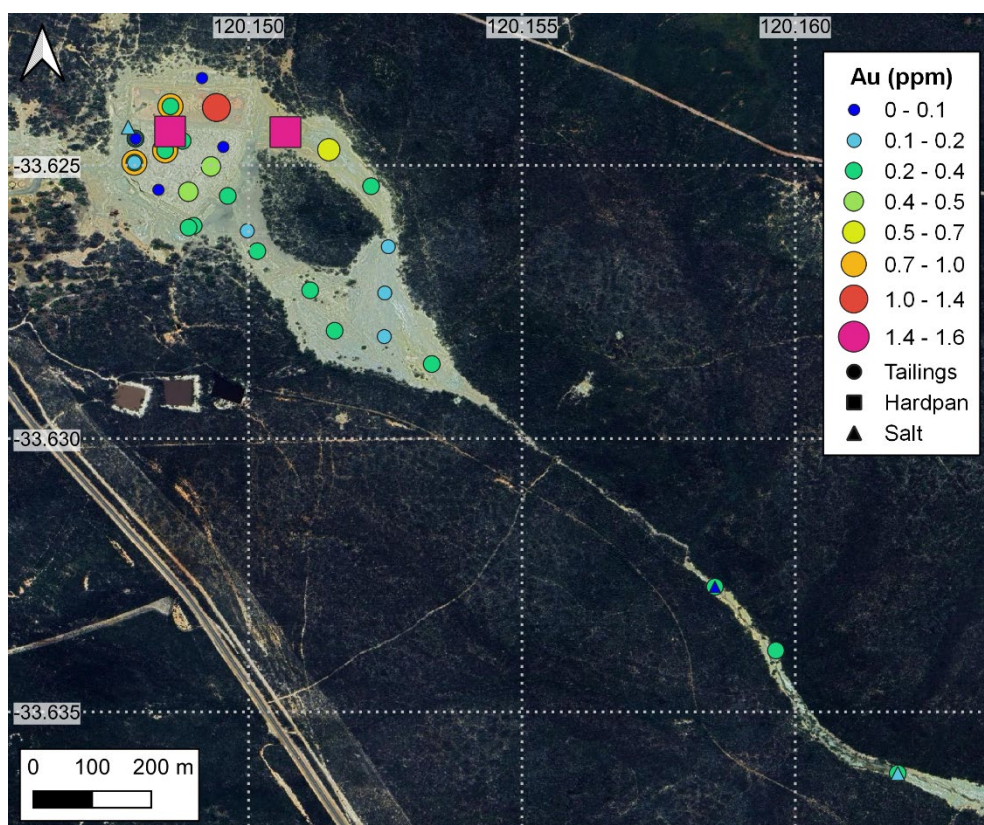


Figure 25. Spatial distribution of Au (ppm) in the Elverdton samples. Satellite image from Google Earth.

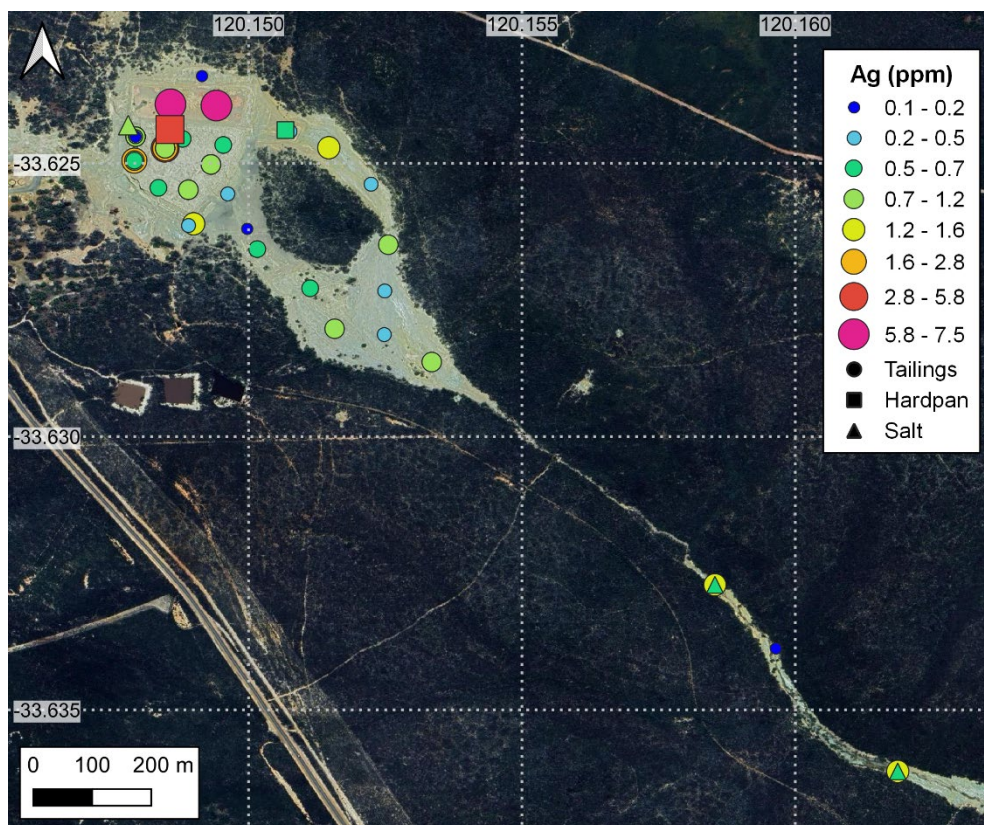


Figure 26. Spatial distribution of Ag (ppm) in the Elverdton samples. Satellite image from Google Earth.

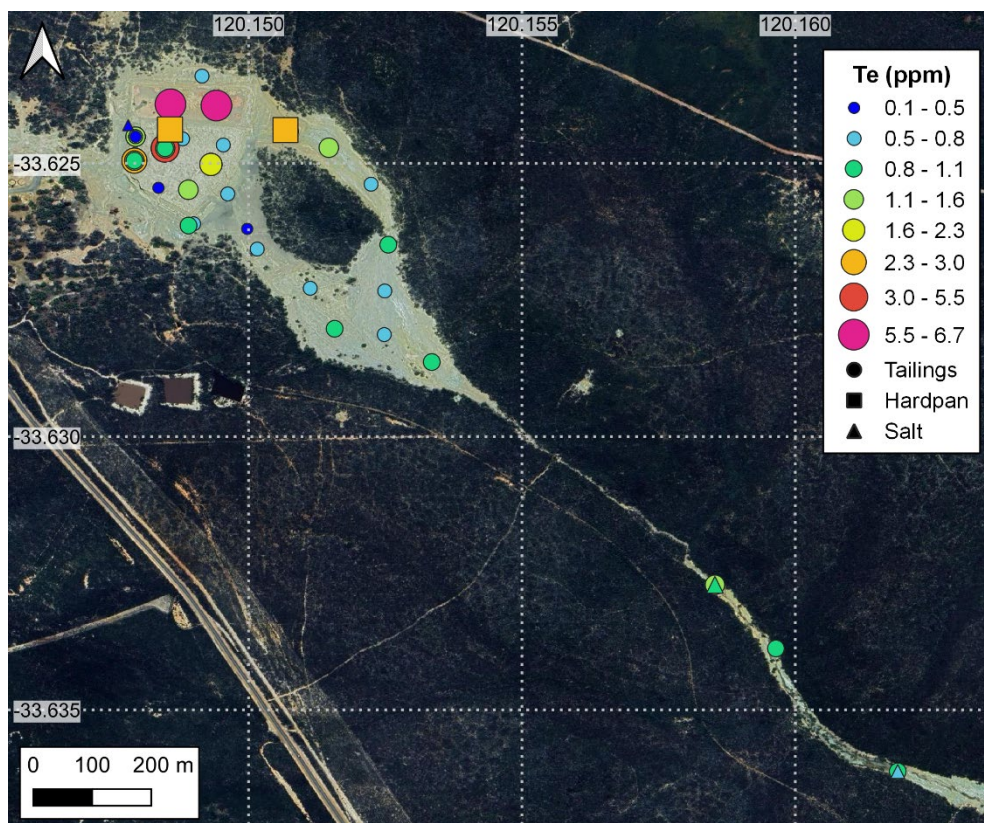


Figure 27. Spatial distribution of Te (ppm) in the Elverdton samples. Satellite image from Google Earth.

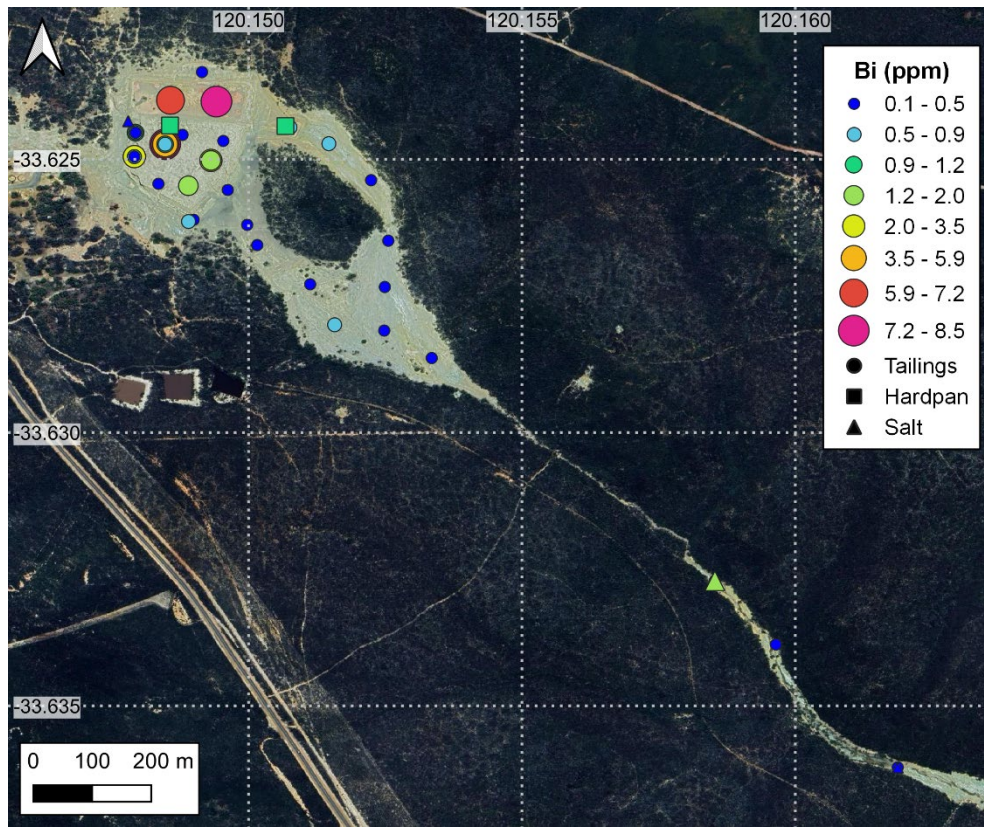


Figure 28. Spatial distribution of Bi (ppm) in the Elverdton samples. Satellite image from Google Earth.

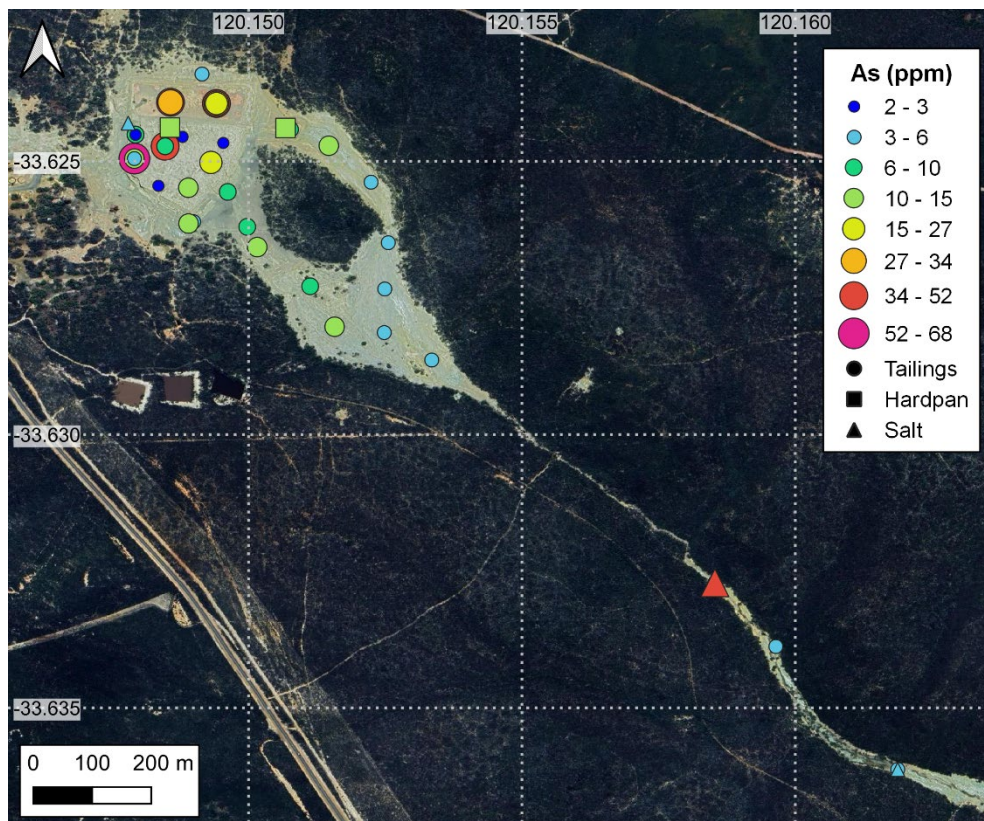


Figure 29. Spatial distribution of As (ppm) in the Elverdton samples. Satellite image from Google Earth.

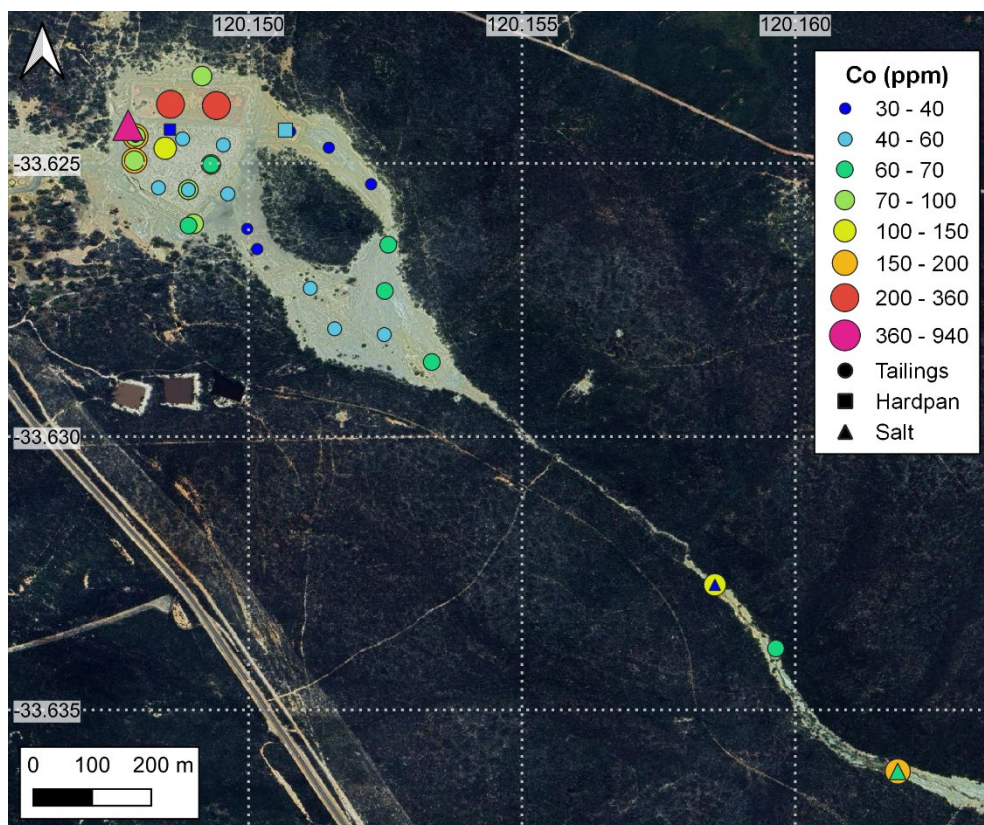


Figure 30. Spatial distribution of Co (ppm) in the Elverdton samples. Satellite image from Google Earth.

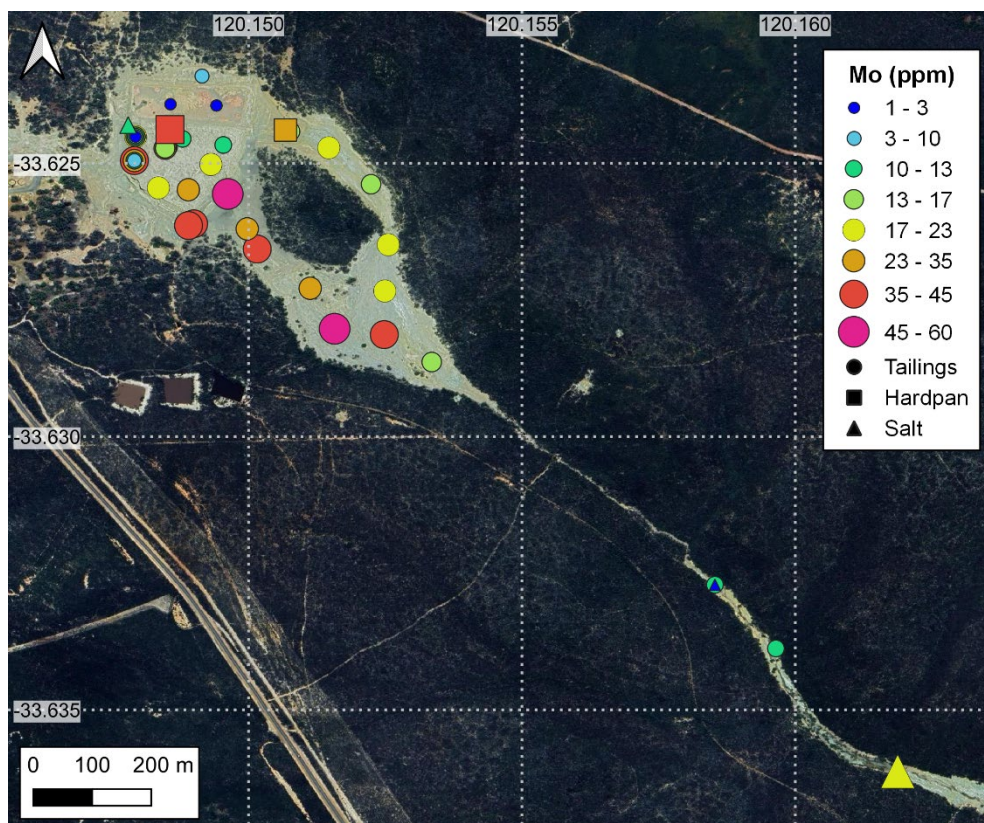


Figure 31. Spatial distribution of Mo (ppm) in the Elverdton samples. Satellite image from Google Earth.

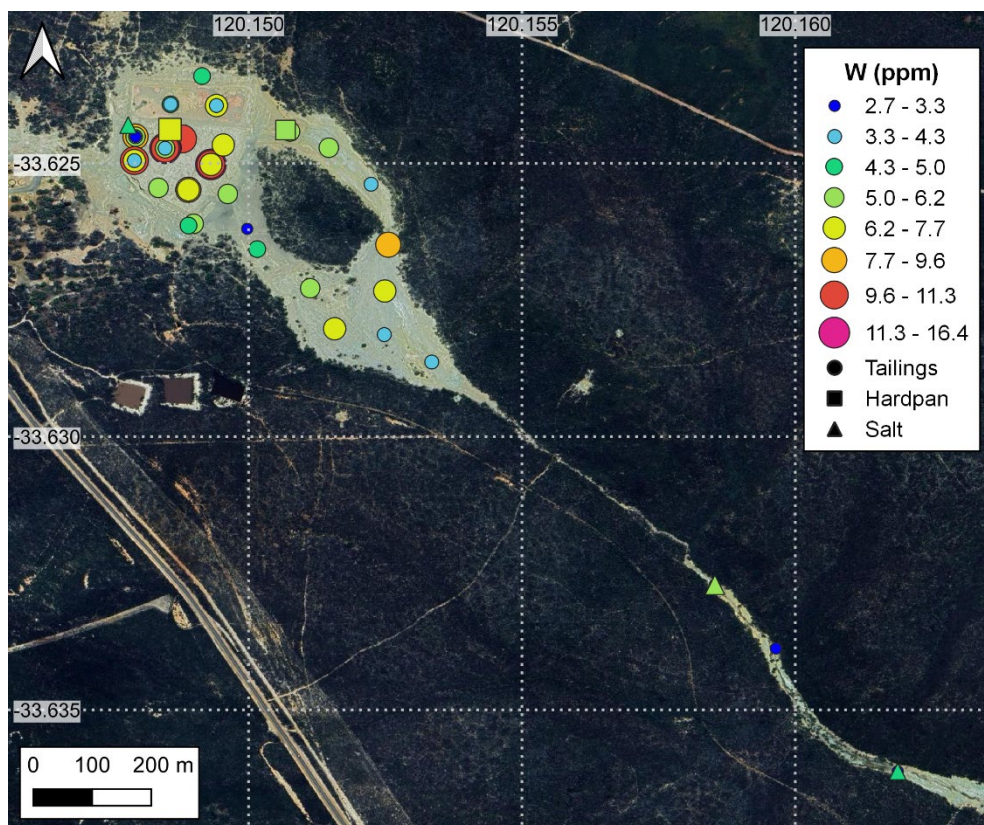


Figure 32. Spatial distribution of W (ppm) in the Elverdton samples. Satellite image from Google Earth.

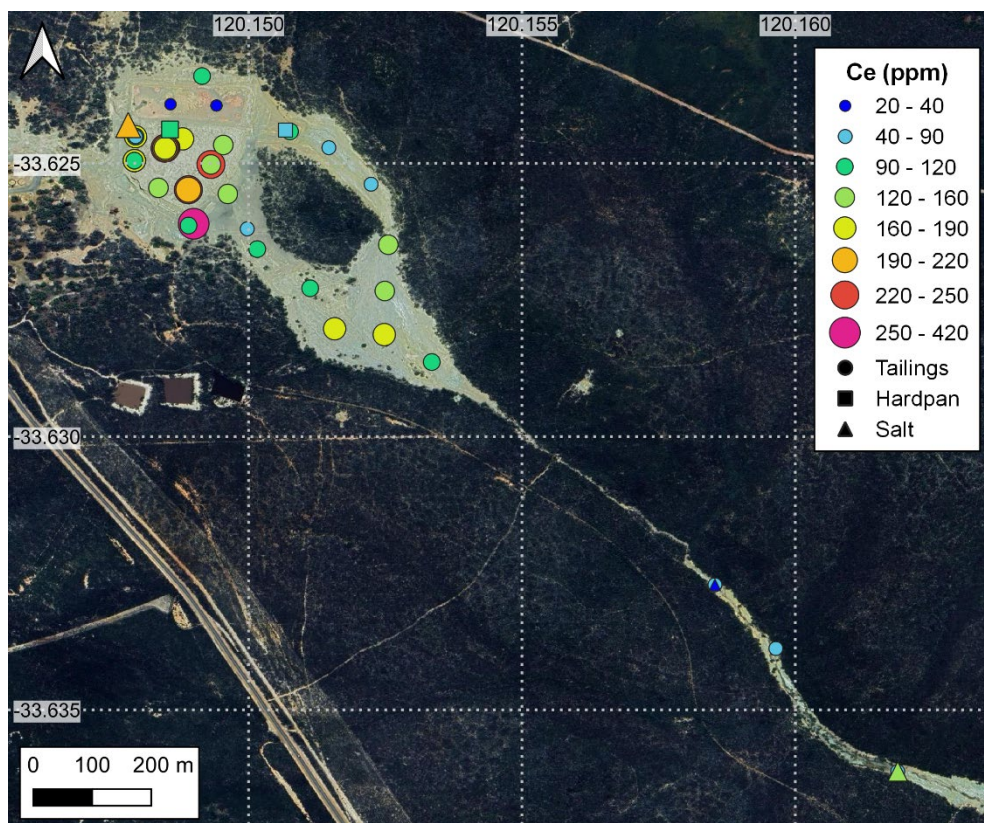


Figure 33. Spatial distribution of Ce (ppm) in the Elverdton samples. Satellite image from Google Earth.

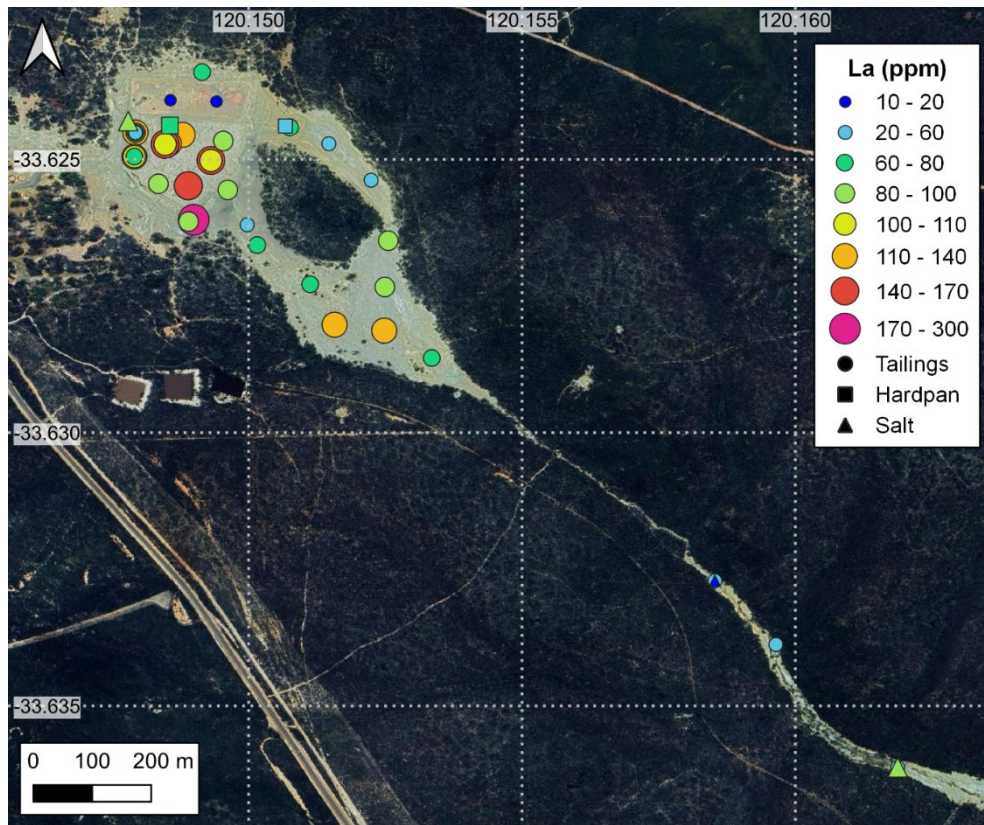


Figure 34. Spatial distribution of La (ppm) in the Elverdton samples. Satellite image from Google Earth.

4.1.4 *Element correlations*

Elemental correlations of the geochemical data are presents in Table 6 for the sulphide-associated and chalcophile elements and Table 7 for the more lithophile and siderophile elements. The correlations were calculated for all samples given that there were insufficient numbers of samples for TSF2 and the hardpan and salt samples to calculate correlations separately. Bivariant plots of selected pairs of elements which show strong correlations are seen in Figure 35 and Figure 36.

Gold is correlated with a range of elements (Table 6), including Te (0.72, Figure 35.A), As (0.68), Ag (0.65), Bi (0.59), Cu (0.55) and Pb (0.54). Gold is also correlated with Fe (0.57) and S to some extent (0.47). This implies an association of Au with sulphide mineralisation, which agrees with the chalcopyrite-gold-pyrite-magnetite(-pyrrhotite-ilmenite)-quartz association at Elverdton (Low, 1963; Marston, 1979). Silver is strongly correlated with Te (0.76, Figure 35.B) and Cu (0.70, Figure 35.C) in particular, as well as Pb (0.58), Fe (0.57), Bi (0.56), As (0.51) and Se (0.50). Rare silver-bismuth tellurides occur in the Elverdton deposit (Low, 1963; Marston, 1979), which may partly explain the Ag-Bi-Te correlation, with Te and Bi also strongly correlated (0.84, Figure 35.D). Bismuth is also strongly correlated with As (0.81, Figure 35.E), as well as Cu (0.56) and Pb (0.58), while As is correlated with Cu (0.61) and Pb (0.55, Figure 35.F). Most elements are correlated with Fe and S to some extent, suggesting that they are hosted by sulphide minerals, with Co having a correlation of 0.62 with S (Figure 35.F).

Table 6. Correlation matrix of bulk geochemical assay for sulphide-associated and chalcophile elements in the Elverdton samples, calculated using Spearman correlation with log-transformed data.

	Au_ppm	Cu_ppm	Te_ppm	Se_ppm	Ag_ppm	Bi_ppm	As_ppm	Co_ppm	Pb_ppm	Fe_pct	S_pct
Au_ppm	1										
Cu_ppm	0.55	1									
Te_ppm	0.72	0.59	1								
Se_ppm	0.48	0.55	0.49	1							
Ag_ppm	0.65	0.70	0.76	0.50	1						
Bi_ppm	0.59	0.56	0.84	0.20	0.56	1					
As_ppm	0.68	0.61	0.72	0.31	0.51	0.81	1				
Co_ppm	0.11	0.38	0.31	0.25	0.33	0.16	0.09	1			
Pb_ppm	0.54	0.41	0.61	0.16	0.58	0.55	0.55	-0.00	1		
Fe_pct	0.57	0.52	0.60	0.63	0.57	0.38	0.44	0.38	0.18	1	
S_pct	0.47	0.43	0.44	0.47	0.42	0.20	0.32	0.62	-0.05	0.67	1

Molybdenum does not correlate with the sulphide-associated elements, and instead is more associated with other siderophile and lithophile elements, including U (0.38, Figure 35.H) and more so Ce (0.48), La (0.44) and P (0.45) (Table 7).

Lanthanum and Ce are strongly correlated, as could be expected, with a correlation coefficient of 0.98 (Figure 36.A). To investigate the potential mineral hosts of the REEs, the correlations of Ce and La with P and Ca were investigated (monazite and apatite), and Mg, Al, Fe, Ti, Ca and Zr (garnet and zircon). Weak correlations are observed with Ca, at 0.32 for La (Figure 36.B) and 0.35 for Ce (Figure 36.C). The correlations of La and Ce with P are strong (Figure 36.D,E), at 0.69 and 0.74, which implies that the REEs are hosted by monazite and by apatite to some extent. No correlation was observed with Fe, Ti and Zr, while weak to moderate correlations are seen with Al and Mg, which may infer that Ce and La are partially hosted by Al-Mg garnet (pyrope) (Table 7).

Uranium is well correlated with La (0.83), Ce (0.81) and P (0.57), which may indicate that U predominantly occurs in monazite. Tungsten has a slight correlation with Ca (0.35) which may indicate presence of some scheelite, as well as wolframite. Tungsten is also correlated with La and Ce (both 0.59), which may indicate an associations of REE-bearing and W-bearing phases originating from the local country rock.

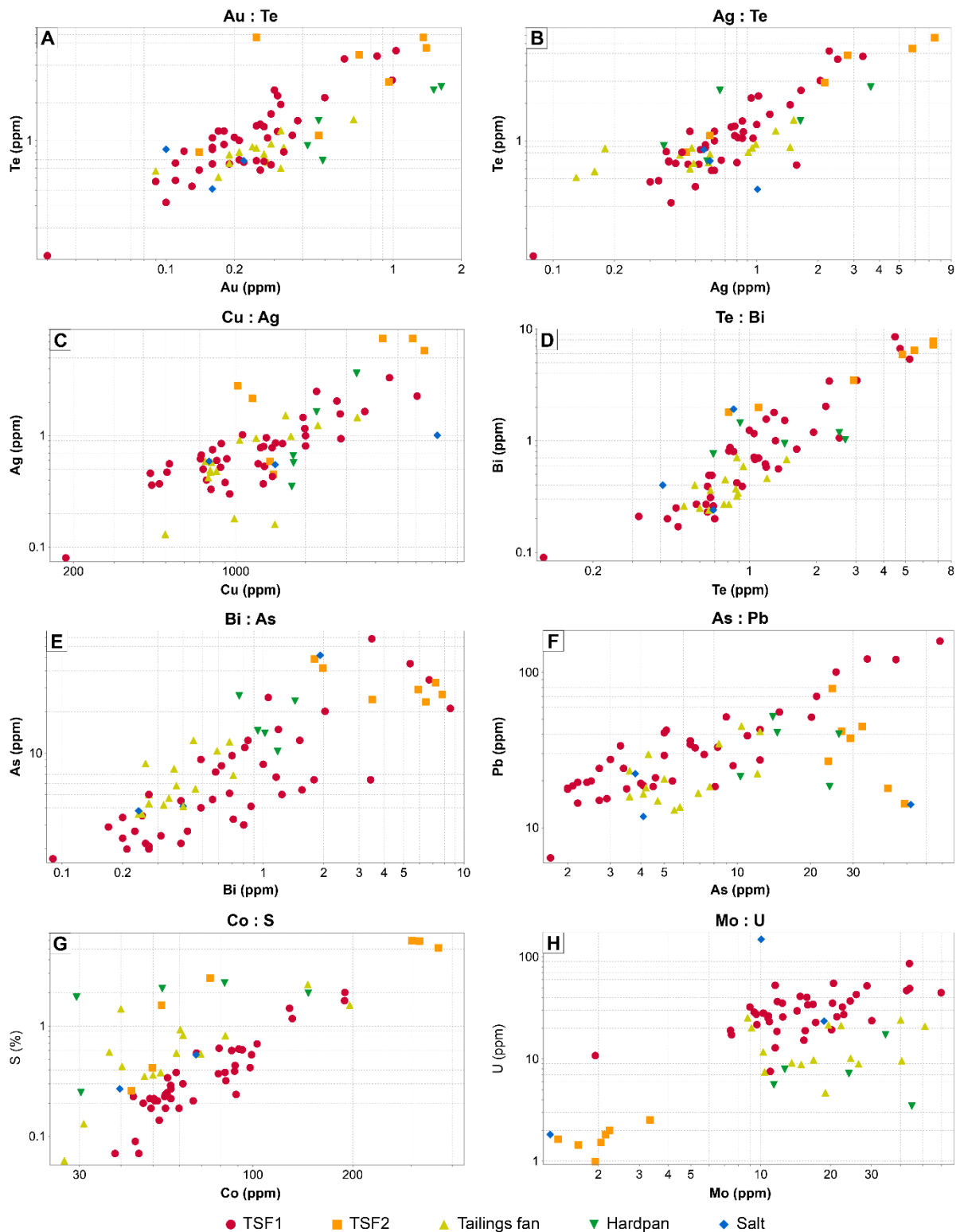


Figure 35. Bivariate plots for Elverdton samples; A. Au (ppm) vs Te (ppm); B. Ag (ppm) vs Te (ppm); C. Cu (ppm) vs Ag (ppm); D. Te (ppm) vs Bi (ppm); E. Bi (ppm) vs As (ppm); F. As (ppm) vs Pb (ppm); G. Co (ppm) vs S (%); H. Mo (ppm) vs U (ppm).

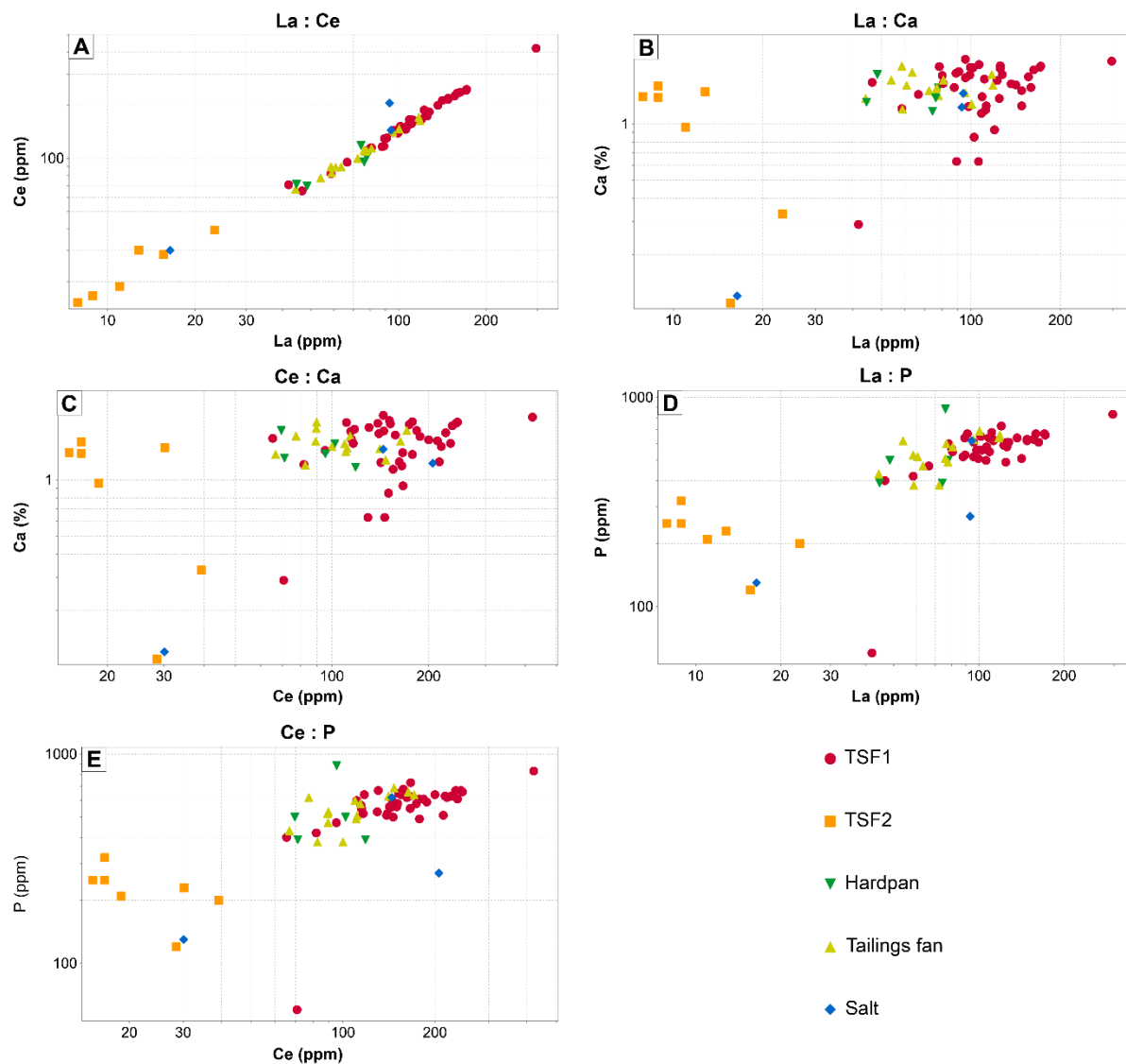


Figure 36. Bivariate plots for Elverdton samples; A. La (ppm) vs Ce (ppm); B. La (ppm) vs Ca (ppt); C. Ce (ppm) vs Ca (ppt); D. La (ppm) vs P (ppm); E. Ce (ppm) vs P (ppm).

Table 7. Correlation matrix of bulk geochemical assay more lithophile and siderophile elements in the Elverdton samples, calculated using Spearman correlation with log-transformed data.

	Mo_ppm	U_ppm	W_ppm	Ca_pct	Mg_pct	Al_pct	P_ppm	La_ppm	Ce_ppm
Mo_ppm	1								
U_ppm	0.38	1							
W_ppm	0.20	0.33	1						
Ca_pct	0.15	0.22	0.35	1					
Mg_pct	-0.03	0.61	0.13	-0.05	1				
Al_pct	-0.11	0.38	0.35	-0.02	0.48	1			
P_ppm	0.55	0.57	0.37	0.42	0.39	0.18	1		
La_ppm	0.44	0.83	0.59	0.32	0.51	0.33	0.69	1	
Ce_ppm	0.48	0.81	0.59	0.35	0.49	0.37	0.74	0.98	1

4.2 Mineralogy

4.2.1 Bulk mineralogy

The bulk mineralogy of 10 selected samples was measured with XRD, including tailings samples from TSF1 (n = 4), TSF2 (n = 2) and the tailings fan (n = 1), as well as two hardpan samples and one salt sample. The tailings samples selected were from facies B and F, the most enriched facies. The results for the tailings samples are shown in Figure 37 and for the hardpan and salt samples in Figure 38. In addition, the summary statistics of modal abundances are presented in Table 8 for the tailings samples and Table 9 for the hardpan and salt samples. The full results for the XRD analyses are provided in Appendix D.

The tailings samples are dominated by quartz, chlorite, plagioclase, amorphous phases, mica and amphibole (Table 8). The quartz contents range from 22.4-34.8 wt. % (average: 27.5 wt. %), chlorite from 6.8-33.8 wt. % (average: 20.1 wt. %), plagioclase from 2.5-21.1 wt. % (average: 11.5 wt. %) and amorphous phases from 14.0-26.1 wt. % (average: 20.9 wt. %). Other abundant minerals include mica (range: 3.8-12.6 wt. %), amphibole (up to 13.0 wt. %), K-feldspar (up to 1.8 wt. %) and kaolinite (up to 2.6 wt. %). The sulphide minerals pyrite and chalcopyrite were identified, at up to 8.5 wt. % and 1.0 wt. %, respectively. Magnetite (up to 1.8 wt. %), hematite (up to 0.8 wt. %) and goethite (up to 2.3 wt. %) also occur, as well as secondary phases halite (up to 2.0 wt. %), gypsum (up to 1.3 wt. %), bassanite (up to 3.0 wt. %) and jarosite (up to 3.7 wt. %). The pyralspite garnet group was identified, at up to 0.7 wt. %, corroborating the geochemical results which suggested that REEs may partly occur in Al-Mg garnet (pyrope).

Variations can be seen between the composition of the TSF1 and TSF2 tailings, with the tailings fan sample (in the Steere River) having a similar composition to the TSF1 samples (Figure 37). In general, the TSF1 samples have higher plagioclase, amphibole, chlorite, K-feldspar, magnetite and goethite contents, while the TSF2 samples are more abundant in quartz, mica and pyrite. The pyrite contents in the TSF2 samples are 2.6-4.4 wt. %, and negligible in TSF1, confirming the geochemical results showing significantly higher S contents in TSF2.

The hardpan samples (Table 9, Figure 38) have high contents of quartz (26.0-26.8 wt. %), plagioclase (11.5-22.0 wt. %), amphibole (10.7-19.1 wt. %), jarosite (10.2-10.3 wt. %) and amorphous phases (14.6-18.1 wt. %). They also contain chlorite (3.8-5.7 wt. %), mica (2.2-4.7 wt. %), magnetite (3.1-3.3 wt. %), goethite (up to 4.8 wt. %) and gypsum (up to 0.7 wt. %). The salt sample (Table 9, Figure 38) contains a range of abundant secondary phases, including bloedite (27.3 wt. %), hexahydrite (15.6 wt. %), starkeyite (3.5 wt. %), bassanite (1.2 wt. %), halite (0.9 wt. %), jarosite (0.7 wt. %), alunite and gypsum (each 0.1 wt. %). Residual contents of the tailings mineralogy remain, including quartz (15.5 wt. %), plagioclase (7.2 wt. %), chlorite (2.6 wt. %) and amphibole (2.5 wt. %), as well as 22.4 wt. % amorphous phases.

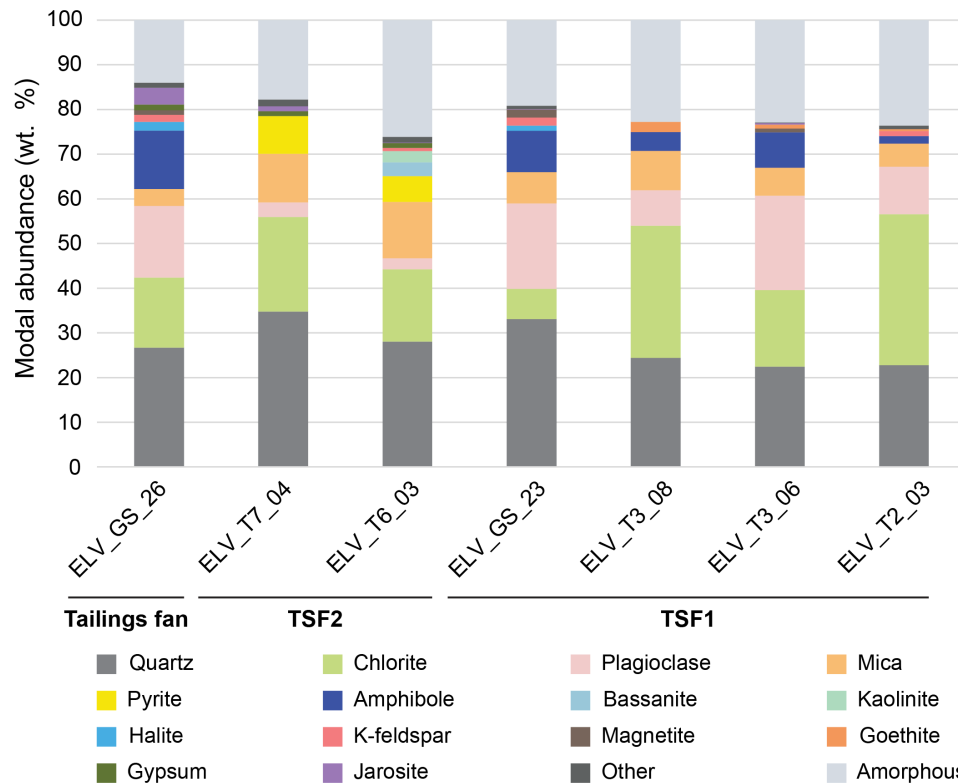


Figure 37. Modal mineralogy of selected Elverdton tailings samples, obtained by XRD (n = 7). Minerals with an average abundance of <1 wt. % are grouped as 'Other'.

Table 8. Summary statistics of the XRD mineralogy (wt. %) of the Elverdton tailings samples (n = 7). BDL = below detection limit.

Minerals	Formula	Minimum	Maximum	Average
Quartz	SiO ₂	22.4	34.8	27.5
Chlorite	(Mg,Fe) ₃ (Si,Al) ₄ O ₁₀ (OH) ₂ ·(Mg,Fe) ₃ (OH) ₆	6.8	33.8	20.1
Amorphous	-	14.0	26.1	20.9
Plagioclase	NaAlSi ₃ O ₈ – CaAl ₂ Si ₂ O ₈	2.5	21.1	11.5
Mica	(K,H ₃ O)(Al,Mg,Fe) ₂ (Si,Al) ₄ O ₁₀ [(OH) ₂ ·(H ₂ O)]	3.8	12.6	7.8
Pyrite	FeS ₂	BDL	8.5	2.0
Amphibole	(Mg, Fe, Ca) ₁₄ [(OH) ₄ Si ₁₆ O ₄₄]	BDL	13.0	5.2
Bassanite	2CaSO ₄ ·H ₂ O	BDL	3.0	0.4
Kaolinite	Al ₂ Si ₂ O ₅ (OH) ₄	BDL	2.6	0.4
Halite	NaCl	BDL	2.0	0.5
K-Feldspar	KAlSi ₃ O ₈	BDL	1.8	0.7
Magnetite	Fe ²⁺ Fe ³⁺ ₂ O ₄	BDL	1.8	0.5
Goethite	FeO(OH)	BDL	2.3	0.5
Gypsum	CaSO ₄ ·2H ₂ O	BDL	1.3	0.5
Jarosite	KFe ₃ (SO ₄) ₂ (OH) ₆	BDL	3.7	0.8
Hematite	Fe ₂ O ₃	BDL	0.8	0.1
Chalcopyrite	CuFeS ₂	BDL	1.0	0.2
Pyrralspite garnet	(Ca,Mg,Fe) ₃ (Al,Fe,Cr) ₂ (SiO ₄) ₃	BDL	0.7	0.2
Dolomite	CaMg(CO ₃) ₂	BDL	0.5	0.1
Calcite	CaCO ₃	BDL	0.1	0.0

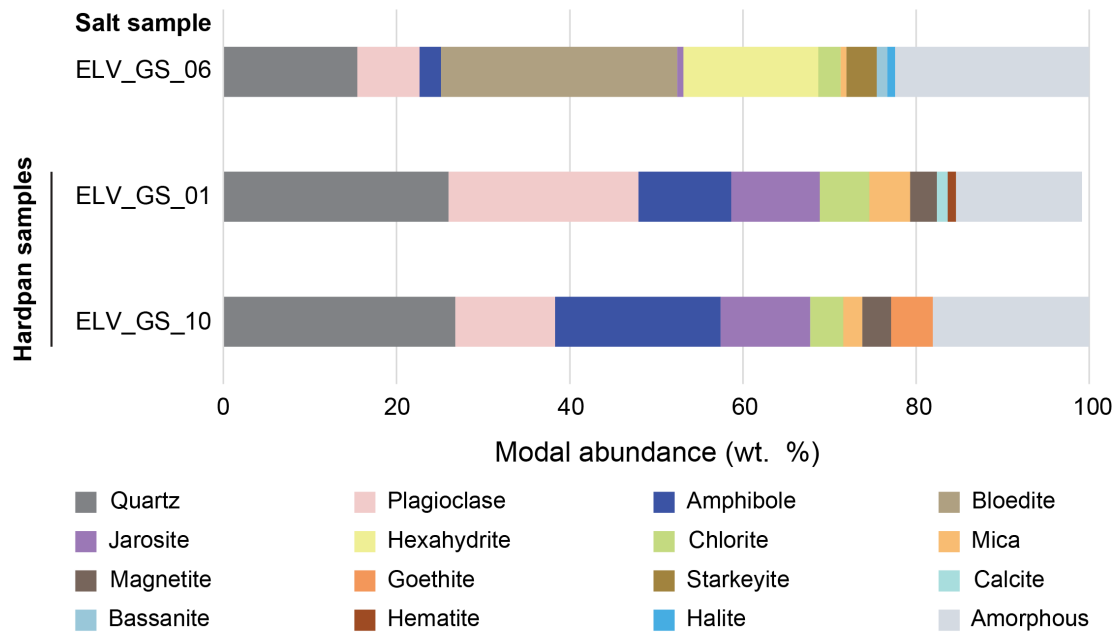


Figure 38. Modal mineralogy of selected Elverdton hardpan and salt samples, obtained by XRD (n = 3).

Table 9. Summary statistics of the XRD mineralogy (wt. %) of the Elverdton hardpan and salt samples (n = 3).
BDL = below detection limit.

Minerals	Formula	Hardpan		Salt
		Elv_GS_01	ELV_GS_10	ELV_GS_06
Quartz	SiO ₂	26.0	26.8	15.5
Amorphous	-	14.6	18.1	22.4
Plagioclase	NaAlSi ₃ O ₈ – CaAl ₂ Si ₂ O ₈	22.0	11.5	7.2
Amphibole	(Mg, Fe, Ca) ₁₄ [(OH) ₄ Si ₁₆ O ₄₄]	10.7	19.1	2.5
Bloedite	Na ₂ Mg(SO ₄) ₂ ·4H ₂ O	BDL	BDL	27.3
Jarosite	KFe ₃ (SO ₄) ₂ (OH) ₆	10.2	10.3	0.7
Hexahydrite	MgSO ₄ ·6(H ₂ O)	BDL	BDL	15.6
Chlorite	(Mg,Fe) ₃ (Si,Al) ₄ O ₁₀ (OH) ₂ ·(Mg,Fe) ₃ (OH) ₆	5.7	3.8	2.6
Mica	(K,H ₃ O)(Al,Mg,Fe) ₂ (Si,Al) ₄ O ₁₀ [(OH) ₂ ·(H ₂ O)]	4.7	2.2	0.7
Magnetite	Fe ²⁺ Fe ³⁺ ₂ O ₄	3.1	3.3	BDL
Goethite	FeO(OH)	BDL	4.8	BDL
Starkeyite	MgSO ₄ ·4(H ₂ O)	BDL	BDL	3.5
Calcite	CaCO ₃	1.3	BDL	BDL
Bassanite	2CaSO ₄ ·H ₂ O	BDL	BDL	1.2
Hematite	Fe ₂ O ₃	1.0	BDL	0.0
Halite	NaCl	BDL	BDL	0.9

4.2.2 In situ mineralogy

To complement observations by XRD and attempt to resolve the mineralogy of the amorphous phases, the same 10 samples were analysed with automated mineralogy liberation analysis (MLA). The corresponding MLA back-scattered electron (BSE) images and classified mineralogy map results are given in full in Appendix E.

Examples of the classified mineralogy map outputs and corresponding BSE images for a tailings sample from TSF1 is shown in Figure 39, a sample from TSF2 in Figure 40. The difference in the mineralogy is apparent, with high abundances of chlorite, quartz, plagioclase, biotite and muscovite in TSF1, and more abundant quartz, pyrite, pyrrhotite and chalcopyrite in TSF2. A hardpan sample is shown in Figure 41, with chalcopyrite, iron oxide, schwertmannite and jarosite present, and a salt sample in Figure 42 with abundant secondary sulphate phases (Mg-Na and Mg sulphate, gypsum) displaying a fine-grained and amorphous nature.

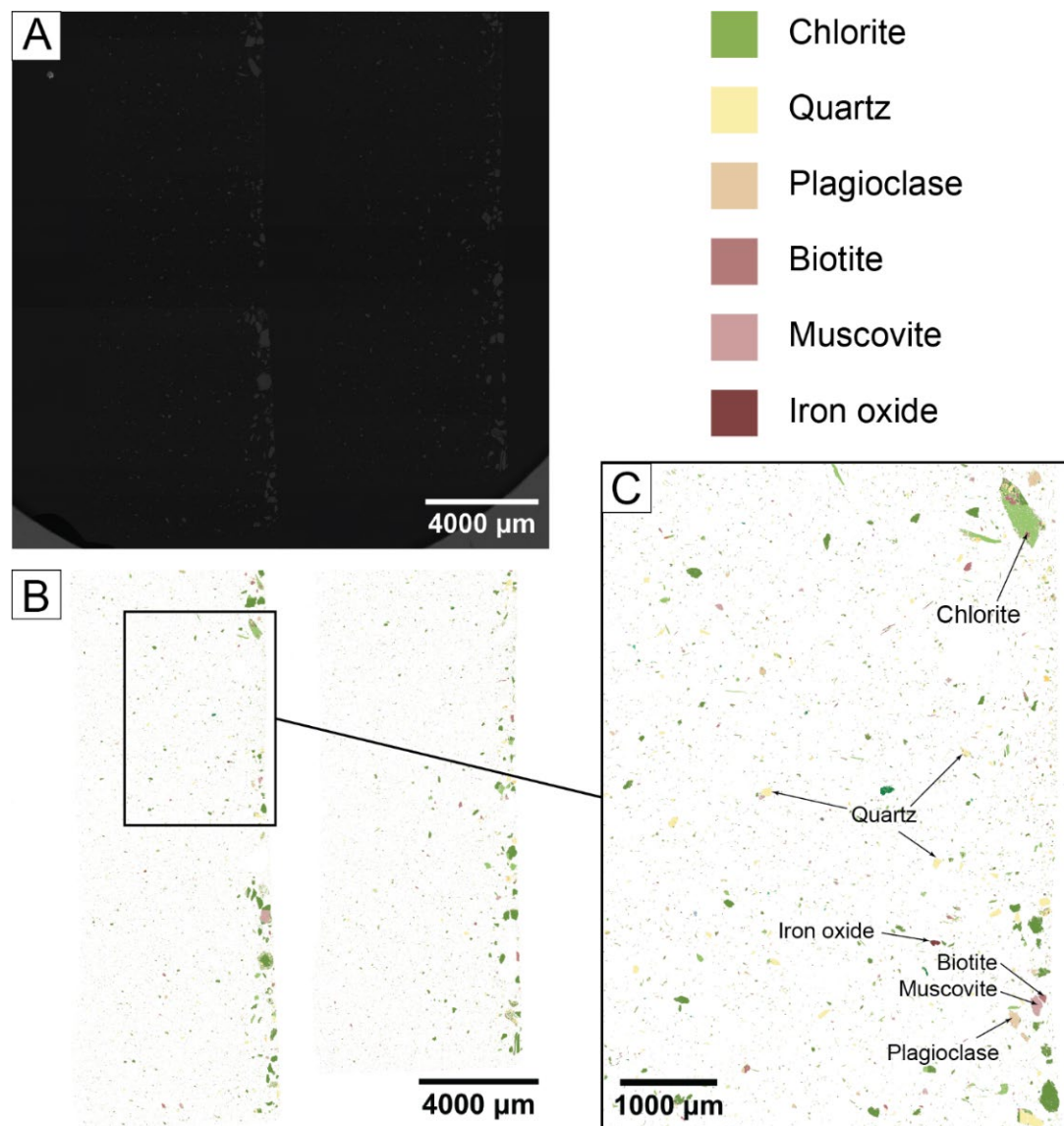


Figure 39. A. BSE and B. classified mineralogy image for ELV_T2_03 (TSF1) as reported by MLA, C. Zoom-in view to show the main mineralogy of the sample.

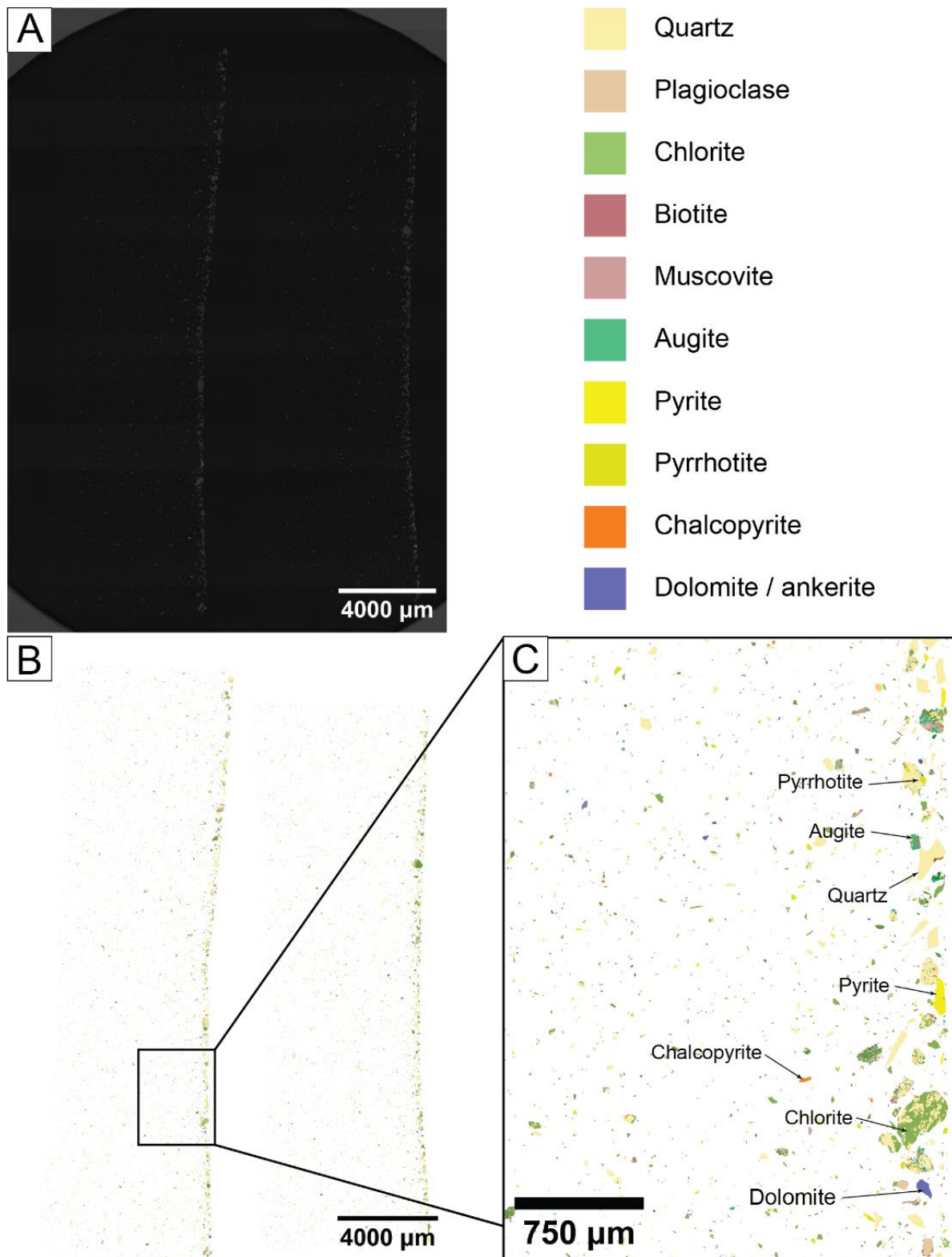


Figure 40. A. BSE and B. classified mineralogy image for ELV_T7_04 (TSF2) as reported by MLA, C. Zoom-in view to show the main mineralogy of the sample.

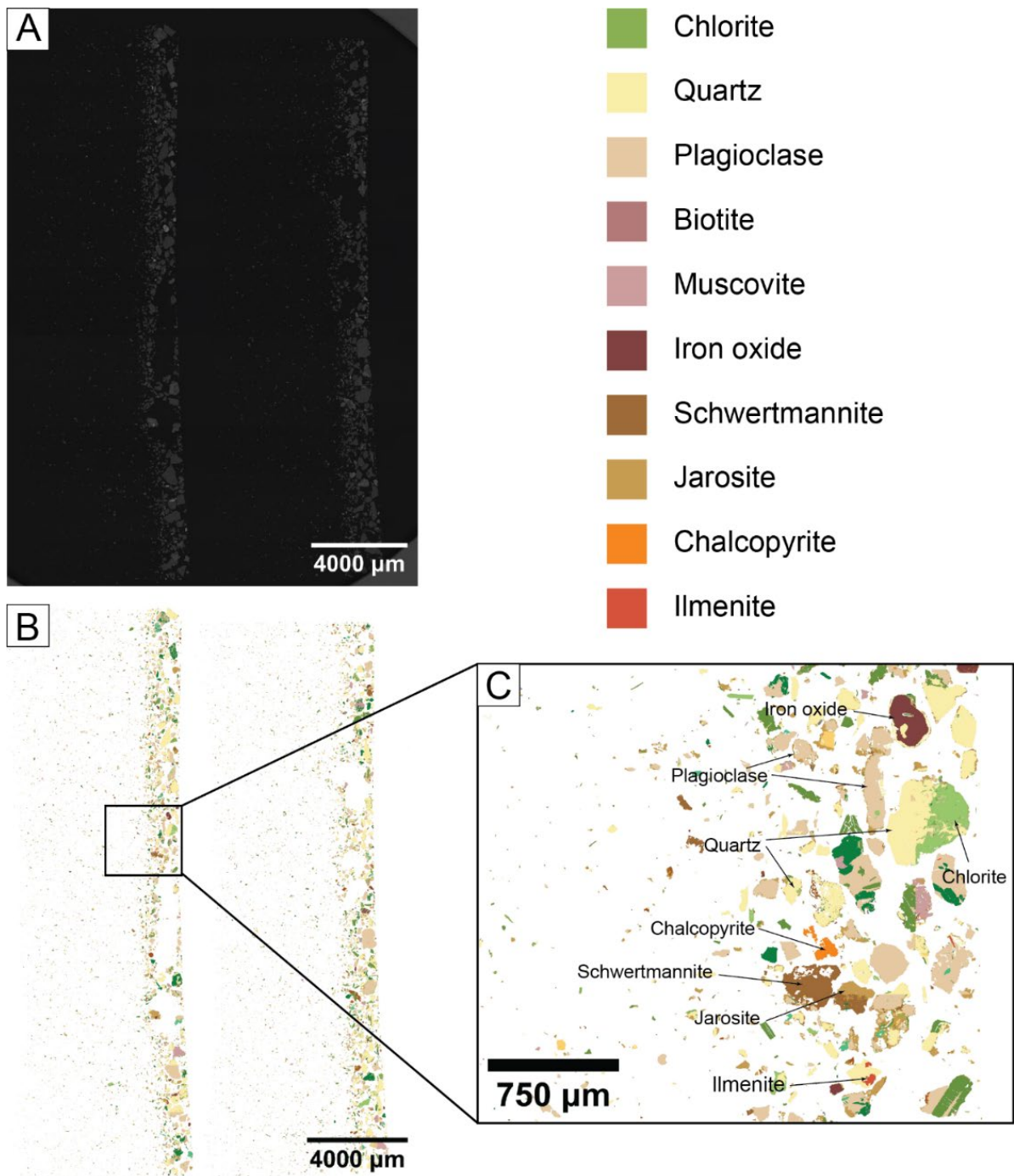


Figure 41. A. BSE and B. classified mineralogy image for ELV_GS_01 (hardpan) as reported by MLA, C. Zoom-in view to show the main mineralogy of the sample.

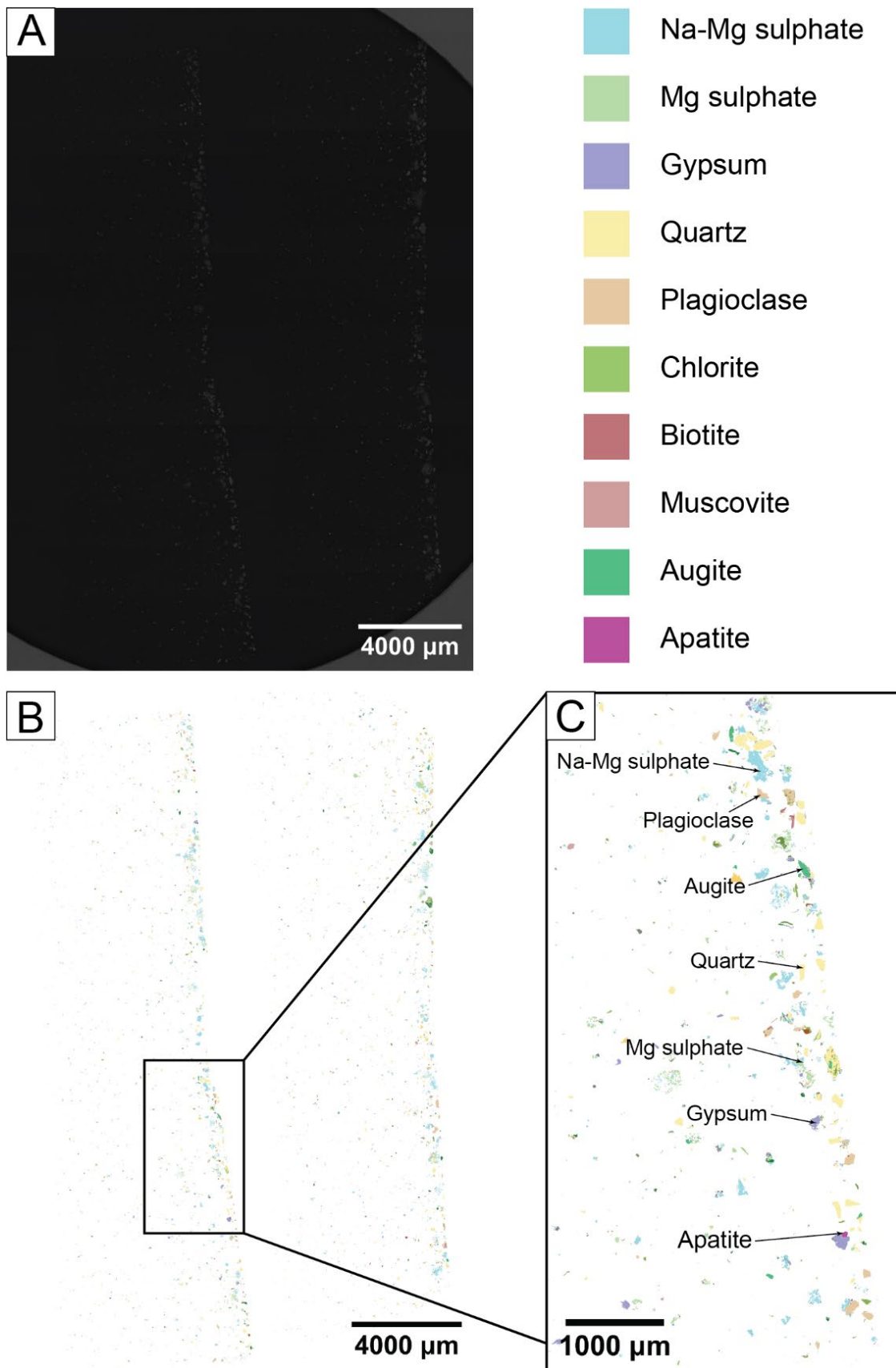


Figure 42. A. BSE and B. classified mineralogy image for ELV_GS_06 (salt) as reported by MLA, C. Zoom-in view to show the main mineralogy of the sample.

Modal mineralogy

The modal mineralogy of the tailings samples ($n = 7$) from MLA is plotted in Figure 43, while the summary statistics are provided in Table 10. The mineralogy of the tailings is dominated by chlorite (range: 14.6-5 wt. %, average: 37 wt. %), quartz (range: 17.7-40 wt. %, average: 28 wt. %), plagioclase (range: 1.8-19.3 wt. %, average: 9.5 wt. %), biotite (range: 2.1-9.4 wt. %, average: 4.5 wt. %) and muscovite (range: 2.0-10.5 wt. %, average: 4.3 wt. %). The tailings also contain significant to minor amounts of hornblende (range: 0.6-10.6 wt. %), kaolinite (range: 0.7-7.4 wt. %), augite (up to 7.8 wt. %), orthoclase (up to 1.6 wt. %) and garnet (up to 1.8 wt. %). The potentially REE-bearing minerals apatite (up to 0.9 wt. %) and monazite (up to 0.03 wt. %) were detected in minor amounts.

Secondary phases include jarosite (up to 5.6 wt. %), gypsum (up to 0.7 wt. %), schwertmannite (up to 0.3 wt. %), Mg sulphate (up to 0.3 wt. %), iron oxides and hydroxides (up to 2.6 wt. %), which may also be partly primary. Sulphide minerals present include pyrite (up to 4.4 wt. %), pyrrhotite (up to 5.6 wt. %) and chalcopyrite (up to 0.8 wt. %). Minor amounts of bornite (up to 0.03 wt. %), molybdenite (up to 0.01 wt. %) and tetrahedrite (up to 0.01 wt. %) were identified in some samples, as well as trace (<0.01 wt. %) amounts of covellite, chalcocite, sphalerite, galena, stannite, cobaltite and an Au-Ag mineral (electrum: 88 wt. % Au, 12 wt. % Ag). It is likely that many of the critical metals identified (e.g., Te, Se, Bi, Co) are hosted by these sulphide minerals as well as secondary minerals.

Similarly to the XRD results, the tailings samples from TSF1 have higher contents of chlorite, plagioclase, biotite, augite and hornblende, while the TSF2 samples have higher quartz, mica, pyrrhotite and pyrite contents (Figure 43). The tailings fan sample is most similar in composition to the TSF1 samples, but with a significant jarosite content (5.6 wt. %) indicating weathering and re-precipitation processes are prevalent in the tailings deposited in the Steere River channel.

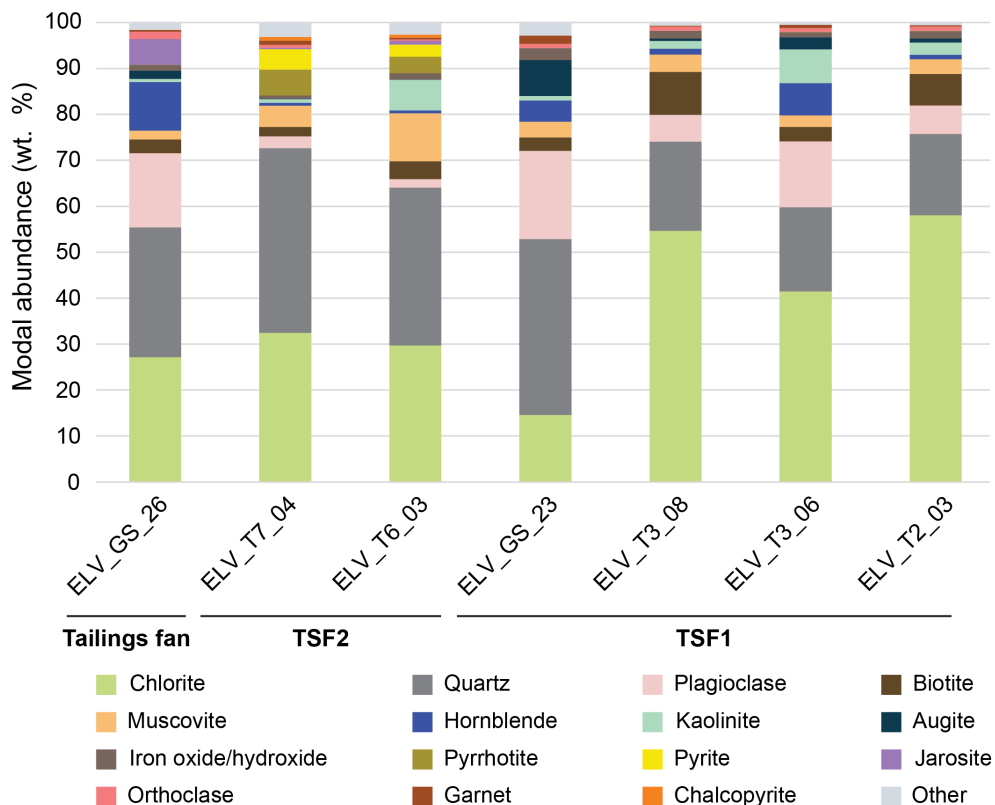


Figure 43. Modal mineralogy of selected Elverdton tailings samples, obtained by MLA ($n = 7$). Minerals with an average abundance of <0.2 wt. % are grouped as 'Other'.

Table 10. Summary statistics of the MLA mineralogy (wt. %) of the Elverdton tailings samples (n = 7). Minerals with a maximum abundance of >0.5 wt. % are shown. BDL = below detection limit, in this case <0.1 rounded to one decimal place.

Minerals	Formula	Minimum	Maximum	Average
Chlorite	$(\text{Mg,Fe})_3(\text{Si,Al})_4\text{O}_{10}(\text{OH})_2 \cdot (\text{Mg,Fe})_3(\text{OH})_6$	14.6	58.0	36.9
Quartz	SiO_2	17.7	40.1	28.1
Plagioclase	$\text{NaAlSi}_3\text{O}_8 - \text{CaAl}_2\text{Si}_2\text{O}_8$	1.8	19.3	9.5
Biotite	$\text{K}(\text{Mg,Fe})_3\text{AlSi}_3\text{O}_{10}(\text{F,OH})_2$	2.1	9.4	4.5
Muscovite	$(\text{K,H}_3\text{O})(\text{Al,Mg,Fe})_2(\text{Si,Al})_4\text{O}_{10}[(\text{OH})_2 \cdot (\text{H}_2\text{O})]$	2.0	10.5	4.3
Hornblende	$(\text{Ca,Na})_2(\text{Mg,Fe,Al})_5(\text{Al,Si})_8\text{O}_{22}(\text{OH})_2$	0.6	10.6	3.7
Kaolinite	$\text{Al}_2\text{Si}_2\text{O}_5(\text{OH})_4$	0.7	7.4	3.0
Augite	$(\text{Ca,Na})(\text{Mg,Fe,Al,Ti})(\text{Si,Al})_2\text{O}_6$	0.1	7.8	2.0
Iron oxide / hydroxide	Fe_2O_3	0.7	2.6	1.5
Pyrrhotite	Fe_{1-x}S	BDL	5.6	1.3
Pyrite	FeS_2	BDL	4.4	1.0
Jarosite	$\text{KFe}_3(\text{SO}_4)_2(\text{OH})_6$	BDL	5.6	1.0
Orthoclase	KAlSi_3O_8	0.4	1.6	0.9
Garnet	$[\text{Mg,Fe,Mn}]_3\text{Al}_2(\text{SiO}_4)_3$	0.2	1.8	0.6
Chalcopyrite	CuFeS_2	BDL	0.8	0.2
Apatite	$\text{Ca}_5(\text{PO}_4)_3(\text{OH,F,Cl})$	BDL	0.9	0.2
Calcite	CaCO_3	BDL	0.9	0.1
Gypsum	$\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$	BDL	0.7	0.1
Dolomite	$\text{CaMg}(\text{CO}_3)_2$	BDL	0.5	0.1
Alunite	$\text{KAl}_3(\text{SO}_4)_2(\text{OH})_6$	BDL	0.5	0.1
Ankerite	$\text{Ca}(\text{Fe,Mg,Mn})(\text{CO}_3)_2$	BDL	0.5	0.1

The modal mineralogy of the hardpan and salt samples (n = 3) is plotted in Figure 44, while the summary statistics are provided in Table 11. The mineralogy of the hardpan samples is dominated by the major minerals of the tailings samples, quartz (26.1-26.4 wt. %), plagioclase (11.0-22.3 wt. %), hornblende (6.7-18.1 wt. %) and chlorite (11.2-16.3 wt. %), as well as secondary phases including jarosite (8.6-13.6 wt. %), iron oxide and hydroxide (5.1-11.4 wt. %) and schwertmannite (2.3-8.9 wt. %). Minor chalcopyrite (0.2 wt. %) was also identified in hardpan sample ELV_GS_10.

The salt sample (Table 11, Figure 44) also has high contents of the tailings minerals quartz (22.8 wt. %), plagioclase (11.8 wt. %), chlorite (9.8 wt. %) and others. Major secondary mineral phases comprise Na-Mg sulphate at 19.8 wt. % (likely bloedite as detected by XRD) and Mg sulphate at 13.6 wt. % (likely hexahydrite and starkeyite as detected by XRD). The salt sample also contains minor gypsum (2.8 wt. %), halite (0.6 wt. %) and jarosite (0.2 wt. %). Molybdenite (0.5 wt. %), tetrahedrite (0.5 wt. %) and chalcopyrite (0.06 wt. %) were also identified, which could host the critical metals, as well as the secondary sulphate phases.

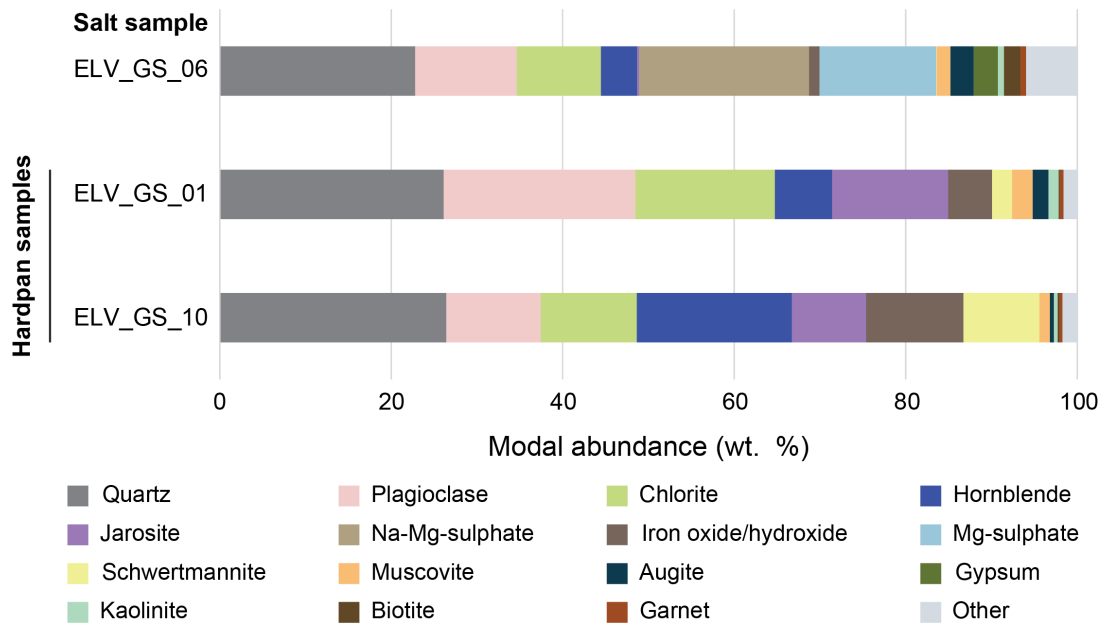


Figure 44. Modal mineralogy of selected Elverdton hardpan and salt samples, obtained by MLA (n = 3). Minerals with an average abundance of <0.5 wt. % are grouped as 'Other'.

Table 11. Summary statistics of the MLA mineralogy (wt. %) of the Elverdton hardpan and salt samples (n = 3). Minerals with a maximum abundance of >0.2 wt. % are shown. BDL = below detection limit, in this case <0.1 rounded to one decimal place.

Minerals	Formula	Hardpan		Salt
		Elv_GS_01	ELV_GS_10	ELV_GS_06
Quartz	SiO ₂	26.4	26.1	22.8
Plagioclase	NaAlSi ₃ O ₈ – CaAl ₂ Si ₂ O ₈	11.0	22.3	11.8
Chlorite	(Mg,Fe) ₃ (Si,Al) ₄ O ₁₀ (OH) ₂ ·(Mg,Fe) ₃ (OH) ₆	11.2	16.3	9.8
Hornblende	(Ca,Na) ₂ (Mg,Fe,Al) ₅ (Al,Si) ₈ O ₂₂ (OH) ₂	18.1	6.7	4.2
Jarosite	KFe ₃ (SO ₄) ₂ (OH) ₆	8.6	13.6	0.2
Na-Mg sulphate	Na ₂ Mg(SO ₄) ₂ ·4H ₂ O	BDL	BDL	19.8
Iron oxide / hydroxide	Fe ₂ O ₃	11.4	5.1	1.2
Mg sulphate	MgSO ₄ ·4(H ₂ O)	BDL	BDL	13.6
Schwertmannite	Fe ₈ O ₈ (OH) ₆ SO ₄	8.9	2.3	0.1
Muscovite	(K,H ₃ O)(Al,Mg,Fe) ₂ (Si,Al) ₄ O ₁₀ [(OH) ₂ ·(H ₂ O)]	1.2	2.4	1.6
Augite	(Ca,Na)(Mg,Fe,Al,Ti)(Si,Al) ₂ O ₆	0.5	1.8	2.7
Gypsum	CaSO ₄ ·2H ₂ O	BDL	BDL	2.8
Kaolinite	Al ₂ Si ₂ O ₅ (OH) ₄	0.4	1.2	0.7
Biotite	K(Mg,Fe) ₃ AlSi ₃ O ₁₀ (F,OH) ₂	0.2	0.1	1.9
Garnet	[Mg,Fe,Mn] ₃ Al ₂ (SiO ₄) ₃	0.4	0.5	0.7
Halite	NaCl	BDL	BDL	0.6
Molybdenite	MoS ₂	BDL	BDL	0.5
Ilmenite	FeTiO ₃	0.2	0.2	0.1
Tetrahedrite	(Cu,Fe,Zn,Ag) ₁₂ Sb ₄ S ₁₃	BDL	BDL	0.5
Apatite	Ca ₅ (PO ₄) ₃ (OH,F,Cl)	BDL	BDL	0.3
Chalcopyrite	CuFeS ₂	BDL	0.2	0.1

Particle size distribution

The particle size distributions of all mineralogy samples were investigated using the MLA software Dataview and are plotted in Figure 45. Additionally, the $p80$ values (i.e., the size that 80% of the particles, by mass, are equal to or smaller than) are reported. The tailings samples have variable particle sizes, with $p80$ s of around 90-200 μm . The samples in TSF2 generally have slightly finer particle size distributions than the TSF1 samples. The salt sample has a fine particle size distribution, with a $p80$ of around 100 μm . The hardpan samples have coarser particle sizes, with $p80$ s of around 200 and 350 μm , which may be related to the cementation of particles with secondary phases.

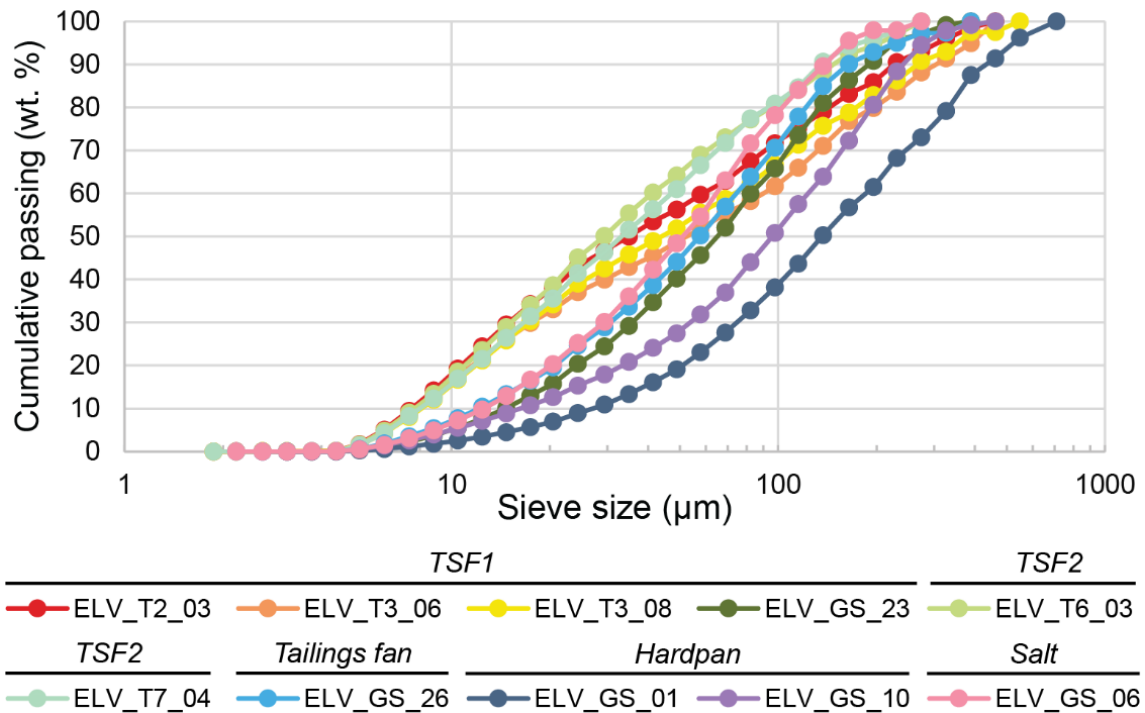


Figure 45. Particle size distribution of the Elverdton samples, based on the equivalent circle diameter obtained from MLA measurements ($n = 10$).

Mineral grain size and mineral associations

The grain size distributions and mineral associations of minerals which may host the metals of interest investigated using the MLA software Dataview. The minerals assessed include the primary sulphide minerals pyrite, pyrrhotite and chalcopyrite, iron oxide and goethite, the secondary mineral phases jarosite, schwertmannite, Mg sulphate and Na-Mg sulphate, and the potentially REE-bearing phases apatite and garnet.

Pyrite

The grain size distributions of pyrite are plotted in Figure 46 and the mineral associations in Figure 47. The pyrite contents are low in most samples and show fine and variable grain sizes, with $p80$ s ranging from around 5-35 μm (Figure 46). The pyrite grains in TSF2 samples, where pyrite is abundant, have smooth distributions, with $p80$ s of around 20 and 35 μm . Pyrite grains have high free surfaces, at 71-81 %, except in sample ELV_GS_23 where pyrite is fully associated with goethite (Figure 47). Pyrite is variably associated with alunite (0-28 %), Na-Mg sulphate (0-13 %), chlorite (0-11 %), jarosite (0-9 %), quartz (0-8 %) and kaolinite (0-6 %). Pyrite grains also have minor associations with other minerals such as plagioclase, gypsum, Mg sulphate, pyrrhotite, schwertmannite and chalcopyrite.

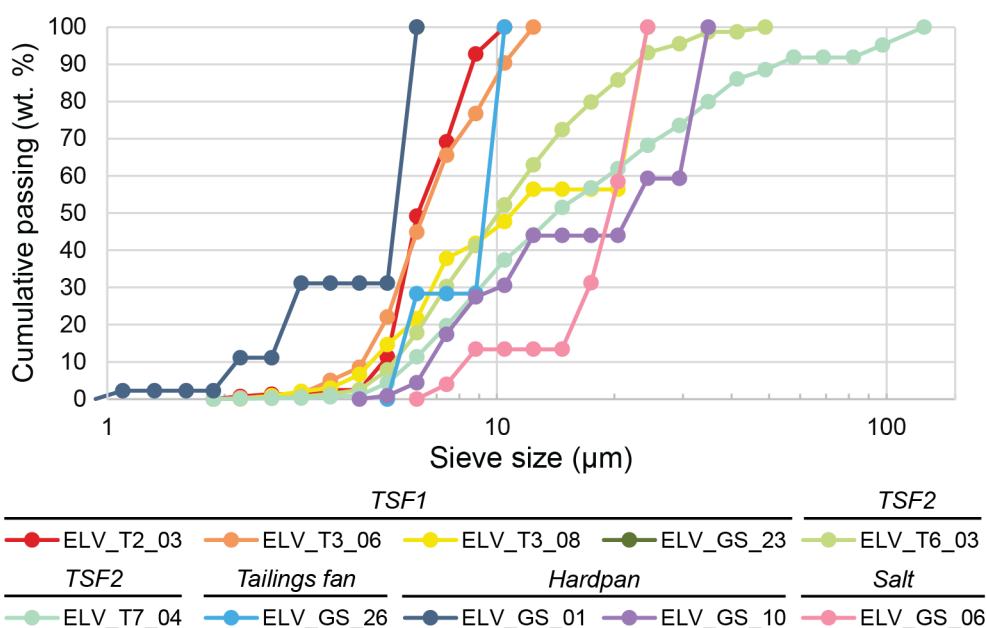


Figure 46. Pyrite grain size distribution of the Elverdton samples, based on the equivalent circle diameter obtained from MLA measurements (n = 10).

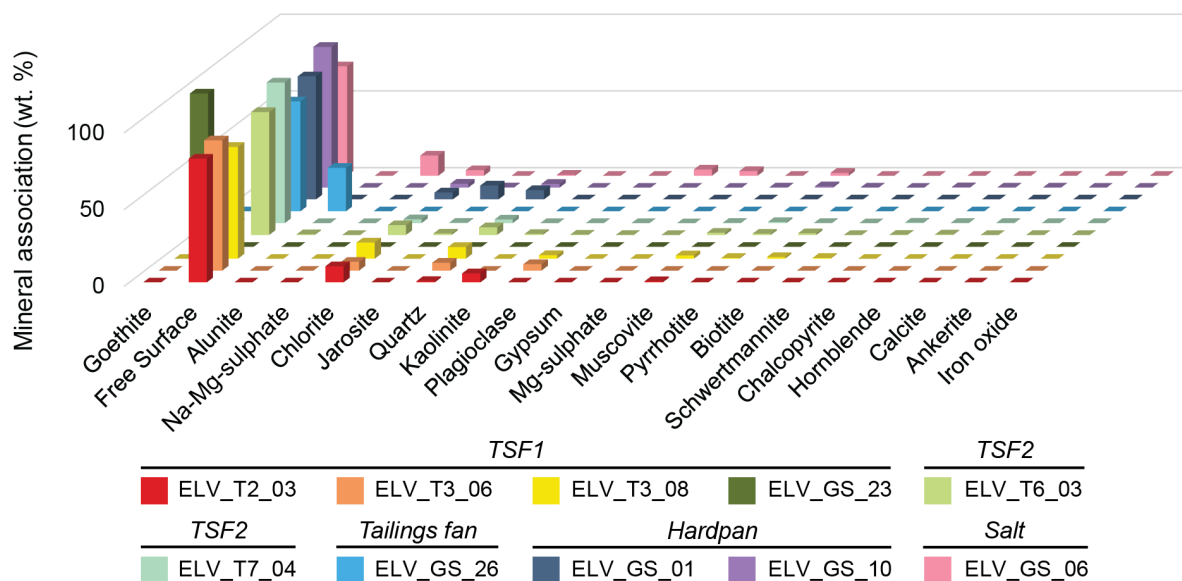


Figure 47. Mineral associations of pyrite grains of the Elverdton samples, based on MLA (n = 10). Free surface refers to the portion of the mineral grains that are exposed and not locked within another mineral.

Pyrrhotite

The grain size distributions of pyrrhotite are plotted in Figure 48 and the mineral associations in Figure 49. The pyrrhotite grains are generally fine, with $p80$ s ranging from around 10-35 μm (Figure 48). The pyrrhotite grains in TSF2 samples have smoother and coarser distributions, with $p80$ s of around 20 and 35 μm . Pyrrhotite grains have high free surfaces, at 62-100 %, except in sample ELV_GS_23 where pyrrhotite is instead associated with goethite (94 %) (Figure 49). Pyrrhotite is variably associated with chlorite (0-29 %), hornblende (0-13 %), schwertmannite (0-13 %), Mg sulphate (0-11 %), quartz (0-9 %) and jarosite (0-9 %). Pyrrhotite grains also have minor associations with other minerals such as biotite, muscovite, iron oxide and pyrite

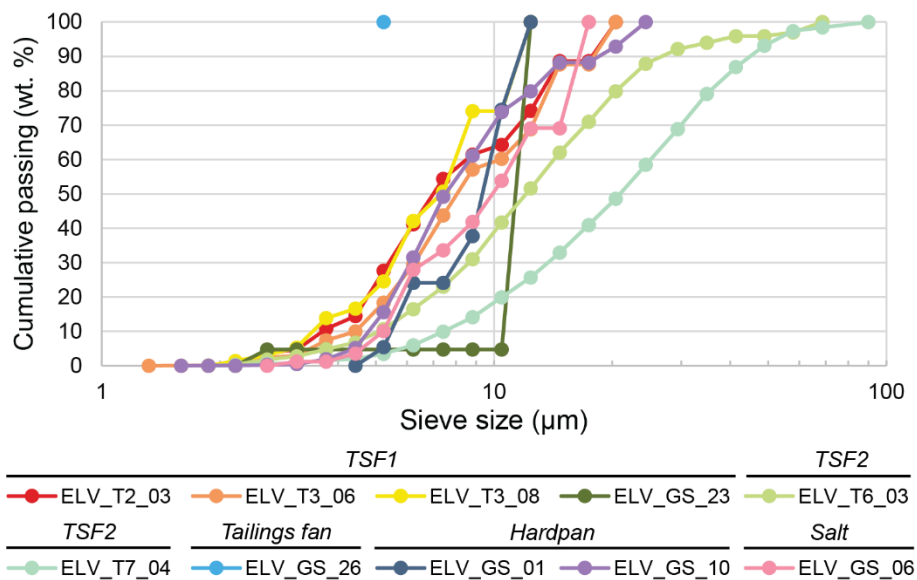


Figure 48. Pyrrhotite grain size distribution of the Elverdton samples, based on the equivalent circle diameter obtained from MLA measurements ($n = 10$).

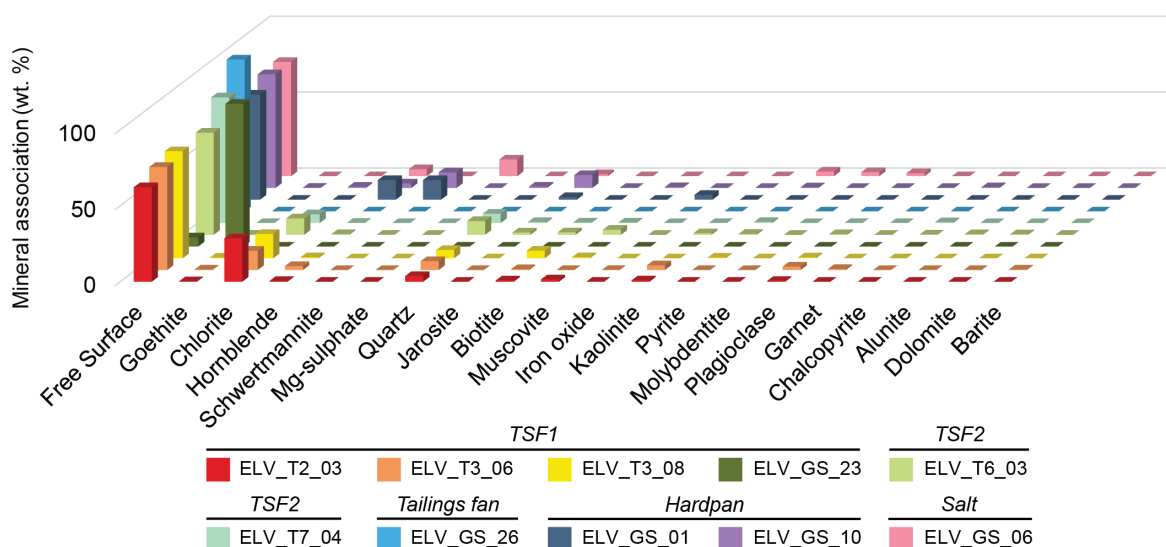


Figure 49. Mineral associations of pyrrhotite grains of the Elverdton samples, based on MLA ($n = 10$). Free surface refers to the portion of the mineral grains that are exposed and not locked within another mineral.

Chalcopyrite

The grain size distributions of chalcopyrite are plotted in Figure 50 and the mineral associations in Figure 51. The chalcopyrite grains are fine, with $p80$ s ranging from around 7-30 μm (Figure 50). The TSF2 samples generally have coarser chalcopyrite grains, but the coarsest grain sizes are seen in hardpan sample ELV_GS_01, with a $p80$ of around 100 μm . Chalcopyrite grains have variable free surfaces at 0-71 % and are particularly low in the salt sample and tailings sample ELV_GS_23 (Figure 51). Chalcopyrite is variably associated with augite (0-37 %), hornblende (0-33 %), garnet (0-33 %), chlorite (0-31 %), quartz (0-28 %), plagioclase (0-8 %) and pyrrhotite (0-6 %). Chalcopyrite grains also have minor associations with other minerals such as muscovite, kaolinite, jarosite, biotite, pyrite, schwertmannite and goethite.

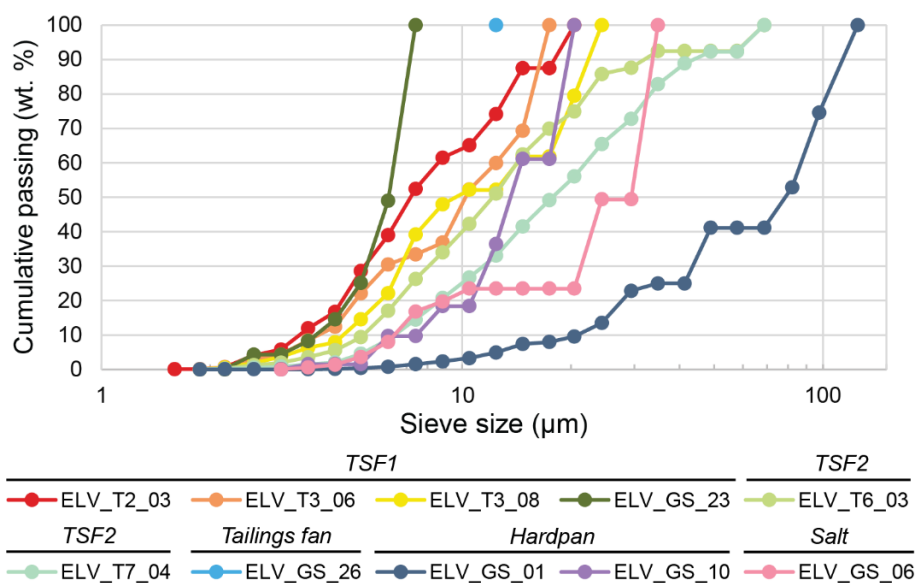


Figure 50. Chalcopyrite grain size distribution of the Elverdton samples, based on the equivalent circle diameter obtained from MLA measurements ($n = 10$).

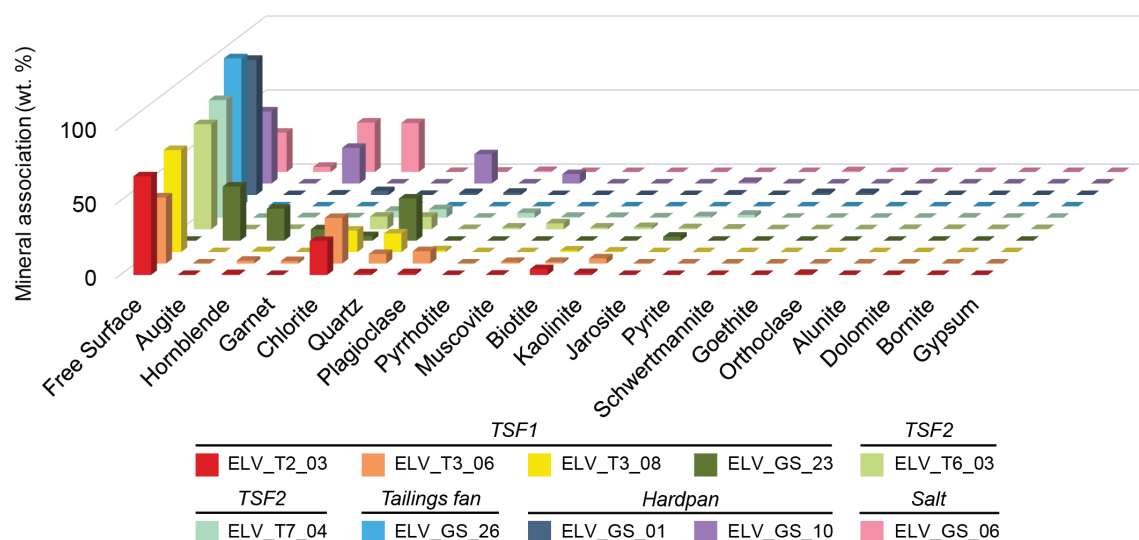


Figure 51. Mineral associations of chalcopyrite grains of the Elverdton samples, based on MLA ($n = 10$). Free surface refers to the portion of the mineral grains that are exposed and not locked within another mineral.

Goethite

The grain size distributions of goethite are plotted in Figure 52 and the mineral associations in Figure 53. The goethite grains have variable sizes, with *p80s* generally ranging from around 15-100 μm (Figure 52). The finest goethite grain sizes are observed in the TSF1 samples, while the coarsest grain size is seen in the hardpan sample ELV_GS_01, with a *p80* of around 150 μm , likely related to the precipitation of goethite as a secondary phase. Goethite grains have free surfaces of 45-75 % (Figure 53). Goethite is variably associated with chlorite (7-29 %), quartz (3-16 %), jarosite (0-17 %), schwertmannite (0-9 %) and iron oxide (0-7 %). Goethite grains also have minor associations with other minerals such as muscovite, kaolinite, hornblende and plagioclase.

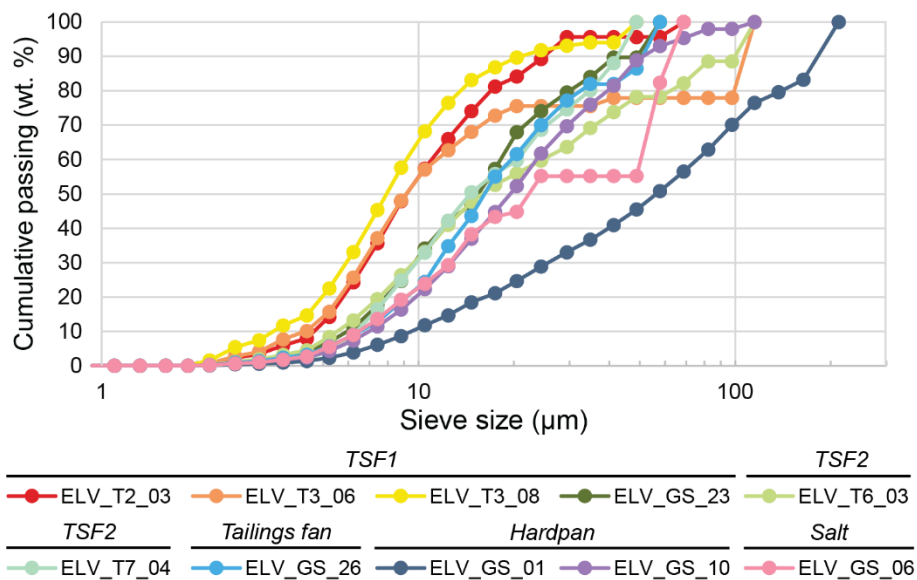


Figure 52. Goethite grain size distribution of the Elverdton samples, based on the equivalent circle diameter obtained from MLA measurements ($n = 10$).

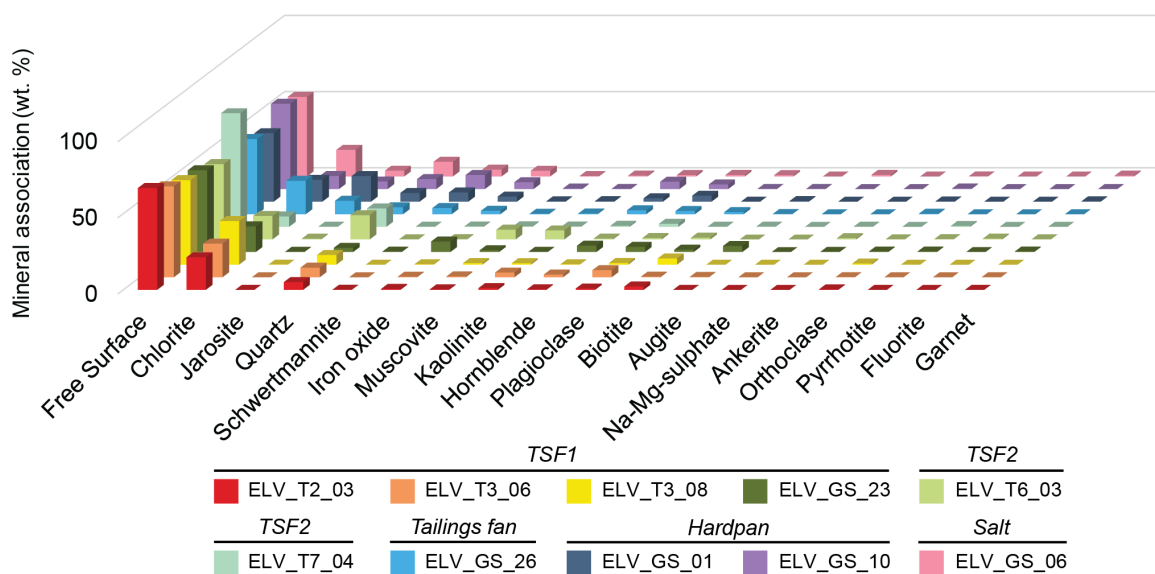


Figure 53. Mineral associations of goethite grains of the Elverdton samples, based on MLA ($n = 10$). Free surface refers to the portion of the mineral grains that are exposed and not locked within another mineral.

Jarosite

The grain size distributions of jarosite are plotted in Figure 54 and the mineral associations in Figure 55. The jarosite grain sizes are variable, with $p80$ s ranging from around 8-150 μm (Figure 54). The TSF1 samples generally have a finer jarosite grain size ($p80$: ~8-11 μm), with coarser sizes seen in the TSF2 samples ($p80$: ~20-50 μm) and the salt sample ($p80$: ~20 μm), as well as the hardpan samples ($p80$: ~40-70 μm) and the tailings fan samples ($p80$: ~150 μm). Jarosite grain size appears to be indicative of the amount of jarosite precipitation expected from weathering processes. Jarosite grains have free surfaces of 51-64 % (Figure 55). Jarosite is variably associated with chlorite (7-28 %), quartz (2-16 %), plagioclase (0-11 %), hornblende (1-9 %), goethite (0-8 %), schwertmannite (0-6 %), Na-Mg sulphate (0-5 %) and pyrrhotite (0-4). Jarosite grains also have minor associations with other minerals such as augite, biotite, muscovite, gypsum and pyrite.

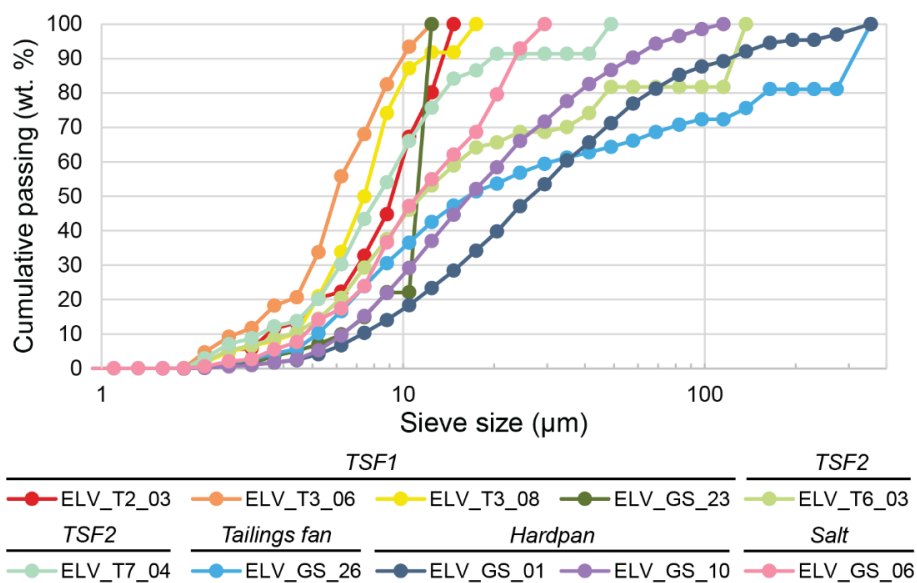


Figure 54. Jarosite grain size distribution of the Elverdton samples, based on the equivalent circle diameter obtained from MLA measurements ($n = 10$).

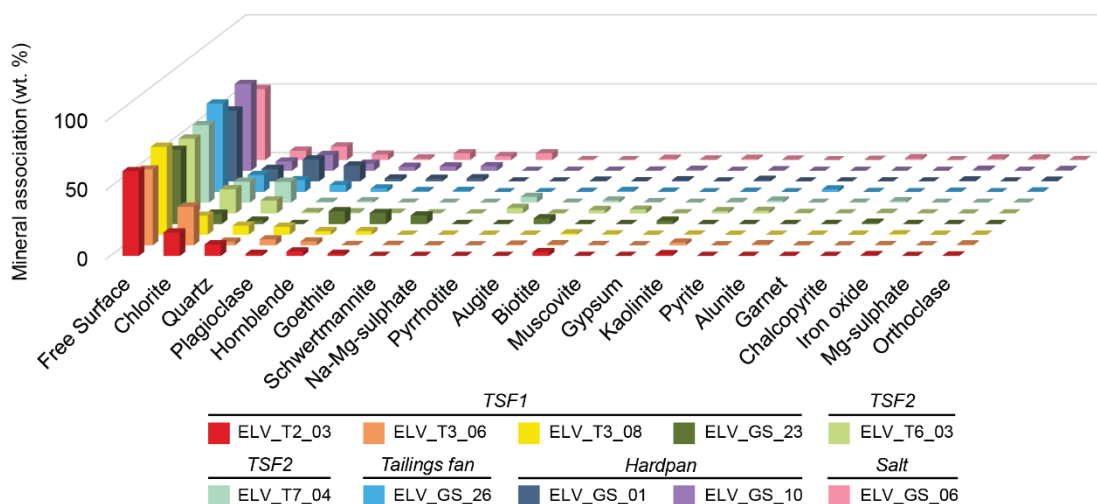


Figure 55. Mineral associations of jarosite grains of the Elverdton samples, based on MLA ($n = 10$). Free surface refers to the portion of the mineral grains that are exposed and not locked within another mineral.

Schwertmannite

The grain size distributions of schwertmannite are plotted in Figure 56 and the mineral associations in Figure 57. The schwertmannite grains in the tailings and salt samples are generally fine, with $p80$ s ranging from around 6-25 μm (Figure 56). The hardpan samples have coarser schwertmannite grain sizes, with $p80$ s of around 60-150 μm , likely due to the precipitation and cementation of the schwertmannite in the hardpan materials. Schwertmannite grains generally have high free surfaces, at 36-85 % (Figure 57). Schwertmannite is variably associated with iron oxide (0-23 %), augite (0-21 %), jarosite (0-19 %), goethite (0-17 %), quartz (0-11 %), chlorite (0-19 %) and Na-Mg sulphate (0-7 %). Schwertmannite grains also have minor associations with other minerals such as plagioclase, Mg sulphate, pyrrhotite, pyrite, muscovite, hornblende and gypsum.

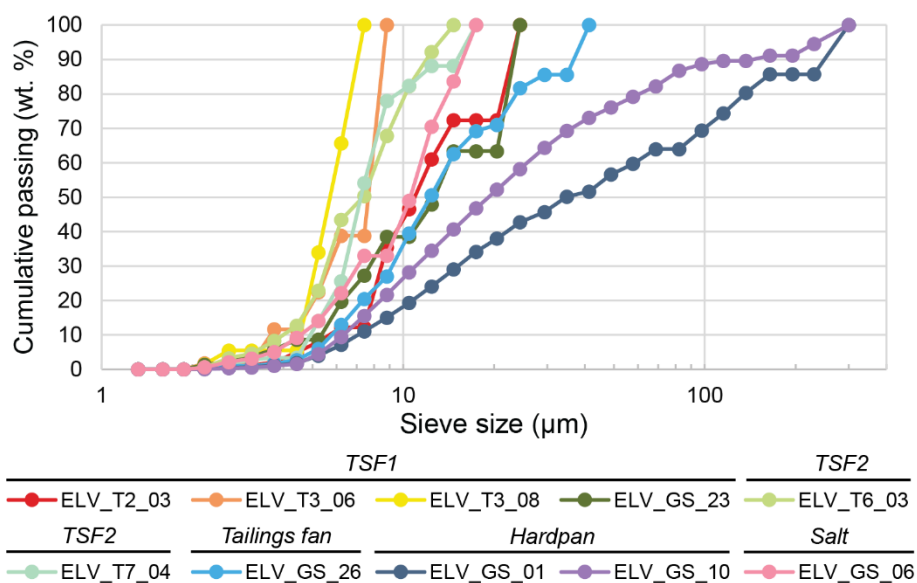


Figure 56. Schwertmannite grain size distribution of the Elverdton samples, based on the equivalent circle diameter obtained from MLA measurements ($n = 10$).

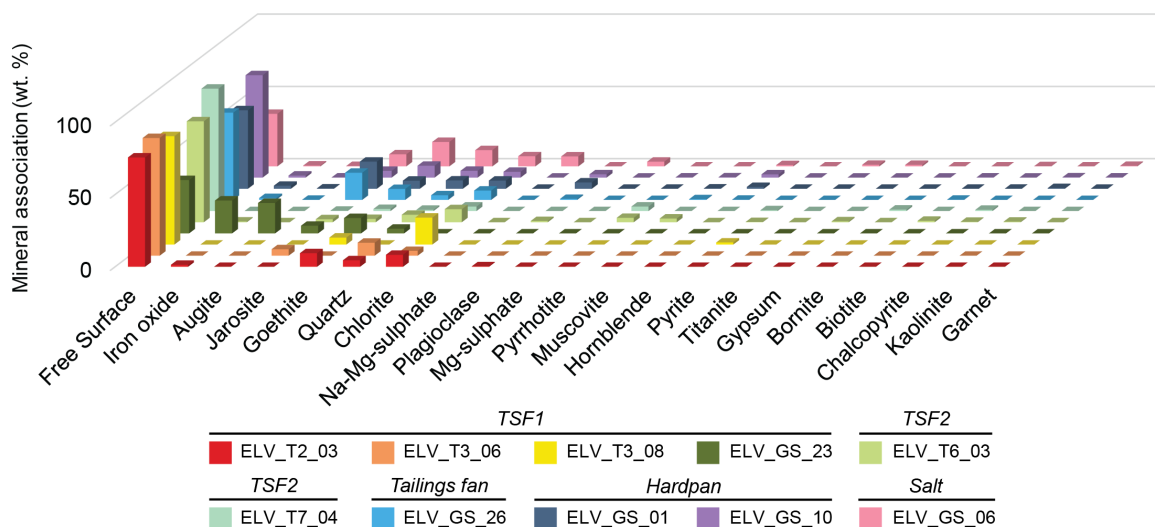


Figure 57. Mineral associations of schwertmannite grains of the Elverdton samples, based on MLA ($n = 10$). Free surface refers to the portion of the mineral grains that are exposed and not locked within another mineral.

Mg and Na-Mg sulphate

The grain size distributions of Mg sulphate are plotted in Figure 58 and the mineral associations in Figure 59. Mg sulphate is not present in all samples, and has fine grain sizes in the tailings samples, with p_{80} s ranging from around 10-30 μm (Figure 58). The salt sample has a coarser grain size, with a p_{80} of around 80 μm . Mg sulphate grains have high free surfaces where present, at 85-95 % (Figure 59). Mg sulphate is variably associated with biotite (0-12 %), Na-Mg sulphate (0-8 %), quartz (0-4 %) and plagioclase (0-1 %).

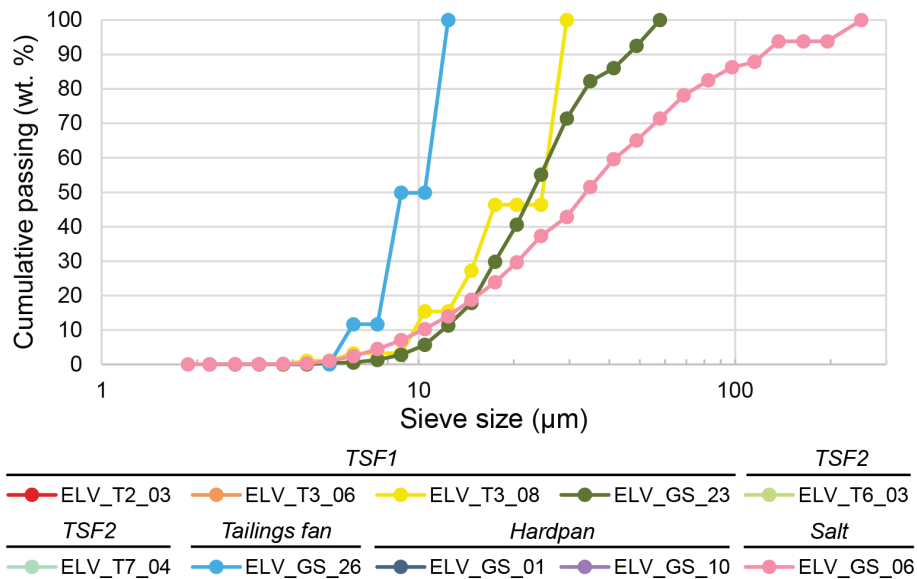


Figure 58. Mg sulphate grain size distribution of the Elverdton samples, based on the equivalent circle diameter obtained from MLA measurements ($n = 10$).

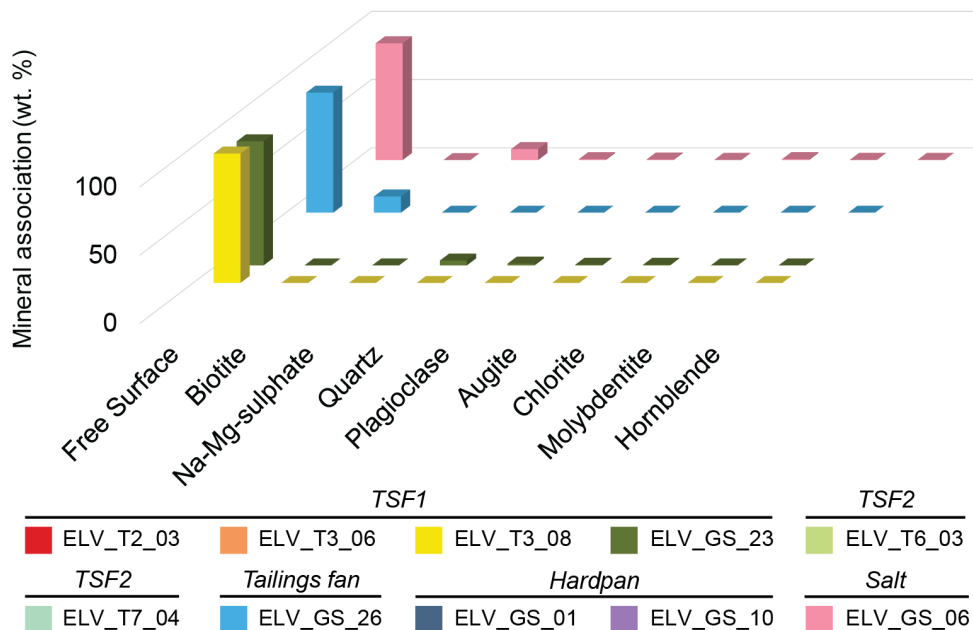


Figure 59. Mineral associations of Mg sulphate grains of the Elverdton samples, based on MLA ($n = 10$). Free surface refers to the portion of the mineral grains that are exposed and not locked within another mineral.

The grain size distributions of Na-Mg sulphate are plotted in Figure 60 and the mineral associations in Figure 61. Na-Mg sulphate is not present in all samples, and has fine grain sizes in the tailings samples, with $p80$ s ranging from around 8-20 μm (Figure 60). The salt sample has a coarser grain size, with a $p80$ of around 100 μm . Na-Mg sulphate grains have high free surfaces when present, at 76-100 % (Figure 61). Na-Mg sulphate is variably associated with pyrrhotite (0-8 %), pyrite (0-8 %), quartz (0-6 %), Mg sulphate (0-5 %) and chlorite (0-4 %).

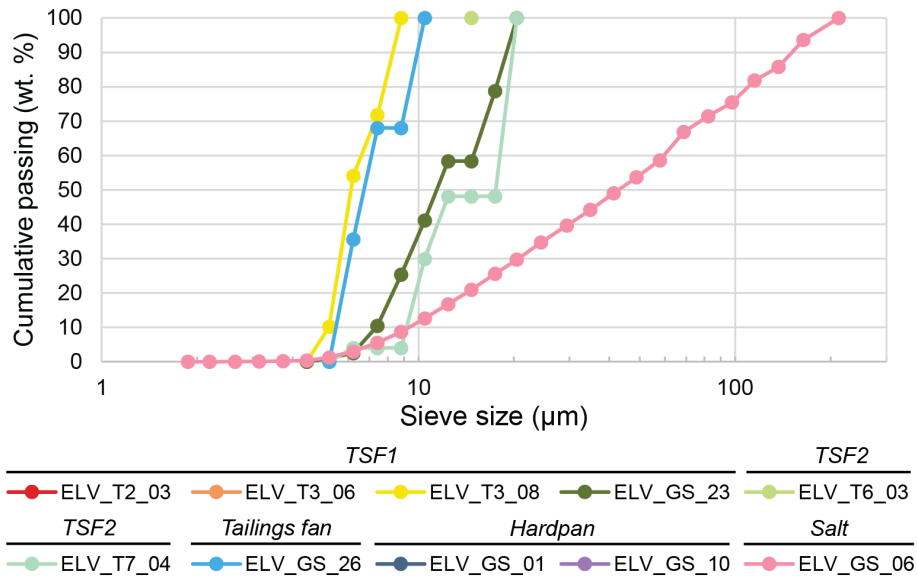


Figure 60. Na-Mg sulphate grain size distribution of the Elverdton samples, based on the equivalent circle diameter obtained from MLA measurements ($n = 10$).

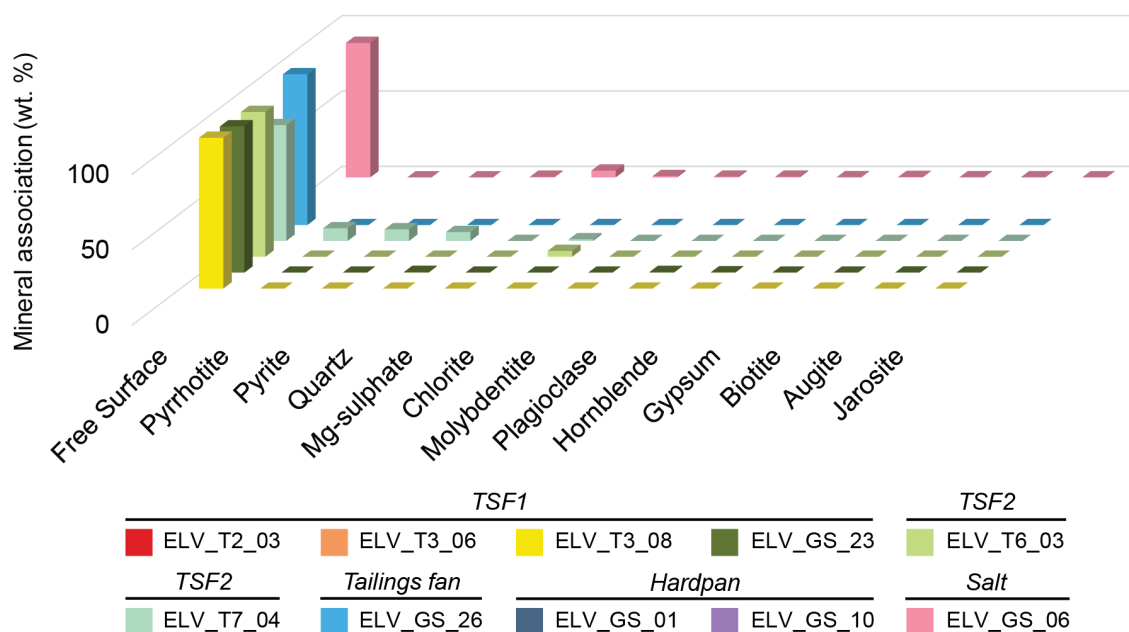


Figure 61. Mineral associations of Na-Mg sulphate grains of the Elverdton samples, based on MLA ($n = 10$). Free surface refers to the portion of the mineral grains that are exposed and not locked within another mineral.

Iron oxide

The grain size distributions of iron oxide are plotted in Figure 62 and the mineral associations in Figure 63. The iron oxide grains in the tailings and salt samples have variable grain sizes, with p_{80} s ranging from around 15-150 μm (Figure 62). The TSF1 samples have coarser iron oxide grain size distributions than the TSF2 samples, with p_{80} s of around 20-80 μm . The coarsest grain sizes occur in the hardpan samples, with p_{80} s of around 100-150 μm , likely related to the precipitation and cementation of iron oxide phases in hardpans. The iron oxide grains have high free surfaces, at 40-66 % (Figure 63). Iron oxide is variably associated with goethite (1-19 %), jarosite (0-18 %), quartz (3-13 %), chlorite (6-13 %) and schwertmannite (0-7 %). Pyrite grains also have minor associations with other minerals such as hornblende, plagioclase, muscovite, kaolinite, biotite and pyrite.

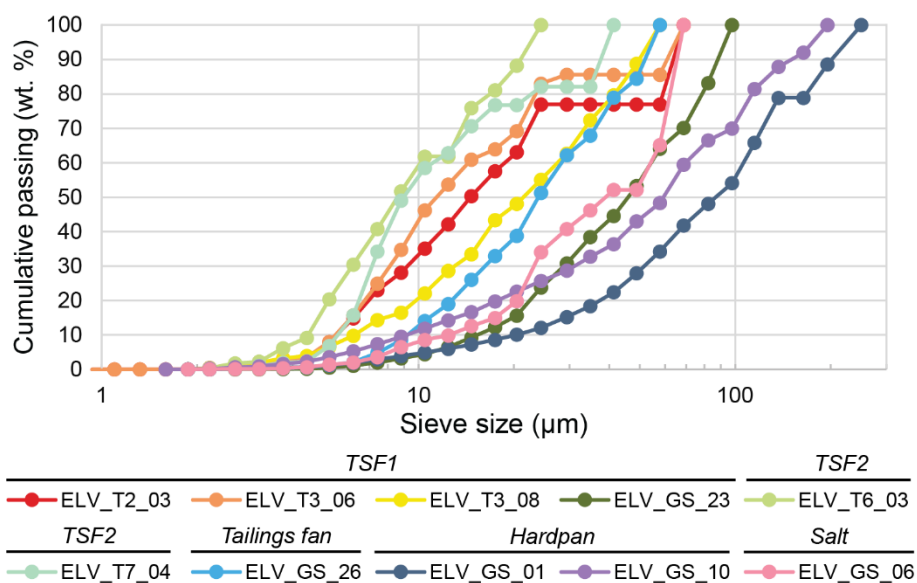


Figure 62. Iron oxide grain size distribution of the Elverdton samples, based on the equivalent circle diameter obtained from MLA measurements ($n = 10$).

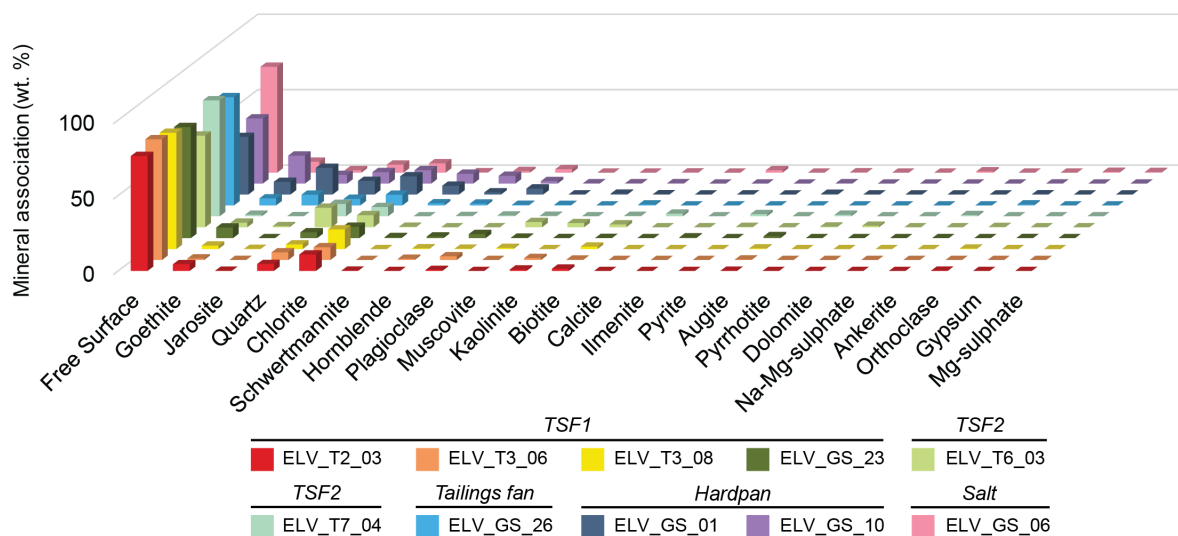


Figure 63. Mineral associations of iron oxide grains of the Elverdton samples, based on MLA ($n = 10$). Free surface refers to the portion of the mineral grains that are exposed and not locked within another mineral.

Apatite

The grain size distributions of apatite are plotted in Figure 64 and the mineral associations in Figure 65. The apatite grains are generally fine, with $p80$ s ranging from around 15-150 μm (Figure 64). The TSF2 samples gave finer apatite grain sizes than the TSF1 samples. Apatite grains generally have high free surfaces, at 72-94 % (Figure 65). Apatite is variably associated with chlorite (0-11 %), quartz (0-10 %), gypsum (0-6 %), plagioclase (0-6 %), hornblende (0-3 %), muscovite (0-3 %), kaolinite (0-2 %) and augite (0-2 %), and has minor associations with orthoclase, biotite, garnet and monazite.

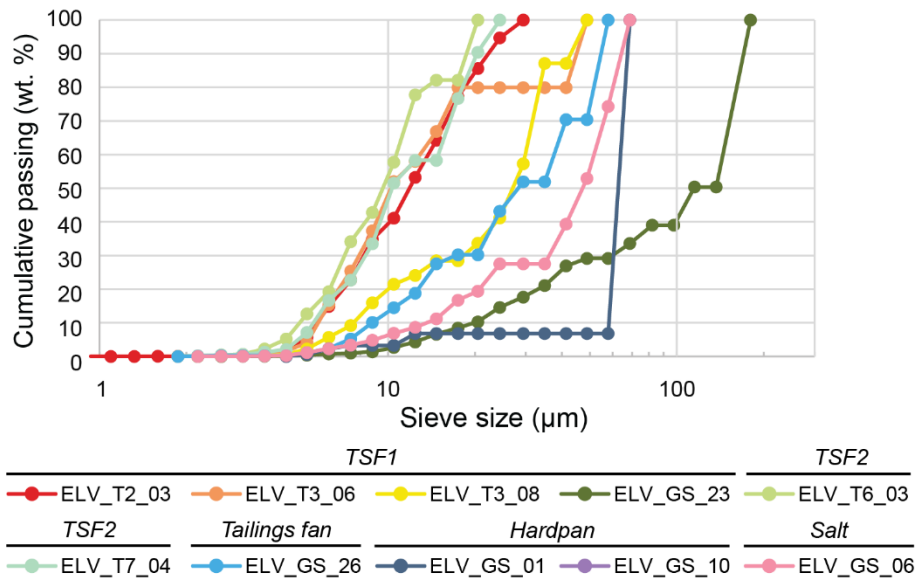


Figure 64. Apatite grain size distribution of the Elverdton samples, based on the equivalent circle diameter obtained from MLA measurements ($n = 10$).

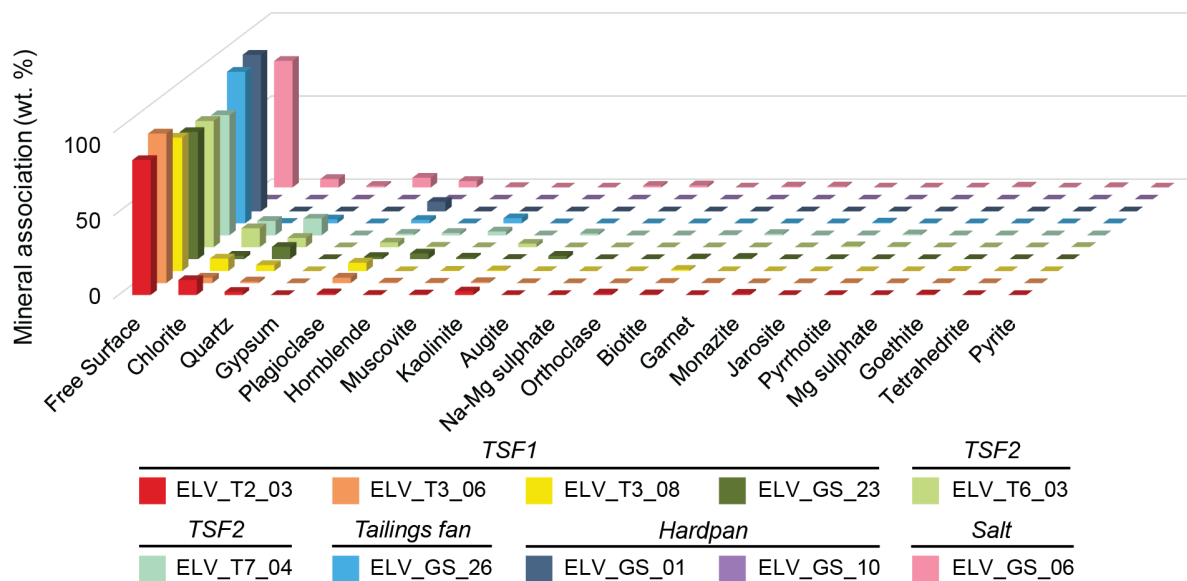


Figure 65. Mineral associations of apatite grains of the Elverdton samples, based on MLA ($n = 10$). Free surface refers to the portion of the mineral grains that are exposed and not locked within another mineral.

Garnet

The grain size distributions of garnet are plotted in Figure 66 and the mineral associations in Figure 67. Garnet has variable grain sizes in the tailings samples, with *p80s* ranging from around 20-75 μm (Figure 66). The hardpan and salt samples have coarser grain sizes, with *p80s* of around 60-180 μm . Garnet grains generally have moderate to high free surface areas, at 46-73 % in the tailings and salt samples (Figure 67). In the hardpan samples, the free surfaces are low, at 19-25 %, likely due to agglomeration and cementation. Garnet is variably associated with plagioclase (2-39 %), quartz (3-22%), chlorite (3-13 %), muscovite (0-12 %), hornblende (1-10 %), orthoclase (0-7 %), chalcopyrite (0-4 %) and kaolinite (0-3 %), and has minor associations with jarosite, schwertmannite and goethite.

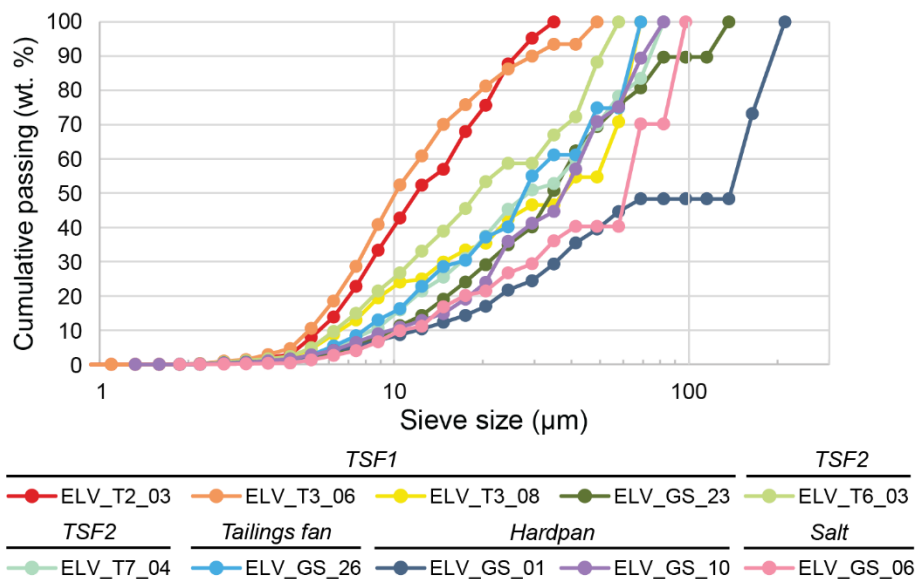


Figure 66. Garnet grain size distribution of the Elverdton samples, based on the equivalent circle diameter obtained from MLA measurements ($n = 10$).

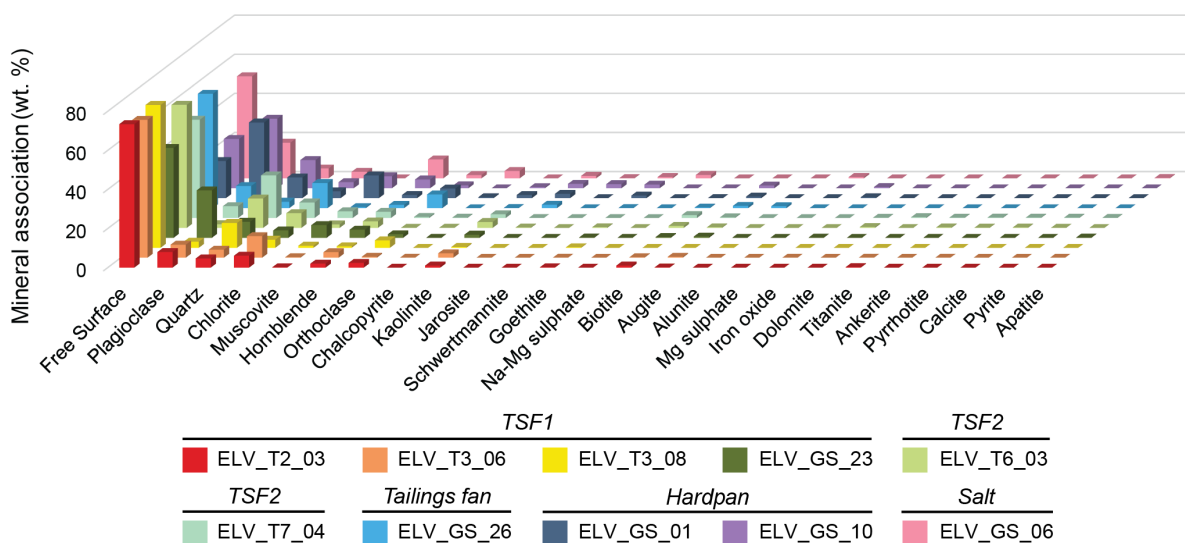


Figure 67. Mineral associations of garnet grains of the Elverdton samples, based on MLA ($n = 10$). Free surface refers to the portion of the mineral grains that are exposed and not locked within another mineral.

4.3 Mineral chemistry

Mineral chemistries for a range of analysed minerals are discussed in this section. The enriched elements in the primary sulphide minerals pyrite, pyrrhotite and chalcopyrite are summarised in the boxplot in Figure 68 and in Table 12. The compositions of the secondary mineral phases iron oxide, goethite, jarosite, schwertmannite, Mg sulphate and Na-Mg sulphate, are shown in the boxplot in Figure 69 and in Table 13. The potentially REE-bearing phases apatite, garnet and iron oxide were analysed for REEs and are shown in Figure 70 and Table 14. The LA-ICP-MS maps showing the locations of the point measurements are provided in Appendix F.

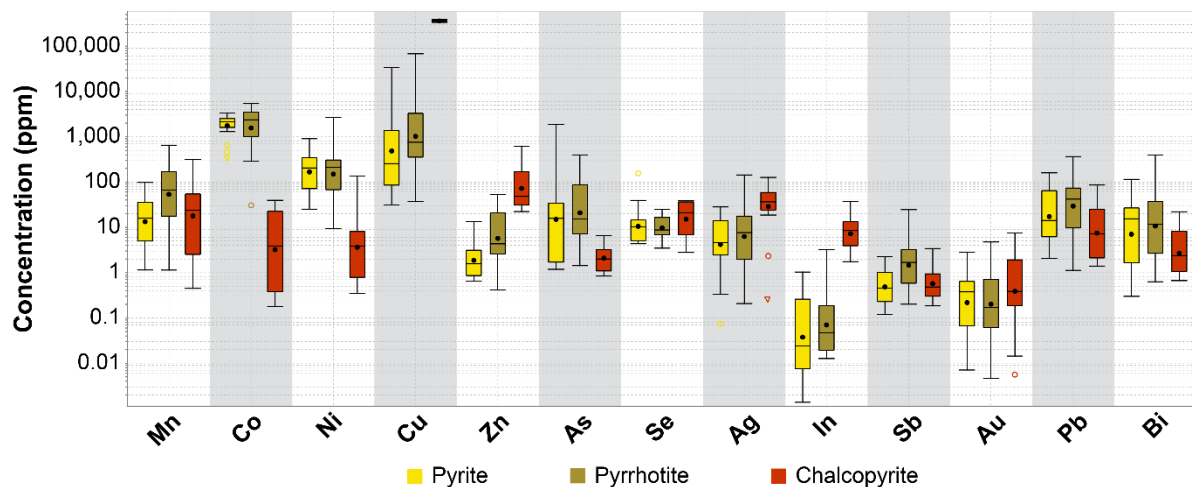


Figure 68. Tukey log box plots summarising the concentrations of enriched critical and strategic elements in pyrite (n = 20), pyrrhotite (n = 24) and chalcopyrite (n = 18).

Table 12. Statistical summary of concentrations (ppm) of trace elements in pyrite, pyrrhotite and chalcopyrite. BDL = below detection limit, in this case <0.1 rounded to one decimal place.

	Mn	Co	Ni	Cu	Zn	As	Se	Ag	In	Sb	Au	Pb	Bi
Pyrite (n = 20)													
Min.	1.1	331	25	31	0.6	1.2	4.4	0.1	BDL	0.1	BDL	2.1	0.3
Max.	98	3,341	905	33,659	14	1,875	156	28	1.0	2.2	2.8	159	115
Ave.	25	2,008	243	4,218	3.0	147	20	8	0.2	0.7	0.5	36	22
Med.	16	2,149	206	256	1.6	16	10	4.6	BDL	0.5	0.4	15	16
Pyrrhotite (n = 24)													
Min.	1.1	31	9	38	0.4	1.4	3.5	0.2	BDL	0.2	BDL	1.1	0.6
Max.	649	5,425	2,686	67,903	53	399	25	144	3.2	24.6	4.8	365	398
Ave.	121	2,279	311	4,624	13	72	11	15	0.3	3.2	0.6	61	42
Med.	66	2,372	211	756	4	15	8.8	7.7	BDL	1.7	0.2	42	12
Chalcopyrite (n = 18)													
Min.	0.4	0.2	0.4	336,129	22	0.8	2.8	0.2	1.7	0.2	BDL	1.4	0.7
Max.	314	40	134	392,059	615	6.6	39	127	36.9	3.4	7.5	86	22
Ave.	67	12	17	361,213	125	2.6	21	47	9.9	0.8	1.3	16	4.7
Med.	24	3.9	3.8	362,009	48	2.0	21	37	8.5	0.5	0.4	7.3	2.3

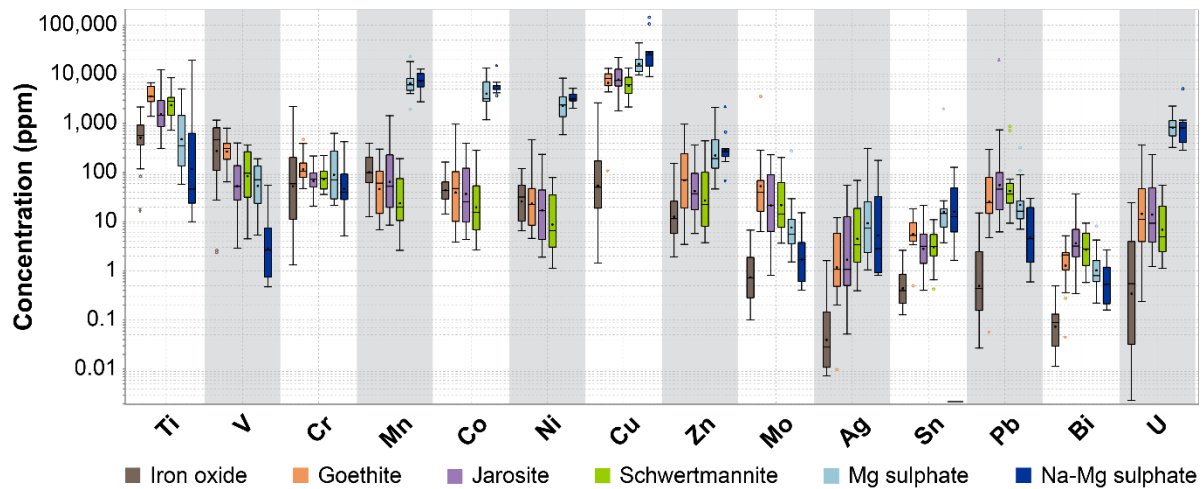


Figure 69. Tukey log box plots summarising the concentrations of enriched critical and strategic elements in iron oxide (n = 48), goethite (n = 22), jarosite (n = 39), schwertmannite (n = 21), Mg sulphate (n = 17) and Na-Mg sulphate (n = 11).

Table 13. Statistical summary of concentrations (ppm) of trace elements in iron oxide, goethite, jarosite, schwertmannite, Mg sulphate and Na-Mg sulphate. BDL = below detection limit, in this case <0.1 rounded to one decimal place.

	Ti	V	Cr	Mn	Co	Ni	Cu	Zn	Mo	Ag	Sn	Pb	Bi	U
Iron oxide (n = 48)														
Min.	16	2.4	1.3	13	14	6.5	1.4	1.9	0.1	BDL	0.1	BDL	BDL	BDL
Max.	2,171	1,171	2,218	394	164	120	2,637	155	6.7	1.6	2.6	15.1	0.5	24
Ave.	725	493	201	130	50	37	233	21	1.3	0.1	0.7	1.8	0.1	3.2
Med.	575	466	60	100	44	32	50	12	0.7	BDL	0.4	0.4	0.1	0.5
Goethite (n = 22)														
Min.	1,398	65	47	6.9	3.9	4.6	104	3.5	6.3	BDL	0.5	0.1	BDL	0.2
Max.	6,746	805	474	301	973	465	13,187	966	3,576	12	18	296	5.2	363
Ave.	3,920	313	140	76	112	51	8,191	162	403	2.9	6.8	56	1.9	45
Med.	3,539	310	106	61	48	22	8,276	72	40	1.1	5.3	25	2.1	11
Jarosite (n = 39)														
Min.	311	2.9	20.9	8.5	4.3	1.9	1,816	5.7	0.8	0.1	0.4	6.2	0.3	1.2
Max.	12,490	402	218	1,443	394	236	21,870	365	230	55	22	19,541	36	232
Ave.	2,119	92	79	161	81	44	9,191	74	52	6.9	4.4	600	6.7	40
Med.	1,473	52	74	53	25	17	7,480	37	22	1.1	3.2	46	3.2	9.3
Schwertmannite (n = 21)														
Min.	731	4.5	36.0	2.6	2.7	1.1	2,166	3.8	3.7	0.4	0.4	9.3	0.6	1.1
Max.	8,499	363	223	193	283	79	13,299	440	203	69	11	872	9.3	55
Ave.	2,870	145	82	44	60	19	6,460	89	45	14	4.0	109	3.6	14
Med.	2,837	97	76	20	15	6.6	6,144	23	14	3.4	3.2	36	2.8	4.9
Mg sulphate (n = 17)														
Min.	58	5.4	21	1,947	1,183	590	9,767	46	1.5	1.1	3.7	7.0	0.2	326
Max.	5,057	192	631	22,911	13,457	8,351	43,402	2,125	277	311	1,991	321	8.1	2,258
Ave.	1,009	81	168	7,782	4,860	2,777	17,659	357	24	40	130	44	1.6	922
Med.	350	72	71	6,074	3,173	2,367	14,866	193	5.6	7.5	15	16	0.8	841
Na-Mg sulphate (n = 11)														
Min.	10	0.5	5.1	2,763	3,680	2,020	9,035	66	0.4	0.8	1.6	0.6	0.2	285
Max.	19,389	55	424	12,743	14,857	5,155	14,4351	2,188	15	177	128	30	2.7	5,077
Ave.	3,288	8.5	95	7,917	6,316	3,367	40,165	442	3.3	26	31	10	0.8	1,128
Med.	47	2.6	40	7,451	5,863	3,147	25,073	267	1.7	2.9	13	4.5	0.5	812

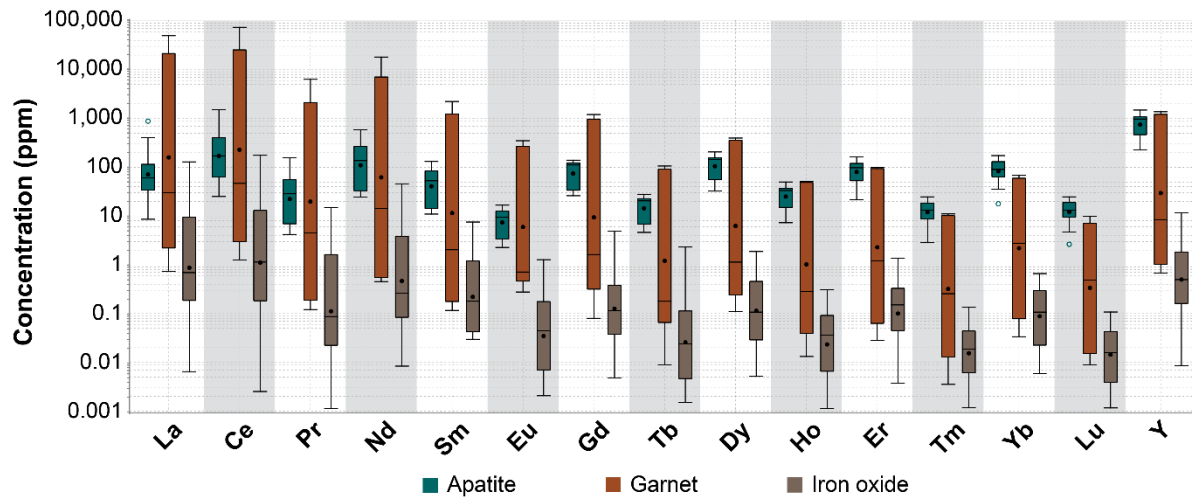


Figure 70. Tukey log box plots summarising the concentrations of enriched REEs in apatite (n = 16), garnet (n = 12) and iron oxide (n = 33).

Table 14. Statistical summary of concentrations (ppm) of trace elements in apatite, garnet and iron oxide. BDL = below detection limit, in this case <0.1 rounded to one decimal place.

	La	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Y
Apatite (n = 16)															
Min.	8.6	25	4.2	24	11	2.3	26	4.6	32	7.3	21	2.9	18	2.6	230
Max.	883	1,517	157	591	131	17	140	28	206	50	164	25	174	25	1,492
Ave.	144	302	38	172	55	9	89	17	120	28	90	14	95	14	834
Med.	61	179	30	137	53	9	112	21	145	34	98	13	91	14	978
Garnet (n = 12)															
Min.	0.7	1.2	0.1	0.5	0.1	0.3	0.1	BDL	0.1	BDL	BDL	BDL	BDL	BDL	0.7
Max.	50,107	74,375	6,369	18,282	2,238	351	1,208	106	397	52	100	11	68	10	1,380
Ave.	11,928	16,672	1,409	4,194	580	104	369	34	134	18	36	4.0	24	3.1	476
Med.	30	48	4.6	14	2.1	0.7	1.7	0.2	1.2	0.3	1.2	0.3	2.8	0.5	8.5
Iron oxide (n = 33)															
Min.	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Max.	129	176	15	45	7.6	1.3	4.9	2.3	1.9	0.3	1.4	0.1	0.7	0.1	12
Ave.	10	13	1.1	3.4	0.8	0.1	0.5	0.1	0.4	0.1	0.2	BDL	0.2	BDL	1.8
Med.	0.7	1.2	0.1	0.3	0.2	BDL	0.1	BDL	0.1	BDL	0.2	BDL	0.1	BDL	0.5

Pyrite

The chemistry of the pyrite grains in the TSF2 samples was investigated, demonstrating enrichment in Cu and Co, and minor enrichments in As, Ni, Se, Pb and Bi (Figure 71). Copper concentrations in pyrite range from 31-33,659 ppm (average: 4,218 ppm, median: 256 ppm) and Co contents range from 331-3,341 ppm (average: 2,008 ppm, median: 2,149 ppm). Arsenic concentrations range from 1.2-1,875 ppm (average: 147 ppm, median: 16 ppm) while Ni contents range from 25-905 ppm (average: 243 ppm, median: 206 ppm). The contents of Se, Pb and Bi reach up to 156, 159 and 115 ppm, respectively, and maximums of 2.8 ppm Au and 28 ppm Ag were measured (Table 12).

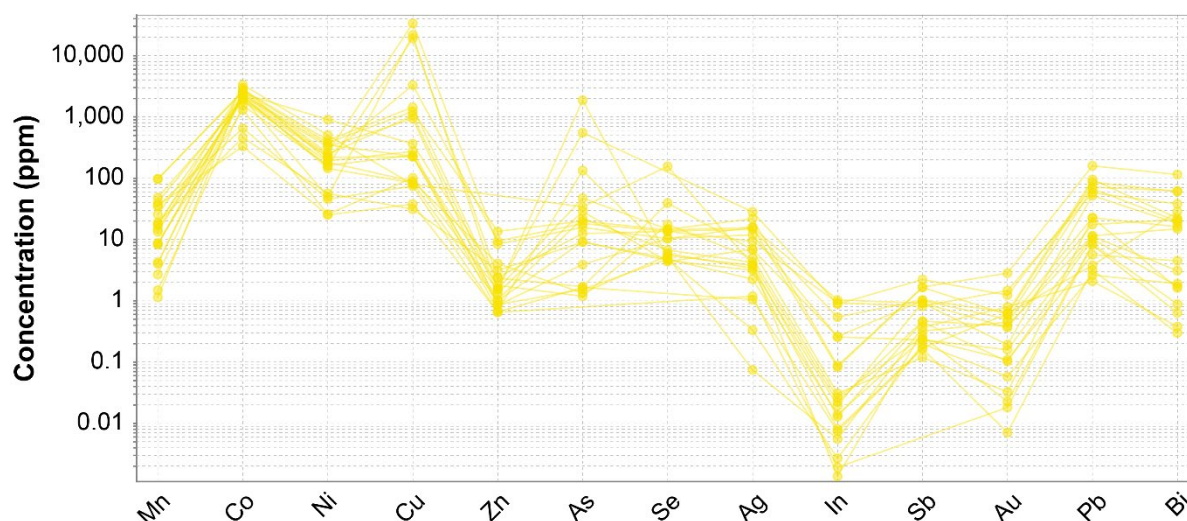


Figure 71. Concentrations of selected elements in pyrite (n = 20).

A correlation matrix of selected elements in pyrite is provided in Table 15. Copper is well correlated with In (0.95), Ag (0.88), Pb (0.79), Sb (0.68), Bi (0.66) and Au (0.57). Nickel correlates highly with Co (0.83), Se (0.76) and Ag (0.57), while As is well correlated with Au (0.74) and Sb (0.65). Lead is well correlated with Ag (0.90), Sb (0.79), Cu (0.79), Bi (0.77), In (0.73), Au (0.57) and Ni (0.57).

Table 15. Correlation matrix for select elements in pyrite (n = 20).

	Mn	Co	Ni	Cu	Zn	As	Se	Ag	In	Sb	Au	Pb	Bi
Mn	1												
Co	-0.23	1											
Ni	-0.31	0.83	1										
Cu	0.00	0.47	0.38	1									
Zn	0.38	0.31	0.41	0.46	1								
As	-0.34	-0.04	-0.08	0.28	-0.03	1							
Se	-0.09	0.47	0.76	0.26	0.40	-0.01	1						
Ag	0.02	0.54	0.57	0.88	0.48	0.25	0.54	1					
In	0.05	0.34	0.33	0.95	0.46	0.13	0.22	0.86	1				
Sb	0.06	0.15	0.11	0.68	0.35	0.65	0.13	0.67	0.59	1			
Au	-0.31	0.25	0.06	0.57	0.28	0.74	-0.02	0.49	0.44	0.69	1		
Pb	-0.12	0.51	0.57	0.79	0.45	0.42	0.49	0.90	0.73	0.79	0.57	1	
Bi	-0.18	0.42	0.27	0.66	0.32	0.52	0.07	0.70	0.58	0.74	0.78	0.77	1

The LA-ICP-MS patterns reveal different modes of occurrence of the trace elements in the pyrite grains. Cobalt and Ni appear to occur in the pyrite lattice, as seen in Figure 72 to Figure 74. Copper occurs both in the lattice (Figure 72) and in Cu-rich inclusions (Figure 73 and Figure 74). Bismuth, Pb, As, Se, Ag, Au and Sb mainly occur in the pyrite lattice, as seen in Figure 72 and Figure 73, but may also be associated with Cu-rich inclusions, as seen in Figure 74. Zinc and In are also associated with the Cu-rich inclusion seen in Figure 74, whereas the inclusion seen in Figure 73 does not appear to have any other enriched elements.

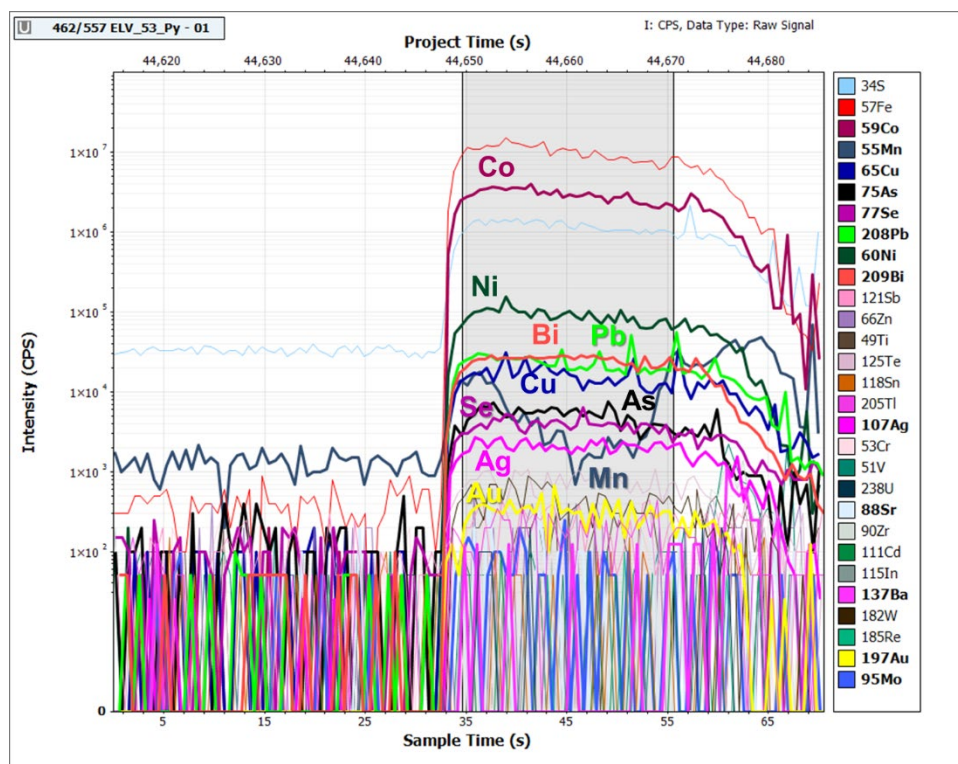


Figure 72. LA-ICP-MS pattern for ELV_53_Py-01 (sample ELV_T7_04, TSF2), relatively inclusion free, with lattice bound Co (3,341 ppm), Ni (505 ppm), Bi (16 ppm), Pb (23 ppm), Cu (80 ppm) and Se (156 ppm).

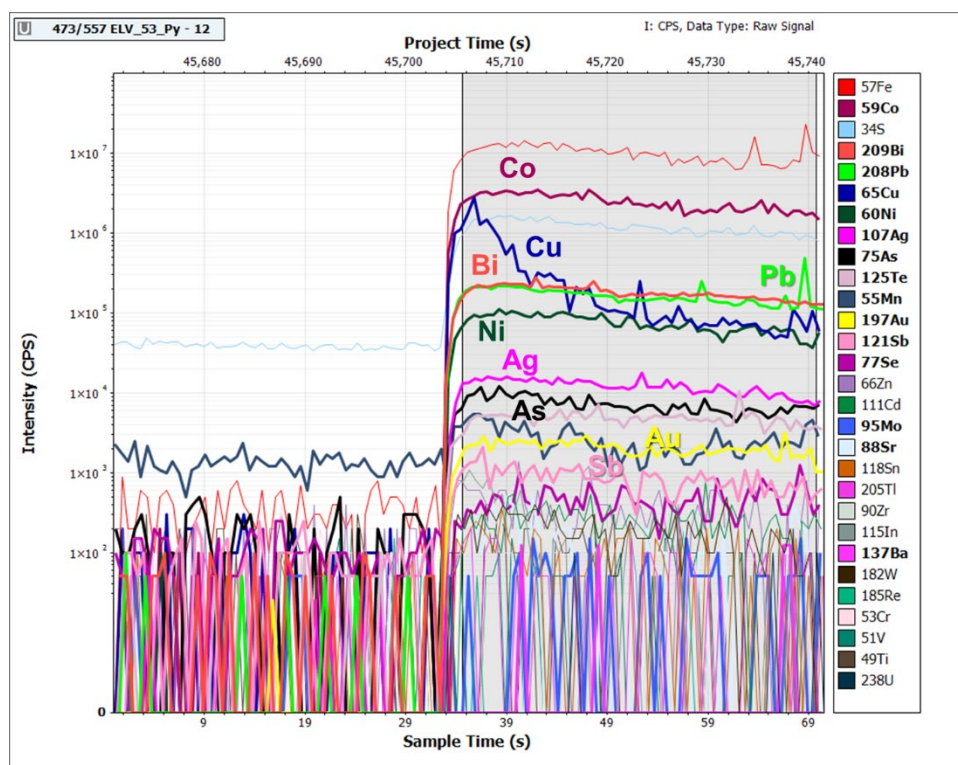


Figure 73. LA-ICP-MS pattern for ELV_53_Py-12 (sample ELV_T7_04, TSF2), with Cu-rich inclusion (Cu: 1,441 ppm) and lattice bound Co (2,785 ppm), Ni (415 ppm), Bi (115 ppm), Pb (159 ppm) and Ag (22 ppm).

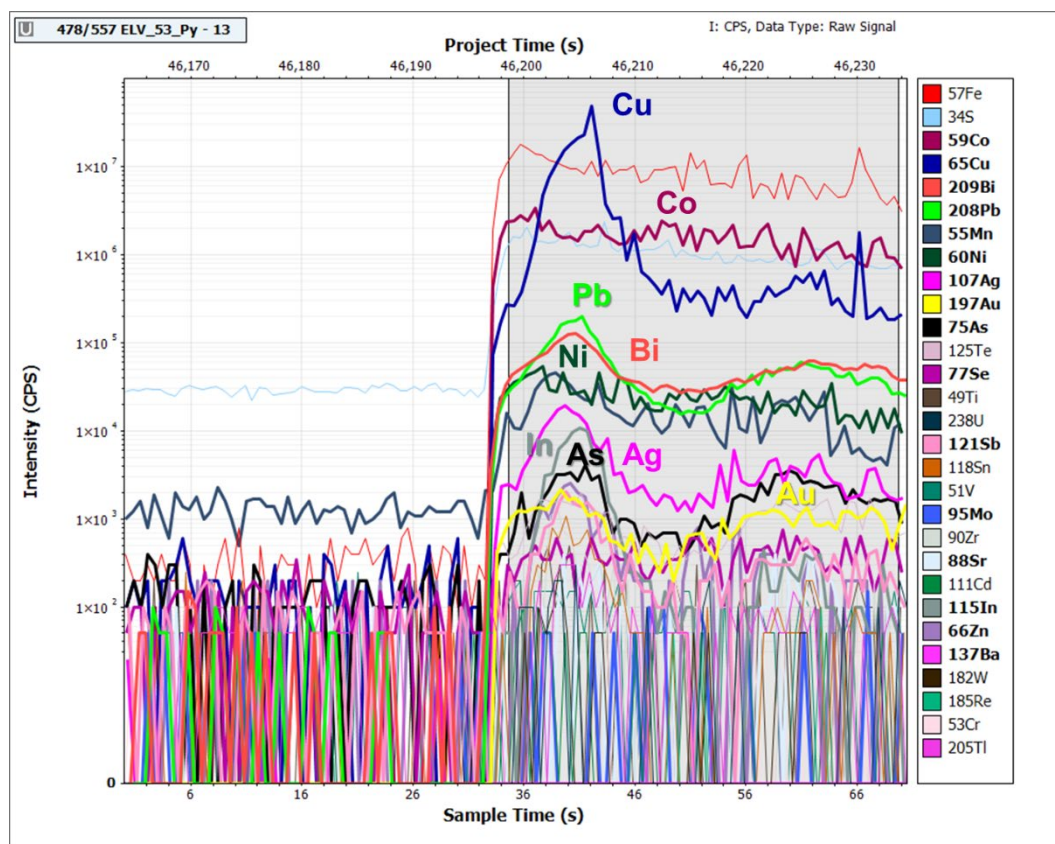


Figure 74. LA-ICP-MS pattern for ELV_53_Py-13 (sample ELV_T7_04, TSF2), with inclusion rich in Cu (19,134 ppm), Pb (58 ppm), Bi (38 ppm) and Ag (8 ppm), and lattice bound Co (2,086 ppm) and Ni (157 ppm).

Pyrrhotite

The chemistry of the pyrrhotite grains in the TSF2 samples was investigated, demonstrating enrichment in Cu and Co, and minor enrichments in Ni, Mn, As, Bi, Pb, Ag and Sb (Figure 75). Copper concentrations range from 38-67,903 ppm (average: 4,624 ppm, median: 756 ppm) and Co contents range from 31-5,425 ppm (average: 2,279 ppm, median: 2,372 ppm). Nickel concentrations range from 9-2,686 ppm (average: 311 ppm, median: 211 ppm) while Mn contents range from 1-649 ppm (average: 121 ppm, median: 66 ppm). The contents of As, Bi, Pb, Ag and Sb reach up to 399, 398, 365, 144 and 25 ppm, respectively, and maximum of 4.8 ppm Au was measured (Table 12).

A correlation matrix of selected elements in pyrrhotite is shown in Table 16. Copper is correlated with In (0.67), As (0.60), Bi (0.57), Zn (0.55) and Ag (0.50). Cobalt correlates highly with Ni (0.82) and Ag (0.51), while Mn is highly associated with Zn (0.94). Arsenic is associated with many elements, including Bi (0.77), Pb (0.75), Au (0.74), As (0.65) and so on. Bismuth is well correlated with Au (0.87), Ag (0.83), As (0.77), Pb (0.76) and In (0.73).

The LA-ICP-MS patterns reveal similar modes of occurrence of trace elements as those seen in pyrite. Cobalt, Ni and Pb are mainly lattice bound in pyrrhotite, as seen in Figure 76 and Figure 77. Copper appears to occur both in the lattice and in Cu-rich inclusions, with the inclusions associated with Bi, As and Ag.

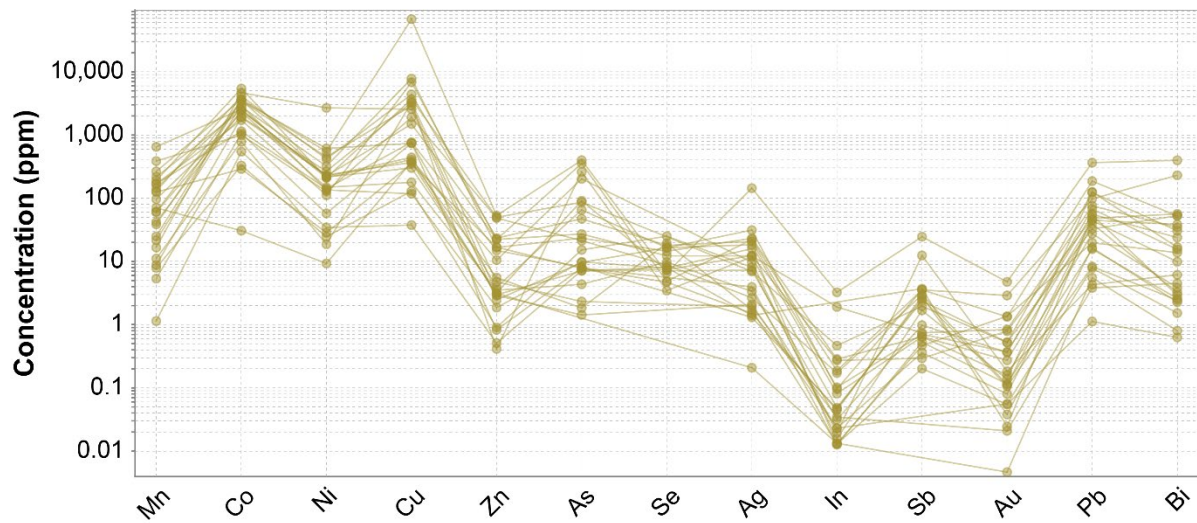


Figure 75. Concentrations of selected elements in pyrrhotite (n = 24).

Table 16. Correlation matrix for select elements in pyrrhotite (n = 24).

	Mn	Co	Ni	Cu	Zn	As	Se	Ag	In	Sb	Au	Pb	Bi
Mn	1												
Co	0.24	1											
Ni	0.21	0.82	1										
Cu	0.55	0.32	0.43	1									
Zn	0.94	0.22	0.27	0.55	1								
As	0.42	0.44	0.23	0.60	0.37	1							
Se	-0.06	0.13	0.14	-0.18	0.02	-0.33	1						
Ag	0.15	0.51	0.50	0.50	0.20	0.65	0.07	1					
In	0.56	0.19	0.44	0.67	0.64	0.48	-0.22	0.54	1				
Sb	0.21	-0.12	-0.07	0.15	0.21	0.50	-0.20	0.04	0.33	1			
Au	0.20	0.34	0.29	0.43	0.22	0.74	-0.25	0.87	0.57	0.12	1		
Pb	0.43	0.49	0.43	0.41	0.45	0.75	-0.22	0.63	0.66	0.34	0.67	1	
Bi	0.29	0.33	0.36	0.57	0.31	0.77	-0.36	0.83	0.73	0.22	0.87	0.76	1

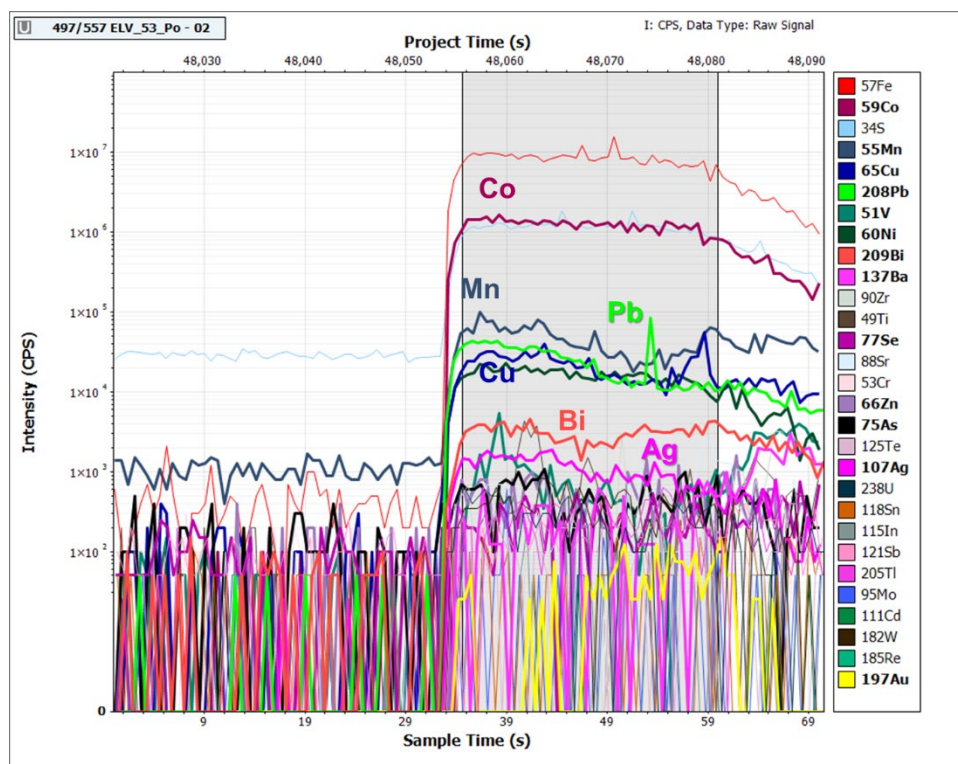


Figure 76. LA-ICP-MS pattern for ELV_53_Po-02 (sample ELV_T7_04, TSF2), relatively inclusion-free with lattice bound Co (2,318 ppm), Mn (60 ppm), Cu (179 ppm), Pb (40 ppm), Bi (3 ppm) and Ag (3 ppm).

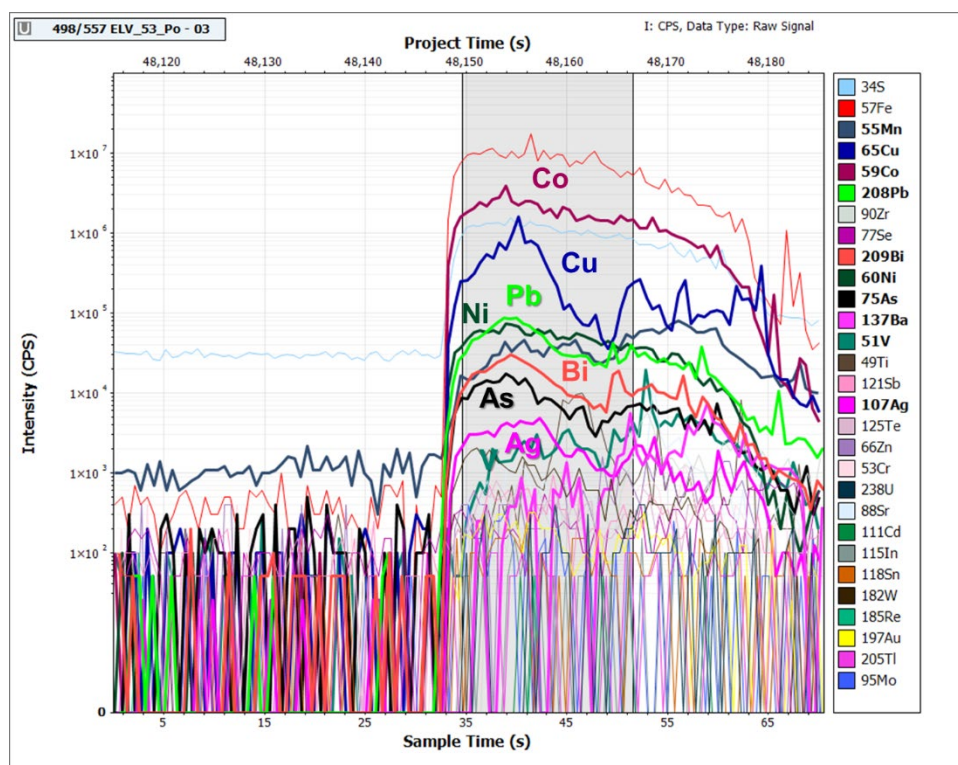


Figure 77. LA-ICP-MS pattern for ELV_53_Po-03 (sample ELV_T7_04, TSF2), with inclusion rich in Cu (2,908 ppm), Pb (68 ppm), As (91 ppm) and Ag (7 ppm), and lattice bound Co (3,486 ppm) and Ni (448 ppm).

Chalcopyrite

The chemistry of the chalcopyrite grains in the TSF2 and hardpan samples was investigated, demonstrating some enrichment in Zn, Mn, Ag, Pb, In and Se (Figure 78). Zinc concentrations range from 22-615 ppm (average: 125 ppm, median: 48 ppm) and Mn contents range from 0.4-314 ppm (average: 67 ppm, median: 24 ppm). The contents of Ag, Pb, In and Se reach up to 127, 85, 37 and 39 ppm, respectively, and maximum of 7.5 ppm Au was measured (Table 12).

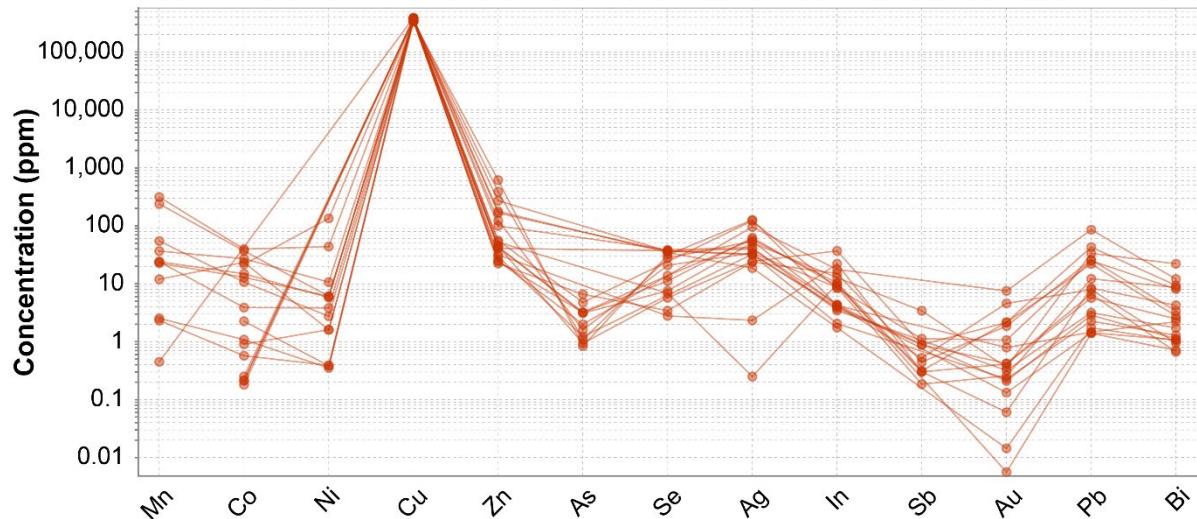


Figure 78. Concentrations of selected elements in chalcopyrite (n = 18).

A correlation matrix of selected elements in chalcopyrite is shown in Table 17. Manganese is correlated with Ag (0.80), Se (0.79), Ni (0.79), Co (0.73), Au (0.68) and Pb (0.65). Cobalt correlates highly with Ni (0.76), As (0.76), Au (0.74), Pb (0.69) and Bi (0.66). Zinc and Se are associated (0.55), while As is correlated with Bi (0.57) and Pb (0.54). Silver and gold contents are associated, with a correlation coefficient of 0.67.

Table 17. Correlation matrix for select elements in chalcopyrite (n = 18).

	Mn	Co	Ni	Cu	Zn	As	Se	Ag	In	Sb	Au	Pb	Bi
Mn	1												
Co	0.73	1											
Ni	0.79	0.76	1										
Cu	-0.87	-0.51	-0.32	1									
Zn	0.13	-0.33	-0.01	-0.03	1								
As	0.22	0.76	0.35	-0.09	-0.60	1							
Se	0.79	-0.61	0.28	-0.34	0.55	-0.55	1						
Ag	0.80	0.54	0.53	-0.71	0.13	-0.04	0.31	1					
In	-0.55	0.51	-0.23	0.20	-0.54	0.29	-0.91	-0.04	1				
Sb	0.28	0.30	0.04	-0.21	0.08	-0.08	-0.17	0.16	-0.13	1			
Au	0.68	0.74	0.22	-0.60	-0.23	-0.04	-0.14	0.67	0.22	0.30	1		
Pb	0.65	0.69	0.27	-0.28	-0.56	0.54	-0.44	0.38	0.50	0.36	0.70	1	
Bi	0.55	0.66	0.51	-0.21	-0.46	0.57	-0.24	0.37	0.36	0.06	0.40	0.79	1

The LA-ICP-MS patterns reveal compositional differences between the TSF2 samples and the hardpan samples. As seen in Figure 79 and Figure 80, the TSF2 chalcopryite grains appear to have more inclusions, and higher Mn contents. The hardpan chalcopryite grains are somewhat 'cleaner', i.e. fewer inclusions, with higher Zn and Ag contents (Figure 81). In general, In, Bi and Pb appear to be lattice-bound, while Mn, Ag and Zn are also present in inclusions within the chalcopryite grains. In the grain shown in Figure 81, Au and Ag appear to co-occur in an inclusion. Higher Se contents in chalcopryite grains are found in the hardpan sample ELV_GS_01, with concentrations of 28-39 ppm (Figure 81).

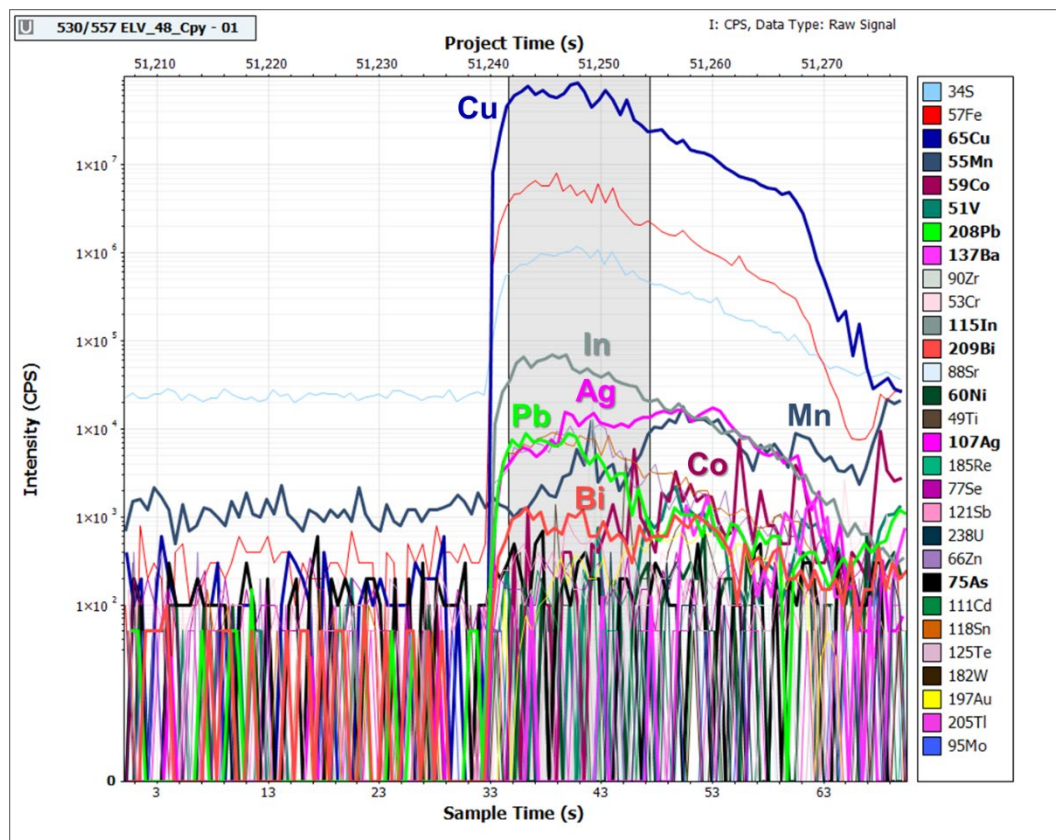


Figure 79. LA-ICP-MS pattern for ELV_48_Cpy-01 (sample ELV_T6_03, TSF2), with mainly lattice bound In (37 ppm) and Pb (7 ppm), and inclusion-hosted Ag (24 ppm).

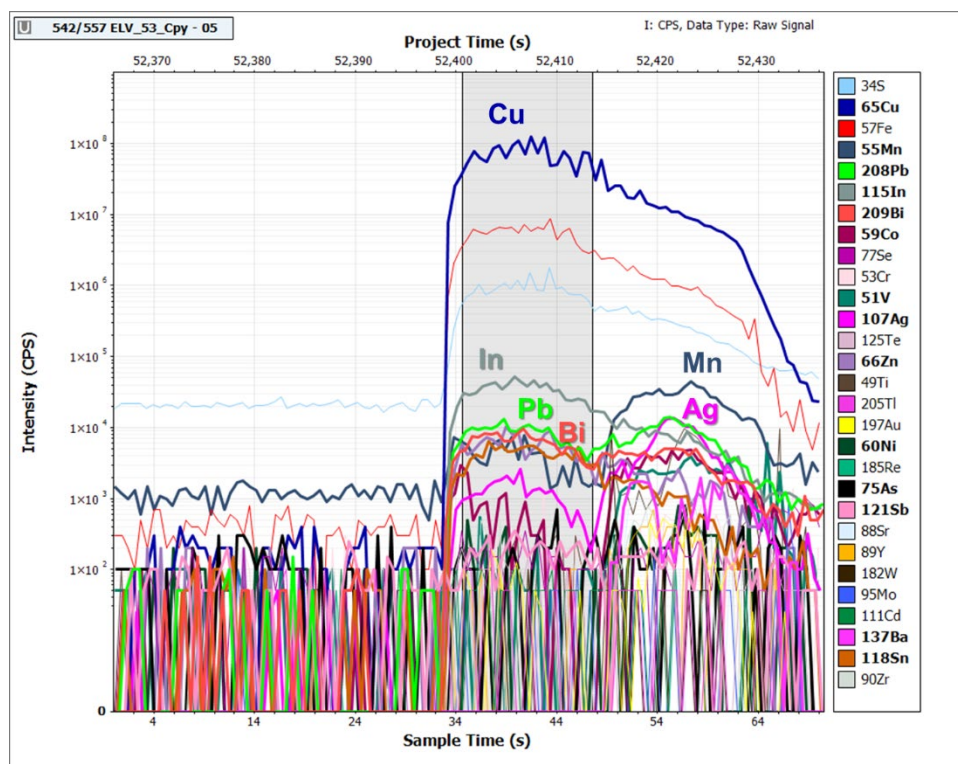


Figure 80. LA-ICP-MS pattern for ELV_53_Cpy-05 (sample ELV_T7_04, TSF2), with lattice-hosted In (22 ppm), inclusion-related Mn (8 ppm), Pb (4 ppm) and Bi (4 ppm).

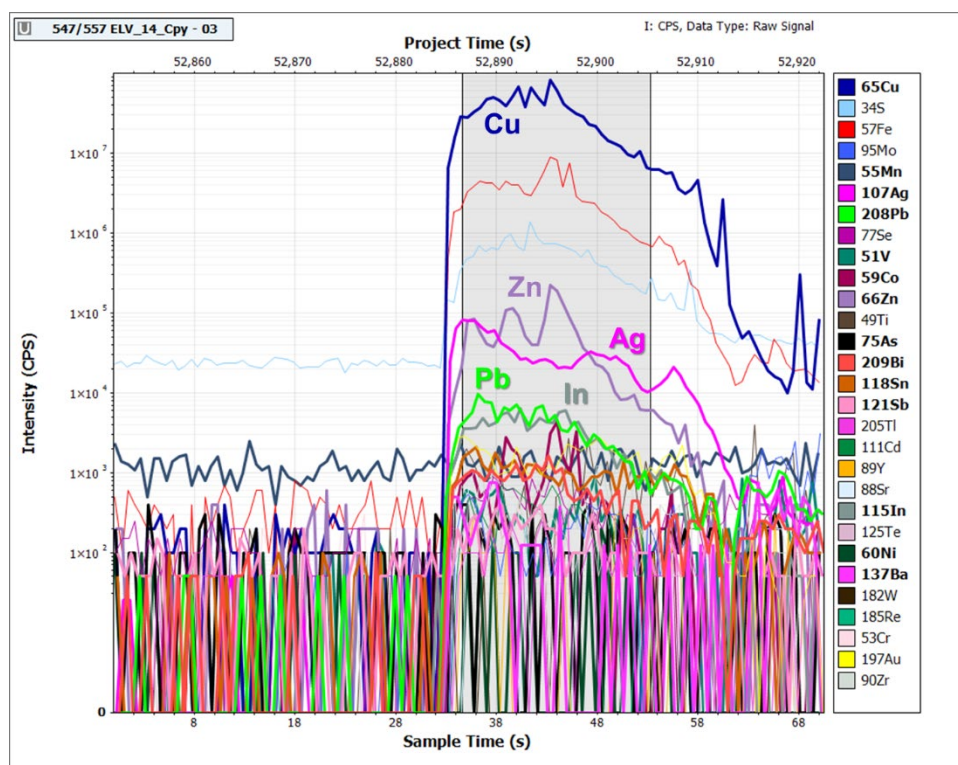


Figure 81. LA-ICP-MS pattern for ELV_14_Cpy-03 (sample ELV_GS_01, hardpan), with predominantly inclusion-hosted Zn (615 ppm), Ag (127 ppm) Au (5 ppm) and Se (31 ppm).

Goethite

The chemistry of the goethite grains in the hardpan and salt samples was investigated, demonstrating some enrichment in Ti, Cu, Mo, Co, Zn, V and Cr (Figure 82). Titanium concentrations range from 1,398-6,746 ppm (average: 3,920 ppm, median: 3,539 ppm) and Cu contents range from 104-13,187 ppm (average: 8,191 ppm, median: 8,276 ppm). The Mo concentrations range from 6.3-3,576 ppm (average: 403 ppm, median: 40 ppm), while the Co contents range from 3.9-973 ppm (average: 112 ppm, median: 48 ppm). The contents of Zn, V and Cr reach up to 966, 805 and 474 ppm, respectively (Table 13).

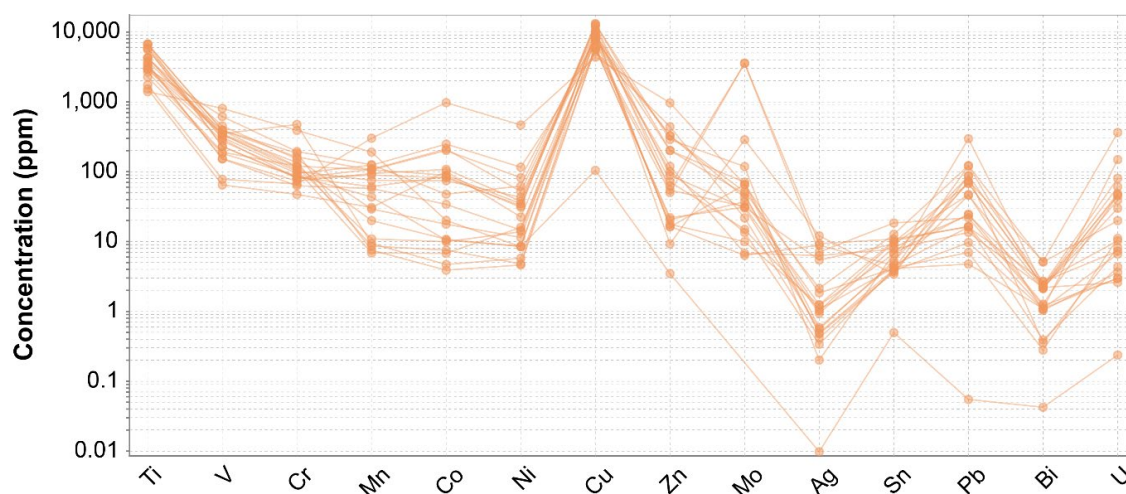


Figure 82. Concentrations of selected elements in goethite (n = 21).

A correlation matrix of selected elements in goethite is shown in Table 18, with little correlation seen between most elements. Vanadium is correlated with Cr (0.89) while Mn is correlated with Co (0.80) and Ni (0.73). Cobalt correlates highly with Ni (0.87), Zn (0.82) and U (0.70). Nickel is associated with Zn (0.82) and U (0.62), and Zn is also correlated with U (0.70).

Table 18. Correlation matrix for select elements in goethite (n = 21).

	Ti	V	Cr	Mn	Co	Ni	Cu	Zn	Mo	Ag	Sn	Pb	Bi	U
Ti	1													
V	0.28	1												
Cr	0.18	0.89	1											
Mn	-0.30	-0.15	-0.16	1										
Co	-0.22	-0.54	-0.55	0.80	1									
Ni	-0.11	-0.43	-0.43	0.73	0.87	1								
Cu	0.35	-0.11	-0.22	0.07	0.16	0.13	1							
Zn	0.01	-0.65	-0.62	0.49	0.82	0.82	0.02	1						
Mo	0.10	-0.23	-0.31	-0.18	-0.07	-0.03	0.03	0.04	1					
Ag	0.03	0.08	0.24	-0.68	-0.55	-0.40	-0.06	-0.43	0.14	1				
Sn	0.46	-0.04	-0.02	-0.52	-0.21	-0.14	-0.03	0.09	0.19	0.47	1			
Pb	0.17	-0.52	-0.53	-0.08	0.19	0.08	0.28	0.35	0.26	-0.02	0.10	1		
Bi	-0.11	-0.71	-0.63	0.09	0.43	0.28	0.30	0.42	0.13	0.14	-0.02	0.55	1	
U	0.16	-0.43	-0.59	0.51	0.70	0.62	0.34	0.70	-0.07	-0.55	-0.22	0.41	0.46	1

The LA-ICP-MS patterns suggest that the critical elements are mainly lattice-hosted in goethite (Figure 83 to Figure 85). In Figure 83, Cu, Pb, Ti, V, U, Co, Mn, Zn, Mo, As, Bi and Ni all mainly occur in the goethite lattice, while in Figure 84, Co, U, Pb and Bi appear to partly occur in inclusions and Cu, Zn, V, Ti, Mo, As and W are mainly lattice-bound. The goethite grains in sample ELV_GS_01 are 'cleaner', with clearly lattice-hosted Cu, Mo, V, Ti, As and Pb (Figure 85).

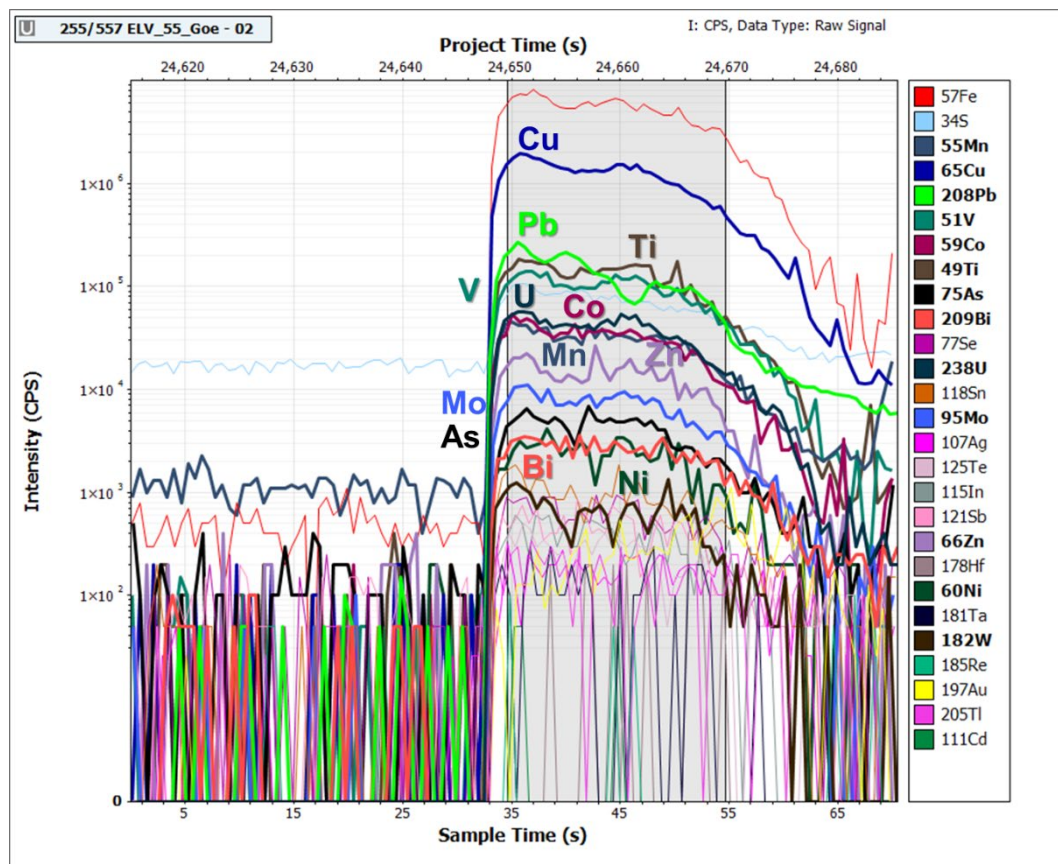


Figure 83. LA-ICP-MS pattern for ELV_55_Goe-02 (sample ELV_GS_10, hardpan), with mainly lattice-hosted Cu (13,187 ppm), Pb (296 ppm), Ti (5,787 ppm), V (230 ppm), U (46 ppm), Co (85 ppm), Mn (61 ppm), Zn (200 ppm), Mo (70 ppm) and Ni (31 ppm).

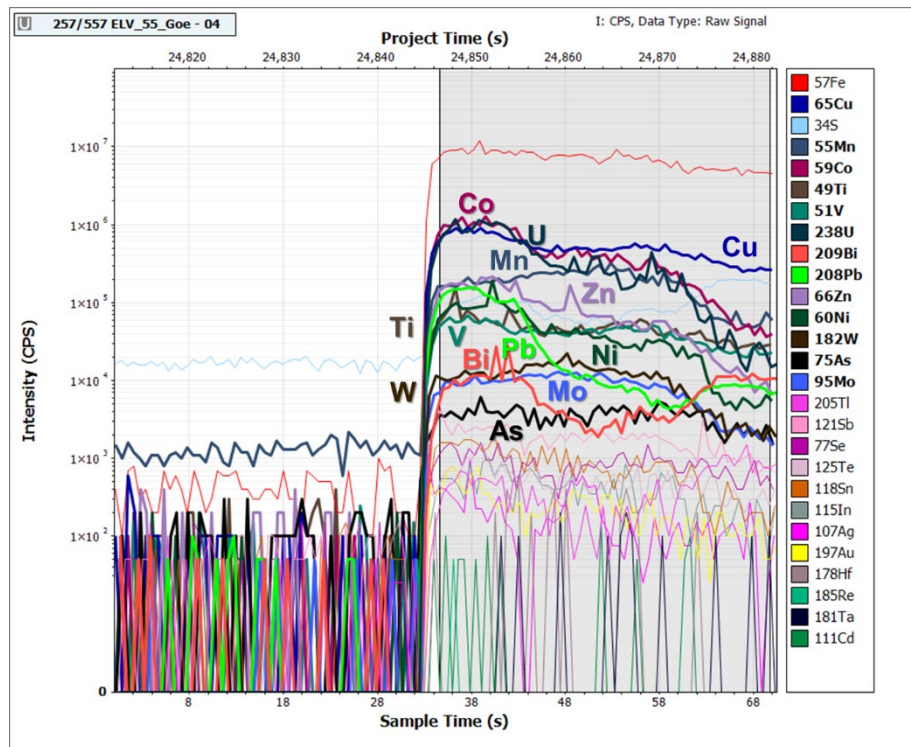


Figure 84. LA-ICP-MS pattern for ELV_55_Goe-04 (sample ELV_GS_10, hardpan), with partly inclusion-hosted Co (973 ppm), U (363 ppm) and Pb (73 ppm), and lattice-bound Cu (4,363 ppm), Zn (966 ppm), V (78 ppm), Ti (1,753 ppm), Ni (465 ppm), Mo (65 ppm) and W (42 ppm).

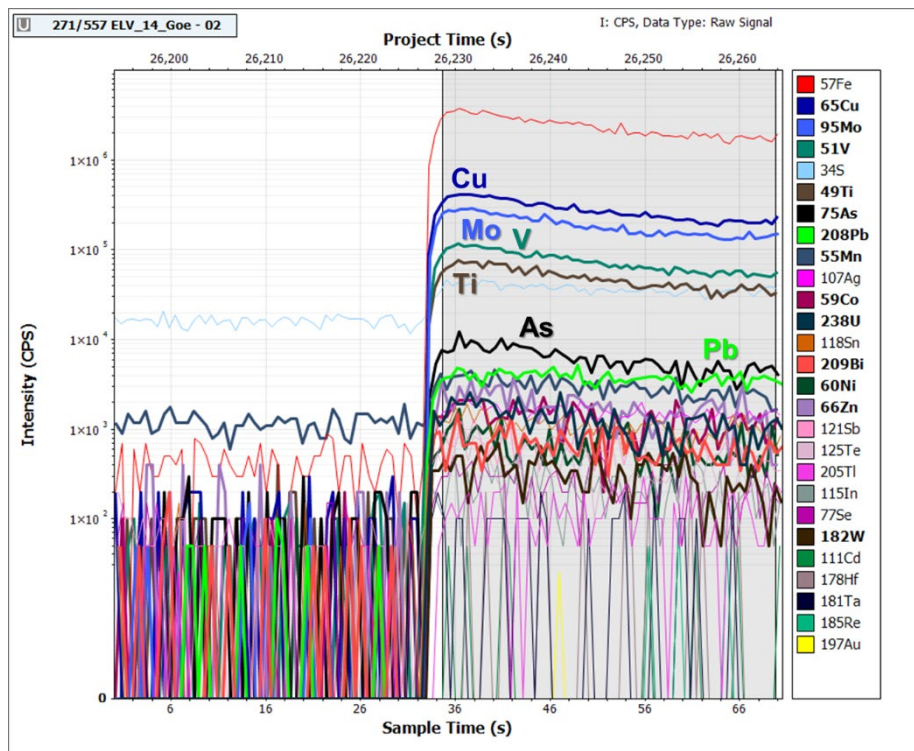


Figure 85. LA-ICP-MS pattern for ELV_14_Goe-02 (sample ELV_GS_01, hardpan), inclusion-free with lattice-bound Cu (5,628 ppm), Mo (3,576 ppm), V (341 ppm), Ti (4,271 ppm) and Pb (16 ppm).

Jarosite

The chemistry of the jarosite grains in the hardpan samples and tailings fan sample was investigated, demonstrating enrichment in Cu, Pb and Ti (Figure 86). Copper concentrations range from 1,816-21,870 ppm (average: 9,191 ppm, median: 7,480 ppm) and Pb contents range from 6.2-19,541 ppm (average: 600 ppm, median: 46 ppm). The Ti concentrations range from 311-12,490 ppm (average: 2,119 ppm, median: 1,473 ppm). The content of Mn also reaches up to 1,443 ppm (Table 13).

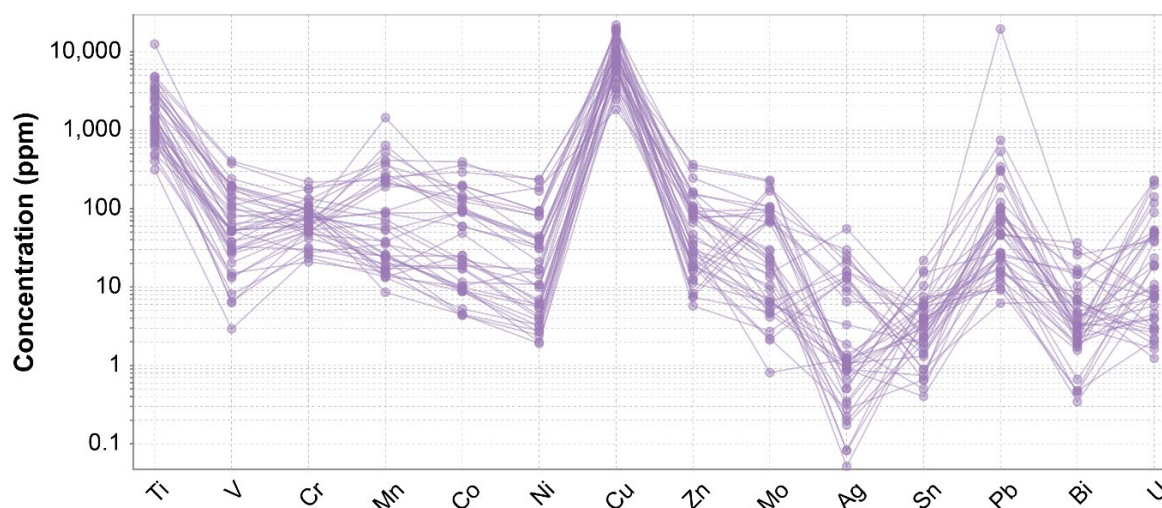


Figure 86. Concentrations of selected elements in jarosite (n = 39).

A correlation matrix of selected elements in jarosite is shown in Table 19. Cobalt is highly correlated with Ni (0.93) and Zn (0.91), while Mn is highly associated with Co (0.81) and Ni (0.85) as well as U (0.69), Zn (0.67) and Sn (0.65). Titanium is associated with V (0.68) and V is correlated with Cr (0.68). Both Cu and Pb are not well correlated with any other elements. Uranium is highly associated with a range of elements, including Co (0.74), Ni (0.76), Zn (0.78), Mo (0.65) and Sn (0.67).

Table 19. Correlation matrix for select elements in jarosite (n = 39).

	Ti	V	Cr	Mn	Co	Ni	Cu	Zn	Mo	Ag	Sn	Pb	Bi	U
Ti	1													
V	0.68	1												
Cr	0.42	0.68	1											
Mn	0.32	0.30	0.31	1										
Co	0.18	0.07	0.08	0.81	1									
Ni	0.20	0.16	0.19	0.85	0.93	1								
Cu	-0.24	0.23	0.27	0.00	0.04	0.15	1							
Zn	0.17	0.04	-0.02	0.67	0.91	0.82	0.02	1						
Mo	0.27	0.37	0.48	0.42	0.34	0.38	0.28	0.38	1					
Ag	-0.02	0.20	0.12	-0.61	-0.71	-0.59	0.25	-0.65	-0.03	1				
Sn	0.40	0.52	0.48	0.65	0.57	0.61	0.00	0.52	0.61	-0.28	1			
Pb	0.09	0.25	0.10	-0.45	-0.30	-0.40	0.18	-0.11	0.20	0.35	0.10	1		
Bi	-0.48	-0.51	-0.42	-0.38	-0.18	-0.25	0.25	-0.09	-0.15	0.04	-0.30	0.35	1	
U	0.19	0.33	0.44	0.69	0.74	0.76	0.35	0.78	0.65	-0.36	0.67	-0.01	-0.17	1

The LA-ICP-MS patterns suggest that the critical elements occurring in jarosite are lattice-bound and the grains are relatively free of inclusions (Figure 87 and Figure 88). In Figure 87, the jarosite grain is enriched in Cu, Ti, Pb, U, etc., while the grain shown in Figure 88 is enriched in Ti, Cu, Mn and V.

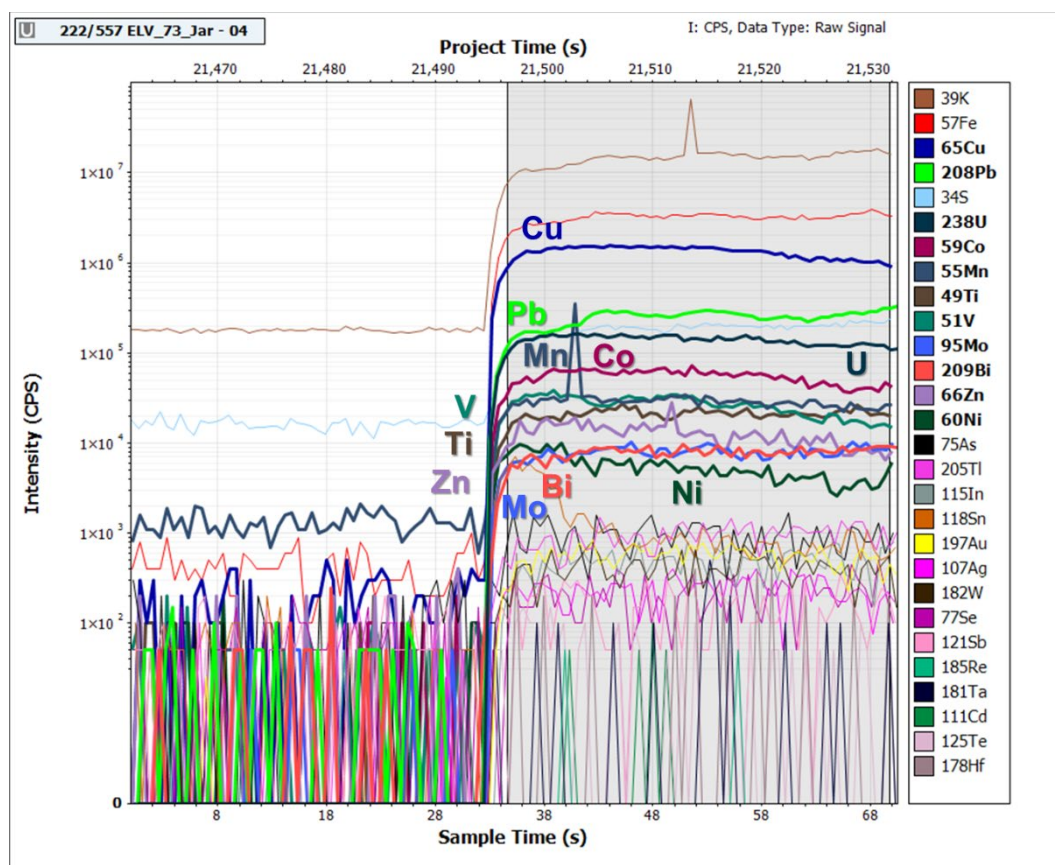


Figure 87. LA-ICP-MS pattern for ELV_73_Jar-04 (ELV_GS_26, tailings fan), relatively inclusion-free with lattice-bound Cu (19,129 ppm), Pb (743 ppm), Mn (92 ppm), U (222 ppm), Co (194 ppm), V (84 ppm), Ti (1,280 ppm), Zn (244 ppm), Mo (103 ppm) and Ni (94 ppm).

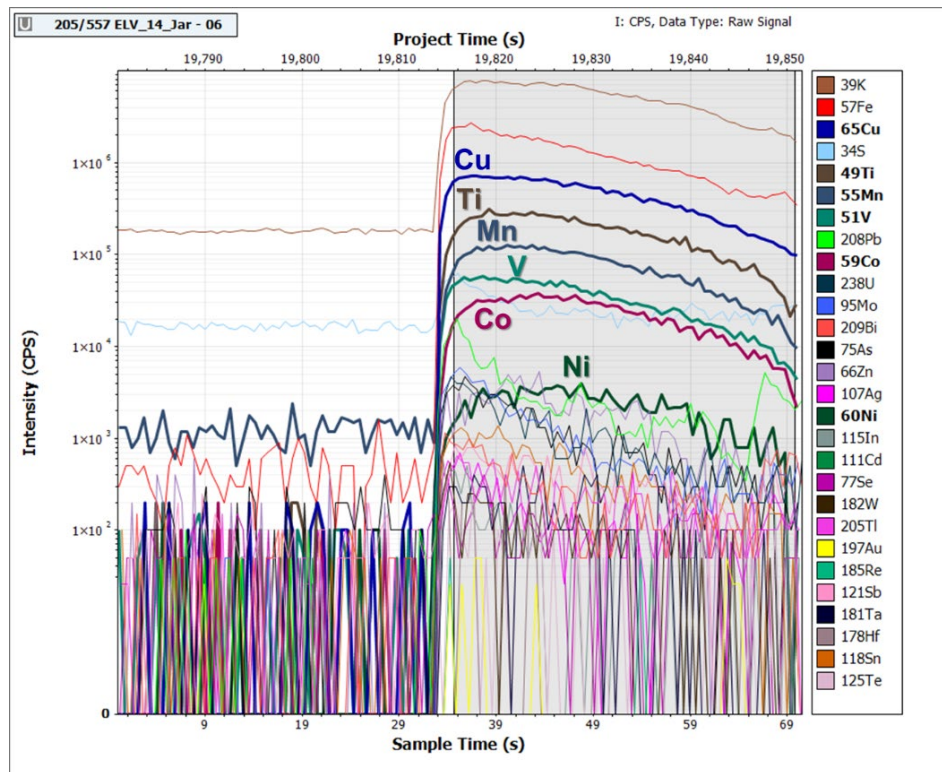


Figure 88. LA-ICP-MS pattern for ELV_14_Jar-06 (sample ELV_GS_01, hardpan), inclusion-free with lattice-bound Cu (7,757 ppm), Ti (12,490 ppm), Mn (242 ppm), V (121 ppm), Co (94 ppm) and Ni (44 ppm).

Schwertmannite

The chemistry of the schwertmannite grains in the hardpan samples was investigated, demonstrating some enrichment in Cu, Ti and Pb (Figure 89). Copper values range from 2,166-13,299 ppm (average: 6,460 ppm, median: 6,144 ppm) and Ti contents range from 731-8,499 ppm (average: 2,870 ppm, median: 2,837 ppm). The Pb content reaches up to 872 ppm and Zn up to 440 ppm (Table 13).

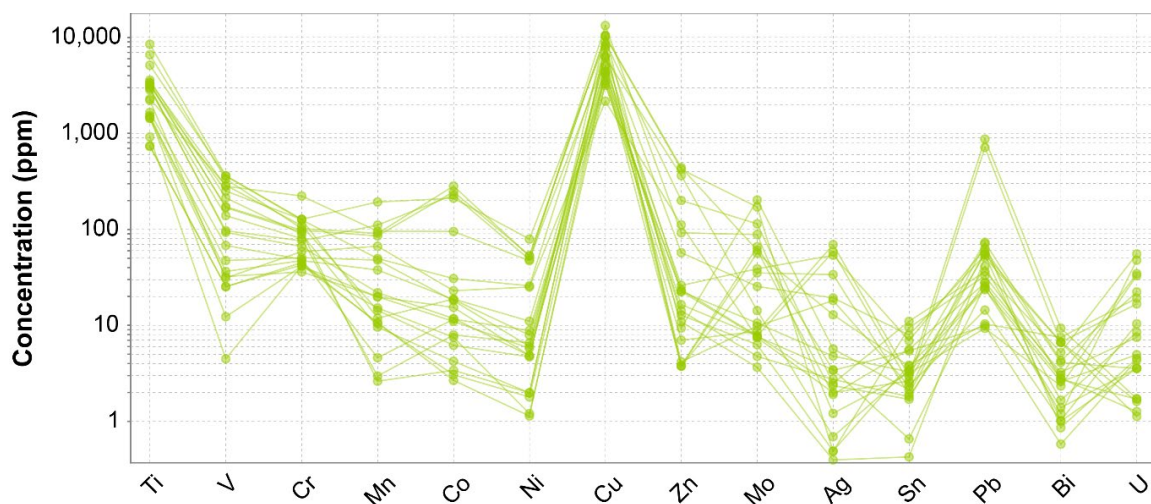


Figure 89. Concentrations of selected elements in schwertmannite (n = 21).

A correlation matrix of selected elements in schwertmannite is shown in Table 20. Vanadium is highly correlated with Cr (0.94), Ti (0.90), Cu (0.84) and Mo (0.80). Titanium is also associated with Cr (0.87), Sn (0.73) and Cu (0.71), while copper is correlated with Cr (0.80) and Mo (0.77). Cobalt and Ni are highly correlated (0.94), while Mn and Zn are correlated with a coefficient of 0.90. Uranium is associated with a range of elements, including Co (0.81), Mn (0.80), Ni (0.76) and Zn (0.72).

Table 20. Correlation matrix for select elements in schwertmannite (n = 21).

	Ti	V	Cr	Mn	Co	Ni	Cu	Zn	Mo	Ag	Sn	Pb	Bi	U
Ti	1													
V	0.90	1												
Cr	0.87	0.94	1											
Mn	0.37	0.31	0.33	1										
Co	0.55	0.48	0.48	0.86	1									
Ni	0.62	0.58	0.58	0.74	0.94	1								
Cu	0.71	0.84	0.80	0.26	0.31	0.36	1							
Zn	0.39	0.32	0.38	0.90	0.87	0.77	0.25	1						
Mo	0.64	0.80	0.80	0.14	0.32	0.51	0.77	0.19	1					
Ag	-0.21	-0.01	-0.07	-0.62	-0.53	-0.35	-0.19	-0.48	0.06	1				
Sn	0.73	0.69	0.71	0.33	0.52	0.60	0.49	0.45	0.59	-0.06	1			
Pb	-0.42	-0.20	-0.17	-0.04	-0.10	-0.08	-0.29	0.07	-0.09	0.37	-0.13	1		
Bi	-0.45	-0.54	-0.42	0.19	0.01	-0.08	-0.58	0.17	-0.53	-0.14	-0.05	0.41	1	
U	0.64	0.61	0.58	0.80	0.81	0.76	0.60	0.72	0.42	-0.56	0.61	-0.26	-0.07	1

The LA-ICP-MS patterns suggest that the critical elements are mainly lattice-bound in schwertmannite (Figure 90 and Figure 91). In Figure 90, Cu, Ti, Zn, V, Co and more occur in the crystal lattice, while Pb appears to be inclusion related. The schwertmannite grain shown in Figure 91, is inclusion-free, with lattice-hosted Cu, Pb, Ti and Ag.

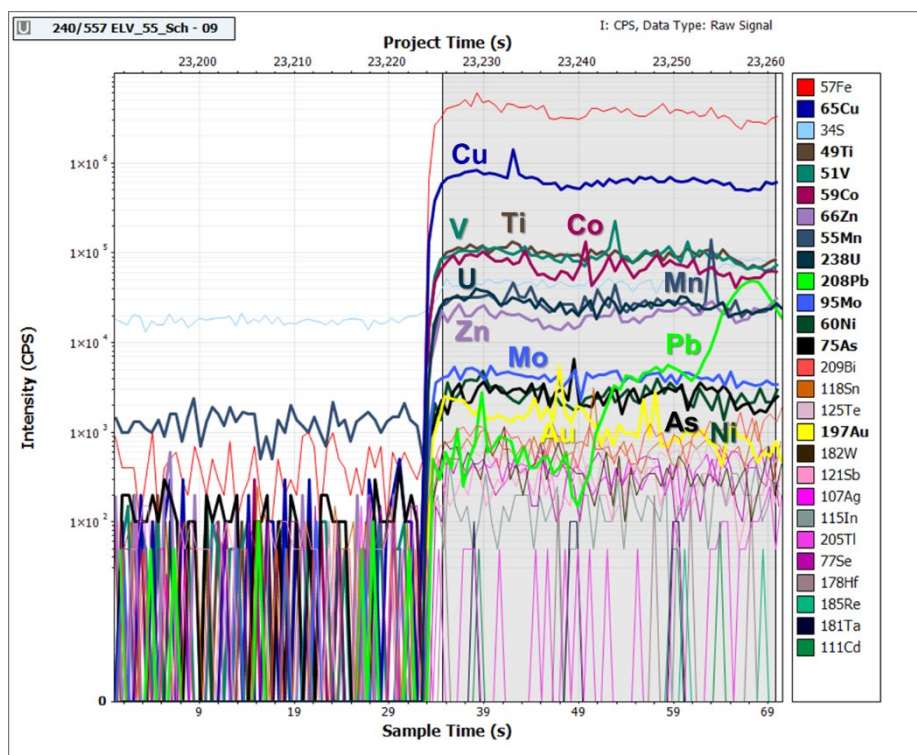


Figure 90. LA-ICP-MS pattern for ELV_55_Sch-09 (sample ELV_GS_10, hardpan), with mainly lattice bound Cu (10,408 ppm), Ti (6,611 ppm), Zn (440 ppm), V (336 ppm), Co (283 ppm), U (48 ppm) and Mn (91 ppm), and inclusion-hosted Pb (28 ppm).

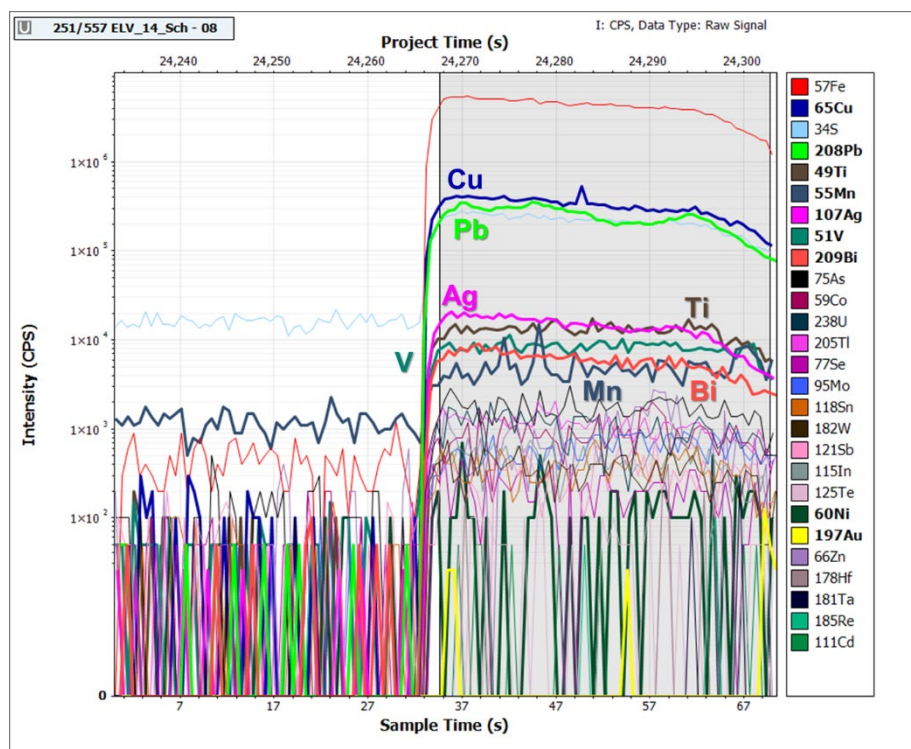


Figure 91. LA-ICP-MS pattern for ELV_14_Sch-08 (sample ELV_GS_01, hardpan), with lattice-bound Cu (4,350 ppm), Pb (715 ppm), Ti (742 ppm) and Ag (58 ppm).

Mg and Na-Mg sulphate

The chemistry of the Mg sulphate and Na-Mg sulphate grains in the salt sample was investigated, demonstrating high enrichment in a range of elements, including Cu, Mn, Ti, Co and Ni (Figure 92). Copper concentrations range from 9,767-43,402 ppm (average: 17,659 ppm, median: 14,866 ppm) in Mg sulphate and 9,035-144,351 ppm (average: 40,165 ppm, median: 25,073 ppm) in Na-Mg sulphate. Manganese concentrations range from 1,947-22,911 ppm (average: 7,782 ppm, median: 6,074 ppm) in Mg sulphate and 2,763-12,743 ppm (average: 7,917 ppm, median: 7,451 ppm) in Na-Mg sulphate.

The Ti concentrations range up to 5,057 ppm in Mg sulphate and 19,389 ppm in Na-Mg sulphate, Co up to 13,457 ppm in Mg sulphate and 14,857 ppm in Na-Mg sulphate, and Ni up to 8,351 ppm in Mg sulphate and 5,155 ppm in Na-Mg sulphate. The contents of U reach up to 5,077 ppm, Zn up to 2,188 ppm, Sn up to 1,991 ppm and Ag up to 311 ppm (Table 13).

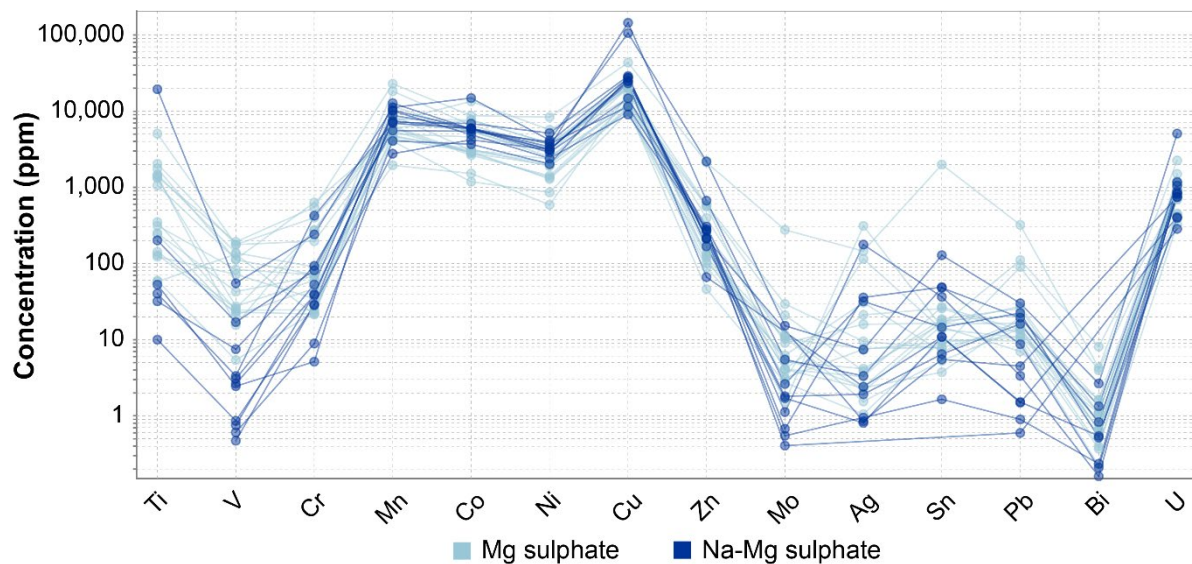


Figure 92. Concentrations of selected elements in Mg sulphate (n = 17) and Na-Mg sulphate (n = 11).

A correlation matrix of selected elements in Mg and Na-Mg sulphate is shown in Table 21. Cobalt and Ni are highly correlated (0.93), while Cu is mostly strongly correlated with Ni (0.64), Co (0.58) and Bi (0.53). Manganese is also associated with Co (0.67), Ni (0.54) and Sn (0.51). Titanium is correlated with Mo (0.70), V (0.69) and Pb (0.60).

The LA-ICP-MS patterns of the Mg and Na-Mg sulphate grains suggest that the critical elements are predominantly lattice-hosted (Figure 93 to Figure 95). In Figure 93 and Figure 94, Mn, Cu, Co, U, Ni, Ag and Zn occur in the Mg sulphate lattice, many at relatively high abundances. Figure 95 shows a Na-Mg sulphate grain which high contents of Cu, Co, Mn, U, Ni and Zn. The LA-ICP-MS pattern is relatively 'unclean', but the elements appear to be mainly lattice bound, aside from Ti which is inclusion hosted.

Table 21. Correlation matrix for select elements in Mg sulphate (n = 17) and Na-Mg sulphate (n = 11).

	Ti	V	Cr	Mn	Co	Ni	Cu	Zn	Mo	Ag	Sn	Pb	Bi	U
Ti	1													
V	0.69	1												
Cr	0.46	0.51	1											
Mn	-0.10	-0.04	0.03	1										
Co	-0.11	-0.22	0.16	0.67	1									
Ni	-0.13	-0.21	0.30	0.54	0.93	1								
Cu	0.12	-0.22	0.07	0.41	0.58	0.64	1							
Zn	0.05	0.14	0.32	0.40	0.22	0.27	0.42	1						
Mo	0.70	0.79	0.50	-0.16	-0.16	-0.11	0.03	0.22	1					
Ag	-0.02	0.23	0.23	0.49	0.19	0.13	-0.13	0.31	0.01	1				
Sn	0.09	0.07	0.41	0.51	0.49	0.44	0.18	0.41	0.18	0.49	1			
Pb	0.60	0.75	0.55	0.05	-0.07	0.00	0.01	0.49	0.85	0.19	0.29	1		
Bi	0.42	0.56	0.41	0.21	0.11	0.23	0.53	0.54	0.62	0.15	0.12	0.67	1	
U	0.31	0.48	0.23	0.38	0.14	0.05	0.20	0.29	0.33	0.32	0.29	0.36	0.21	1

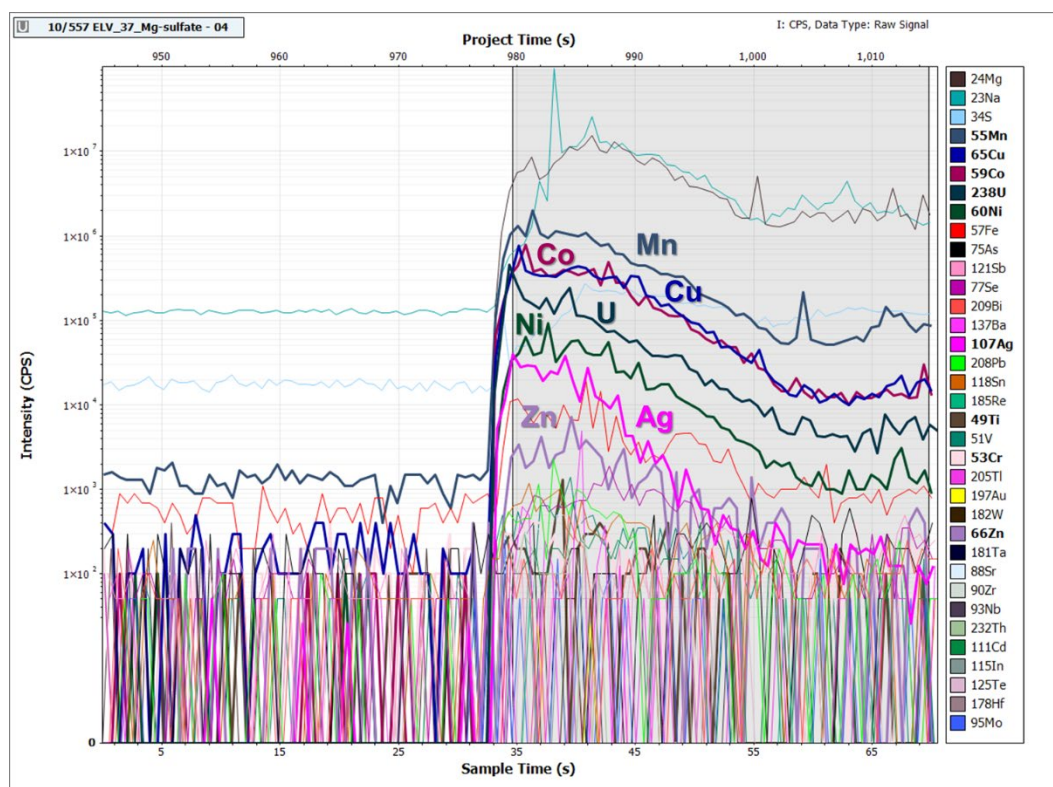


Figure 93. LA-ICP-MS pattern for ELV_37_Mg-sulphate-04 (sample ELV_GS_06, salt), with lattice bound Mn (11,579 ppm), Cu (21,997 ppm), Co (5,320 ppm), U (820 ppm), Ni (2,855 ppm), Ag (311 ppm) and Zn (209 ppm).

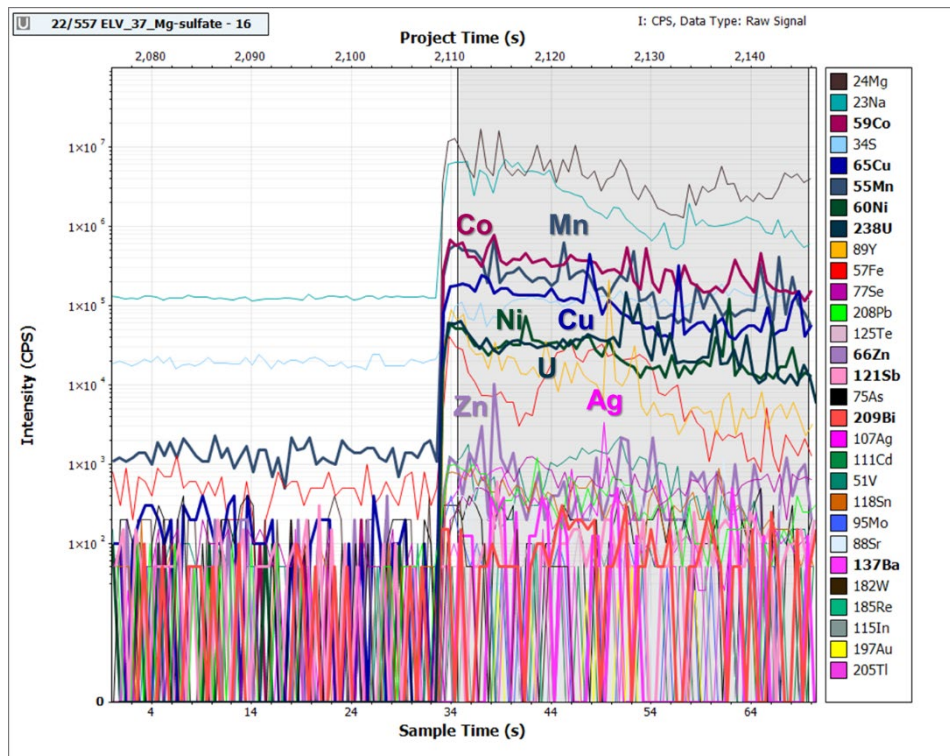


Figure 94. LA-ICP-MS pattern for ELV_37_Mg-sulphate-16 (sample ELV_GS_06, salt), with lattice bound Co (13,457 ppm), Mn (7,369 ppm), Cu (20,195 ppm), U (693 ppm), Ni (5,692 ppm), Ag (21 ppm) and Zn (180 ppm).

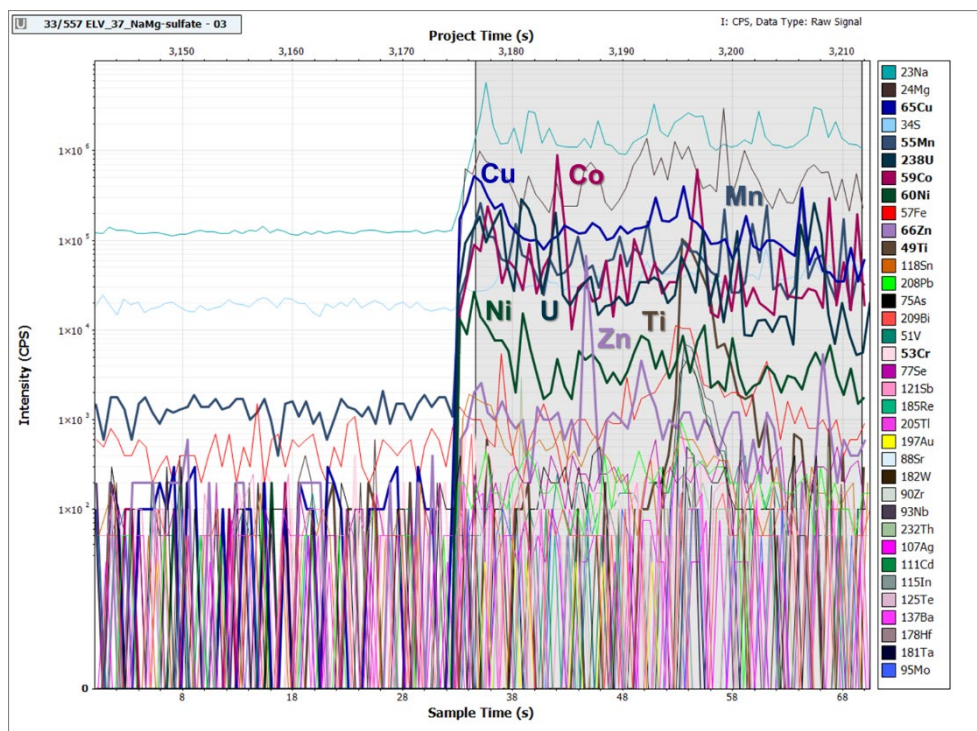


Figure 95. LA-ICP-MS pattern for ELV_37_NaMg-sulphate-03 (sample ELV_GS_06, salt), with mainly lattice bound Cu (105,775 ppm), Co (14,857 ppm), Mn (11,161 ppm), U (5,077 ppm), Ni (4,161 ppm) and Zn (2,188 ppm), and inclusion-hosted Ti (19,389 ppm).

Iron oxide

The chemistry of the iron oxide grains in the TSF1, tailings fan and hardpan samples was investigated, demonstrating minor enrichment in Cu, Cr, Ti and V (Figure 96). Copper concentrations range from 1.4-2,637 ppm (average: 233 ppm, median: 50 ppm) and Cr contents from 1.3-2,218 ppm (average: 201 ppm, median: 60 ppm). Titanium contents range from 16-2,171 ppm (average: 725 ppm, median: 575 ppm), while V ranges from 2.4-1,171 ppm (average: 493 ppm, median: 466 ppm). The contents of Mn, Co, Ni and Zn reach up to 394, 164, 120 and 155 ppm, respectively (Table 13).

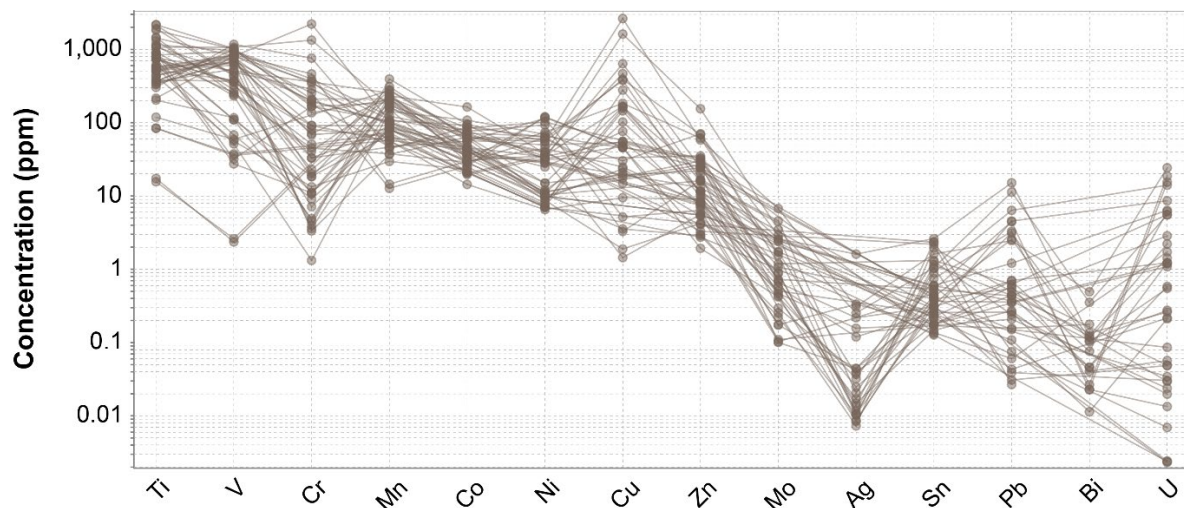


Figure 96. Concentrations of selected critical and strategic elements in iron oxide (n = 48).

A correlation matrix of selected elements in iron oxide is shown in Table 22. Copper is well correlated with Pb (0.77), Mo (0.74) and U (0.71), as well as Bi (0.56) and Zn (0.52). Chromium and vanadium are well associated (0.63), while U is correlated with Zn (0.79), Pb (0.72) and Mo (0.70). Zinc is also correlated with Mo (0.61), Co (0.55) and Pb (0.54), and Pb is correlated with Mo (0.73).

Table 22. Correlation matrix for selected critical and strategic elements in iron oxide (n = 48).

	Ti	V	Cr	Mn	Co	Ni	Cu	Zn	Mo	Ag	Sn	Pb	Bi	U
Ti	1													
V	0.18	1												
Cr	0.03	0.63	1											
Mn	0.16	-0.18	-0.20	1										
Co	-0.12	0.01	-0.01	0.46	1									
Ni	-0.23	0.36	0.05	0.12	0.48	1								
Cu	-0.07	-0.30	-0.54	0.21	0.18	0.00	1							
Zn	0.27	0.16	-0.20	0.34	0.55	0.30	0.52	1						
Mo	0.28	-0.08	-0.49	0.27	0.14	-0.01	0.74	0.61	1					
Ag	-0.14	-0.24	-0.06	0.45	0.04	-0.19	0.19	0.02	0.10	1				
Sn	-0.07	-0.39	-0.36	0.25	0.19	0.20	0.40	0.14	0.33	-0.11	1			
Pb	-0.04	-0.04	-0.47	-0.06	0.07	0.10	0.77	0.54	0.73	0.12	0.24	1		
Bi	-0.09	-0.29	-0.19	0.19	0.30	-0.01	0.56	0.22	0.22	0.35	0.21	0.26	1	
U	0.08	-0.03	-0.55	0.24	0.30	0.21	0.71	0.79	0.70	0.08	0.22	0.72	0.30	1

The LA-ICP-MS patterns suggest that the critical elements, including V, Mn, Ti, Co, Cr and Ni, are mainly lattice-bound in iron oxide grains (Figure 97). However, Cu occurs in inclusions, for example in Figure 98, where the Cu-rich inclusion is also associated with Pb, Zn, As and Bi.

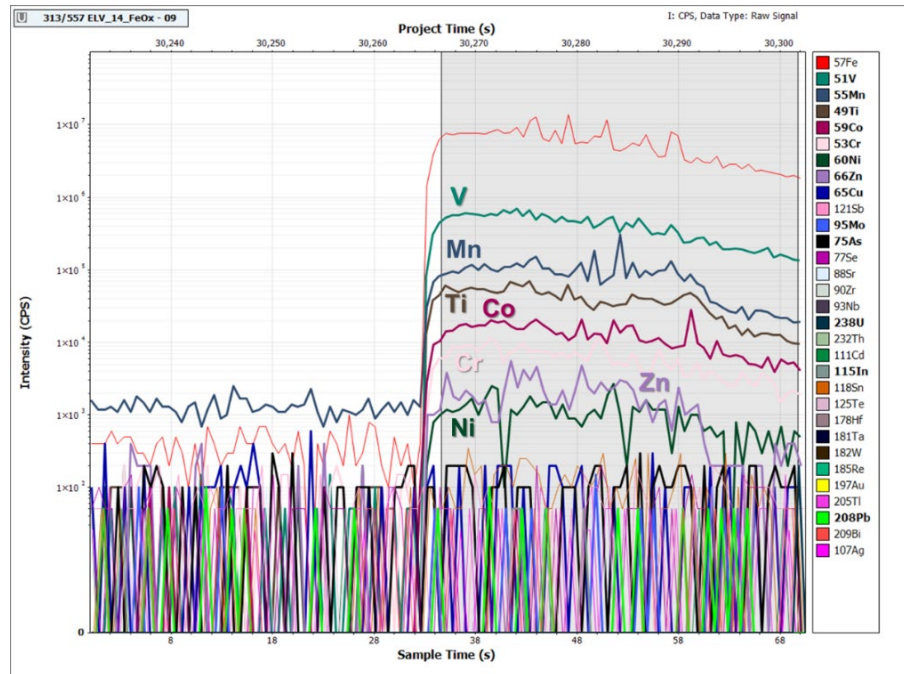


Figure 97. LA-ICP-MS pattern for ELV_14_FeOx-09 (sample ELV_GS_01, hardpan), with lattice bound V (1,004 ppm), Mn (186 ppm), Ti (1,822 ppm), Co (36 ppm) and Cr (167 ppm).

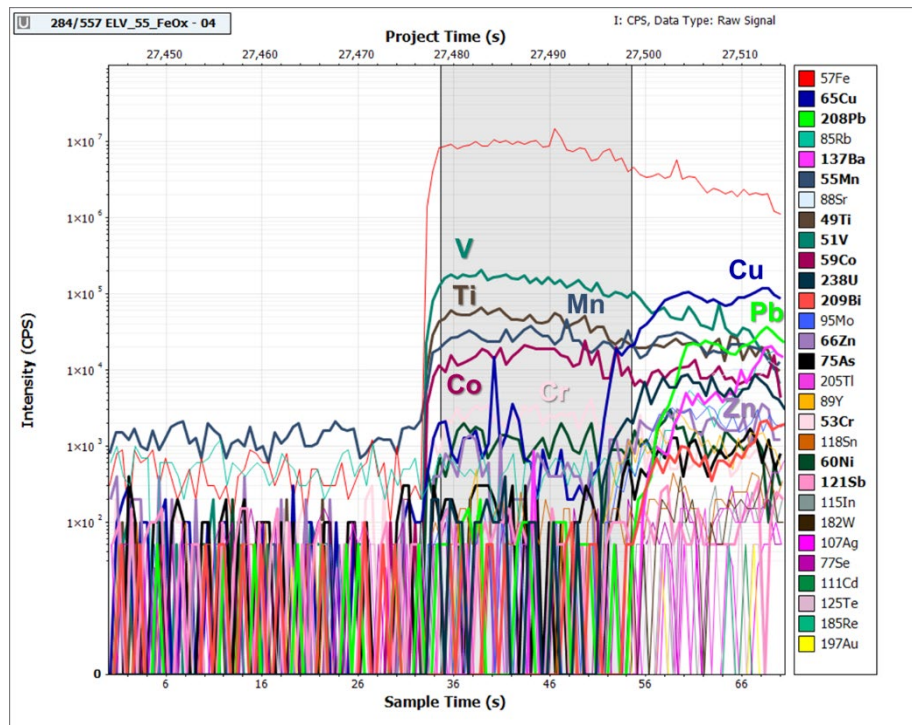


Figure 98. LA-ICP-MS pattern for ELV_55_FeOx-04 (sample ELV_GS_10, hardpan), with lattice bound Ti (1,452 ppm), Mn (38 ppm), V (243 ppm), Co (29 ppm) and Cr (45 ppm), and a Cu, Pb and Zn-rich inclusion.

The REE contents of the iron oxide were also measured, demonstrating little enrichment (Figure 99). Please note that the REEs were measured and quantified in a different laser run to the other analyses. Contents of up to 176 ppm Ce, 129 ppm La and 45 ppm Nd were detected (Table 14). A correlation matrix of REEs in iron oxide is shown in Table 23. All REEs correlate well with each other and have strong negative correlations with Fe. The LA-ICP-MS patterns suggest that the REEs in iron oxide occur in inclusions, as seen in Figure 100 which shows the most enriched grain.

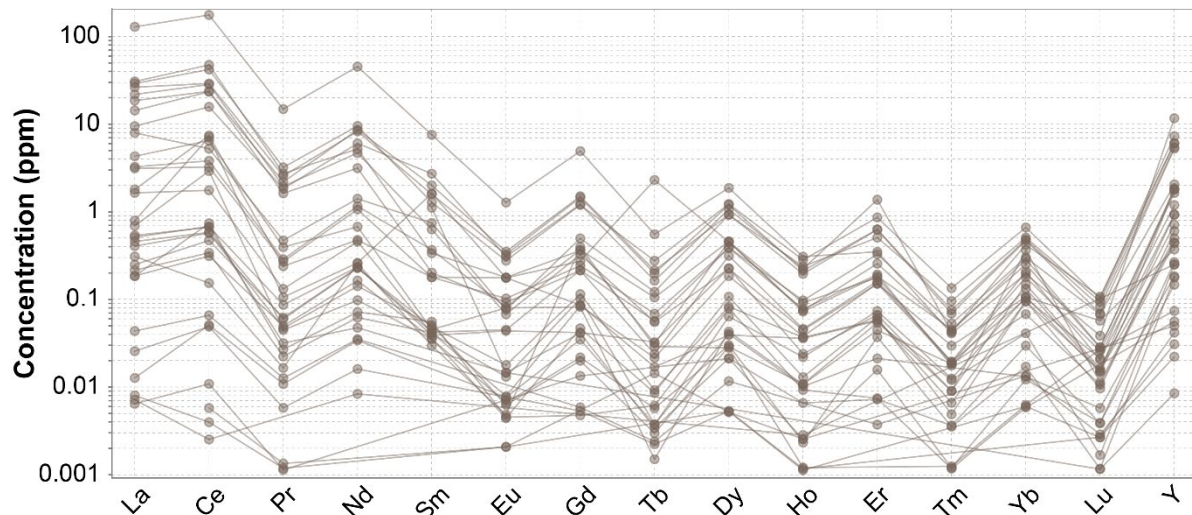


Figure 99. Concentrations of REEs in iron oxide (n = 33).

Table 23. Correlation matrix for REEs in iron oxide (n = 33).

	La	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Y	Fe
La	1															
Ce	0.97	1														
Pr	0.97	0.96	1													
Nd	0.95	0.91	0.97	1												
Sm	0.74	0.81	0.79	0.79	1											
Eu	0.86	0.88	0.89	0.86	0.81	1										
Gd	0.80	0.72	0.82	0.89	0.69	0.78	1									
Tb	0.64	0.65	0.70	0.78	0.66	0.73	0.87	1								
Dy	0.78	0.80	0.87	0.83	0.73	0.82	0.83	0.87	1							
Ho	0.75	0.76	0.84	0.81	0.79	0.85	0.82	0.85	0.95	1						
Er	0.69	0.64	0.76	0.79	0.69	0.78	0.89	0.88	0.94	0.96	1					
Tm	0.77	0.72	0.82	0.78	0.69	0.81	0.77	0.76	0.86	0.89	0.91	1				
Yb	0.67	0.70	0.76	0.69	0.74	0.84	0.70	0.75	0.83	0.89	0.90	0.89	1			
Lu	0.55	0.57	0.65	0.68	0.50	0.65	0.81	0.79	0.85	0.82	0.93	0.79	0.81	1		
Y	0.76	0.75	0.85	0.80	0.62	0.84	0.85	0.87	0.96	0.98	0.96	0.90	0.90	0.85	1	
Fe	-0.73	-0.72	-0.76	-0.72	-0.45	-0.72	-0.54	-0.54	-0.66	-0.71	-0.63	-0.73	-0.70	-0.51	-0.68	1

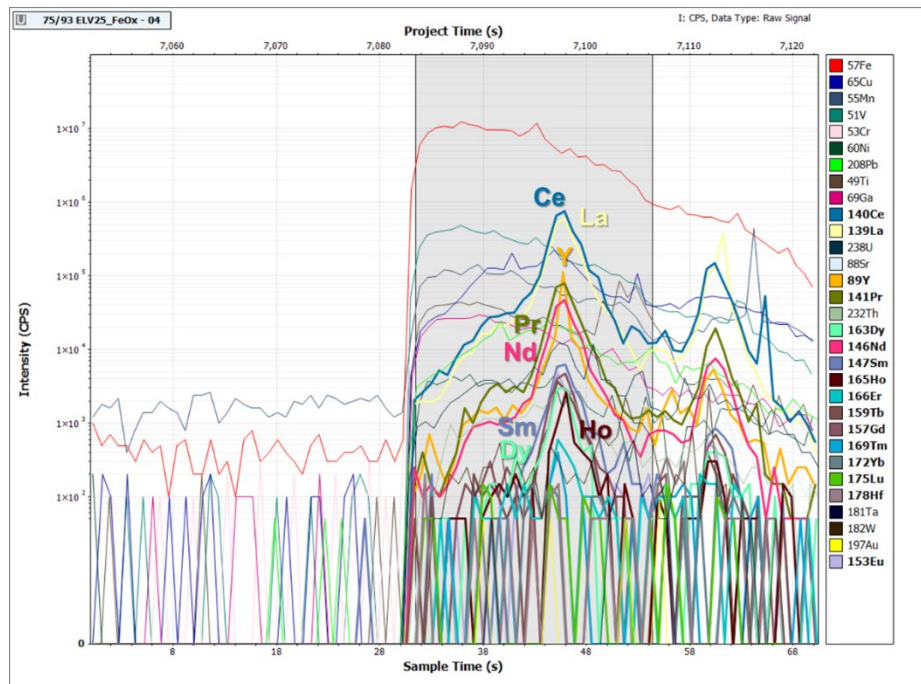


Figure 100. LA-ICP-MS pattern for ELV25_FeOx-04 (sample ELV_T3_08, TSF1), with inclusion-hosted REEs (176 ppm Ce, 129 ppm La and 45 ppm Nd) as well as mainly lattice bound V, Cu, Mn, Ti and Ga.

Apatite

The chemistry of the apatite grains in the TSF1 samples was investigated, demonstrating some enrichment in Ce, La, Y and Nd (Figure 101). Cerium concentrations range from 25-1,517 ppm (average: 302 ppm, median: 179 ppm) and Y contents from 230-1,492 ppm (average: 834 ppm, median: 978 ppm). Lanthanum concentrations range from 8.6-883 ppm (average: 144 ppm, median: 61 ppm). The content of Nd ranges up to 591 ppm, Dy up to 206 ppm, Yb up to 174 ppm, Er up to 164 ppm, Pr up to 157 ppm, Gd up to 140 ppm and Sm up to 131 ppm (Table 14).

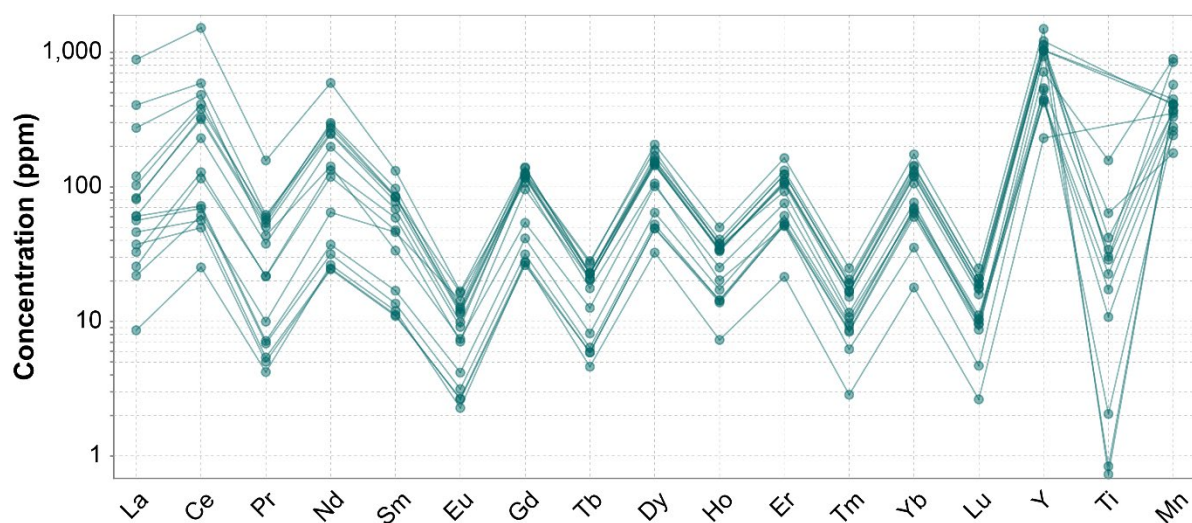


Figure 101. Concentrations of REEs, Ti and Mn in apatite (n = 16).

A correlation matrix of selected elements in apatite is shown in Table 24. No significant correlations were observed between Ca and P and the REEs in apatite. The REEs generally correlate well with each other, while the light REEs (La, Ce, Pr, Nd, Sm and Eu) also correlate well with Mn and weakly with Ti (Table 24).

Table 24. Correlation matrix for REEs, Ti and Mn in apatite (n = 16).

	La	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Y	Ti	Mn
La	1																
Ce	0.91	1															
Pr	0.84	0.96	1														
Nd	0.77	0.91	0.97	1													
Sm	0.67	0.84	0.94	0.98	1												
Eu	0.61	0.76	0.87	0.85	0.87	1											
Gd	0.37	0.61	0.74	0.80	0.85	0.88	1										
Tb	0.15	0.43	0.56	0.63	0.69	0.75	0.92	1									
Dy	0.03	0.36	0.48	0.53	0.61	0.64	0.82	0.95	1								
Ho	0.03	0.36	0.45	0.51	0.58	0.52	0.72	0.88	0.96	1							
Er	0.07	0.34	0.43	0.51	0.56	0.38	0.64	0.75	0.84	0.91	1						
Tm	0.07	0.34	0.43	0.51	0.56	0.38	0.64	0.75	0.84	0.91	1.00	1					
Yb	0.04	0.29	0.40	0.48	0.55	0.36	0.63	0.74	0.82	0.89	0.99	0.99	1				
Lu	0.06	0.24	0.36	0.44	0.51	0.26	0.53	0.61	0.69	0.78	0.94	0.94	0.97	1			
Y	0.21	0.51	0.60	0.66	0.70	0.56	0.75	0.82	0.90	0.94	0.95	0.95	0.94	0.87	1		
Ti	0.29	0.41	0.35	0.35	0.23	0.46	0.24	0.20	0.17	0.12	-0.12	-0.12	-0.23	-0.47	0.06	1	
Mn	0.78	0.87	0.79	0.76	0.68	0.52	0.42	0.26	0.21	0.26	0.24	0.24	0.16	0.12	0.40	0.20	1

The LA-ICP-MS patterns suggest that the higher concentrations of REEs in apatite coincide with the occurrence of inclusions, while lower concentrations also occur lattice-bound in the apatite. In Figure 102, Ce, La, Pr and Nd traces shown inclusion related, with high concentrations, while Y, Dy, Er, Sm, Yb and Gd are mainly lattice-hosted. In Figure 103, the REEs all appear to occur in the apatite lattice, with lower concentrations of Ce, La, Pr and Nd.

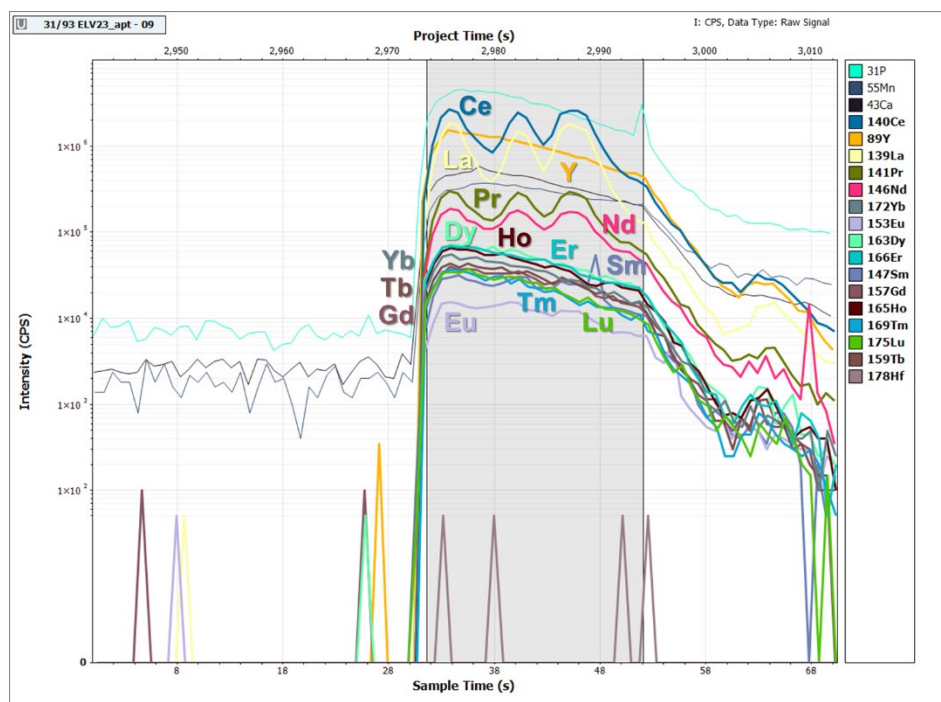


Figure 102. LA-ICP-MS pattern for ELV23 apt-09 (sample ELV_T3_06, TSF1), with inclusion-hosted Ce (1,517 ppm), La (883 ppm), Pr (157 ppm) and Nd (591 ppm), and mainly lattice-bound Y (1,038 ppm), Dy (148 ppm), Er (106 ppm), Sm (131 ppm), Yb (120 ppm) and Gd (140 ppm).

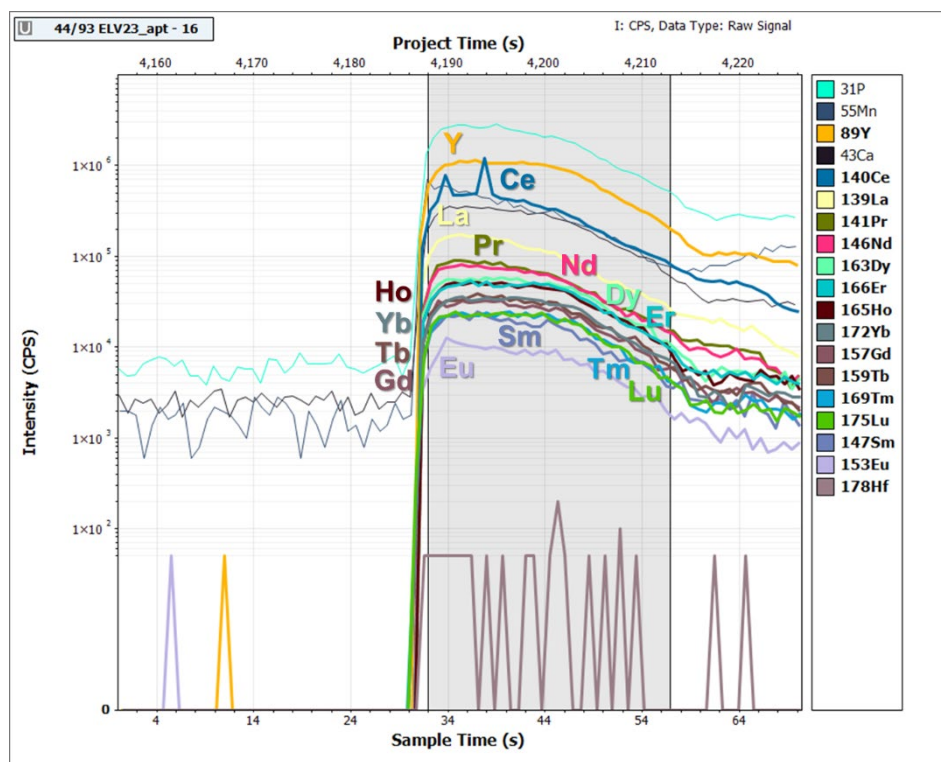


Figure 103. LA-ICP-MS pattern for ELV23 apt-16 (sample ELV_T3_06, TSF1), with mainly lattice-bound Y (1,028 ppm), Ce (411 ppm), La (120 ppm), Pr (57 ppm), Nd (299 ppm), Dy (152 ppm), Er (104 ppm), Sm (97 ppm), Yb (106 ppm) and Gd (138 ppm).

Garnet

The chemistry of the garnet grains in the TSF1 samples was investigated, demonstrating significant enrichment of Ce, La, Nd in some garnet grains, and some enrichment in other REEs (Figure 104). Cerium concentrations range from 1.2-74,375 ppm (average: 16,672 ppm, median: 48 ppm) and La contents from 0.7-50,107 ppm (average: 11,928 ppm, median: 30 ppm). Neodymium concentrations range from 0.5-18,282 ppm (average: 4,194 ppm, median: 12 ppm), while the Pr contents range from 0.1-6,369 ppm (average: 1,409 ppm, median: 4.6 ppm). The content of Y ranges up to 1,380 ppm, Sm up to 2,238 ppm, Gd up to 1,208 ppm, Dy up to 397 ppm, Eu up to 351 ppm, Pr up to 157 ppm, Tb up to 106 ppm and Er up to 100 ppm (Table 14). Elevated values of Cu also occur in garnet, ranging from 76-11,421 ppm (average: 3,233 ppm, median: 1,004 ppm).

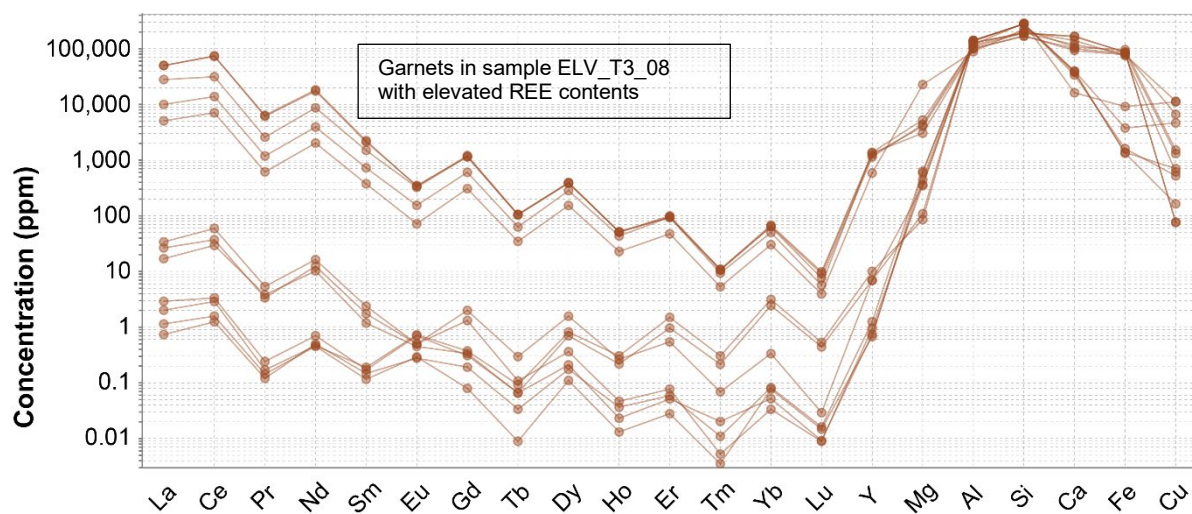


Figure 104. Concentrations of REEs, major elements and Cu in garnet (n = 12).

The major element composition of the garnets is also variable and was different in the three samples where garnets were analysed (Figure 104). In sample ELV_T2_03 (2 points analysed), the garnets have contents of 16.5-16.9 wt. % Ca, 12.8-12.9 wt. % Al and 8.6-8.7 wt. % Fe. In sample ELV_T3_06 (5 points analysed), the garnets have contents of 11.8-14.2 wt. % Al, 4.7-7.9 wt. % Na, 1.6-4.0 wt. % Ca, and 0.1-1.9 wt. % Fe. The garnets in the previous two samples have low REE contents, as seen in Figure 104. In sample ELV_T3_08 (5 points analysed), the garnets measured are elevated in REEs and have contents of 9.3-14.0 wt. % Ca, 8.9-11.5 wt. % Al, 7.5-9.6 wt. % Fe and 0.3-2.3 wt. % Mg. A correlation matrix of selected elements in garnet is shown in Table 25, which highlights that the REEs are correlated with Mg, Fe and Ca, and strongly negatively correlated with Al. The REEs are all highly correlated with each other.

The LA-ICP-MS patterns suggest that the elevated REEs in the garnets in sample ELV_T3_08 mainly occur in the crystal lattice (Figure 105). In the other garnets, with significantly lower REE contents, the REEs tend to occur in inclusions within garnet (Figure 106).

Table 25. Correlation matrix for REEs and major elements in garnet (n = 12).

	La	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Y	Mg	Al	Ca	Fe
La	1																		
Ce	1.00	1																	
Pr	0.99	0.99	1																
Nd	0.98	0.98	0.97	1															
Sm	0.99	0.99	0.98	0.98	1														
Eu	0.87	0.87	0.86	0.83	0.87	1													
Gd	0.96	0.96	0.94	0.94	0.98	0.90	1												
Tb	0.95	0.95	0.92	0.94	0.97	0.92	0.99	1											
Dy	0.89	0.89	0.86	0.87	0.90	0.94	0.96	0.97	1										
Ho	0.84	0.84	0.81	0.83	0.87	0.94	0.93	0.95	0.99	1									
Er	0.84	0.84	0.82	0.83	0.86	0.97	0.89	0.92	0.93	0.95	1								
Tm	0.78	0.78	0.77	0.76	0.80	0.92	0.83	0.85	0.90	0.90	0.95	1							
Yb	0.73	0.73	0.71	0.71	0.74	0.92	0.79	0.82	0.87	0.90	0.95	0.94	1						
Lu	0.73	0.73	0.71	0.71	0.74	0.92	0.79	0.82	0.87	0.90	0.95	0.94	1.00	1					
Y	0.78	0.78	0.76	0.78	0.81	0.93	0.87	0.90	0.96	0.99	0.95	0.92	0.93	0.93	1				
Mg	0.59	0.59	0.61	0.64	0.59	0.48	0.57	0.55	0.54	0.54	0.49	0.52	0.54	0.54	0.55	1			
Al	-0.67	-0.67	-0.66	-0.72	-0.72	-0.77	-0.73	-0.76	-0.76	-0.82	-0.85	-0.78	-0.83	-0.83	-0.85	-0.70	1		
Ca	0.27	0.27	0.28	0.18	0.24	0.58	0.30	0.36	0.47	0.52	0.56	0.58	0.52	0.52	0.56	0.04	-0.39	1	
Fe	0.29	0.29	0.29	0.28	0.33	0.60	0.40	0.45	0.55	0.63	0.64	0.59	0.60	0.60	0.69	0.21	-0.73	0.77	1

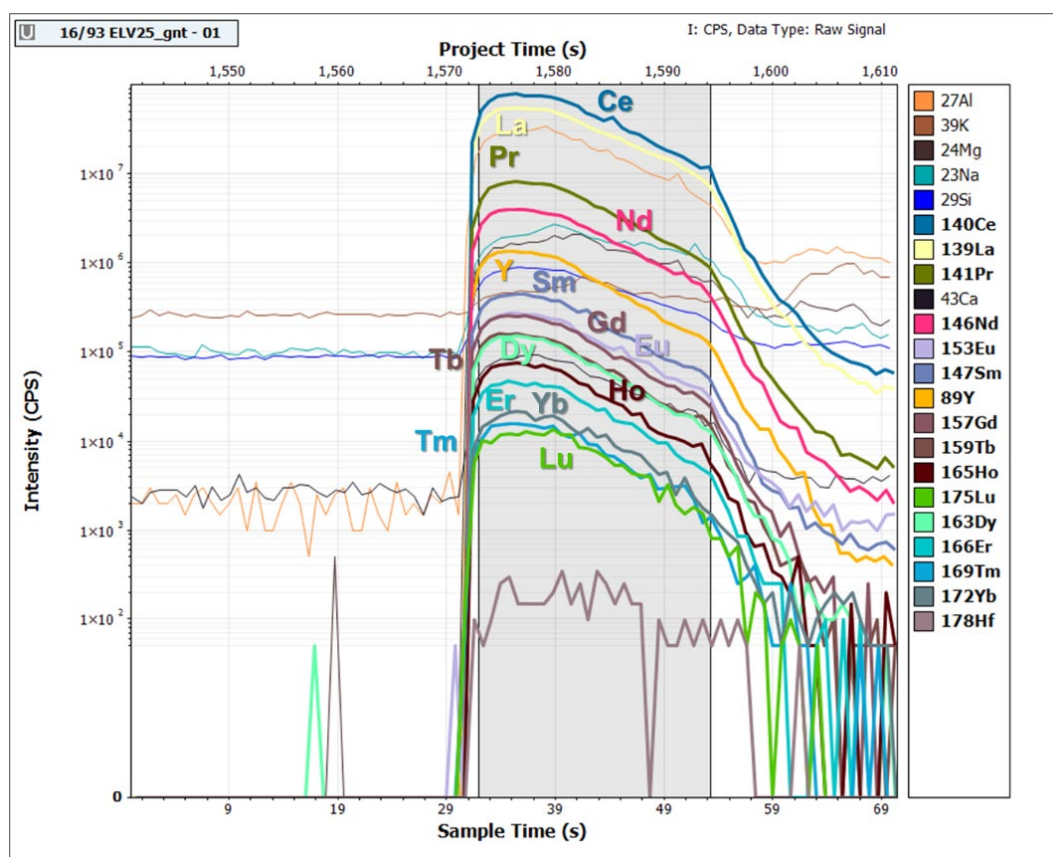


Figure 105. LA-ICP-MS pattern for ELV25_gnt-01 (sample ELV_T3_08, TSF1), with lattice-bound Ce (73,156 ppm), La (49,886 ppm), Nd (17,359 ppm), Pr (6,141 ppm), Sm (2,113 ppm), Y (1,246 ppm), Gd (1,145 ppm), Dy (386 ppm), Eu (350 ppm), Tb (103 ppm) and Er (95 ppm).

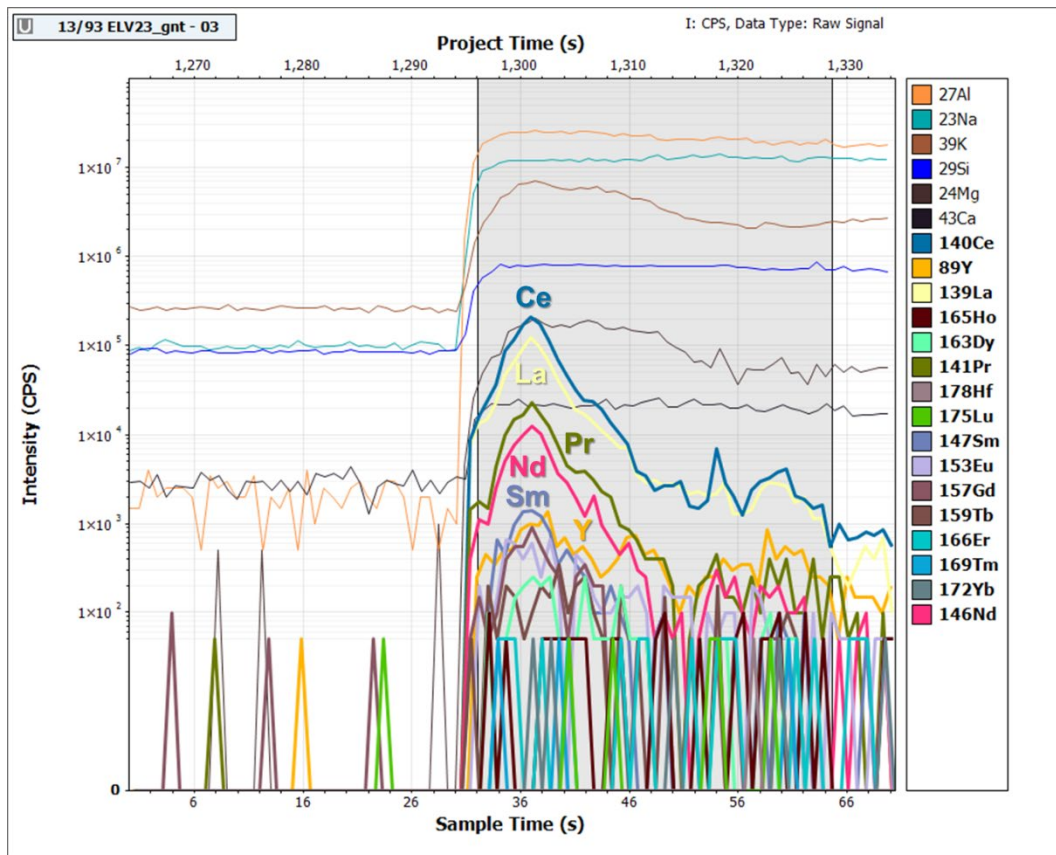


Figure 106. LA-ICP-MS pattern for ELV23_gnt-03 (sample ELV_T3_06, TSF1), with inclusion-hosted Ce (59 ppm), La (34 ppm), Nd (16 ppm), Pr (5 ppm) and Sm (2 ppm).

5. Valorisation potential

5.1 Critical metal tenor

The summary statistics for critical metals listed by the [Australian Government](#) are shown in Table 26 and Table 27. The average concentration of Te is 1,500 times higher than crustal abundance, while the average concentration of Bi is over 150 times higher than crustal abundance (Table 26). Furthermore, the average concentrations of Se, Mo and Mg are over 10 times higher than the average crustal abundance. Summary statistics for REEs show that no REE average concentrations are significantly above crustal abundance (Table 27).

Table 26. Summary statistics for critical metals in the Elverdton samples (n = 71). BDL = below detection limit. Enrichment levels are shown with average / crustal abundance, and values of ≥ 2 are shown in bold.

Element	Min.	Max.	Average	Median	SD	Crustal abundance (Rumble, 2021)	Average / crustal abundance
As (ppm)	1.7	68	12	6	14	1.8	6.7
Be (ppm)	0.2	0.8	0.5	0.5	0.1	2.8	0.2
Bi (ppm)	0.1	8.5	1.4	0.7	2.0	0.0085	165
Co (ppm)	27	940	94	59	120	25	3.8
Cr (ppm)	31	153	71	69	23	102	0.7
Ga (ppm)	8.0	30	20	21	4	19	1.1
Ge (ppm)	0.1	0.8	0.3	0.2	0.2	1.5	0.2
Hf (ppm)	1.9	4.9	3.5	3.5	0.7	3.0	1.2
In (ppm)	BDL	0.5	0.1	0.1	0.1	0.25	0.4
Li (ppm)	9.2	54	30	29	8.7	20	1.5
Mg (%)	0.6	6.2	3.0	3.0	1.1	0.233	13
Mn (ppm)	137	1320	517	487	196	950	0.5
Mo (ppm)	1.2	60	17	14	13	1.2	14
Nb (ppm)	2.4	7.7	5.7	6.0	1.2	20	0.3
Ni (ppm)	25	592	76	65	67	84	0.9
Re (ppm)	BDL	0.008	BDL	BDL	BDL	0.0007	NA
Sb (ppm)	0.2	1.4	0.5	0.4	0.3	0.2	2.5
Sc (ppm)	5.1	20	13	14	2.7	22	0.6
Se (ppm)	1.0	6.0	1.4	1.0	0.8	0.05	28
Ta (ppm)	0.2	0.7	0.4	0.5	0.1	2.0	0.2
Te (ppm)	0.1	6.7	1.5	0.9	1.5	0.001	1,500
Ti (%)	0.1	0.3	0.3	0.3	0.0	0.565	0.5
V (ppm)	39	144	97	98	17	120	0.8
W (ppm)	2.7	16	6.3	5.5	2.8	1.25	5.0
Zr (ppm)	76	194	137	140	26	165	0.8

Table 27. Summary statistics for REEs in the Elverdton samples (n = 71). Enrichment levels are shown with average / crustal abundance, and values of ≥ 2 are shown in bold.

Element	Min.	Max.	Average	Median	SD	Crustal abundance (Rumble, 2021)	Average / crustal abundance
La (ppm)	7.9	297	91	93	48	39	2.3
Ce (ppm)	15	421	133	139	68	66.5	2.0
Pr (ppm)	1.8	36	13	13	6.3	9.2	1.4
Nd (ppm)	7.4	115	42	43	20	41.5	1.0
Sm (ppm)	1.2	18	7.4	7.7	3.3	7.05	1.0
Eu (ppm)	0.4	3.0	1.4	1.4	0.5	2.0	0.7
Gd (ppm)	1.4	15	6.5	6.8	2.7	6.2	1.0
Tb (ppm)	0.2	2.2	0.9	0.9	0.4	1.2	0.8
Dy (ppm)	1.5	13	5.8	6.1	2.0	5.2	1.1
Ho (ppm)	0.4	2.6	1.1	1.1	0.4	1.3	0.8
Er (ppm)	1.1	7.9	3.4	3.5	1.1	3.5	1.0
Tm (ppm)	0.2	1.0	0.5	0.5	0.1	0.52	1.0
Yb (ppm)	1.0	6.6	3.2	3.3	0.9	3.2	1.0
Lu (ppm)	0.2	1.0	0.5	0.5	0.2	0.8	0.6

5.2 Potential valorisation and beneficiation routes

Although a number of strategic and critical metals are enriched in the Elverdton tailings, the levels of enrichment may not be sufficient for economically viable recovery. As such, any potential valorisation pathways would likely need to focus on recovering as many of the strategic and critical metals as possible. A clear understanding of the mineralogical hosts of the metals of interest, and the textural properties of the relevant minerals, is needed to determine appropriate processing routes for maximising recovery of multiple elements.

The mineralogical hosts of the enriched strategic and critical metals are summarised in Table 28. There are a wide range of mineralogical hosts, including primary sulphide and sulfosalt minerals, Au-Ag minerals, and secondary phases such as jarosite, iron hydroxides and sulphates. It is vital to understand the variability of metal distribution between the mineral hosts across the site and between the different mine residue types. In the tailings, the main mineral hosts are the primary sulphides, but significant amounts of the strategic and critical metals are hosted by the secondary phases in the more weathered tailings samples, as well as in the hardpan and salt samples.

Not all expected mineral hosts were identified in the present study, likely due to low contents in the samples which could not be quantified by XRD or MLA. Limitations with the LA-ICP-MS method also meant that some elements (As, Te, Se, Au) could not be quantified in all minerals. As a result, no mineralogical hosts could be identified for Te, Se, Bi and W, and incomplete information was obtained for As and Au. Further in-depth mineralogical work may be required to better constrain and quantify metal deportment, as well as the distribution of the metals between primary and secondary minerals, in order to determine optimum processing pathways.

In addition to mineral abundance, the textural properties of the relevant minerals will determine the most appropriate processing route for their recovery. The sulphide minerals (pyrite, pyrrhotite and chalcopyrite) are generally fine grained, with $p80$ s of 5-35 μm . The chalcopyrite free surfaces are fairly low, at 45-71 %, while the pyrite and pyrrhotite free surfaces are higher, at around 60-100 %. Therefore, the grain sizes of the sulphide minerals may be amenable to flotation, but some milling may be required to improve the liberation and flotation response. However, the chalcopyrite contents are

negligible (0-0.04 wt. %) in the Elverdton tailings and higher in the tailings originating from Kundip (0.7-0.8 wt. %), and therefore flotation may not be economically viable. Leaching methods may be a cheaper and more appropriate alternative to recover strategic/critical metals from the tailings (e.g., Whitworth et al., 2022).

Table 28. Mineral hosts of the enriched strategic and critical metal identified by XRD, MLA and/or LA-ICP-MS. The minerals are ranked in order of decreasing abundance and/or metal content. The other potential mineral hosts are those which were not identified in the samples but are likely based on the ore deposit, geology and weathering processes.

Element	Mineral hosts identified	Other potential mineral hosts
Au	Au-Ag mineral (electrum)	Native gold, iron oxide (secondary)
Cu	Chalcopyrite, Na-Mg and Mg sulphate, goethite, jarosite, schwertmannite, tetrahedrite, covellite, bornite	Cuprite, malachite, azurite
Te	-	Ag-Bi tellurides, sulphide minerals (pyrite)
Se	-	
Ag	Au-Ag mineral (electrum)	Ag-Bi tellurides
Mo	Molybdenite	
U	Mg and Na-Mg sulphate	Uraninite?
Bi	-	Ag-Bi tellurides
As	Arsenopyrite, cobaltite	Secondary minerals – iron oxide, hydroxides and sulphate phases
W	-	Scheelite? Wolframite?
Co	Cobaltite, Na-Mg and Mg sulphate, pyrite, pyrrhotite	Erythrite
Pb	Galena	
REEs	Garnet, apatite	Monazite

The secondary mineral phases may also host significant amounts of critical and strategic metals. The schwertmannite, Mg and Na-Mg sulphate grains have fine sizes, with $p80$ s of around 6-30 μm , while goethite, iron oxide and jarosite have coarser grain sizes, with $p80$ s of around 10-150 μm . Leaching methods may be more appropriate for hydroxide and sulphate minerals. Metals may be recovered from jarosite by a combination of roasting and leaching (Conić et al., 2024). The sulphate minerals may also be water soluble, and therefore it may be possible to recover some of the metals with simple water or acid leaching (Alajoki et al., 2024).

The REEs occur at relatively low grades and appear to mainly occur in garnet, which is considered an unconventional source of REEs. Little work has been done at present to recover REEs from garnet, however Zirakparvar (2022) suggests that efficient processing technique may be possible in the near future to provide an alternative source of REEs.

As well as metal recovery, the Elverdton tailings may be suitable for industrial applications. At present, the upper sections of the tailings are extracted and successfully used as mineral soil conditioner by Paxton Enterprises Pty Ltd. Due to the relatively low contents of S and heavy metals, it may also be possible to utilise the tailings as aggregate material in ceramics (e.g., Veiga Simão et al., 2021) or in cement (e.g., Martins et al., 2021).

6. Summary and recommendations

The Elverdton mine site is located around 540 km south-east of Perth and 11 km south-east of Ravensthorpe. It is situated within the Ravensthorpe greenstone belt, at the southern margin of the Yilgarn Craton. The majority of Cu-Au and Cu-Zn mineralisation in the Ravensthorpe greenstone belt is hosted by the Ravensthorpe Terrane, which comprises a calc-alkaline intrusive/extrusive complex that is similar to modern island arc associations (Witt, 1998, 1999). The Elverdton Cu-Au deposit is hosted by a north trending shear zone, which dips steeply to the east, with a length of ~700 m and width of ~12 m. Copper mineralisation occurs in Cu-bearing quartz veins, with an assemblage of chalcopyrite-gold-pyrite-magnetite(-pyrrhotite-ilmenite)-quartz and an overlying oxidised zone.

The Elverdton deposit was mined for copper, silver and gold over several periods, mainly between 1957 and 1971, with further processing of the nearby Kundip ore taking place from 1988 to 1992. The tailings from these periods were deposited on site in two TSFs. The tenement holder Paxton Enterprises Pty Ltd is currently excavating the tailings for use as mineral soil conditioner. The tailings do not have engineered containment and are subject to erosion. A large fan of eroded tailings is found to the southeast of the TSFs, and tailings materials are deposited for several kilometres down the Steere River. Sampling of the two TSFs with auger sampling, and grab sampling of the tailings fan and hardpan and salt samples across the site took place in October 2023, for a total of 71 samples.

The Elverdton mine residue samples are found to be somewhat enriched in the base and precious metals Cu, Pb, Au and Ag, and the critical metals Te, Se, Bi, Mo, Co, Re, W, and the REEs, La and Ce (Figure 107). On average, enrichment is seen in Cu, Mo, U and Se at > 10 x crustal abundance, Au at > 100 x crustal abundance and Te at > 1000 x crustal abundance (Figure 13). In the TSF1 tailings, Cu contents range from 186-6,050 ppm and tend to increase with depth, while Au contents range up to 1 ppm. Also enriched in the TSF1 tailings are Te (0.1-5.2 ppm), Mo (1.9-60 ppm), Co (38-190 ppm), Ce (65-421 ppm) and La (42-297 ppm). The tailings fan samples have a very similar geochemical composition to the TSF1 samples, but with higher Se contents (1-3 ppm) and slightly lower values of many of the other elements. The TSF2 tailings are more enriched in Cu (1,020-6,500 ppm) and Au (up to 1.4 ppm), as well as Te (0.8-6.7 ppm), Co (43-363 ppm), Bi (1.8-7.9 ppm) and As (24-49 ppm). The hardpan samples appear to have preferential enrichment of Au (0.4-1.6 ppm) and Se (1-6 ppm), while the salt composition is highly variable and enriched in Cu (768-7,390 ppm), U (1.8-149 ppm) and Co (40-940 ppm).

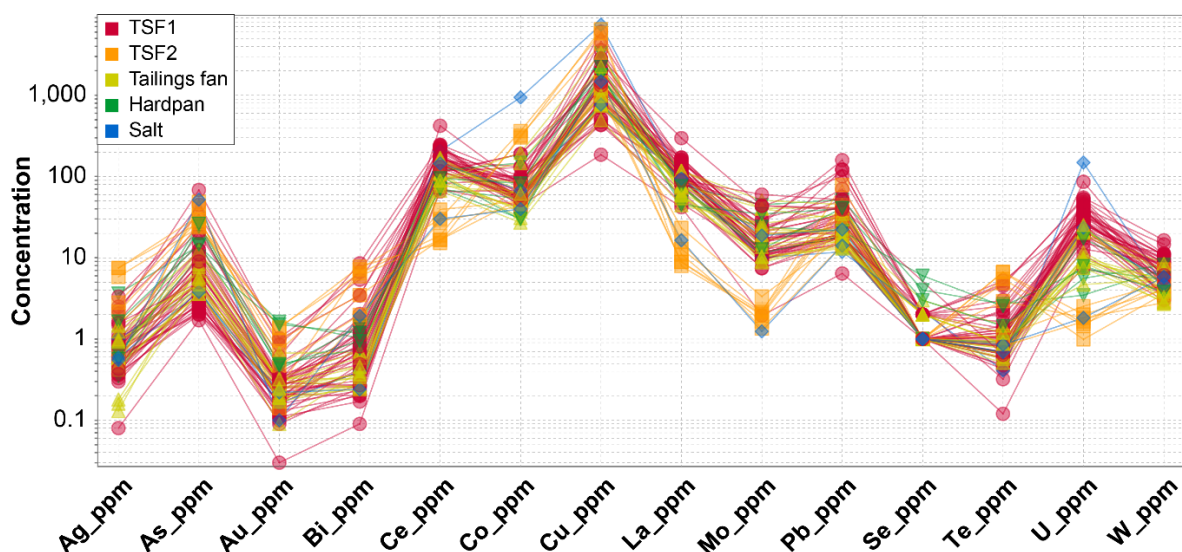


Figure 107. Summary bulk-rock composition of abundant critical, precious and base metals from the Elverdton samples (n = 71).

The mineralogy of the Elverdton tailings samples is dominated by quartz (22.4-34.8 wt. %), chlorite (6.8-33.8 wt. %), plagioclase (2.5-21.1 wt. %), amorphous phases (14.0-26.1 wt. %), mica (3.8-12.6 wt. %) and amphibole (0.0-13.0 wt. %). Magnetite (up to 1.8 wt. %), hematite (up to 0.8 wt. %) and goethite (up to 2.3 wt. %) also occur, as well as secondary phases jarosite (up to 5.6 wt. %), gypsum (up to 0.7 wt. %) and schwertmannite (up to 0.3 wt. %). Sulphide minerals present include pyrite (up to 4.4 wt. %), pyrrhotite (up to 5.6 wt. %) and chalcopyrite (up to 0.8 wt. %) and minor/trace amounts of bornite, molybdenite, tetrahedrite, covellite, chalcocite, sphalerite, galena, stannite, cobaltite and electrum. The TSF1 samples have higher plagioclase, amphibole, chlorite, K-feldspar, magnetite and goethite, while the TSF2 samples are more abundant in quartz, mica and pyrite.

The mineralogy of the hardpan samples is dominated by the major minerals of the tailings samples, as well as secondary phases jarosite (8.6-13.6 wt. %), iron oxide and hydroxide (5.1-11.4 wt. %) and schwertmannite (2.3-8.9 wt. %). The salt sample contains a range of abundant secondary phases, including bloedite (27.3 wt. %), hexahydrite (15.6 wt. %), starkeyite (3.5 wt. %), bassanite (1.2 wt. %), halite (0.9 wt. %), jarosite (0.7 wt. %), alunite and gypsum (each 0.1 wt. %).

The strategic and critical metals are hosted by a range of primary sulphide and secondary sulphate minerals. In the tailings samples, pyrite and pyrrhotite are generally fine grained, with *p80s* of 5-35 µm, and high free surfaces of >60 %. For most minerals, the grain sizes are coarser in the hardpan and salt samples and free surfaces lower to agglomeration and cementation processes. Pyrite and pyrrhotite grains are most enriched in Cu, at 31-33,659 ppm in pyrite and 38-67,903 ppm in pyrrhotite, and Co, with 331-3,341 ppm in pyrite and 31-5,425 ppm in pyrrhotite. Chalcopyrite also has fine grain sizes, with *p80s* mostly between 7-30 µm, but lower free surfaces of 45-71 %. The chalcopyrite grains are relatively inclusion-free and have minor Zn (up to 615 ppm), Mn (up to 314 ppm) and Ag (up to 127 ppm) contents.

Goethite, iron oxide and jarosite have coarser grain sizes, with *p80s* of around 10-150 µm, and low to moderate free surfaces of around 40-75 %. Goethite exhibits some enrichment in Ti (1,398-6,746 ppm), Cu (104-13,187 ppm), Mo (6.3-3,576 ppm), Co (973 ppm) and Zn (966 ppm). Jarosite is enriched in Cu (1,816-21,870 ppm), Pb (6.2-19,541 ppm) and Ti (311-12,490 ppm), while iron oxide grains have minor contents of Cu (1.4-2,637 ppm), Cr (1.3-2,218 ppm), Ti (16-2,171 ppm) and V (2.4-1,171 ppm). The schwertmannite, Mg and Na-Mg sulphate grains have finer sizes, with *p80s* generally ranging from around 6-30 µm. Mg and Na-Mg sulphate grains have high free surfaces of around 75-100 %, while schwertmannite has lower free surfaces of 36-85 %. Schwertmannite has some enrichment in Cu (2,166-13,299 ppm) and Ti (731-8,499 ppm), while Mg sulphate and Na-Mg are highly enriched in a range of elements, including Cu (9,035-144,351 ppm), Mn (1,947-22,911 ppm), Ti (up to 19,389 ppm), Co (up to 14,857 ppm) and Ni (up to 8,351 ppm).

Apatite and garnet have variable grain sizes in the tailings samples, with *p80s* ranging from 15-150 µm and 20-75 µm, respectively. Apatite grains have high free surface areas of 72-94 % while garnets have lower free surfaces of 46-73 %. The REEs were found to be most enriched in garnet, with some high concentrations of Ce (1.2-74,375 ppm), La (0.7-50,107 ppm), Nd (0.5-18,282 ppm) and Pr (0.1-6,369 ppm). The REE concentrations in apatite are lower, with Ce ranging from 25-1,517 ppm and Y contents from 230-1,492 ppm.

6.1 Recommendations

Based on the findings of this study, the following recommendations are proposed to improve the understanding of the critical metal endowment and economic potential of the Elverdton tailings:

- Critical metals that have elevated concentrations relative to crustal abundance include Te, Se, Bi, Mo, Co, Re, W, Ce and La. Base and precious metals such as Cu and Au are also elevated compared to crustal abundance and may add value to the site. A range of mineral hosts were identified for these elements, but not all possible mineralogical hosts were identified with XRD, MLA and LA-ICP-MS. Further mineralogical analyses and microanalytical work (e.g., EPMA, SEM) on the sulphide minerals (pyrite, chalcopyrite, pyrrhotite) and any secondary phases (jarosite, schwertmannite, sulphate phases) should be conducted to provide a more detailed and accurate insight into the department of critical and strategic metals which may be of economic interest.
- If economic potential is identified in the Elverdton tailings based on the contents of critical and strategic metals, targeted processing methods could be tested to identify potential processing routes. Any minerals processing would likely require the recovery of multiple mineral phases, including sulphide and sulphate minerals, in order to recover the metals of interest. Leaching methods may be appropriate for the recovery of critical metals from sulphide minerals and the secondary phases forming in the tailings (e.g., Whitworth et al., 2022).
- The Elverdton tailings are currently extracted by the tenement holders Paxton Enterprises and utilised as a certified organic input and soil conditioner. This highlights the clear potential for tailings and mined residues to be utilised in industrial and agricultural applications. Due to the relatively low contents of S and heavy metals in the Elverdton tailings, further work could focus on whether it is possible to utilise the tailings in other industrial applications, such as in ceramics (e.g., Drif et al., 2021; Veiga Simão et al., 2021), concrete (e.g., Gou et al., 2019; Martins et al., 2021), and/or so-called “minerals sands” (Golev et al., 2022).
- Furthermore, the market demand for critical and strategic metals and for industrial raw materials from tailings could be investigated to determine whether exploitation of the Elverdton mined residues is economically viable.

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Appendices

Appendix A

Auger hole field logs and sampling.



Mine waste sampling and characterisation in Western Australia

Elverdton – samples and logging

Rosie Blannin

Hole 1 – TSF1

ELV_T1_01 = 0 - 0.4 m

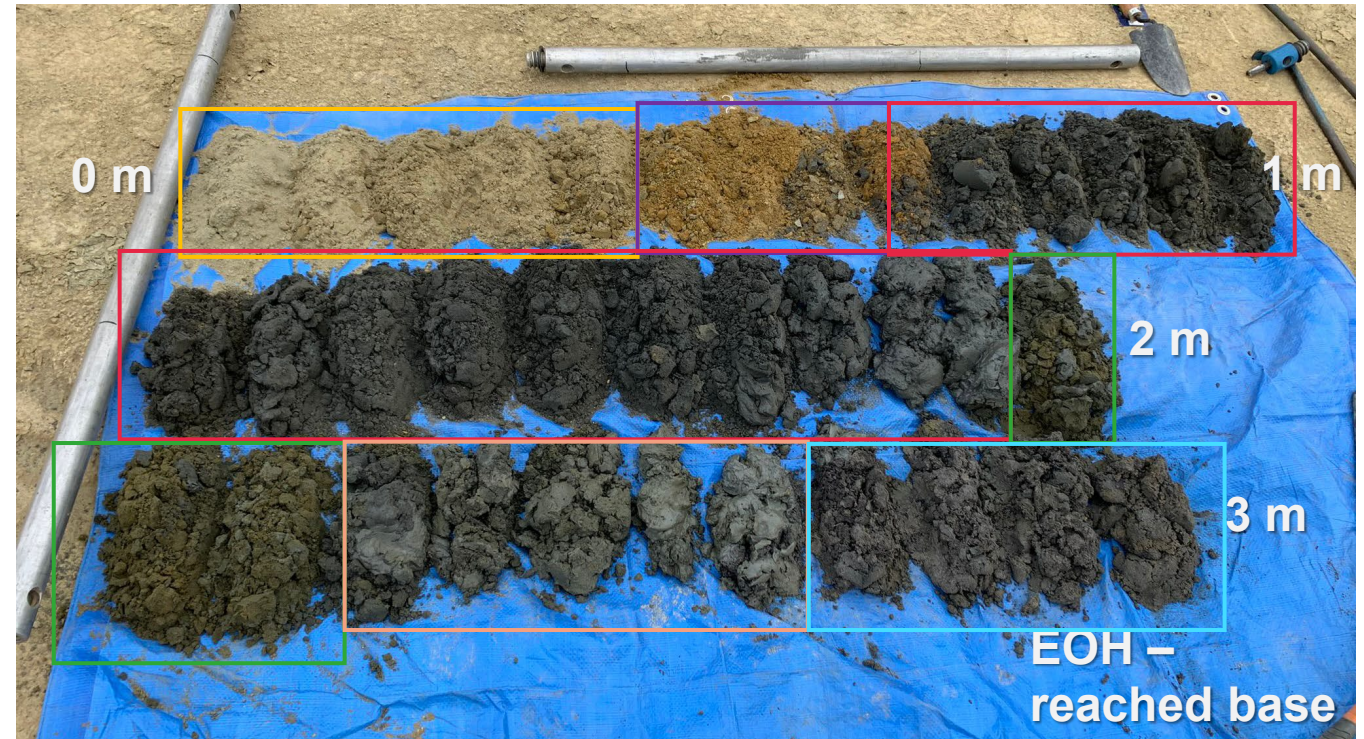
ELV_T1_02 = 0.4 – 0.6 m

ELV_T1_03 = 0.6 – 1.9 m

ELV_T1_04 = 1.9 – 2.2 m

ELV_T1_05 = 2.2 – 2.6 m

ELV_T1_06 = 2.6 – 3.0 m



Elev = 260m

DEPTH (m)	LITHOLOGY	HANDSPECIMENS & PHOTOGRAPHS	GRAIN SIZE & SEDIMENTARY STRUCTURES							DESCRIPTION	INTERP'N (1): DEPOSITIONAL PROCESS	INTERP'N (2): DEPOSITIONAL ENVIRONMENT
			CLAY	SILT	SAND	GRANULE	PEBBLE	COBBLE	BOULDER			
	A	ELV. -2								Fine to medium sand Pale brown, Dry grey	ELV. T1-01	
40	B	ELV. -4								Muddy orange sand, interlayers of blue black clay	orange hard pans Dry - 02	
60	C	ELV. -8								Interlaying of fine white clay to and half brown grey sand dry to v. wet	- 03	
100												
200												
220												
240	D	ELV. -5								Coarse brown green sand mixture of colors, some interlayering clay-silt and fine sand - wet	- 04	
260	E	ELV. -6								brown to pale blue grey	- 05	
280	F	ELV. -7								Coarse blue grey sand - root material, possible base of talus?	- 06	
300												
												End of hole - findings fresh

Hole 2 – TSF1

ELV_T2_01 = 0.3 - 0.5 m

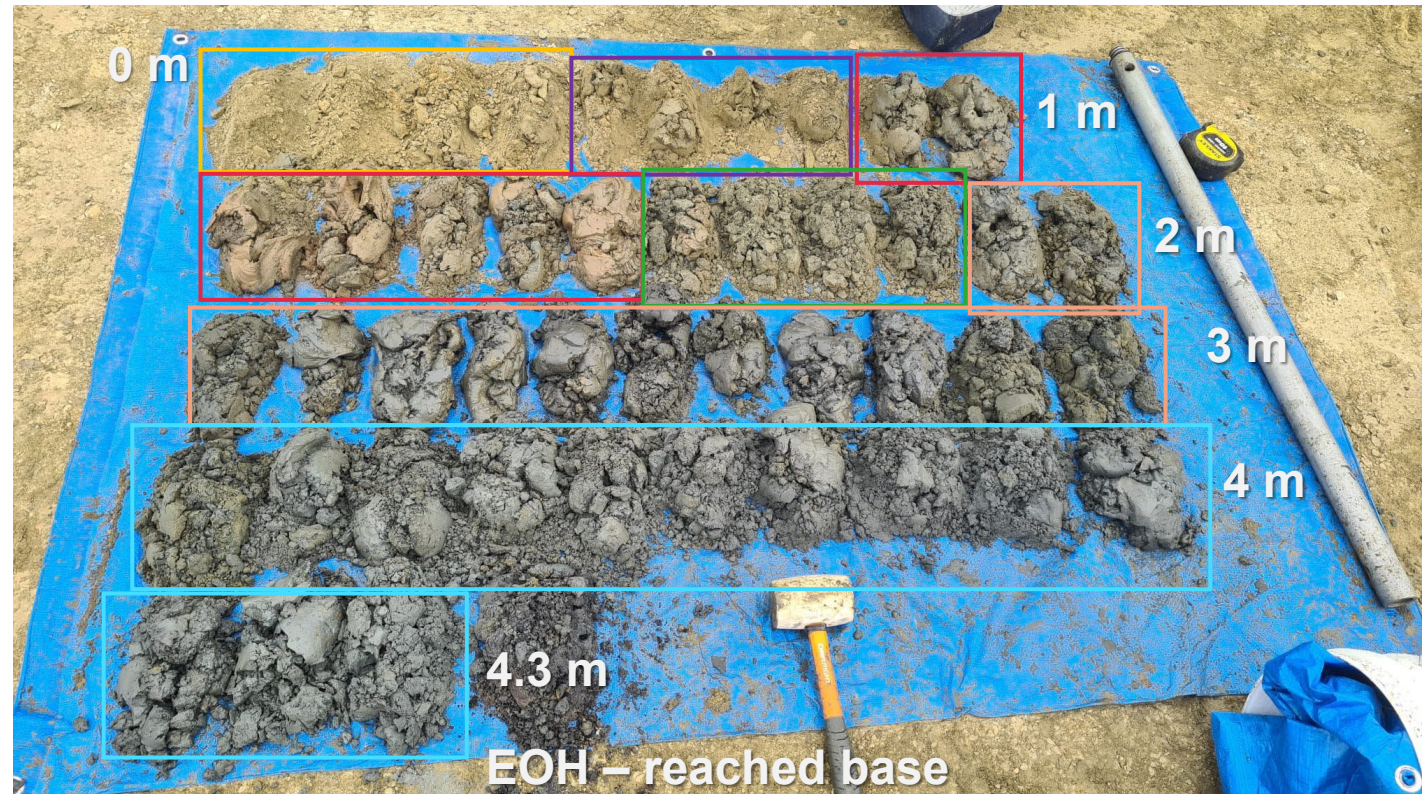
ELV_T2_02 = 0.5 - 0.9 m

ELV_T2_03 = 0.9 - 1.4 m

ELV_T2_04 = 1.4 - 1.8 m

ELV_T2_05 = 1.8 - 3.0 m

ELV_T2_06 = 3.0 - 4.3 m



Elev = 267m

DEPTH (m)	LITHOLOGY	HANDSPECIMENS & PHOTOGRAPHS	GRAIN SIZE & SEDIMENTARY STRUCTURES							NAME: RESIF B DATE: 10-10-23 SHEET No.: 2			LOCATION: Hole 2 UNIT: SCALE:	
			CLAY	SILT	SAND	GRANULE	PEBBLE	COBBLE	BOULDER	DESCRIPTION	INTERP'N (1): DEPOSITIONAL PROCESS	INTERP'N (2): DEPOSITIONAL ENVIRONMENT		
20	ELV-09	A?	↑ Skipped first ~ 30cm - not in situ							fine brown sand	dry	churned up tailings		
60	ELV-09	B	↑							fine brown sand, dark grey clay layers	dry to wet	ELV-T2-01		
90	ELV-11	C	↑							Reddish pink brown clay, interlayered sand		-02		
140	ELV-11	D	↑							Dark brown grey sand, some finer layers, mostly dry		-03		
180	ELV-12	E	↑							Dark grey black clay - wet		-04		
200	ELV-12	F	↑							sandy grey to brown		-05		
300	ELV-13	G	↑							fine to medium sand		-06		
4.38			↑ Some cm's burnt soil							burnt plants before mining and tailings dep.		End of hole - tailings finished		

Hole 3 – TSF1

ELV_T3_01 = 0 – 1.2 m

ELV_T3_02 = 1.2 – 2.0 m

ELV_T3_03 = 2.0 – 3.0 m

ELV_T3_04 = 3.0 – 4.0 m

ELV_T3_05 = 4.0 – 4.5 m

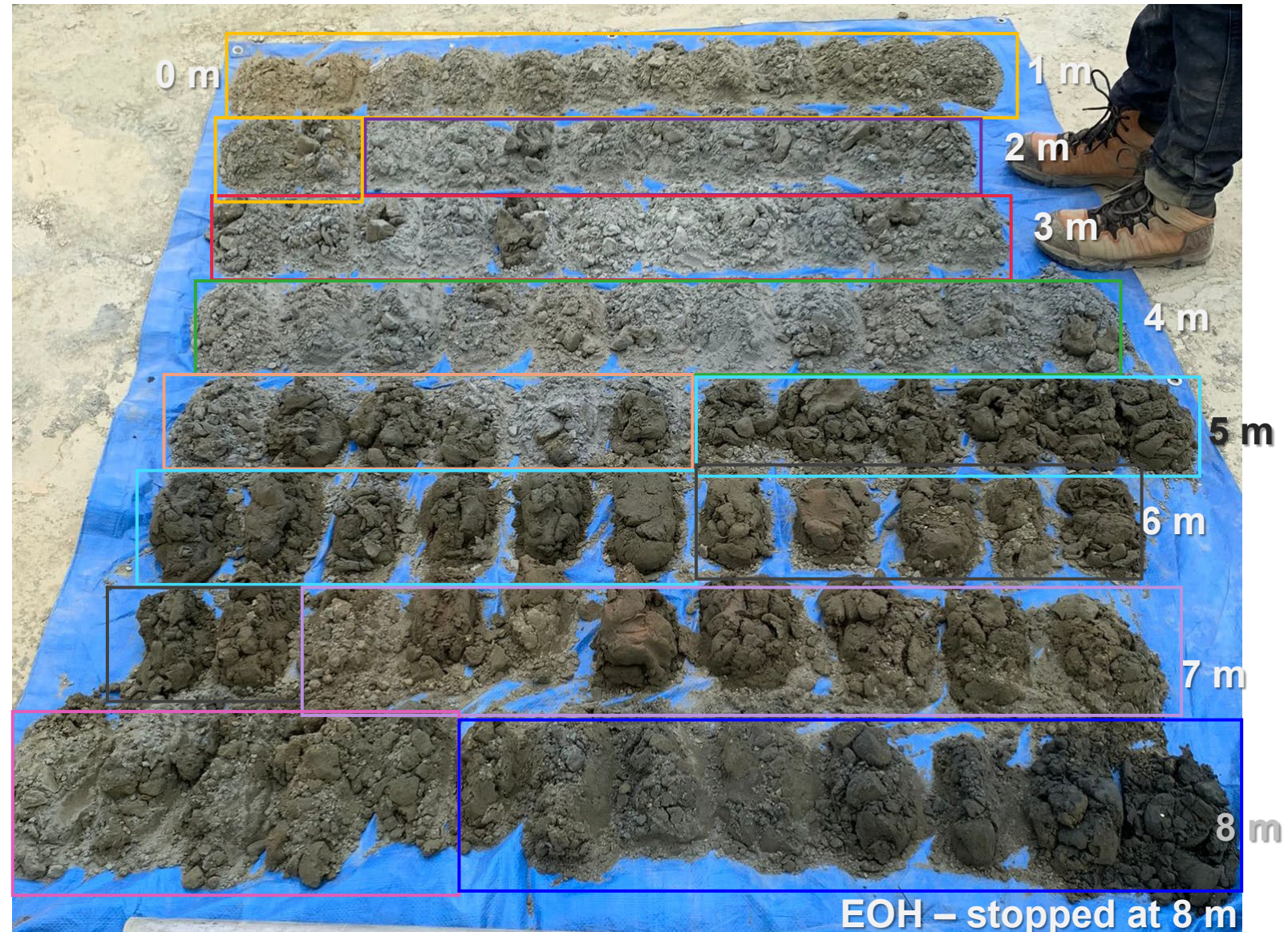
ELV_T3_06 = 4.5 – 5.5 m

ELV_T3_07 = 5.5 – 6.2 m

ELV_T3_08 = 6.2 – 7.0 m

ELV_T3_09 = 7.0 – 7.4 m

ELV_T3_10 = 7.4 – 8.0 m



Depth = 8.04m

ELV-14, 15, 17
Gravel Samples
(16 = Standard)

DEPTH (m)	LITHOLOGY	HAND SPECIMENS & PHOTOGRAPHS	GRAIN SIZE & SEDIMENTARY STRUCTURES						DESCRIPTION	INTERP'N (1): DEPOSITIONAL PROCESS	INTERP'N (2): DEPOSITIONAL ENVIRONMENT
			CLAY	SILT	SAND	GRANULE	PEBBLE	COBBLE			
1		ELV-18							Brown orange at surface, transitions to greyer tending down hole, more orange brown again ~ 0.8-1.2m layers of fine pale grey sand throughout - dry	ELV-T3-01	
1.2		ELV-19							Layers of fine to medium sand - pale grey blue to white	02	
2									some layers of clay throughout		
3									layers of dark blue green clay at 2.35m	03	
4									mostly dry some wetter layers	04	
4.5		22							Transition of above material to below	05	
5									fine clay, silt (wet) dark blue grey fairly homogeneous but layers of fine sand with dark colour	06	

DEPTH (m)	LITHOLOGY	HANDS SPECIMENS & PHOTOGRAPHS	GRAIN SIZE & SEDIMENTARY STRUCTURES							DESCRIPTION	INTERP'N (1): DEPOSITIONAL PROCESS	INTERP'N (2): DEPOSITIONAL ENVIRONMENT
			CLAY	SILT	SAND	GRANULE	PEBBLE	COBBLE	BOULDER			
5.5										Same as previous page	wet!	06
5.6										variable colour, mainly dark blue grey, some sandy layers - red clay layers ~ 5-8 m		07
6										Reddish orange to purple blue clay, some blue		08
6.2										Transition to blue grey dark clay at end		09
6.8										Inter layers of pale brown grey to pale grey sand and clay of light grey and blue clay		10
7										Back to dark blue material grader from sand down to clay, increasing water content and darkness.		
8										Not end of hole - tailings continued but no more reeds		

Hole 4 – TSF1

ELV_T4_01 = 0 - 0.3 m

ELV_T4_02 = 0.3 – 1.5 m

ELV_T4_03 = 1.5 – 3.2 m

ELV_T4_04 = 3.2 – 4.2 m

ELV_T4_05 = 4.2 – 5.3 m

ELV_T4_06 = 5.3 – 6.0 m



31 = STD

Depth = 6.07m

817										NAME: ROSE B		LOCATION: Hole 4	
										DATE: 11.10.23		UNIT:	
										SHEET No.:		SCALE:	

Hole 5 – TSF1

ELV_T5_01 = 0 - 0.9 m

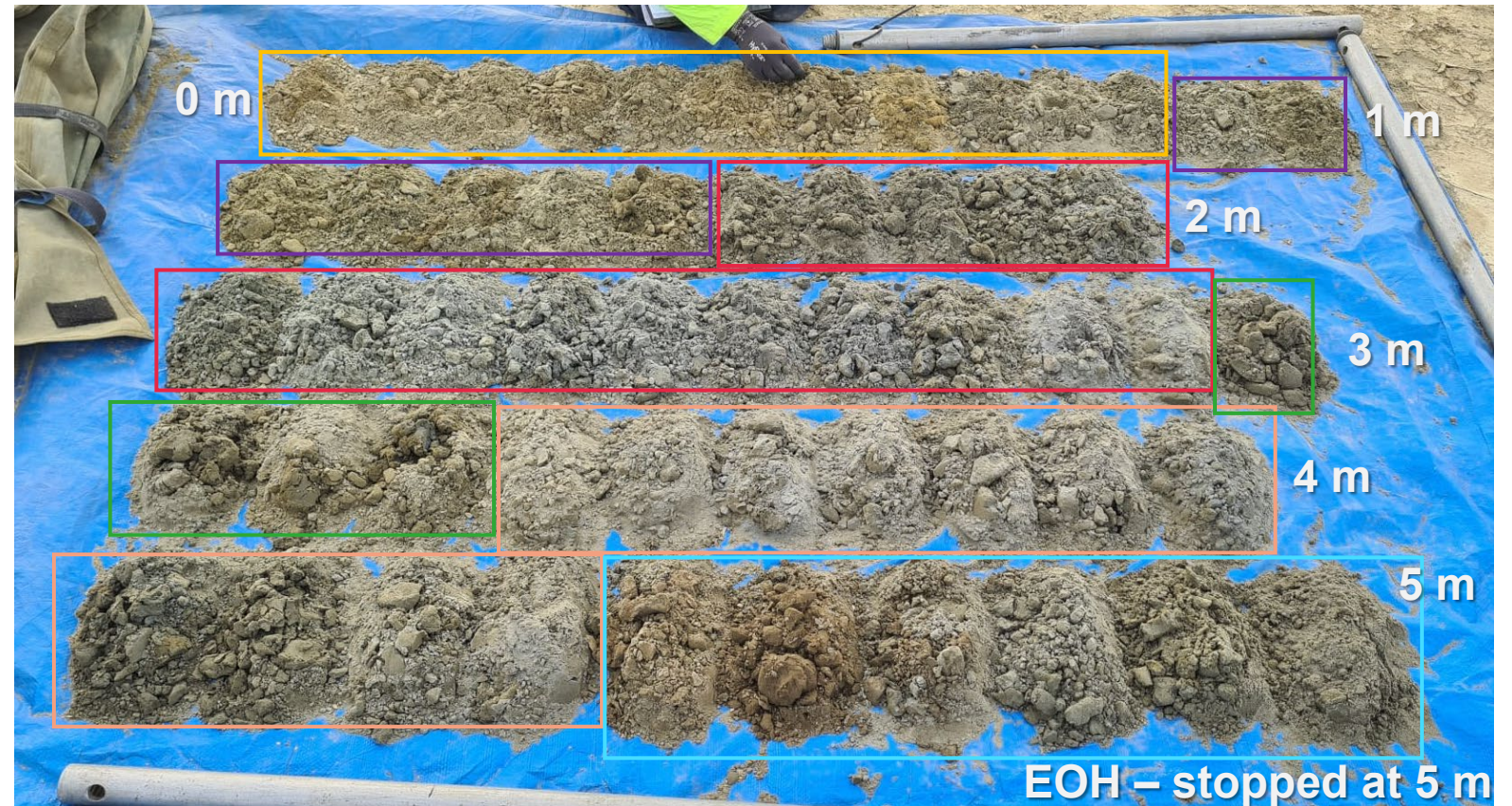
ELV_T5_02 = 0.9 – 1.5 m

ELV_T5_03 = 1.5 – 2.9 m

ELV_T5_04 = 2.9 – 3.3m

ELV_T5_05 = 3.3 – 4.4 m

ELV_T5_06 = 4.4 – 5.0 m



Hole 6 – TSF2

ELV_T6_01 = 0 - 0.2 m

ELV_T6_02 = 0.2 – 0.9 m

ELV_T6_03 = 0.9 – 1.6 m



Depth = 1.55 m

ELV - 44 = GS (F)

ELV - 46 = ST

DEPTH (m)	LITHOLOGY	HANDSPECIMENS & PHOTOGRAPHS	GRAIN SIZE & SEDIMENTARY STRUCTURES						NAME: ROSIE B. DATE: 12.16.23 SHEET No.: 7			LOCATION: Hole 6 UNIT: SCALE:		
			CLAY	SILT	SAND	GRANULE	PEBBLE	COBBLE	BOULDER	DESCRIPTION	INTERP'N (1): DEPOSITIONAL PROCESS	INTERP'N (2): DEPOSITIONAL ENVIRONMENT		
		ELV - 45							Brown orange sand, varying grain size	Same small hard pans starting to form	ELV - -02			
0.20		ELV - 47							Brown to red clay layers starting	→ Dry				
		ELV - 48							Bright red clay, very homogeneous		-03			
0.9									Thin layer of brown coarse sand - hard pans and red clay layers					
1.55									Blackish blue clay and fine sand grading into sand with clay layers (hard and clay) then back to clay, becoming red again					
Did not sample, similar to -45														
* Too wet, hole collapsing														

Did not sample, similar to -45

ELV - 46 - 01

-02

-03

* Too wet, hole collapsing

Hole 7 – TSF2

ELV_T7_01 = 0 - 0.5 m

ELV_T7_02 = 0.5 – 0.7 m

ELV_T7_03 = 0.7 – 1.0 m

ELV_T7_04 = 1.0 – 1.6 m



LOCATION: Hole 7
UNIT:
SCALE:

DEPTH (m)	LITHOLOGY	HANDSPECIMENS & PHOTOGRAPHS	GRAIN SIZE & SEDIMENTARY STRUCTURES						NAME: <u>ROSIE B</u> DATE: <u>12.10.23</u> SHEET No.: <u>8</u>			LOCATION: <u>Hole 7</u> UNIT: SCALE:	
			CLAY	SILT	SAND	GRANULE	PEBBLE	COBBLE	BOULDER	DESCRIPTION	INTERP'N (1): DEPOSITIONAL PROCESS	INTERP'N (2): DEPOSITIONAL ENVIRONMENT	
40		ELV-50							Red clay with sandy layers	Dry	ELV-T 7-0		
50		ELV-51							Orange sand with hard clay and hard pan layers	Dry	-02		
75		ELV-52							Pale brown grey green sand, coarser sand layers - hard layer	Dry	-03		
1		ELV-53							Blue grey sand, fairly coarse grading into wet (very wet) dark blue grey clay some red layers at end		-04		
Too wet to continue = infilling													

Appendix B

Whole-rock geochemistry results.



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INDOOROOPILLY QLD 4068

Page: 1
Total # Pages: 3 (A – F)
Plus Appendix Pages
Finalized Date: 12-DEC-2023
Account: UNIQUE

CERTIFICATE BR23315396

Project: UQ-23-094 – Elverdton (WA)

P.O. No.: 4280008329

This report is for 78 samples of Tailings submitted to our lab in Brisbane, QLD,
Australia on 1-NOV-2023.

The following have access to data associated with this certificate:

KAMINI BHOWANY

ANITA PARBHAKAR-FOX

SAMPLE PREPARATION	
ALS CODE	DESCRIPTION
WEI-21	Received Sample Weight
DRY-22	Drying – Maximum Temp 60C
CRU-21	Crush entire sample
PUL-QC	Pulverizing QC Test
LEV-01	Waste Disposal Levy
LOG-22	Sample login – Rcd w/o BarCode
LOG-24	Pulp Login – Rcd w/o BarCode
PUL-23	Pulp Sample – Split/Retain
BAG-01	Bulk Master for Storage
BAG-21	Raw Sample in a new bag
SPL-21	Split sample – riffle splitter
TRA-21	Transfer sample

ANALYTICAL PROCEDURES		
ALS CODE	DESCRIPTION	INSTRUMENT
ME-MS61	48 element four acid ICP-MS	ICP-MS PXRF
ME-MS81	Lithium Borate Fusion ICP-MS	
pXRF-34	pXRF – Si, Ti & Zr Add on Package	

This is the Final Report and supersedes any preliminary report with this certificate number. Results apply to
samples as submitted. All pages of this report have been checked and approved for release.

***** See Appendix Page for comments regarding this certificate *****

Signature:

Shaun Kenny, Brisbane Laboratory Manager



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Project: UQ-23-094 – Elverdton (WA)

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CERTIFICATE OF ANALYSIS BR23315396

Sample Description	Method Analyte Units LOD	WEI-21	PUL-QC	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61
		Recvd Wt. kg	Pass75um %	Ag ppm	Al %	As ppm	Ba ppm	Be ppm	Bi ppm	Ca %	Cd ppm	Ce ppm	Co ppm	Cr ppm	Cs ppm	Cu ppm	
ELV_01		0.07		50.2	6.79	381	390	2.25	21.9	0.98	2.77	72.2	4.5	15	5.06	1130	
ELV_02		1.93	98.3	0.85	6.39	6.7	180	0.62	1.16	1.84	0.09	173.5	46.7	40	1.31	867	
ELV_03		1.61	99.1	1.00	6.05	4.6	180	0.42	0.56	1.87	0.25	116.5	129.0	53	1.93	2000	
ELV_04		5.42	97.6	0.86	6.67	8.1	180	0.50	0.62	2.03	0.36	105.5	189.5	65	2.72	1485	
ELV_05		2.12		0.37	5.40	2.2	120	0.41	0.26	1.67	0.05	65.3	67.6	50	1.24	469	
ELV_06		2.85		0.46	6.39	2.7	150	0.45	0.23	1.21	0.18	79.2	92.9	48	1.06	429	
ELV_07		3.30		0.08	3.89	1.7	140	0.38	0.09	0.29	0.03	68.3	43.6	29	0.57	185.5	
ELV_08		1.97		1.46	6.53	14.9	150	0.53	1.19	1.19	0.08	168.0	54.2	42	1.15	1950	
ELV_09		2.12		1.65	6.72	25.5	150	0.52	1.06	0.93	0.32	157.5	88.1	46	1.22	3600	
ELV_10		3.19		2.05	8.06	68.3	160	0.61	3.47	0.63	0.15	142.5	88.4	58	1.17	2730	
ELV_11		2.18		0.62	6.69	7.3	140	0.52	0.58	1.25	0.19	166.0	78.7	60	1.25	916	
ELV_12		4.30		1.16	7.30	12.4	190	0.48	0.84	1.82	0.43	110.5	189.0	63	2.72	1985	
ELV_13		4.33		0.56	6.80	4.5	160	0.44	0.39	1.44	0.17	94.8	103.0	56	1.36	518	
ELV_14		2.38		3.63	5.06	14.0	140	0.37	1.02	1.56	0.07	101.0	29.4	56	1.37	3320	
ELV_15		3.47		0.62	6.29	2.0	160	0.51	0.27	2.05	0.07	168.0	44.2	56	1.78	705	
ELV_16		0.07		49.2	6.77	370	430	2.19	22.3	0.96	2.74	71.1	4.5	15	5.02	1090	
ELV_17		2.16		0.80	6.54	2.5	170	0.49	0.31	1.98	0.05	162.0	55.2	61	2.02	1320	
ELV_18		3.86		0.52	6.57	2.2	170	0.55	0.39	2.22	0.09	137.0	50.3	55	1.83	860	
ELV_19		2.71		0.30	6.66	3.5	180	0.59	0.25	1.62	0.13	207	89.0	44	1.05	942	
ELV_20		3.21		0.47	7.08	5.4	170	0.63	1.56	1.24	0.12	136.5	66.1	40	1.33	506	
ELV_21		3.11		0.53	6.92	3.0	170	0.62	0.80	1.95	0.12	237	49.3	40	0.99	1330	
ELV_22		1.89		0.96	7.48	3.3	190	0.61	0.71	1.71	0.12	172.0	56.5	45	1.22	1355	
ELV_23		4.40		2.50	7.54	21.2	230	0.82	8.53	2.04	0.48	256	99.1	55	3.96	2230	
ELV_24		2.08		3.32	7.38	34.3	180	0.69	6.69	1.25	0.30	214	86.3	65	2.77	4600	
ELV_25		3.62		2.27	7.96	45.0	150	0.63	5.38	0.63	0.18	129.5	98.1	77	1.19	6050	
ELV_26		1.81		0.78	6.48	8.3	130	0.56	1.00	1.14	0.08	163.5	56.6	44	0.99	1435	
ELV_27		2.09		0.78	6.24	9.6	160	0.48	0.70	1.74	0.38	158.5	131.5	55	1.64	1280	
ELV_28		2.07		0.38	6.78	2.0	170	0.57	0.21	2.00	0.16	146.0	38.4	38	0.98	900	
ELV_29		3.83		0.56	6.88	2.7	180	0.53	0.42	2.08	0.16	147.5	82.4	55	1.96	1250	
ELV_30		3.26		0.36	6.68	4.1	160	0.55	0.87	1.37	0.09	170.5	56.6	41	1.17	435	
ELV_31		0.07		49.4	6.80	378	420	2.24	22.3	0.96	2.71	70.7	4.6	16	5.08	1105	
ELV_32		3.30		1.02	7.24	6.4	180	0.64	3.42	1.64	0.26	195.5	61.5	44	1.62	1070	
ELV_33		3.32		0.75	6.44	6.4	200	0.66	1.79	2.01	0.21	246	54.5	37	1.64	795	
ELV_34		3.01		0.94	5.86	20.2	100	0.50	2.03	0.85	0.07	128.5	59.9	47	0.67	2840	
ELV_35		2.28		0.60	6.58	2.1	170	0.53	0.27	1.83	0.07	138.5	45.3	50	1.54	829	
ELV_36		2.39		0.50	6.52	2.4	180	0.56	0.20	2.01	0.11	132.5	54.5	52	1.32	724	
ELV_37		0.63		1.01	2.88	4.1	70	0.39	0.40	1.23	1.66	210	940	23	0.47	7390	
ELV_38		2.80		0.67	6.69	3.4	170	0.51	0.20	1.65	0.04	120.5	55.3	51	1.51	711	
ELV_39		3.16		0.33	6.83	2.9	170	0.56	0.17	1.77	0.13	144.0	82.9	51	1.30	783	
ELV_40		3.02		0.40	6.99	4.0	170	0.57	0.49	1.40	0.15	161.5	90.7	45	1.02	749	



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Project: UQ-23-094 – Elverdton (WA)

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CERTIFICATE OF ANALYSIS BR23315396

Sample Description	Method Analyte Units LOD	ME-MS61 Fe %	ME-MS61 Ca ppm	ME-MS61 Ce ppm	ME-MS61 Hf ppm	ME-MS61 In ppm	ME-MS61 K %	ME-MS61 La ppm	ME-MS61 Li ppm	ME-MS61 Mg %	ME-MS61 Mn ppm	ME-MS61 Mo ppm	ME-MS61 Na %	ME-MS61 Nb ppm	ME-MS61 Ni ppm	ME-MS61 P ppm
ELV_01		2.33	23.0	0.24	5.0	0.551	2.72	35.0	27.1	0.16	226	3.31	1.92	15.4	6.2	370
ELV_02		6.79	19.80	0.26	2.7	0.117	0.77	116.0	27.7	2.79	489	21.3	1.62	4.9	54.9	610
ELV_03		10.75	20.6	0.44	2.2	0.145	0.98	86.1	28.6	1.18	491	17.25	1.18	4.0	90.4	640
ELV_04		11.35	20.5	0.60	2.2	0.138	0.97	69.3	39.4	3.83	617	9.63	1.26	3.4	121.5	600
ELV_05		7.69	16.10	0.23	2.1	0.071	0.72	43.1	23.3	2.63	403	11.00	1.33	2.8	46.6	400
ELV_06		7.19	20.3	0.48	2.3	0.058	0.83	52.9	29.9	3.65	399	7.49	1.12	3.0	70.7	420
ELV_07		2.34	8.95	0.11	1.7	0.022	0.40	37.6	14.3	0.56	137	1.94	0.65	3.4	37.5	60
ELV_08		8.03	22.6	0.63	2.5	0.184	0.74	112.5	31.8	3.92	421	30.1	1.15	4.2	63.2	630
ELV_09		8.88	25.1	0.61	2.1	0.236	0.80	103.5	41.2	4.43	452	42.5	1.01	4.3	92.4	730
ELV_10		10.30	27.9	0.67	2.6	0.203	0.92	98.6	50.1	5.76	493	25.8	0.97	4.4	105.0	500
ELV_11		8.18	24.8	0.66	2.4	0.102	0.78	104.5	35.8	4.29	487	12.45	1.32	4.5	79.1	620
ELV_12		11.25	23.2	0.66	3.2	0.161	0.98	76.3	44.3	4.53	577	10.80	1.25	3.8	133.5	570
ELV_13		8.11	22.0	0.53	2.3	0.082	0.86	65.4	33.2	4.09	446	7.41	1.32	3.2	78.3	470
ELV_14		13.45	18.00	0.29	2.4	0.232	0.83	72.1	12.0	1.44	462	44.8	1.85	4.4	33.5	500
ELV_15		8.92	18.85	0.55	2.6	0.164	0.77	117.0	24.7	2.79	471	11.75	1.66	4.5	53.3	610
ELV_16		2.28	23.0	0.25	4.9	0.549	2.66	34.0	26.6	0.16	219	3.23	1.89	14.3	6.6	360
ELV_17		8.94	19.95	0.38	2.8	0.172	0.85	114.0	27.0	3.18	486	10.75	1.58	4.5	65.8	580
ELV_18		8.70	19.75	0.31	2.7	0.183	0.81	89.9	25.0	2.92	509	11.55	1.71	4.6	58.9	610
ELV_19		6.39	20.1	0.29	2.9	0.071	0.84	140.0	31.3	3.39	518	11.55	1.55	4.4	96.1	510
ELV_20		6.13	20.6	0.47	3.2	0.057	0.91	90.7	36.0	4.37	499	10.30	1.20	3.7	68.1	560
ELV_21		6.50	20.8	0.30	3.2	0.100	0.80	159.5	30.6	3.28	527	15.95	1.59	4.7	58.9	610
ELV_22		7.01	21.9	0.51	2.7	0.130	0.98	115.0	34.4	3.65	523	11.80	1.47	4.4	74.1	590
ELV_23		9.23	24.8	0.57	3.0	0.256	0.90	164.5	47.3	3.56	703	20.6	1.81	6.8	113.5	660
ELV_24		10.50	25.3	0.68	2.8	0.412	0.84	138.0	46.2	3.92	531	28.7	1.42	5.1	106.0	630
ELV_25		11.20	27.2	0.84	3.1	0.522	0.84	83.7	45.8	5.14	472	14.35	0.98	3.2	128.5	530
ELV_26		7.40	22.0	0.49	2.7	0.142	0.78	110.5	30.4	3.91	425	15.55	1.36	3.8	64.6	640
ELV_27		9.44	20.5	0.39	2.3	0.138	0.89	104.0	32.9	3.40	579	15.80	1.34	4.1	99.4	680
ELV_28		6.43	20.6	0.21	2.9	0.071	0.74	91.0	24.9	2.92	452	9.38	1.98	5.5	49.2	650
ELV_29		8.39	21.3	0.50	2.7	0.188	0.77	99.2	30.7	3.62	549	8.99	1.70	4.7	94.4	580
ELV_30		6.35	20.9	0.52	2.6	0.063	0.82	108.0	31.6	4.13	483	10.25	1.31	4.0	64.8	490
ELV_31		2.31	23.1	0.20	5.0	0.541	2.71	35.5	27.1	0.16	223	3.35	1.91	14.4	6.6	370
ELV_32		7.02	21.9	0.29	2.9	0.130	0.89	127.5	34.7	3.83	547	14.80	1.54	4.3	71.7	640
ELV_33		6.96	19.75	0.34	3.0	0.122	0.75	158.5	31.3	2.82	558	20.4	1.83	5.5	62.8	670
ELV_34		7.23	17.75	0.17	2.0	0.226	0.55	85.8	31.1	3.41	411	22.5	0.93	3.6	71.9	560
ELV_35		7.35	19.75	0.22	2.6	0.129	0.73	90.2	26.2	2.98	474	10.90	1.59	4.7	56.0	560
ELV_36		7.16	18.80	0.18	2.6	0.113	0.77	93.2	24.8	2.58	509	20.2	1.89	4.9	60.1	510
ELV_37		3.54	7.50	0.23	1.3	0.053	0.33	91.3	27.4	6.19	1180	10.05	5.60	2.1	592	270
ELV_38		7.89	20.4	0.18	2.7	0.187	0.77	79.8	26.3	3.32	441	15.35	1.43	4.6	66.7	550
ELV_39		7.36	20.5	0.17	2.5	0.108	0.76	93.6	29.0	3.27	503	9.58	1.57	4.3	91.1	520
ELV_40		6.38	20.3	0.23	2.7	0.068	0.79	103.0	33.8	4.35	596	12.40	1.37	3.7	86.1	550



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Project: UQ-23-094 – Elverdton (WA)

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CERTIFICATE OF ANALYSIS BR23315396

Sample Description	Method Analyte Units LOD	ME-MS61															
		Pb ppm 0.5	Rb ppm 0.1	Re ppm 0.002	S % 0.01	Sb ppm 0.05	Sc ppm 0.1	Se ppm 1	Sn ppm 0.2	Sr ppm 0.2	Ta ppm 0.05	Te ppm 0.05	Th ppm 0.01	Ti % 0.005	Tl ppm 0.02	U ppm 0.1	
ELV_01		329	109.0	<0.002	1.57	36.0	3.5	8	4.1	214	1.04	7.51	11.10	0.139	1.70	4.0	
ELV_02		32.7	29.9	<0.002	0.20	0.58	9.6	1	3.1	60.6	0.38	1.05	4.99	0.213	0.12	22.2	
ELV_03		21.0	39.9	<0.002	1.45	0.35	12.3	2	3.6	43.8	0.27	1.35	3.67	0.214	0.19	20.4	
ELV_04		18.4	40.5	<0.002	2.02	0.59	14.4	2	3.3	41.6	0.24	1.18	3.31	0.235	0.21	18.8	
ELV_05		14.4	32.2	<0.002	0.57	0.26	11.3	1	2.2	38.7	0.22	0.69	3.46	0.191	0.11	6.6	
ELV_06		15.0	30.5	<0.002	0.61	0.58	11.2	1	2.1	32.7	0.23	0.65	3.88	0.179	0.11	14.6	
ELV_07		6.4	20.8	<0.002	0.23	0.27	5.4	1	0.8	18.8	0.31	0.12	4.79	0.170	0.11	9.2	
ELV_08		55.5	29.6	<0.002	0.23	0.71	11.3	2	3.4	42.0	0.36	1.94	5.08	0.186	0.16	20.5	
ELV_09		100.5	29.3	<0.002	0.39	0.80	11.7	2	3.8	31.4	0.30	2.53	5.41	0.179	0.19	41.6	
ELV_10		159.0	30.9	<0.002	0.44	0.97	13.0	2	4.2	26.3	0.32	3.03	6.64	0.192	0.15	39.7	
ELV_11		29.6	31.9	0.002	0.37	0.43	11.9	1	3.7	37.9	0.33	1.19	4.92	0.203	0.14	23.6	
ELV_12		27.3	39.5	<0.002	1.70	0.54	15.1	2	3.9	39.2	0.28	1.63	4.45	0.241	0.21	23.7	
ELV_13		18.4	34.5	<0.002	0.69	0.42	13.4	1	2.4	38.0	0.25	0.93	4.26	0.205	0.12	16.6	
ELV_14		51.8	36.5	<0.002	1.83	0.60	9.3	4	3.0	59.0	0.33	2.69	2.21	0.226	0.19	2.9	
ELV_15		18.0	31.2	<0.002	0.09	0.30	11.4	1	3.3	58.7	0.35	0.58	4.10	0.234	0.12	16.0	
ELV_16		321	108.0	<0.002	1.53	35.2	3.5	8	3.9	211	1.01	7.49	11.00	0.133	1.78	4.1	
ELV_17		20.0	35.1	<0.002	0.25	0.35	12.0	1	3.4	59.1	0.35	0.67	4.22	0.241	0.12	21.2	
ELV_18		19.6	32.6	<0.002	0.22	0.27	11.6	1	3.2	59.5	0.36	0.65	4.42	0.242	0.13	11.1	
ELV_19		17.8	30.3	<0.002	0.24	0.22	11.2	1	2.4	50.9	0.35	0.47	4.99	0.213	0.11	47.9	
ELV_20		20.0	30.8	<0.002	0.21	0.37	11.0	1	2.4	40.0	0.33	1.19	5.08	0.187	0.10	24.8	
ELV_21		27.5	30.1	<0.002	0.18	0.59	10.4	1	2.8	65.5	0.37	0.85	5.17	0.213	0.11	30.1	
ELV_22		33.7	32.0	<0.002	0.29	0.70	10.6	1	3.4	56.3	0.36	1.05	6.07	0.212	0.13	33.1	
ELV_23		70.1	34.4	0.003	0.55	1.27	12.5	2	5.7	67.5	0.57	4.49	7.77	0.253	0.20	54.1	
ELV_24		122.0	32.9	0.002	0.60	1.42	12.6	2	5.0	49.7	0.39	4.73	6.61	0.212	0.21	50.1	
ELV_25		121.0	28.3	<0.002	0.42	0.86	14.4	2	4.2	27.2	0.23	5.22	5.49	0.185	0.14	26.0	
ELV_26		33.0	30.9	<0.002	0.22	0.38	10.4	1	3.0	36.3	0.29	1.31	4.99	0.179	0.11	16.6	
ELV_27		25.1	34.8	<0.002	1.17	0.37	11.8	1	3.4	42.1	0.31	1.10	3.92	0.221	0.17	37.5	
ELV_28		17.7	28.8	<0.002	0.07	0.24	9.1	<1	2.8	70.3	0.42	0.32	4.75	0.239	0.10	25.4	
ELV_29		24.1	29.7	<0.002	0.38	0.36	11.9	1	3.7	61.7	0.35	0.88	4.94	0.232	0.12	31.3	
ELV_30		18.7	29.7	<0.002	0.27	0.33	10.9	1	2.6	42.9	0.31	0.82	5.26	0.184	0.11	24.4	
ELV_31		327	109.0	<0.002	1.55	38.9	3.5	8	4.1	214	1.01	7.77	11.20	0.135	1.75	4.2	
ELV_32		36.3	30.5	<0.002	0.30	0.84	10.2	1	3.3	53.9	0.35	2.28	5.59	0.202	0.13	41.2	
ELV_33		34.4	26.1	<0.002	0.18	0.72	9.2	1	3.4	64.9	0.44	1.29	5.30	0.215	0.13	34.8	
ELV_34		51.5	21.8	0.002	0.18	0.79	8.8	1	2.4	30.6	0.25	2.20	3.70	0.171	0.08	28.1	
ELV_35		18.6	28.2	<0.002	0.07	0.25	11.4	1	2.8	53.1	0.37	0.58	4.45	0.222	0.10	21.6	
ELV_36		19.6	32.0	<0.002	0.24	0.28	11.5	1	2.7	64.4	0.39	0.43	4.60	0.236	0.11	19.3	
ELV_37		11.8	12.8	0.006	>10.0	0.29	4.4	<1	1.3	24.3	0.17	0.41	1.81	0.096	0.05	141.0	
ELV_38		24.1	34.3	<0.002	0.34	0.33	11.4	1	3.9	58.1	0.33	0.70	4.75	0.209	0.10	16.2	
ELV_39		15.4	31.9	<0.002	0.32	0.26	11.8	1	3.2	50.0	0.34	0.48	4.74	0.222	0.09	27.8	
ELV_40		19.3	26.6	<0.002	0.62	0.35	11.2	1	2.4	37.8	0.30	0.66	4.90	0.183	0.09	34.2	



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CERTIFICATE OF ANALYSIS BR23315396

Sample Description	Method Analyte Units LOD	ME-MS61 V ppm 1	ME-MS61 W ppm 0.1	ME-MS61 Y ppm 0.1	ME-MS61 Zn ppm 2	ME-MS61 Zr ppm 0.5	ME-MS61 Ba ppm 0.5	ME-MS81 Ce ppm 0.1	ME-MS81 Cr ppm 5	ME-MS81 Cs ppm 0.01	ME-MS81 Dy ppm 0.05	ME-MS81 Er ppm 0.03	ME-MS81 Eu ppm 0.02	ME-MS81 Ga ppm 0.1	ME-MS81 Gd ppm 0.05	ME-MS81 Hf ppm 0.05
ELV_01		14	4.4	11.7	422	175.0	3280	72.3	21	4.93	3.19	0.90	1.02	23.2	5.12	5.94
ELV_02		75	7.2	27.9	52	105.5	201	183.5	55	1.47	6.69	3.83	1.64	21.8	7.39	4.09
ELV_03		81	2.5	25.1	64	78.1	183.5	117.5	66	1.95	5.89	3.41	1.36	22.0	6.23	2.58
ELV_04		96	4.0	27.6	94	80.3	184.5	111.0	90	2.89	6.59	4.14	1.46	22.7	6.96	2.82
ELV_05		73	1.9	22.9	37	73.2	127.5	65.4	69	1.36	5.48	3.79	1.08	18.0	5.27	3.56
ELV_06		72	2.0	21.4	57	80.2	169.0	81.8	71	1.16	5.91	3.33	1.24	22.8	6.30	3.24
ELV_07		41	0.9	15.7	15	59.3	149.5	70.8	39	0.56	3.66	2.20	1.13	10.6	4.82	4.24
ELV_08		75	4.8	27.6	50	98.2	154.5	165.0	59	1.19	6.13	3.46	1.50	22.0	7.14	3.00
ELV_09		79	3.2	29.7	69	75.9	167.0	166.5	73	1.34	7.80	4.71	1.82	28.6	8.16	2.99
ELV_10		86	2.5	29.9	65	89.9	160.0	146.0	85	1.28	7.64	4.61	1.44	29.6	8.55	2.96
ELV_11		78	2.5	29.1	60	84.4	151.5	162.0	78	1.23	6.64	4.36	1.90	26.2	9.03	3.11
ELV_12		96	4.0	31.3	102	87.0	210	114.5	95	2.74	6.70	4.11	1.64	25.1	7.70	2.72
ELV_13		83	2.5	24.4	57	81.4	172.5	95.2	80	1.32	6.33	3.76	1.50	24.3	6.82	3.19
ELV_14		83	7.3	16.9	29	86.6	151.0	102.0	77	1.49	3.76	2.56	0.87	20.0	3.53	3.10
ELV_15		79	10.6	34.1	39	91.6	176.0	178.0	81	1.78	7.73	4.72	2.12	22.0	8.47	3.81
ELV_16		14	4.5	11.5	408	174.5	3420	78.5	22	5.23	2.53	0.84	1.27	25.6	5.06	5.90
ELV_17		82	8.4	32.2	48	93.2	193.5	174.0	93	2.24	7.27	4.77	1.68	24.1	8.67	3.62
ELV_18		81	7.9	30.8	44	95.2	177.0	144.5	71	2.02	6.21	3.90	1.49	20.3	6.14	3.48
ELV_19		74	4.0	33.6	54	94.6	177.0	213	61	1.08	7.91	3.95	2.16	20.1	9.31	3.53
ELV_20		73	4.2	24.5	52	95.6	176.0	142.0	54	1.34	6.49	4.33	1.57	23.1	7.67	3.68
ELV_21		81	6.4	30.3	49	110.0	175.5	237	57	1.04	6.64	4.44	1.65	23.0	9.07	3.63
ELV_22		81	6.0	29.8	60	98.1	197.0	188.0	60	1.24	6.66	3.74	1.52	21.4	7.86	3.45
ELV_23		92	16.2	39.4	141	106.0	240	246	74	3.92	8.59	4.32	2.06	27.0	11.80	3.12
ELV_24		92	9.7	33.6	118	101.0	180.0	216	84	2.84	8.51	4.45	1.95	27.8	10.05	3.02
ELV_25		95	3.3	31.2	118	112.0	158.5	129.5	104	1.20	7.43	5.59	1.50	29.7	8.57	3.04
ELV_26		71	4.6	26.6	53	90.4	141.0	155.0	63	1.06	6.77	3.95	1.32	24.6	7.38	3.38
ELV_27		81	3.4	31.2	89	79.9	164.5	157.5	76	1.60	7.10	4.42	1.72	22.9	8.04	2.93
ELV_28		67	7.2	28.8	40	107.0	184.5	152.0	51	0.98	6.25	3.46	1.76	23.7	8.30	3.86
ELV_29		83	8.0	35.8	62	99.2	187.5	151.0	83	2.05	7.79	4.82	1.79	23.7	9.06	3.35
ELV_30		72	5.2	26.3	46	93.9	179.0	178.0	59	1.24	7.03	4.27	1.60	23.8	8.26	3.79
ELV_31		14	4.4	11.6	416	175.0	3240	73.0	21	5.21	2.61	0.95	1.16	24.2	4.87	5.92
ELV_32		79	12.8	31.9	74	99.5	189.0	200	60	1.69	6.92	3.75	1.58	24.3	8.53	3.49
ELV_33		72	10.5	32.5	68	101.5	208	243	50	1.78	7.93	3.69	2.16	22.6	10.15	3.57
ELV_34		70	4.9	24.5	54	82.7	108.5	150.0	68	0.88	6.65	3.67	1.26	22.0	7.33	3.00
ELV_35		77	5.8	28.0	45	93.6	191.5	145.0	73	1.71	7.03	4.26	1.90	20.8	8.00	3.97
ELV_36		82	4.7	27.7	48	96.9	189.0	139.0	72	1.61	6.09	3.53	1.66	20.5	7.01	4.02
ELV_37		34	2.3	85.0	166	44.4	65.1	206	31	0.56	13.20	7.88	2.86	8.0	14.90	2.14
ELV_38		74	7.2	29.7	41	95.6	168.5	115.0	67	1.52	6.09	3.75	1.42	19.8	6.34	3.36
ELV_39		80	7.4	29.5	54	85.3	171.5	140.0	69	1.36	6.26	3.97	1.88	21.6	6.92	3.67
ELV_40		75	3.9	28.3	55	94.5	169.0	166.0	62	1.17	7.12	3.47	1.84	21.7	7.73	3.49



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Project: UQ-23-094 – Elverdton (WA)

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CERTIFICATE OF ANALYSIS BR23315396

Sample Description	Method Analyte Units LOD	ME-MS81																ME-MS81			
		Ho	La	Lu	Nb	Nd	Pr	Rb	Sc	Sm	Sn	Sr	Ta	Tb	Th	Ti	%				
ELV_01		0.42	39.1	0.10	16.10	31.9	9.00	105.5	5.6	6.53	4.2	243	1.1	0.61	12.15	0.15					
ELV_02		1.08	127.5	0.40	7.29	54.9	17.45	34.0	10.8	10.05	3.7	67.7	0.6	1.08	5.79	0.28					
ELV_03		1.20	89.1	0.47	4.90	35.7	11.30	38.3	17.0	7.00	3.9	45.3	0.5	0.98	4.16	0.25					
ELV_04		1.29	78.3	0.54	5.49	35.0	11.10	43.1	17.0	7.89	3.7	43.3	0.5	1.08	3.67	0.31					
ELV_05		1.22	46.6	0.55	5.24	22.0	6.10	33.9	15.9	4.51	2.6	40.4	0.4	0.82	3.88	0.26					
ELV_06		0.97	58.6	0.34	5.96	28.0	8.16	31.5	14.8	5.47	3.4	34.3	0.5	0.72	4.78	0.28					
ELV_07		0.73	41.9	0.24	5.51	30.9	9.09	22.1	8.9	5.82	1.0	20.2	0.5	0.77	5.55	0.23					
ELV_08		1.10	112.0	0.45	6.52	52.3	15.45	29.5	12.8	8.51	3.9	40.7	0.5	1.08	5.85	0.25					
ELV_09		1.58	120.0	0.60	6.78	51.4	16.60	29.9	12.2	9.62	4.1	32.8	0.6	1.26	6.25	0.25					
ELV_10		1.36	106.0	0.57	6.44	44.7	14.05	31.1	16.1	8.43	5.3	26.1	0.5	1.05	7.83	0.25					
ELV_11		1.29	112.5	0.59	6.78	51.7	15.45	35.4	12.6	9.04	3.5	35.8	0.5	1.12	5.15	0.27					
ELV_12		1.28	80.1	0.49	5.15	39.6	11.25	43.7	16.6	7.38	6.6	40.8	0.4	1.09	5.02	0.31					
ELV_13		1.10	66.6	0.46	6.50	30.1	8.98	35.3	16.2	6.76	2.8	39.3	0.4	0.95	4.94	0.30					
ELV_14		0.76	77.8	0.42	5.81	26.2	8.84	37.4	15.0	3.71	3.3	57.5	0.4	0.63	2.42	0.27					
ELV_15		1.56	125.5	0.81	6.63	57.7	17.60	36.7	12.1	9.68	3.8	65.3	0.5	1.28	4.67	0.31					
ELV_16		0.40	41.6	0.08	16.75	30.7	9.00	117.0	3.9	6.63	4.1	256	1.2	0.69	12.80	0.15					
ELV_17		1.48	125.5	0.78	6.64	51.6	16.70	36.7	14.5	9.20	5.0	65.3	0.6	1.22	4.81	0.32					
ELV_18		1.31	95.8	0.57	6.18	44.8	13.45	35.1	13.9	7.71	4.0	60.4	0.5	0.93	5.12	0.30					
ELV_19		1.52	141.5	0.52	6.23	67.5	19.95	34.4	14.0	11.05	2.6	52.3	0.5	1.29	5.87	0.28					
ELV_20		1.24	98.2	0.53	7.34	45.0	14.25	29.8	16.1	7.97	3.2	40.6	0.6	1.09	6.06	0.30					
ELV_21		1.23	162.5	0.60	7.39	67.9	22.2	31.2	11.6	10.95	3.8	63.5	0.6	1.15	5.77	0.29					
ELV_22		1.32	122.5	0.48	6.69	57.5	17.60	33.9	15.3	10.30	4.2	58.5	0.6	1.12	7.01	0.27					
ELV_23		1.65	171.5	0.69	7.73	74.6	24.0	31.8	12.2	12.20	6.2	73.9	0.7	1.44	8.21	0.30					
ELV_24		1.52	148.0	0.62	6.50	65.7	21.8	30.9	18.8	12.80	6.2	50.5	0.5	1.44	7.52	0.27					
ELV_25		1.39	89.5	0.62	4.52	42.6	13.65	29.5	20.0	8.48	5.3	27.7	0.3	1.24	6.54	0.25					
ELV_26		1.18	108.5	0.58	6.81	46.1	14.75	30.7	11.4	8.52	3.8	36.7	0.4	1.23	5.51	0.27					
ELV_27		1.37	111.0	0.51	6.03	46.6	14.75	36.4	14.4	9.29	4.3	42.2	0.4	1.15	4.37	0.28					
ELV_28		1.14	101.5	0.53	7.02	47.8	15.10	33.8	10.0	8.51	3.2	71.0	0.5	1.05	5.50	0.29					
ELV_29		1.57	106.5	0.74	6.10	48.0	14.50	32.9	15.4	9.30	4.6	62.2	0.5	1.22	5.21	0.29					
ELV_30		1.16	124.5	0.56	6.85	55.0	16.90	29.3	13.8	9.67	3.1	45.1	0.4	1.12	6.03	0.28					
ELV_31		0.34	39.1	0.08	15.75	29.3	8.61	113.5	4.6	6.14	3.9	245	1.1	0.58	12.40	0.15					
ELV_32		1.34	136.5	0.73	7.40	58.2	18.95	30.2	12.0	9.97	3.9	53.2	0.5	1.34	6.12	0.27					
ELV_33		1.40	170.5	0.60	6.88	73.3	22.4	29.6	15.2	12.25	5.0	68.0	0.5	1.41	5.90	0.26					
ELV_34		1.26	102.5	0.57	5.94	47.3	14.35	20.4	14.0	8.84	3.0	30.2	0.3	1.20	4.30	0.25					
ELV_35		1.34	99.1	0.58	6.34	49.5	14.85	31.6	12.6	8.04	3.8	65.5	0.5	1.02	5.04	0.29					
ELV_36		1.21	99.5	0.52	6.46	45.0	13.40	32.1	14.2	7.72	2.8	73.5	0.5	1.02	4.87	0.29					
ELV_37		2.63	93.2	1.00	2.43	92.6	24.2	11.5	5.1	16.05	1.2	24.8	0.2	2.15	1.91	0.11					
ELV_38		1.08	80.7	0.56	5.96	40.3	11.50	25.4	14.0	7.08	3.5	53.4	0.5	0.89	4.84	0.26					
ELV_39		1.26	95.8	0.54	5.98	48.0	13.30	29.1	13.0	8.52	3.0	52.3	0.5	1.05	5.01	0.28					
ELV_40		1.28	109.0	0.52	6.10	55.0	16.25	27.6	13.3	8.80	2.9	43.3	0.5	1.16	5.29	0.26					



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CERTIFICATE OF ANALYSIS BR23315396

Sample Description	Method Analyte Units LOD	ME-MS81 Tm ppm 0.01	ME-MS81 U ppm 0.05	ME-MS81 V ppm 5	ME-MS81 W ppm 0.5	ME-MS81 Y ppm 0.1	ME-MS81 Yb ppm 0.03	ME-MS81 Zr ppm 1	pXRF-34 Si % 0.5	pXRF-34 Ti % 0.1	pXRF-34 Zr ppm 5
ELV_01		0.12	4.57	19	4.6	13.4	0.60	222	34.7	0.2	164
ELV_02		0.61	25.9	91	7.9	33.0	3.53	157	24.4	0.2	116
ELV_03		0.47	22.8	102	3.8	31.3	3.62	102	17.4	0.2	85
ELV_04		0.53	21.7	123	5.4	34.6	3.40	115	17.3	0.2	93
ELV_05		0.54	7.55	94	4.0	32.4	3.70	139	25.6	0.2	117
ELV_06		0.48	17.25	98	3.3	30.4	3.27	121	21.0	0.2	86
ELV_07		0.29	10.80	55	3.0	19.6	1.94	184	35.1	0.2	158
ELV_08		0.49	23.7	98	10.1	35.1	3.14	126	19.1	0.2	100
ELV_09		0.66	46.8	107	3.2	40.9	4.30	112	17.8	0.2	73
ELV_10		0.60	42.8	117	3.1	37.5	3.89	109	18.8	0.2	100
ELV_11		0.57	25.8	99	3.5	36.0	3.71	112	20.0	0.2	98
ELV_12		0.60	26.4	127	7.5	36.6	3.54	108	17.4	0.2	88
ELV_13		0.53	19.05	111	3.7	32.6	3.70	121	21.1	0.2	124
ELV_14		0.41	3.46	109	7.3	22.7	2.92	147	18.6	0.2	164
ELV_15		0.72	18.60	102	11.3	42.5	4.45	153	23.6	0.2	120
ELV_16		0.13	4.48	17	4.7	11.6	0.61	243	35.5	0.3	204
ELV_17		0.68	25.3	108	9.6	42.8	4.56	141	21.1	0.2	99
ELV_18		0.64	12.85	97	8.6	37.5	3.96	142	23.2	0.2	112
ELV_19		0.53	52.6	91	5.2	41.6	3.69	135	24.1	0.2	118
ELV_20		0.48	28.0	89	6.9	34.9	3.70	130	22.9	0.2	97
ELV_21		0.51	33.9	97	8.6	36.8	3.73	149	24.0	0.2	119
ELV_22		0.54	36.5	112	10.8	36.6	3.41	137	22.2	0.2	95
ELV_23		0.58	55.1	122	16.4	44.0	4.55	121	21.5	0.2	95
ELV_24		0.62	52.1	117	11.2	40.5	4.27	122	18.1	0.2	105
ELV_25		0.66	29.6	120	4.6	46.2	4.79	127	18.2	0.2	115
ELV_26		0.54	18.95	94	6.2	33.9	3.49	134	21.4	0.2	122
ELV_27		0.67	40.2	107	4.3	37.7	3.87	118	21.6	0.2	88
ELV_28		0.54	28.7	89	8.7	34.7	3.65	150	25.9	0.2	125
ELV_29		0.71	32.3	104	10.8	41.1	4.17	129	20.6	0.2	98
ELV_30		0.53	28.1	100	6.5	35.6	3.71	143	21.2	0.2	101
ELV_31		0.10	4.45	21	5.0	11.6	0.74	225	34.2	0.3	184
ELV_32		0.55	41.0	101	14.6	37.7	3.76	138	22.8	0.2	116
ELV_33		0.55	35.2	98	10.8	38.9	3.47	149	24.2	0.2	115
ELV_34		0.51	32.3	89	6.8	36.5	3.85	118	22.4	0.2	101
ELV_35		0.57	23.2	100	7.7	37.6	3.92	150	24.0	0.2	122
ELV_36		0.52	19.30	98	5.7	34.0	3.33	164	22.9	0.2	128
ELV_37		0.97	148.5	39	4.5	86.6	6.57	81	8.8	0.1	40
ELV_38		0.52	15.25	85	8.8	34.8	3.30	146	21.0	0.2	96
ELV_39		0.54	27.4	92	6.6	38.2	3.85	144	21.3	0.2	100
ELV_40		0.54	35.2	95	5.0	39.2	3.43	137	19.3	0.2	80



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CERTIFICATE OF ANALYSIS BR23315396

Sample Description	Method Analyte Units LOD	ME-MS61																ME-MS61			
		WEI-21 Recvd Wt. kg	PUL-QC Pass75um %	ME-MS61 Ag ppm	ME-MS61 Al %	ME-MS61 As ppm	ME-MS61 Ba ppm	ME-MS61 Be ppm	ME-MS61 Bi ppm	ME-MS61 Ca %	ME-MS61 Cd ppm	ME-MS61 Ce ppm	ME-MS61 Co ppm	ME-MS61 Cr ppm	ME-MS61 Cs ppm	ME-MS61 Cu ppm	ME-MS61 Pb ppm	ME-MS61			
ELV_41		2.26		0.81	6.70	5.1	170	0.56	0.68	1.57	0.15	239	50.6	37	1.03	2000					
ELV_42		2.98		0.62	6.17	5.0	170	0.62	1.24	1.79	0.20	218	52.2	33	1.17	706					
ELV_43		3.41		0.85	6.11	12.4	170	0.62	1.52	1.51	0.12	217	48.9	37	1.22	1590					
ELV_44		2.14		0.16	6.57	4.1	160	0.53	0.40	1.48	0.08	113.5	82.6	58	0.74	1475					
ELV_45		1.89		2.16	5.52	24.6	180	0.29	3.48	1.39	0.05	16.15	53.1	91	0.87	1180					
ELV_46		0.07		49.5	6.77	376	470	2.24	21.0	0.92	2.79	74.2	4.9	15	4.78	1130					
ELV_47		4.38		0.45	8.87	48.8	400	0.50	1.80	0.11	0.04	26.5	43.0	114	0.55	1455					
ELV_48		2.58		7.47	7.30	32.7	230	0.47	7.22	1.49	0.30	32.6	363	121	0.87	5800					
ELV_49		1.36	99.1	0.35	6.03	24.0	190	0.50	1.44	1.17	0.14	113.5	147.0	49	0.70	1745					
ELV_50		2.07		0.59	7.67	41.7	340	0.43	1.98	0.33	0.05	38.5	49.8	67	0.56	1405					
ELV_51		1.75		2.80	4.56	29.2	150	0.24	5.91	1.60	0.04	17.10	74.3	74	0.53	1020					
ELV_52		2.23		5.82	4.59	23.7	130	0.29	6.44	0.96	0.25	15.70	302	66	0.47	6500					
ELV_53		2.96		7.49	5.45	26.9	180	0.31	7.77	1.40	0.27	15.20	318	76	0.64	4310					
ELV_54		1.74		0.48	6.25	6.9	150	0.55	0.71	1.51	0.03	99.9	36.9	48	1.24	826					
ELV_55		1.87		0.66	3.97	10.3	130	0.34	1.18	1.84	0.05	69.3	53.3	57	0.98	1770					
ELV_56		2.35		1.52	5.30	12.1	160	0.36	0.68	1.89	0.04	93.2	40.0	64	1.33	1640					
ELV_57		2.05		0.47	5.22	3.6	140	0.40	0.25	1.20	0.09	82.5	40.3	42	0.76	780					
ELV_58		2.85		0.91	6.24	5.0	130	0.54	0.27	1.28	0.07	146.0	58.8	43	0.90	1040					
ELV_59		2.87		0.49	6.14	3.6	130	0.49	0.24	1.47	0.17	139.5	69.6	50	1.11	777					
ELV_60		2.34		0.42	6.20	4.3	150	0.56	0.27	1.61	0.08	165.0	47.1	42	0.97	762					
ELV_61		0.07		49.1	6.95	384	430	2.30	20.2	0.93	2.70	70.8	4.8	15	4.71	1165					
ELV_62		2.38		0.95	5.84	4.2	150	0.42	0.32	1.72	0.14	116.0	60.4	58	1.46	1225					
ELV_63		2.29		0.99	6.41	10.4	200	0.56	0.59	1.84	0.22	169.5	50.0	41	1.00	1730					
ELV_64		2.38		0.58	5.76	7.7	160	0.46	0.36	1.42	0.06	107.5	52.7	44	0.86	786					
ELV_65		2.22		0.59	6.51	12.4	210	0.55	0.45	1.56	0.02	111.5	30.9	41	0.92	741					
ELV_66		1.83		0.13	5.70	8.4	210	0.50	0.26	1.37	0.04	60.9	27.0	36	0.87	497					
ELV_67		1.32		0.57	5.77	26.2	220	0.53	0.76	1.31	0.05	76.4	30.3	29	0.87	1775					
ELV_68		2.64		0.37	6.59	9.0	220	0.59	0.49	1.91	0.19	136.0	51.5	40	1.12	1315					
ELV_69		1.55		1.57	5.81	5.0	160	0.57	0.27	2.17	0.55	416	79.1	33	0.70	2820					
ELV_70		2.27		0.43	6.09	11.0	210	0.51	0.81	1.57	0.38	120.0	58.7	39	1.06	1440					
ELV_71		0.07		50.4	6.87	375	520	2.24	21.9	0.92	2.71	74.7	4.7	15	5.30	1125					
ELV_72		0.39		0.59	6.08	3.8	130	0.48	0.24	1.46	0.15	142.0	67.4	49	1.20	768					
ELV_73		3.08		1.46	5.86	4.7	150	0.42	0.34	1.61	0.50	88.5	196.0	53	2.01	3340					
ELV_74		1.30		1.64	4.74	14.6	140	0.40	0.94	1.38	0.08	103.0	82.2	70	3.97	2230					
ELV_75		1.79		0.18	6.24	5.8	160	0.41	0.37	1.72	0.02	81.7	61.6	61	2.48	987					
ELV_76		0.47		0.55	9.12	51.8	410	0.50	1.92	0.12	0.05	29.7	39.7	117	0.63	1480					
ELV_77		1.66		1.24	5.33	5.5	150	0.37	0.46	2.04	0.34	88.8	146.5	59	2.48	2260					
ELV_78		0.07		51.7	7.08	384	580	2.29	22.3	0.95	2.78	78.5	5.0	16	5.51	1155					



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Project: UQ-23-094 – Elverdton (WA)

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CERTIFICATE OF ANALYSIS BR23315396

Sample Description	Method Analyte Units LOD	ME-MS61 Fe %	ME-MS61 Ca ppm	ME-MS61 Ce ppm	ME-MS61 Hf ppm	ME-MS61 In ppm	ME-MS61 K %	ME-MS61 La ppm	ME-MS61 Li ppm	ME-MS61 Mg %	ME-MS61 Mn ppm	ME-MS61 Mo ppm	ME-MS61 Na %	ME-MS61 Nb ppm	ME-MS61 Ni ppm	ME-MS61 P ppm
ELV_41		6.05	22.2	0.24	2.6	0.134	0.74	156.5	28.5	3.24	495	22.8	1.29	4.8	67.6	670
ELV_42		5.82	18.25	0.20	2.7	0.096	0.69	142.5	26.9	2.38	517	16.80	1.56	5.4	56.5	630
ELV_43		6.46	19.80	0.17	2.5	0.140	0.65	141.0	29.9	2.65	497	24.3	1.46	4.7	56.0	620
ELV_44		7.98	20.2	0.15	2.3	0.091	0.63	78.5	33.2	3.43	581	9.14	2.46	4.0	68.8	510
ELV_45		9.16	13.75	0.09	2.0	0.122	0.80	8.5	47.4	2.48	646	2.15	0.64	2.6	59.3	320
ELV_46		2.20	22.6	0.15	4.9	0.623	2.59	36.3	27.0	0.15	227	3.77	1.83	14.7	6.4	370
ELV_47		7.48	20.1	0.18	3.0	0.185	1.83	14.4	24.0	0.57	204	1.34	0.15	3.7	82.9	120
ELV_48		11.30	17.45	0.15	2.3	0.272	0.97	13.0	54.2	2.65	1320	2.23	0.37	2.6	113.0	230
ELV_49		7.86	13.55	0.11	2.5	0.136	0.83	69.5	22.6	1.73	717	11.40	1.26	3.6	66.6	390
ELV_50		7.92	17.70	0.11	2.9	0.181	1.61	23.7	23.0	0.86	299	3.34	0.44	3.6	61.1	200
ELV_51		10.75	12.45	0.07	1.8	0.117	0.68	8.9	28.7	1.62	491	1.94	0.73	2.4	44.4	250
ELV_52		10.60	10.35	0.10	1.4	0.255	0.50	7.4	46.5	2.18	659	1.64	0.37	2.1	79.7	210
ELV_53		11.95	13.45	0.23	1.7	0.290	0.74	7.7	48.2	2.89	1130	2.05	0.49	2.4	91.3	250
ELV_54		7.10	16.85	0.12	2.4	0.107	0.70	70.3	23.0	1.91	383	14.95	1.57	4.0	38.9	380
ELV_55		16.90	13.30	0.25	1.9	0.194	0.61	47.9	9.2	1.58	411	24.0	1.48	2.6	29.1	500
ELV_56		10.75	15.85	0.10	2.0	0.185	0.79	64.4	16.5	2.00	432	19.00	1.38	3.3	31.3	470
ELV_57		5.63	14.20	0.08	2.2	0.068	0.65	56.1	20.2	2.05	349	13.60	1.23	3.3	34.8	380
ELV_58		7.44	20.0	0.15	2.4	0.073	0.73	98.1	26.5	3.44	419	22.2	1.39	3.6	51.6	690
ELV_59		7.05	18.55	0.13	2.4	0.078	0.75	91.3	28.1	3.28	458	19.60	1.45	3.6	60.5	630
ELV_60		6.76	18.90	0.25	2.3	0.086	0.75	115.0	28.7	2.97	490	40.1	1.67	4.1	48.1	660
ELV_61		2.25	22.9	0.19	4.7	0.581	2.65	34.8	27.3	0.16	233	3.34	1.86	14.2	6.1	370
ELV_62		8.61	17.05	0.13	2.3	0.107	0.82	78.6	23.6	2.60	425	16.90	1.31	3.3	48.5	580
ELV_63		6.88	19.30	0.18	2.4	0.119	0.84	116.0	29.9	2.38	584	51.0	1.66	4.4	47.6	640
ELV_64		6.93	16.10	0.12	2.4	0.074	0.79	74.0	25.0	2.40	452	24.4	1.29	3.6	40.0	490
ELV_65		6.90	18.45	0.14	2.6	0.097	0.88	75.9	28.2	2.41	480	40.5	1.58	4.5	38.4	600
ELV_66		5.02	14.50	0.10	2.2	0.069	0.81	39.4	24.6	1.64	405	26.4	1.56	4.3	31.7	430
ELV_67		10.30	14.55	0.11	2.5	0.076	0.90	46.9	19.8	1.29	376	34.5	1.69	3.8	25.3	390
ELV_68		6.58	19.30	0.15	2.8	0.107	0.93	92.6	31.9	2.31	578	59.9	1.76	5.1	51.3	670
ELV_69		6.40	19.20	0.26	2.6	0.098	0.67	293	32.4	2.48	1155	43.7	2.15	5.1	68.8	830
ELV_70		6.62	17.60	0.19	2.4	0.110	0.91	93.2	30.1	2.09	632	43.8	1.83	4.7	54.2	520
ELV_71		2.20	24.0	0.17	5.0	0.573	2.60	37.7	26.9	0.15	228	3.50	1.83	16.1	6.4	360
ELV_72		6.99	19.10	0.20	2.3	0.078	0.74	98.0	28.0	3.25	456	18.75	1.44	3.8	59.8	620
ELV_73		8.55	17.80	0.20	1.9	0.103	0.71	62.0	34.8	3.23	406	8.79	2.61	3.1	123.0	520
ELV_74		15.25	15.70	0.25	1.8	0.152	0.98	81.4	22.5	2.67	392	12.70	2.78	2.8	52.1	880
ELV_75		9.43	19.50	0.18	2.2	0.123	0.76	58.9	28.4	3.07	430	10.40	1.57	3.6	52.5	620
ELV_76		7.71	21.4	0.21	3.2	0.203	1.88	16.7	24.6	0.59	210	1.24	0.15	4.3	78.1	130
ELV_77		10.80	17.00	0.19	1.8	0.142	0.67	57.2	33.2	2.63	397	10.25	1.16	2.9	90.1	530
ELV_78		2.26	25.2	0.18	5.2	0.599	2.66	39.1	27.4	0.16	232	3.67	1.88	16.3	6.8	370



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Project: UQ-23-094 – Elverdton (WA)

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CERTIFICATE OF ANALYSIS BR23315396

Sample Description	Method Analyte Units LOD	ME-MS61 Pb ppm 0.5	ME-MS61 Rb ppm 0.1	ME-MS61 Re ppm 0.002	ME-MS61 S % 0.01	ME-MS61 Sb ppm 0.05	ME-MS61 Sc ppm 0.1	ME-MS61 Se ppm 1	ME-MS61 Sn ppm 0.2	ME-MS61 Sr ppm 0.2	ME-MS61 Ta ppm 0.05	ME-MS61 Te ppm 0.05	ME-MS61 Th ppm 0.01	ME-MS61 Ti % 0.005	ME-MS61 Tl ppm 0.02	ME-MS61 U ppm 0.1
ELV_41		42.5	28.0	<0.002	0.21	0.71	9.8	1	3.4	51.5	0.37	1.06	5.48	0.177	0.10	27.4
ELV_42		29.2	28.9	<0.002	0.14	0.91	8.5	1	3.2	57.7	0.41	1.00	5.15	0.191	0.10	31.3
ELV_43		42.9	23.2	<0.002	0.22	0.69	8.5	1	2.9	50.0	0.38	1.44	4.78	0.184	0.11	36.6
ELV_44		16.5	21.9	0.002	0.82	0.31	12.3	1	2.7	50.7	0.31	0.57	3.84	0.219	0.07	21.0
ELV_45		78.7	27.8	<0.002	1.55	0.58	12.7	1	1.6	18.9	0.22	2.93	1.66	0.256	0.15	1.7
ELV_46		313	113.5	<0.002	1.51	39.3	3.7	9	4.3	217	1.08	7.75	12.25	0.132	1.58	4.2
ELV_47		14.3	59.1	<0.002	0.26	0.42	15.3	1	2.8	10.5	0.31	0.81	3.70	0.238	0.17	1.6
ELV_48		44.9	30.2	0.007	5.12	0.70	16.3	1	1.6	16.3	0.22	6.66	2.49	0.243	0.17	2.1
ELV_49		18.4	30.0	0.002	1.99	0.37	11.5	1	2.5	39.8	0.32	0.91	2.90	0.219	0.10	5.5
ELV_50		18.0	46.9	<0.002	0.42	0.39	12.9	1	2.8	19.0	0.31	1.10	3.44	0.236	0.15	2.4
ELV_51		37.7	23.3	<0.002	2.73	0.64	10.7	1	1.7	20.4	0.20	4.84	1.47	0.235	0.13	0.9
ELV_52		26.9	16.5	0.004	5.94	0.55	12.0	1	1.4	10.5	0.17	5.48	1.31	0.231	0.15	1.2
ELV_53		41.9	25.5	0.006	5.91	0.66	12.5	1	1.7	18.0	0.18	6.67	1.56	0.208	0.15	1.4
ELV_54		16.7	28.0	<0.002	0.58	0.30	10.5	1	2.2	51.1	0.32	0.88	4.77	0.207	0.12	9.1
ELV_55		21.3	24.8	<0.002	2.19	0.49	11.9	6	3.2	32.3	0.19	2.53	1.63	0.209	0.24	7.6
ELV_56		22.3	31.4	<0.002	1.43	0.40	12.0	3	2.8	38.0	0.24	1.47	3.07	0.216	0.17	4.5
ELV_57		15.9	23.6	<0.002	0.43	0.33	8.8	1	1.6	36.1	0.29	0.60	3.97	0.183	0.09	9.3
ELV_58		20.6	28.8	<0.002	0.57	0.28	9.2	1	2.6	32.7	0.28	0.81	4.88	0.176	0.12	21.0
ELV_59		23.3	29.7	<0.002	0.56	0.29	10.4	1	2.5	36.4	0.28	0.66	4.11	0.187	0.10	21.6
ELV_60		29.7	30.1	0.003	0.35	0.47	9.8	1	2.7	47.3	0.30	0.77	4.76	0.187	0.12	24.8
ELV_61		322	108.5	<0.002	1.54	36.9	3.6	8	4.0	221	1.03	7.58	11.60	0.135	1.61	4.1
ELV_62		18.1	31.0	<0.002	0.93	0.28	11.9	2	2.6	38.5	0.30	0.88	3.49	0.199	0.15	9.9
ELV_63		45.1	28.2	0.004	0.36	0.78	10.2	1	2.6	53.5	0.43	0.94	4.85	0.209	0.14	21.2
ELV_64		18.4	29.9	<0.002	0.38	0.54	10.4	1	2.3	38.7	0.27	0.67	3.91	0.185	0.11	9.6
ELV_65		41.6	30.4	<0.002	0.13	0.70	9.2	1	2.5	50.1	0.35	0.78	4.72	0.205	0.13	9.9
ELV_66		34.8	32.2	<0.002	0.06	0.38	7.9	1	2.0	52.7	0.36	0.51	4.11	0.191	0.13	7.7
ELV_67		40.1	30.0	0.002	0.25	0.40	7.4	1	1.6	54.9	0.32	0.69	4.74	0.161	0.13	18.5
ELV_68		51.7	32.9	0.004	0.21	0.55	10.4	1	2.6	53.9	0.44	0.68	5.45	0.220	0.15	45.8
ELV_69		40.9	21.5	0.008	0.63	1.44	7.6	<1	3.1	63.9	0.44	0.64	4.96	0.176	0.11	85.9
ELV_70		39.1	35.9	0.005	0.38	0.55	9.2	1	2.5	60.2	0.38	0.81	4.52	0.191	0.15	46.8
ELV_71		313	116.5	<0.002	1.50	40.4	3.6	9	4.2	219	1.16	7.72	13.05	0.131	1.76	4.5
ELV_72		22.3	31.9	<0.002	0.55	0.44	10.4	1	2.6	38.2	0.29	0.69	4.59	0.183	0.12	22.7
ELV_73		14.9	34.1	<0.002	1.55	0.42	11.8	2	2.7	42.8	0.23	0.89	3.55	0.186	0.17	25.7
ELV_74		40.9	45.1	<0.002	2.46	0.66	11.8	3	2.7	40.7	0.20	1.44	4.02	0.182	0.21	7.6
ELV_75		13.6	39.5	<0.002	0.83	0.54	13.4	2	3.0	50.3	0.26	0.87	3.82	0.213	0.21	7.1
ELV_76		14.1	59.2	<0.002	0.27	0.48	16.3	1	2.8	10.6	0.35	0.85	4.22	0.238	0.19	1.7
ELV_77		13.0	31.1	<0.002	2.38	0.40	12.2	2	2.9	38.7	0.23	1.20	3.25	0.205	0.19	11.6
ELV_78		321	121.0	<0.002	1.55	41.2	3.8	9	4.3	226	1.18	8.11	13.15	0.135	1.81	4.5



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CERTIFICATE OF ANALYSIS BR23315396

Sample Description	Method Analyte Units LOD	ME-MS61 V ppm 1	ME-MS61 W ppm 0.1	ME-MS61 Y ppm 0.1	ME-MS61 Zn ppm 2	ME-MS61 Zr ppm 0.5	ME-MS61 Ba ppm 0.5	ME-MS81 Ce ppm 0.1	ME-MS81 Cr ppm 5	ME-MS81 Cs ppm 0.01	ME-MS81 Dy ppm 0.05	ME-MS81 Er ppm 0.03	ME-MS81 Eu ppm 0.02	ME-MS81 Ga ppm 0.1	ME-MS81 Gd ppm 0.05	ME-MS81 Hf ppm 0.05
ELV_41		73	6.4	30.0	56	93.1	176.0	234	52	1.13	7.52	4.44	2.01	22.9	9.38	4.24
ELV_42		68	7.8	28.2	58	92.3	182.0	226	46	1.46	7.44	3.78	2.09	20.7	8.90	3.73
ELV_43		68	6.3	27.9	56	91.3	173.0	219	49	1.44	6.84	3.61	2.09	21.1	8.80	4.19
ELV_44		85	6.4	23.0	55	85.1	165.5	111.5	74	0.79	4.99	3.14	1.18	20.7	5.24	3.09
ELV_45		98	2.2	9.1	70	77.3	187.0	16.6	117	0.92	1.68	1.26	0.35	13.8	1.55	2.27
ELV_46		14	4.5	11.7	413	175.5	320.0	71.2	20	5.13	2.70	0.93	1.16	22.3	4.86	6.45
ELV_47		97	3.3	11.9	50	114.0	445	28.5	145	0.68	2.63	1.75	0.66	21.0	2.69	3.79
ELV_48		105	3.0	15.7	104	85.3	236	30.2	153	0.95	3.27	1.81	0.67	17.6	3.05	2.66
ELV_49		73	6.8	22.3	55	90.6	196.5	118.5	61	0.90	5.12	2.83	1.36	15.5	5.47	4.48
ELV_50		87	3.7	12.4	45	103.5	337	39.2	81	0.70	2.93	1.98	0.61	18.4	2.59	3.68
ELV_51		83	2.6	7.2	46	65.3	148.0	16.6	88	0.67	1.46	1.08	0.39	13.2	1.42	2.45
ELV_52		82	3.0	11.1	77	54.4	137.0	18.8	96	0.57	2.42	1.62	0.54	11.5	2.28	1.92
ELV_53		87	2.9	10.9	81	67.4	192.5	15.2	116	0.85	2.67	1.42	0.52	14.2	2.30	1.97
ELV_54		70	3.7	17.2	31	83.4	157.5	100.0	61	1.49	4.44	2.58	1.20	17.6	4.31	3.77
ELV_55		99	4.3	16.2	48	68.9	123.0	69.6	74	1.11	3.94	2.80	0.82	15.0	3.15	3.74
ELV_56		90	4.3	15.4	37	73.9	155.5	89.4	77	1.53	3.74	2.61	0.84	16.2	3.34	3.97
ELV_57		62	2.2	14.5	36	77.8	152.0	82.6	54	1.02	3.69	2.36	0.84	17.0	4.05	4.86
ELV_58		71	5.8	22.4	42	87.6	128.5	147.0	53	1.00	5.70	3.46	1.58	20.5	6.47	4.48
ELV_59		75	2.4	23.7	56	85.0	133.5	141.0	63	1.30	5.74	3.17	1.41	20.9	6.25	3.28
ELV_60		72	2.6	23.3	53	84.4	155.0	163.5	55	1.16	5.38	2.84	1.54	19.8	6.89	3.91
ELV_61		15	4.1	11.4	425	173.0	329.0	73.2	21	5.24	2.85	0.85	1.02	24.7	4.24	6.13
ELV_62		83	2.8	19.7	52	81.7	153.0	114.0	74	1.68	4.76	3.21	1.06	18.6	5.01	3.34
ELV_63		78	6.0	24.1	73	84.5	202	171.0	55	1.22	5.25	3.01	1.48	20.4	6.75	3.72
ELV_64		70	3.8	18.2	51	88.4	177.0	110.5	61	1.12	5.05	3.38	1.18	19.4	5.42	4.62
ELV_65		72	3.6	19.8	42	93.5	208	109.5	52	1.06	4.32	2.51	1.16	19.8	5.08	4.80
ELV_66		59	1.8	15.4	44	83.4	225	66.8	49	1.08	3.40	2.08	0.89	17.7	3.86	4.40
ELV_67		51	4.6	16.5	89	88.9	214	71.2	35	0.96	3.60	2.15	0.82	15.0	3.77	4.43
ELV_68		80	4.9	25.4	75	99.4	221	130.5	50	1.16	5.73	3.42	1.19	20.0	6.19	4.53
ELV_69		66	3.3	49.0	158	93.0	150.5	421	38	0.86	10.90	4.69	2.96	17.5	15.35	4.57
ELV_70		67	4.5	24.1	101	90.3	209	116.5	46	1.18	4.97	2.73	1.21	17.0	5.23	3.29
ELV_71		14	4.5	12.6	411	180.5	322.0	70.8	18	5.00	2.61	0.85	0.93	22.7	4.32	6.42
ELV_72		73	2.4	25.1	56	88.3	140.0	144.5	61	1.22	5.92	3.32	1.40	19.2	6.45	3.68
ELV_73		78	2.6	20.0	97	73.1	152.0	89.0	69	2.02	4.74	2.90	1.19	16.5	4.44	3.11
ELV_74		97	5.8	16.2	78	67.1	141.0	95.4	85	3.71	3.29	2.13	0.77	13.9	3.03	3.28
ELV_75		85	2.4	20.7	47	83.4	167.5	77.3	75	2.30	4.20	3.26	0.99	17.5	4.35	2.82
ELV_76		99	3.7	12.5	51	124.0	434	30.1	136	0.63	2.95	1.58	0.75	19.2	2.54	3.71
ELV_77		86	2.2	21.9	58	67.7	159.5	89.6	75	2.26	6.06	3.86	1.28	17.6	5.50	3.80
ELV_78		14	4.6	12.6	418	185.5	325.0	73.2	19	4.84	2.92	0.86	1.07	22.6	4.30	5.80



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To: UNIVERSITY OF QUEENSLAND
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Project: UQ-23-094 – Elverdton (WA)

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Plus Appendix Pages
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CERTIFICATE OF ANALYSIS BR23315396

Sample Description	Method Analyte Units LOD	ME-MS81 Ho ppm 0.01	ME-MS81 La ppm 0.1	ME-MS81 Lu ppm 0.01	ME-MS81 Nb ppm 0.05	ME-MS81 Nd ppm 0.1	ME-MS81 Pr ppm 0.02	ME-MS81 Rb ppm 0.2	ME-MS81 Sc ppm 0.5	ME-MS81 Sm ppm 0.03	ME-MS81 Sn ppm 0.5	ME-MS81 Sr ppm 0.1	ME-MS81 Ta ppm 0.1	ME-MS81 Tb ppm 0.01	ME-MS81 Th ppm 0.05	ME-MS81 Ti % 0.01
ELV_41		1.44	159.0	0.54	6.61	71.9	22.0	27.9	10.6	12.20	4.1	60.5	0.5	1.30	5.68	0.24
ELV_42		1.26	156.0	0.49	6.67	71.6	21.2	26.7	11.6	10.85	3.3	66.7	0.6	1.28	5.59	0.23
ELV_43		1.30	148.0	0.44	6.22	70.8	20.8	25.8	9.2	11.00	3.3	54.4	0.5	1.09	5.42	0.22
ELV_44		0.99	76.1	0.49	5.54	33.2	10.40	22.2	12.8	5.54	3.2	53.4	0.4	0.67	4.28	0.26
ELV_45		0.40	8.9	0.20	3.39	7.6	2.00	28.0	14.7	1.79	2.0	19.0	0.3	0.26	1.90	0.30
ELV_46		0.41	37.1	0.06	14.80	31.9	8.53	106.5	4.7	6.13	4.7	247	1.1	0.57	12.20	0.14
ELV_47		0.61	15.6	0.27	5.18	14.4	3.41	53.1	19.2	2.65	3.0	10.2	0.4	0.36	4.01	0.32
ELV_48		0.63	12.8	0.31	3.19	13.2	3.24	30.4	17.4	3.17	2.1	19.0	0.2	0.44	2.19	0.27
ELV_49		0.92	74.3	0.43	4.86	36.1	11.00	26.8	13.0	6.19	2.3	40.4	0.4	0.80	3.25	0.26
ELV_50		0.60	23.3	0.23	4.51	14.2	3.76	42.0	14.6	2.76	3.2	18.7	0.4	0.44	3.62	0.30
ELV_51		0.35	8.9	0.17	2.82	7.7	1.77	19.4	13.6	1.23	1.4	20.5	0.3	0.23	1.36	0.27
ELV_52		0.53	11.0	0.24	2.46	8.6	2.00	18.2	16.1	2.00	1.7	11.2	0.2	0.40	1.74	0.28
ELV_53		0.49	7.9	0.23	2.70	7.4	1.90	24.5	15.2	2.03	2.2	19.8	0.2	0.32	1.68	0.24
ELV_54		0.79	72.4	0.40	4.95	30.7	9.10	28.9	11.6	4.76	2.3	60.3	0.4	0.74	5.20	0.24
ELV_55		0.88	48.5	0.37	4.10	20.8	6.40	23.7	13.4	3.26	3.7	36.1	0.3	0.53	1.69	0.26
ELV_56		0.81	63.5	0.39	4.42	22.1	7.36	31.8	15.4	3.36	3.4	44.4	0.4	0.52	3.38	0.25
ELV_57		0.73	58.9	0.29	5.21	26.1	7.59	25.4	11.4	5.26	2.2	43.0	0.5	0.60	4.57	0.24
ELV_58		1.09	100.5	0.43	5.83	46.1	14.15	28.8	10.6	8.44	2.8	34.7	0.5	0.90	5.07	0.23
ELV_59		1.16	95.6	0.39	5.97	46.2	13.65	29.1	11.4	8.10	2.9	40.4	0.5	0.86	4.48	0.25
ELV_60		1.03	118.5	0.47	5.82	51.3	14.75	29.0	11.4	7.67	3.6	47.8	0.4	0.89	4.82	0.23
ELV_61		0.37	38.6	0.07	15.25	33.5	8.26	109.0	4.3	6.12	4.6	244	1.1	0.59	11.90	0.14
ELV_62		0.98	80.8	0.34	5.23	34.0	10.35	33.3	14.0	5.70	3.6	44.6	0.4	0.68	3.81	0.25
ELV_63		1.00	117.5	0.46	6.30	52.5	16.55	31.7	11.2	8.30	3.0	59.6	0.5	0.83	5.26	0.23
ELV_64		1.01	77.7	0.43	5.81	35.5	10.25	32.3	14.6	6.19	2.8	47.7	0.5	0.84	4.47	0.26
ELV_65		0.91	76.8	0.42	6.06	36.5	10.35	31.3	11.6	6.12	2.9	55.7	0.4	0.76	4.87	0.23
ELV_66		0.72	44.3	0.34	5.29	24.3	6.72	34.3	10.6	3.90	2.1	61.9	0.5	0.52	4.87	0.22
ELV_67		0.71	44.6	0.30	4.46	25.6	7.06	31.8	7.3	4.34	2.3	58.1	0.4	0.50	4.80	0.18
ELV_68		1.02	91.1	0.58	6.05	42.0	12.50	34.3	12.4	6.95	2.4	62.1	0.5	0.84	5.38	0.24
ELV_69		1.76	297	0.60	6.67	114.5	35.9	24.7	9.4	18.15	3.2	65.1	0.5	1.91	5.31	0.21
ELV_70		0.95	87.9	0.46	5.21	34.0	9.80	33.7	10.3	6.44	2.5	58.5	0.4	0.65	4.63	0.23
ELV_71		0.42	35.7	0.12	15.05	27.8	7.82	105.0	4.0	5.79	5.0	226	1.1	0.52	10.90	0.15
ELV_72		1.10	94.3	0.44	6.03	42.6	13.25	31.2	12.9	7.44	2.8	39.3	0.4	0.91	4.79	0.27
ELV_73		0.81	60.8	0.33	4.60	26.1	7.83	30.6	14.1	4.34	2.7	39.6	0.4	0.67	3.78	0.26
ELV_74		0.71	76.2	0.31	4.02	20.2	7.06	42.2	13.5	3.37	2.9	40.2	0.3	0.47	3.88	0.24
ELV_75		0.83	54.0	0.36	5.37	23.5	7.22	36.6	14.6	4.46	3.5	50.8	0.4	0.72	3.74	0.29
ELV_76		0.56	16.4	0.28	4.96	12.4	3.39	52.6	17.1	2.60	3.4	8.6	0.4	0.45	4.20	0.34
ELV_77		1.10	58.6	0.44	4.66	31.6	8.91	29.0	11.1	7.11	3.0	37.1	0.3	0.92	3.13	0.28
ELV_78		0.34	37.0	0.09	15.10	30.3	8.12	106.0	4.0	5.60	5.5	225	1.2	0.64	11.40	0.15



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Page: 3 – F
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Account: UNIQUE

Project: UQ-23-094 – Elverdton (WA)

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No: 825, Corporate Site No: 818.

CERTIFICATE OF ANALYSIS BR23315396

Sample Description	Method Analyte Units LOD	ME-MS81 Tm ppm 0.01	ME-MS81 U ppm 0.05	ME-MS81 V ppm 5	ME-MS81 W ppm 0.5	ME-MS81 Y ppm 0.1	ME-MS81 Yb ppm 0.03	ME-MS81 Zr ppm 1	pXRF-34 Si % 0.5	pXRF-34 Ti % 0.1	pXRF-34 Zr ppm 5
ELV_41		0.55	27.3	90	8.6	40.6	3.97	155	21.7	0.2	124
ELV_42		0.57	34.3	86	9.4	38.1	3.57	146	23.7	0.2	87
ELV_43		0.48	37.0	81	7.4	35.1	3.34	158	23.3	0.2	128
ELV_44		0.43	20.2	100	4.9	29.9	3.10	126	17.0	0.2	108
ELV_45		0.19	1.82	114	2.8	10.8	1.36	92	16.6	0.2	92
ELV_46		0.10	4.14	18	5.0	11.6	0.61	228	33.8	0.3	179
ELV_47		0.25	1.64	117	5.0	16.2	1.80	151	18.8	0.3	120
ELV_48		0.25	2.00	118	4.0	18.0	1.57	105	17.3	0.3	66
ELV_49		0.41	5.58	86	8.2	28.1	2.65	183	19.4	0.2	148
ELV_50		0.28	2.53	98	4.9	17.4	1.78	143	21.5	0.3	102
ELV_51		0.15	0.99	93	3.6	9.3	1.04	87	17.2	0.2	86
ELV_52		0.20	1.44	144	7.2	15.3	1.56	76	19.4	0.2	42
ELV_53		0.22	1.52	107	4.2	15.2	1.57	89	18.0	0.2	85
ELV_54		0.37	8.83	82	5.5	22.9	2.36	152	21.9	0.2	118
ELV_55		0.35	7.19	114	5.4	24.6	2.64	155	16.4	0.2	132
ELV_56		0.35	4.67	105	5.5	23.1	2.47	154	20.2	0.2	144
ELV_57		0.33	9.14	74	3.8	22.8	2.33	194	25.6	0.2	142
ELV_58		0.45	21.2	81	8.5	31.4	2.90	177	19.1	0.2	122
ELV_59		0.44	21.5	85	6.5	30.9	2.77	131	18.2	0.2	96
ELV_60		0.42	24.1	80	4.0	30.5	2.64	142	21.1	0.2	101
ELV_61		0.11	4.27	17	6.2	12.8	0.65	230	33.9	0.3	228
ELV_62		0.40	9.78	97	4.2	27.6	2.72	132	19.1	0.2	152
ELV_63		0.44	20.9	89	7.1	31.9	3.13	143	20.9	0.2	122
ELV_64		0.45	10.15	86	5.3	30.4	3.02	186	23.3	0.2	124
ELV_65		0.39	9.62	80	4.7	25.8	2.48	178	21.9	0.2	120
ELV_66		0.27	8.95	71	2.8	20.5	2.23	176	28.2	0.2	122
ELV_67		0.30	17.25	56	5.6	19.7	1.77	167	22.0	0.2	135
ELV_68		0.43	44.6	92	6.1	32.2	3.05	168	21.5	0.2	138
ELV_69		0.63	86.0	76	5.6	53.1	3.86	178	19.6	0.2	134
ELV_70		0.42	49.0	75	4.6	26.4	2.86	128	20.5	0.2	121
ELV_71		0.17	4.14	6	5.3	11.8	0.58	217	33.4	0.2	160
ELV_72		0.46	23.5	87	4.7	30.8	3.44	142	18.4	0.2	106
ELV_73		0.39	25.3	95	2.7	25.3	2.27	119	13.3	0.2	48
ELV_74		0.31	7.92	120	3.8	20.2	2.04	131	10.0	0.2	46
ELV_75		0.34	7.47	101	2.9	26.5	2.75	99	18.3	0.2	68
ELV_76		0.27	1.82	123	5.8	15.9	1.83	147	19.7	0.3	128
ELV_77		0.52	11.70	101	3.3	28.5	3.21	140	14.6	0.2	63
ELV_78		0.13	4.26	13	4.5	12.0	0.40	223	33.6	0.3	178



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Page: Appendix 1
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Project: UQ-23-094 – Elverdton (WA)

ALS Brisbane is a NATA Accredited Testing Laboratory. Corporate Accreditation
No: 825, Corporate Site No: 818.

CERTIFICATE OF ANALYSIS BR23315396

CERTIFICATE COMMENTS

Applies to Method:

REEs may not be totally soluble in this method.
ME-MS61

Applies to Method:

NATA Accreditation covers the performance of this service but does not cover the performance of ALS Brisbane Sample Preparation. Corporate
Accreditation No: 825, Corporate Site No: 818. The Technical Signatory is David Jones, ICPMS Supervising Chemist
ME-MS61

Applies to Method:

Processed at ALS Brisbane located at 32 Shand Street, Stafford, Brisbane, QLD, Australia. Processed at ALS Brisbane Sample Preparation at 23
Pineapple Street, Zillmere, QLD, 4034, Australia
BAG-01
LEV-01
ME-MS81
SPL-21
BAG-21
LOG-22
PUL-23
TRA-21
CRU-21
LOG-24
PUL-QC
WEI-21
DRY-22
ME-MS61
pXRF-34



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Finalized Date: 8-JAN-2024
Account: UNIQUE

CERTIFICATE BR23359697

Project: UQ-23-094 - Elverdton (WA)
P.O. No.: 4280008329
This report is for 78 samples of Tailings submitted to our lab in Brisbane, QLD,
Australia on 13-DEC-2023.

The following have access to data associated with this certificate:

KAMINI BHOWANY

ANITA PARBHAKAR-FOX

SAMPLE PREPARATION	
ALS CODE	DESCRIPTION
LOG-20	Sample login - Additional Analysis

ANALYTICAL PROCEDURES	
ALS CODE	DESCRIPTION
Au-AA25	Ore Grade Au 30g FA AA finish
	INSTRUMENT
	AAS

This is the Final Report and supersedes any preliminary report with this certificate number. Results apply to samples as submitted. All pages of this report have been checked and approved for release.

***** See Appendix Page for comments regarding this certificate *****

Signature:

Peter Neville, Laboratory Manager



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Project: UQ-23-094 – Elverdton (WA)

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CERTIFICATE OF ANALYSIS BR23359697

Sample Description	Method Analyte Units LOD	Au-AA25 Au ppm 0.01
ELV_01		1.10
ELV_02		0.28
ELV_03		0.26
ELV_04		0.31
ELV_05		0.25
ELV_06		0.16
ELV_07		0.03
ELV_08		0.32
ELV_09		0.30
ELV_10		0.99
ELV_11		0.18
ELV_12		0.29
ELV_13		0.18
ELV_14		1.63
ELV_15		0.26
ELV_16		1.07
ELV_17		0.22
ELV_18		0.19
ELV_19		0.09
ELV_20		0.17
ELV_21		0.16
ELV_22		0.16
ELV_23		0.61
ELV_24		0.85
ELV_25		1.03
ELV_26		0.25
ELV_27		0.36
ELV_28		0.10
ELV_29		0.16
ELV_30		0.12
ELV_31		1.09
ELV_32		0.31
ELV_33		0.27
ELV_34		0.50
ELV_35		0.14
ELV_36		0.13
ELV_37		0.16
ELV_38		0.21
ELV_39		0.11
ELV_40		0.11



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CERTIFICATE OF ANALYSIS BR23359697

Sample Description	Method Analyte Units LOD	Au-AA25 Au ppm 0.01
ELV_41		0.20
ELV_42		0.21
ELV_43		0.38
ELV_44		0.09
ELV_45		0.96
ELV_46		1.05
ELV_47		0.14
ELV_48		0.25
ELV_49		0.42
ELV_50		0.47
ELV_51		0.71
ELV_52		1.40
ELV_53		1.36
ELV_54		0.33
ELV_55		1.51
ELV_56		0.67
ELV_57		0.32
ELV_58		0.21
ELV_59		0.19
ELV_60		0.19
ELV_61		1.06
ELV_62		0.33
ELV_63		0.29
ELV_64		0.28
ELV_65		0.27
ELV_66		0.17
ELV_67		0.49
ELV_68		0.27
ELV_69		0.29
ELV_70		0.33
ELV_71		1.05
ELV_72		0.22
ELV_73		0.24
ELV_74		0.47
ELV_75		0.25
ELV_76		0.10
ELV_77		0.32
ELV_78		1.05



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CERTIFICATE OF ANALYSIS BR23359697

CERTIFICATE COMMENTS	
Applies to Method:	LABORATORY ADDRESSES Processed at ALS Townsville located at 14-15 Desma Court, Bohle, Townsville, QLD, Australia. Au-AA25 Processed at ALS Brisbane located at 32 Shand Street, Stafford, Brisbane, QLD, Australia. Processed at ALS Brisbane Sample Preparation at 23 Pineapple Street, Zillmere, QLD, 4034, Australia LOG-20
Applies to Method:	



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QC CERTIFICATE BR23315396

Project: UQ-23-094 – Elverdton (WA)

P.O. No.: 4280008329

This report is for 78 samples of Tailings submitted to our lab in Brisbane, QLD,
Australia on 1-NOV-2023.

The following have access to data associated with this certificate:

KAMINI BHOWANY

ANITA PARBHAKAR-FOX

SAMPLE PREPARATION	
ALS CODE	DESCRIPTION
WEI-21	Received Sample Weight
DRY-22	Drying – Maximum Temp 60C
CRU-21	Crush entire sample
PUL-QC	Pulverizing QC Test
LEV-01	Waste Disposal Levy
LOG-22	Sample login – Rcd w/o BarCode
LOG-24	Pulp Login – Rcd w/o BarCode
PUL-23	Pulp Sample – Split/Retain
BAG-01	Bulk Master for Storage
BAG-21	Raw Sample in a new bag
SPL-21	Split sample – riffle splitter
TRA-21	Transfer sample

ANALYTICAL PROCEDURES		
ALS CODE	DESCRIPTION	INSTRUMENT
ME-MS61	48 element four acid ICP-MS	ICP-MS PXRF
ME-MS81	Lithium Borate Fusion ICP-MS	
pXRF-34	pXRF – Si, Ti & Zr Add on Package	

This is the Final Report and supersedes any preliminary report with this certificate number. Results apply to
samples as submitted. All pages of this report have been checked and approved for release.

***** See Appendix Page for comments regarding this certificate *****

Signature:

Shaun Kenny, Brisbane Laboratory Manager



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Project: UQ-23-094 – Elverdton (WA)

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QC CERTIFICATE OF ANALYSIS BR23315396

Sample Description	Method Analyte Units LOD	ME-MS61 Ag ppm 0.01	ME-MS61 Al % 0.01	ME-MS61 As ppm 0.2	ME-MS61 Ba ppm 10	ME-MS61 Be ppm 0.05	ME-MS61 Bi ppm 0.01	ME-MS61 Ca % 0.01	ME-MS61 Cd ppm 0.02	ME-MS61 Ce ppm 0.01	ME-MS61 Co ppm 0.1	ME-MS61 Cr ppm 1	ME-MS61 Cs ppm 0.05	ME-MS61 Cu ppm 0.2	ME-MS61 Fe % 0.01	ME-MS61 Ga ppm 0.05
CGL 208																
Target Range – Lower Bound		65.9	4.59	562	630	1.78	5.45	1.85	19.45	43.6	738	54	6.87	8380	4.67	11.95
Upper Bound		60.9	4.18	522	310	1.60	5.31	1.72	18.15	42.9	686	49	6.56	7750	4.42	10.75
EMOG-17																
Target Range – Lower Bound		74.5	5.13	638	440	2.06	6.51	2.12	22.2	52.5	838	62	8.12	8910	5.42	13.25
Upper Bound		2.86	7.03	54.9	1100	1.41	1.29	3.87	1.82	108.0	27.0	139	3.76	3590	5.59	21.5
GBM321-8																
Target Range – Lower Bound		2.93	7.35	58.3	1140	1.48	1.17	3.81	1.76	112.0	27.4	143	4.07	3760	5.55	20.3
Upper Bound		2.60	6.40	50.2	930	1.27	1.12	3.33	1.53	99.0	24.0	125	3.44	3380	4.98	18.65
MP-2a																
Target Range – Lower Bound		3.20	7.84	61.8	1280	1.66	1.39	4.10	1.91	121.0	29.6	155	4.32	3890	6.10	22.9
Upper Bound																
MP-2a																
MP-2a																
Target Range – Lower Bound																
Upper Bound																
MRCA-21																
Target Range – Lower Bound		8.08	7.52	19.6	1240	2.58	1.52	1.84	2.24	106.0	31.3	40	11.45	921	3.39	20.9
Upper Bound		8.51	7.67	20.6	1260	2.67	1.63	1.78	2.26	107.0	30.9	45	12.80	978	3.28	21.5
MRCA-21																
Target Range – Lower Bound		7.57	6.83	17.2	1050	2.51	1.39	1.58	1.99	92.7	28.0	38	10.75	877	3.05	18.75
Upper Bound		9.27	8.37	21.4	1440	3.17	1.73	1.96	2.47	113.5	34.4	49	13.25	1010	3.75	23.0
OREAS 120																
OREAS 120																
OREAS 120																
OREAS 120																
Target Range – Lower Bound																
Upper Bound																
OREAS 148																
OREAS 148																
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Target Range – Lower Bound																
Upper Bound																
OREAS 20a																
OREAS 20a																
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Target Range – Lower Bound																
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Sample Description	Method Analyte Units LOD	STANDARDS																	
		ME-MS61 Ge ppm 0.05	ME-MS61 Hf ppm 0.1	ME-MS61 In ppm 0.005	ME-MS61 K % 0.01	ME-MS61 La ppm 0.5	ME-MS61 Li ppm 0.2	ME-MS61 Mg % 0.01	ME-MS61 Mn ppm 5	ME-MS61 Mo ppm 0.05	ME-MS61 Na % 0.01	ME-MS61 Nb ppm 0.1	ME-MS61 Ni ppm 0.2	ME-MS61 P ppm 10	ME-MS61 Pb ppm 0.5	ME-MS61 Rb ppm 0.1			
CGL 208																			
Target Range – Lower Bound																			
Upper Bound																			
EMOG-17																			
Target Range – Lower Bound		0.11	1.7	0.831	1.60	21.9	27.7	0.91	740	1075	1.11	13.2	7590	780	6980	98.6			
Upper Bound		0.06	1.6	0.823	1.49	20.7	23.9	0.86	670	997	0.99	12.7	6820	700	6570	98.9			
GBM321-8																			
Target Range – Lower Bound		0.30	2.2	1.015	1.85	26.4	29.7	1.08	830	1220	1.23	15.7	8330	880	8030	121.0			
Upper Bound		0.31	3.5	0.076	2.14	54.0	11.4	1.86	787	59.7	2.31	9.9	2260	980	2030	162.0			
GBM321-8																			
Target Range – Lower Bound		0.15	3.8	0.077	2.14	57.5	11.9	1.83	834	65.8	2.29	11.4	2350	1000	2030	178.0			
Upper Bound		0.12	3.3	0.064	1.87	49.0	9.8	1.61	715	57.9	1.93	9.5	2020	880	1845	153.0			
MP-2a																			
MP-2a																			
MP-2a																			
Target Range – Lower Bound		0.23	2.0	0.115	2.87	57.5	61.1	0.74	7980	23.1	2.10	14.7	945	850	907	170.5			
Upper Bound		0.19	1.9	0.125	2.83	60.1	62.2	0.71	8120	25.3	2.05	15.6	968	850	892	182.5			
MRCA-21																			
Target Range – Lower Bound		0.07	1.5	0.103	2.58	49.0	54.7	0.65	7330	22.5	1.79	12.9	849	770	816	154.5			
Upper Bound		0.31	2.1	0.137	3.18	61.0	67.3	0.82	8970	27.7	2.21	15.9	1040	970	998	189.5			
OREAS 120																			
OREAS 120																			
OREAS 120																			
Target Range – Lower Bound																			
Upper Bound																			
OREAS 148																			
OREAS 148																			
OREAS 148																			
Target Range – Lower Bound																			
Upper Bound																			
OREAS 20a																			
OREAS 20a																			
OREAS 20a																			
Target Range – Lower Bound																			
Upper Bound																			



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Sample Description	Method Analyte Units LOD	ME-MS61 Re ppm 0.002	ME-MS61 S %	ME-MS61 Sb ppm 0.05	ME-MS61 Sc ppm 0.1	ME-MS61 Se ppm 1	ME-MS61 Sn ppm 0.2	ME-MS61 Sr ppm 0.2	ME-MS61 Ta ppm 0.05	ME-MS61 Te ppm 0.05	ME-MS61 Th ppm 0.01	ME-MS61 Ti %	ME-MS61 Tl ppm 0.02	ME-MS61 U ppm 0.1	ME-MS61 V ppm 1	ME-MS61 W ppm 0.1
CGL 208																
Target Range – Lower Bound		0.288	3.12	765	7.7	6	2.4	199.0	0.82	1.38	10.30	0.314	1.93	2.9	70	3.3
Upper Bound		0.286	2.91	643	7.2	4	2.2	184.5	0.78	1.10	10.35	0.285	1.89	2.8	67	3.3
EMOG-17																
Target Range – Lower Bound		0.354	3.57	869	9.0	9	3.2	226	1.08	1.46	12.65	0.359	2.61	3.7	84	4.7
Upper Bound		<0.002	0.39	1.64	17.8	1	3.0	285	0.74	0.06	16.60	0.664	1.22	2.1	136	3.6
GBM321-8																
Target Range – Lower Bound		<0.002	0.39	1.78	18.2	<1	3.1	301	0.80	0.07	18.00	0.676	1.31	2.3	143	3.2
Upper Bound		<0.002	0.33	1.40	16.7	<1	2.7	258	0.64	<0.05	16.00	0.591	1.01	2.0	123	2.9
MP-2a																
MP-2a																
MP-2a																
Target Range – Lower Bound		0.010	0.43	25.8	8.6	1	5.0	171.5	1.05	0.15	14.50	0.367	1.18	3.8	60	11.4
Upper Bound		0.012	0.43	30.4	8.9	1	5.2	177.5	1.15	0.18	16.50	0.366	1.20	4.2	62	10.3
MRCA-21																
Target Range – Lower Bound		0.008	0.38	22.8	8.0	<1	4.3	156.5	0.98	<0.05	13.95	0.328	0.97	3.7	57	9.3
Upper Bound		0.018	0.49	31.0	10.0	3	5.7	191.5	1.30	0.23	17.05	0.412	1.37	4.8	71	12.9
OREAS 120																
OREAS 120																
OREAS 120																
OREAS 120																
Target Range – Lower Bound																
Upper Bound																
OREAS 148																
OREAS 148																
OREAS 148																
Target Range – Lower Bound																
Upper Bound																
OREAS 20a																
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Sample Description	Method Analyte Units LOD	ME-MS61 Y ppm 0.1	ME-MS61 Zn ppm 2	ME-MS61 Zr ppm 0.5	ME-MS81 Ba ppm 0.5	ME-MS81 Ce ppm 0.1	ME-MS81 Cr ppm 5	ME-MS81 Cs ppm 0.01	ME-MS81 Dy ppm 0.05	ME-MS81 Er ppm 0.03	ME-MS81 Eu ppm 0.02	ME-MS81 Ga ppm 0.1	ME-MS81 Gd ppm 0.05	ME-MS81 Hf ppm 0.05	ME-MS81 Ho ppm 0.01	ME-MS81 La ppm 0.1
STANDARDS																
CGL 208		1085				89.4	59	15.95	6.93	3.70	1.36	26.8	7.07	3.64	1.36	42.7
Target Range – Lower Bound		935				83.9	41	14.75	5.70	3.32	1.11	23.3	6.41	3.15	1.16	39.2
Upper Bound		1145				103.0	67	18.05	7.08	4.12	1.40	28.7	7.95	3.97	1.44	48.2
EMOG-17		14.6	7510	60.3												
Target Range – Lower Bound		14.3	6800	55.6												
Upper Bound		17.7	8320	76.4												
GBM321-8		37.2	1065	134.5												
GBM321-8		39.1	1110	141.5												
Target Range – Lower Bound		33.7	961	117.5												
Upper Bound		41.4	1180	160.5												
MP-2a																
MP-2a																
MP-2a																
Target Range – Lower Bound																
Upper Bound																
MRCA-21		18.0	816	61.0												
MRCA-21		18.4	847	62.0												
Target Range – Lower Bound		15.6	740	50.5												
Upper Bound		19.2	908	69.5												
OREAS 120					975	45.8	40	0.74	2.47	1.36	0.96	9.6	3.22	6.17	0.48	20.9
OREAS 120					1060	47.9	50	0.81	2.40	1.36	1.21	11.2	3.21	6.89	0.53	23.1
OREAS 120					1050	47.7	49	2.17	2.43	1.48	0.98	11.1	3.38	7.32	0.55	21.9
OREAS 120					984	44.8	43	0.72	2.40	1.47	0.92	10.6	2.85	6.72	0.46	20.4
Target Range – Lower Bound					875	41.6	35	0.65	2.11	1.24	0.91	9.5	2.69	5.32	0.42	18.9
Upper Bound					1070	51.0	59	0.81	2.69	1.58	1.15	11.9	3.39	6.62	0.54	23.3
OREAS 148																
OREAS 148																
OREAS 148																
Target Range – Lower Bound																
Upper Bound																
OREAS 20a																
OREAS 20a																
OREAS 20a																
Target Range – Lower Bound																
Upper Bound																



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Sample Description	Method Analyte Units LOD	ME-MS81 Lu ppm 0.01	ME-MS81 Nb ppm 0.05	ME-MS81 Nd ppm 0.1	ME-MS81 Pr ppm 0.02	ME-MS81 Rb ppm 0.2	ME-MS81 Sc ppm 0.5	ME-MS81 Sm ppm 0.03	ME-MS81 Sn ppm 0.5	ME-MS81 Sr ppm 0.1	ME-MS81 Ta ppm 0.1	ME-MS81 Tb ppm 0.01	ME-MS81 Th ppm 0.05	ME-MS81 Ti % 0.01	ME-MS81 Tm ppm 0.01	ME-MS81 U ppm 0.05
STANDARDS																
CGL 208		0.52	12.95	40.3	10.25	87.4	15.8	7.58	6.7	1325	1.0	1.06	19.20	0.36	0.51	12.35
Target Range – Lower Bound		0.44	11.55	33.9	8.82	79.3		6.60	4.7	1140	0.8	0.97	18.50	0.29	0.46	11.50
Upper Bound		0.56	14.20	41.7	10.80	97.4		8.14	7.3	1395	1.3	1.21	22.7	0.38	0.59	14.20
EMOG-17																
Target Range – Lower Bound																
Upper Bound																
GBM321-8																
GBM321-8																
Target Range – Lower Bound																
Upper Bound																
MP-2a																
MP-2a																
MP-2a																
Target Range – Lower Bound																
Upper Bound																
MRCA-21																
MRCA-21																
Target Range – Lower Bound																
Upper Bound																
OREAS 120		0.21	7.96	19.7	5.02	86.4	2.6	3.54	1.0	127.5	0.5	0.45	5.50	0.25	0.17	39.9
OREAS 120		0.20	8.39	21.9	5.60	94.0	4.9	4.08	0.6	138.5	0.6	0.40	5.75	0.28	0.22	40.7
OREAS 120		0.26	8.03	19.8	5.27	83.4	3.6	3.88	1.0	128.0	0.6	0.46	5.86	0.26	0.24	40.3
OREAS 120		0.23	7.96	20.0	4.91	87.4	3.5	3.77	0.9	129.5	0.6	0.44	5.34	0.26	0.18	40.4
Target Range – Lower Bound		0.18	7.24	17.1	4.49	78.1		3.34	<0.5	114.0	0.4	0.39	4.86	0.21	0.17	36.7
Upper Bound		0.24	8.96	21.1	5.53	95.9		4.14	2.1	140.0	0.8	0.49	6.05	0.28	0.23	44.9
OREAS 148																
OREAS 148																
OREAS 148																
Target Range – Lower Bound																
Upper Bound																
OREAS 20a																
OREAS 20a																
OREAS 20a																
Target Range – Lower Bound																
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Sample Description	Method Analyte Units LOD	ME-MS81 V ppm 5	ME-MS81 W ppm 0.5	ME-MS81 Y ppm 0.1	ME-MS81 Yb ppm 0.03	ME-MS81 Zr ppm 1	pXRF-34 Si % 0.5	pXRF-34 Ti % 0.1	pXRF-34 Zr ppm 5
STANDARDS									
CGL 208		88	29.9	40.8	3.59	140			
Target Range – Lower Bound		73	27.2	34.7	2.99	117			
Upper Bound		102	34.4	42.6	3.72	145			
EMOG-17									
Target Range – Lower Bound									
Upper Bound									
GBM321-8									
GBM321-8									
Target Range – Lower Bound									
Upper Bound									
MP-2a									
MP-2a									
MP-2a									
Target Range – Lower Bound									
Upper Bound									
MRCA-21									
MRCA-21									
Target Range – Lower Bound									
Upper Bound									
OREAS 120		25	0.8	12.2	1.41	263			
OREAS 120		23	1.6	14.1	1.20	277			
OREAS 120		20	0.6	12.4	1.22	290			
OREAS 120		27	1.6	12.6	1.25	290			
Target Range – Lower Bound		12	<0.5	10.9	1.18	229			
Upper Bound		34	2.1	13.5	1.50	282			
OREAS 148									
OREAS 148									
OREAS 148									
Target Range – Lower Bound									
Upper Bound									
OREAS 20a									
OREAS 20a									
OREAS 20a									
Target Range – Lower Bound									
Upper Bound									



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Sample Description	Method Analyte Units LOD	ME-MS61 Ag ppm 0.01	ME-MS61 Al % 0.01	ME-MS61 As ppm 0.2	ME-MS61 Ba ppm 10	ME-MS61 Be ppm 0.05	ME-MS61 Bi ppm 0.01	ME-MS61 Ca % 0.01	ME-MS61 Cd ppm 0.02	ME-MS61 Ce ppm 0.01	ME-MS61 Co ppm 0.1	ME-MS61 Cr ppm 1	ME-MS61 Cs ppm 0.05	ME-MS61 Cu ppm 0.2	ME-MS61 Fe % 0.01	ME-MS61 Ga ppm 0.05
STANDARDS																
OREAS 507		1.34	7.64	49.7	1100	2.50	2.05	1.72	0.71	79.2	8.0	46	10.90	6250	3.03	21.2
Target Range – Lower Bound		1.20	6.68	41.8	930	2.25	1.59	1.53	0.60	63.0	7.0	38	9.76	5780	2.81	18.20
Upper Bound		1.48	8.18	51.6	1280	2.86	1.97	1.89	0.78	77.0	8.8	49	12.05	6660	3.45	22.4
OREAS-100a																
OREAS-100a																
OREAS-100a																
Target Range – Lower Bound																
Upper Bound																
RTS-3a																
RTS-3a																
RTS-3a																
Target Range – Lower Bound																
Upper Bound																
BLANKS																
BLANK		0.01	<0.01	<0.2	<10	<0.05	<0.01	<0.01	<0.02	<0.01	<0.1	<1	<0.05	0.3	<0.01	<0.05
BLANK		<0.01	<0.01	<0.2	<10	<0.05	0.01	<0.01	<0.02	0.06	<0.1	<1	<0.05	0.7	<0.01	<0.05
BLANK		<0.01	<0.01	<0.2	<10	<0.05	0.01	<0.01	<0.02	0.05	<0.1	1	<0.05	0.7	<0.01	0.05
Target Range – Lower Bound		<0.01	<0.01	<0.2	<10	<0.05	<0.01	<0.01	<0.02	<0.01	<0.1	<1	<0.05	<0.2	<0.01	<0.05
Upper Bound		0.02	0.02	0.4	20	0.10	0.02	0.02	0.04	0.02	0.2	2	0.10	0.4	0.02	0.10
BLANK																
BLANK																
BLANK																
BLANK																
BLANK																
Target Range – Lower Bound																
Upper Bound																



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Project: UQ-23-094 – Elverdton (WA)

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QC CERTIFICATE OF ANALYSIS BR23315396

Sample Description	Method Analyte Units LOD	ME-MS61 Ge ppm 0.05	ME-MS61 Hf ppm 0.1	ME-MS61 In ppm 0.005	ME-MS61 K % 0.01	ME-MS61 La ppm 0.5	ME-MS61 Li ppm 0.2	ME-MS61 Mg % 0.01	ME-MS61 Mn ppm 5	ME-MS61 Mo ppm 0.05	ME-MS61 Na % 0.01	ME-MS61 Nb ppm 0.1	ME-MS61 Ni ppm 0.2	ME-MS61 P ppm 10	ME-MS61 Pb ppm 0.5	ME-MS61 Rb ppm 0.1
STANDARDS																
OREAS 507		0.14	2.0	0.151	3.10	38.5	52.8	0.69	362	116.5	2.15	12.4	16.3	860	39.7	168.0
Target Range – Lower Bound		<0.05	1.7	0.130	2.75	30.0	44.8	0.63	310	102.5	1.88	11.2	14.3	770	32.9	146.5
Upper Bound		0.10	2.3	0.170	3.39	37.8	55.2	0.79	390	125.5	2.32	14.0	17.9	970	41.3	179.5
OREAS-100a																
OREAS-100a																
OREAS-100a																
Target Range – Lower Bound																
Upper Bound																
RTS-3a																
RTS-3a																
RTS-3a																
Target Range – Lower Bound																
Upper Bound																
BLANKS																
BLANK		<0.05	<0.1	<0.005	<0.01	<0.5	<0.2	<0.01	<5	<0.05	<0.01	<0.1	0.2	<10	<0.5	<0.1
BLANK		<0.05	<0.1	<0.005	<0.01	<0.5	<0.2	<0.01	<5	<0.05	<0.01	<0.1	<0.2	<10	<0.5	<0.1
BLANK		<0.05	<0.1	<0.005	<0.01	<0.5	<0.2	<0.01	<5	<0.05	<0.01	<0.1	0.3	<10	<0.5	<0.1
Target Range – Lower Bound		<0.05	<0.1	<0.005	<0.01	<0.5	<0.2	<0.01	<5	<0.05	<0.01	<0.1	<0.2	<10	<0.5	<0.1
Upper Bound		0.10	0.2	0.010	0.02	1.0	0.4	0.02	10	0.10	0.02	0.2	0.4	20	1.0	0.2
BLANK																
BLANK																
BLANK																
BLANK																
BLANK																
BLANK																
Target Range – Lower Bound																
Upper Bound																



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Project: UQ-23-094 – Elverdton (WA)

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QC CERTIFICATE OF ANALYSIS BR23315396

Sample Description	Method Analyte Units LOD	ME-MS61 Re ppm 0.002	ME-MS61 S %	ME-MS61 Sb ppm 0.05	ME-MS61 Sc ppm 0.1	ME-MS61 Se ppm 1	ME-MS61 Sn ppm 0.2	ME-MS61 Sr ppm 0.2	ME-MS61 Ta ppm 0.05	ME-MS61 Te ppm 0.05	ME-MS61 Th ppm 0.01	ME-MS61 Ti %	ME-MS61 Tl ppm 0.02	ME-MS61 U ppm 0.1	ME-MS61 V ppm 1	ME-MS61 W ppm 0.1
STANDARDS																
OREAS 507		0.082	0.73	5.35	8.6	4	5.0	222	1.01	0.77	15.10	0.348	0.85	3.9	64	9.0
Target Range – Lower Bound		0.075	0.66	4.47	7.5	2	4.3	195.0	0.97	0.54	12.50	0.310	0.77	3.6	58	7.8
Upper Bound		0.096	0.82	6.17	9.3	6	5.7	239	1.29	0.80	15.30	0.390	1.09	4.6	73	10.8
OREAS-100a																
OREAS-100a																
OREAS-100a																
Target Range – Lower Bound																
Upper Bound																
RTS-3a																
RTS-3a																
RTS-3a																
Target Range – Lower Bound																
Upper Bound																
BLANKS																
BLANK		<0.002	<0.01	<0.05	<0.1	<1	<0.2	<0.2	<0.05	<0.05	<0.01	<0.005	<0.02	<0.1	<1	<0.1
BLANK		<0.002	<0.01	<0.05	<0.1	<1	<0.2	<0.2	<0.05	<0.05	<0.01	<0.005	<0.02	<0.1	<1	<0.1
BLANK		<0.002	<0.01	<0.05	<0.1	<1	<0.2	<0.2	<0.05	<0.05	<0.01	<0.005	<0.02	<0.1	<1	<0.1
Target Range – Lower Bound		<0.002	<0.01	<0.05	<0.1	<1	<0.2	<0.2	<0.05	<0.05	<0.01	<0.005	<0.02	<0.1	<1	<0.1
Upper Bound		0.004	0.02	0.10	0.2	2	0.4	0.4	0.10	0.10	0.02	0.010	0.04	0.2	2	0.2
BLANK																
BLANK																
BLANK																
BLANK																
BLANK																
BLANK																
Target Range – Lower Bound																
Upper Bound																



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QC CERTIFICATE OF ANALYSIS BR23315396

Sample Description	Method Analyte Units	LOD	ME-MS61 Y ppm	ME-MS61 Zn ppm	ME-MS61 Zr ppm	ME-MS81 Ba ppm	ME-MS81 Ce ppm	ME-MS81 Cr ppm	ME-MS81 Cs ppm	ME-MS81 Dy ppm	ME-MS81 Er ppm	ME-MS81 Eu ppm	ME-MS81 Ga ppm	ME-MS81 Cd ppm	ME-MS81 Hf ppm	ME-MS81 Ho ppm	ME-MS81 La ppm
OREAS 507			15.7	163	66.5												
Target Range – Lower Bound			13.9	143	53.9												
Upper Bound			17.2	179	74.1												
OREAS-100a						439	484	44	2.55	24.3	15.40	3.74	19.9	21.3	14.55	4.81	263
OREAS-100a						429	454	41	2.75	24.2	16.30	3.64	22.5	21.7	14.45	4.92	264
OREAS-100a						427	442	36	2.71	21.4	14.10	3.15	20.6	20.2	13.85	4.41	247
OREAS-100a						432	483	39	2.78	22.9	14.20	3.66	19.9	20.2	13.30	4.87	260
Target Range – Lower Bound			388	417	28	2.51	20.8	13.40	3.32	17.3	21.2	4.32	234				
Upper Bound			475	509	52	3.09	25.6	16.40	4.10	21.3	26.0	16.20	286				
RTS-3a																	
RTS-3a																	
RTS-3a																	
Target Range – Lower Bound																	
Upper Bound																	
BLANK			<0.1	<2	<0.5												
BLANK			<0.1	<2	<0.5												
BLANK			<0.1	<2	<0.5												
Target Range – Lower Bound			<0.1	<2	<0.5												
Upper Bound			0.2	4	1.0												
BLANK			<0.5	<0.5	<0.5	<0.5	0.2	<5	<0.01	<0.05	<0.03	<0.02	0.1	<0.05	<0.05	<0.01	0.1
BLANK			<0.5	<0.5	<0.5	<0.5	<0.1	<5	<0.01	<0.05	<0.03	<0.02	<0.1	<0.05	<0.05	<0.01	<0.1
BLANK			<0.5	<0.5	<0.5	<0.5	<0.1	<5	<0.01	<0.05	<0.03	<0.02	<0.1	<0.05	<0.05	<0.01	<0.1
BLANK			<0.5	<0.5	<0.5	<0.5	0.1	<5	0.23	<0.05	<0.03	<0.02	0.1	<0.05	<0.05	<0.01	0.5
BLANK			<0.5	<0.5	<0.5	<0.5	<0.1	<5	<0.01	<0.05	<0.03	<0.02	<0.1	<0.05	<0.05	<0.01	0.1
BLANK			<0.5	<0.5	<0.5	<0.5	<0.1	<5	0.01	<0.05	<0.03	<0.02	0.1	<0.05	<0.05	<0.01	<0.1
Target Range – Lower Bound			<0.5	<0.1	<5	<0.01	<0.05	<0.03	<0.01	<0.05	<0.03	<0.02	<0.1	<0.05	<0.05	<0.01	<0.1
Upper Bound			1.0	0.2	10	0.02	0.10	0.06	0.04	0.10	0.2	0.10	0.2	0.10	0.10	0.02	0.2

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QC CERTIFICATE OF ANALYSIS BR23315396

Sample Description	Method Analyte Units LOD	ME-MS81 Lu ppm 0.01	ME-MS81 Nb ppm 0.05	ME-MS81 Nd ppm 0.1	ME-MS81 Pr ppm 0.02	ME-MS81 Rb ppm 0.2	ME-MS81 Sc ppm 0.5	ME-MS81 Sm ppm 0.03	ME-MS81 Sn ppm 0.5	ME-MS81 Sr ppm 0.1	ME-MS81 Ta ppm 0.1	ME-MS81 Tb ppm 0.01	ME-MS81 Th ppm 0.05	ME-MS81 Ti % 0.01	ME-MS81 Tm ppm 0.01	ME-MS81 U ppm 0.05
STANDARDS																
OREAS 507																
Target Range – Lower Bound																
Upper Bound																
OREAS-100a		2.02	45.5	150.5	46.5	271	8.8	24.7	8.3	36.3	3.3	3.63	51.4	0.26	2.27	138.0
OREAS-100a		2.20	45.0	148.5	46.7	261	6.6	24.9	8.6	33.4	3.6	3.56	48.1	0.26	2.39	132.0
OREAS-100a		2.23	42.8	143.5	43.5	245	9.0	23.9	9.0	33.6	3.4	3.36	44.5	0.25	2.19	128.0
OREAS-100a		2.14	45.2	155.0	47.4	262	7.1	24.5	9.2	37.0	3.4	3.52	51.8	0.25	2.15	135.5
Target Range – Lower Bound		2.02	39.6	136.5	42.4	235		21.2	7.9	31.9	3.2	3.41	46.4	0.21	2.07	121.5
Upper Bound		2.50	48.6	167.5	51.8	288		26.0	10.9	39.2	4.2	4.19	56.8	0.27	2.55	148.5
RTS-3a																
RTS-3a																
RTS-3a																
Target Range – Lower Bound																
Upper Bound																
BLANKS																
BLANK																
BLANK																
BLANK																
Target Range – Lower Bound																
Upper Bound																
BLANK		<0.01	<0.05	<0.1	<0.02	<0.2	<0.5	<0.03	<0.5	0.1	<0.1	<0.01	<0.05	<0.01	<0.01	<0.05
BLANK		<0.01	<0.05	<0.1	<0.02	0.2	<0.5	<0.03	<0.5	<0.1	<0.1	<0.01	<0.05	<0.01	<0.01	<0.05
BLANK		<0.01	0.13	<0.1	<0.02	<0.2	<0.5	<0.03	<0.5	<0.1	<0.1	0.01	<0.05	<0.01	<0.01	<0.05
BLANK		0.01	<0.05	<0.1	<0.02	<0.2	<0.5	<0.03	<0.5	0.2	<0.1	<0.01	<0.05	<0.01	<0.01	<0.05
BLANK		<0.01	<0.05	<0.1	<0.02	0.4	<0.5	<0.03	<0.5	<0.1	<0.1	<0.01	<0.05	<0.01	<0.01	<0.05
BLANK		<0.01	<0.05	<0.1	<0.02	<0.2	<0.5	<0.03	<0.5	<0.1	0.1	<0.01	<0.05	<0.01	<0.01	<0.05
BLANK		<0.01	<0.05	<0.1	<0.02	<0.2	<0.5	<0.03	<0.5	<0.1	<0.1	<0.01	<0.05	<0.01	<0.01	<0.05
Target Range – Lower Bound		<0.01	<0.05	<0.1	<0.02	<0.2		<0.03	<0.5	<0.1	<0.1	<0.01	<0.05	<0.01	<0.01	<0.05
Upper Bound		0.02	0.10	0.2	0.04	0.4		0.06	1.0	0.2	0.2	0.02	0.10	0.02	0.02	0.10



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QC CERTIFICATE OF ANALYSIS BR23315396

Sample Description	Method Analyte Units LOD	ME-MS81 V ppm 5	ME-MS81 W ppm 0.5	ME-MS81 Y ppm 0.1	ME-MS81 Yb ppm 0.03	ME-MS81 Zr ppm 1	pXRF-34 Si % 0.5	pXRF-34 Ti % 0.1	pXRF-34 Zr ppm 5
STANDARDS									
OREAS 507									
Target Range – Lower Bound									
Upper Bound									
OREAS-100a		38	10.1	142.5	14.95	567			
OREAS-100a		37	12.6	140.5	15.95	566			
OREAS-100a		33	9.6	126.0	14.85	548			
OREAS-100a		46	11.6	146.5	14.60	546			
Target Range – Lower Bound		25	9.3	127.5	13.40	511			
Upper Bound		49	12.5	156.5	16.40	626			
RTS-3a							18.2	0.4	71
RTS-3a							18.4	0.4	75
RTS-3a							18.2	0.4	78
Target Range – Lower Bound							14.1	<0.1	56
Upper Bound							22.4	0.6	100
BLANKS									
BLANK									
BLANK									
BLANK									
Target Range – Lower Bound									
Upper Bound									
BLANK		<5	0.5	0.1	<0.03	<1			
BLANK		<5	<0.5	<0.1	<0.03	<1			
BLANK		7	<0.5	<0.1	<0.03	<1			
BLANK		<5	<0.5	<0.1	<0.03	<1			
BLANK		<5	<0.5	<0.1	<0.03	<1			
BLANK		<5	0.9	<0.1	<0.03	<1			
BLANK		<5	<0.5	<0.1	<0.03	<1			
Target Range – Lower Bound		<5	<0.5	<0.1	<0.03	<1			
Upper Bound		10	1.0	0.2	0.06	2			



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QC CERTIFICATE OF ANALYSIS BR23315396

Sample Description	Method Analyte Units LOD	ME-MS61 Ag ppm 0.01	ME-MS61 Al % 0.01	ME-MS61 As ppm 0.2	ME-MS61 Ba ppm 10	ME-MS61 Be ppm 0.05	ME-MS61 Bi ppm 0.01	ME-MS61 Ca % 0.01	ME-MS61 Cd ppm 0.02	ME-MS61 Ce ppm 0.01	ME-MS61 Co ppm 0.1	ME-MS61 Cr ppm 1	ME-MS61 Cs ppm 0.05	ME-MS61 Cu ppm 0.2	ME-MS61 Fe % 0.01	ME-MS61 Ga ppm 0.05
DUPLICATES																
GRM-01 DUP Target Range – Lower Bound Upper Bound		0.42 0.42 0.39 0.45	5.57 5.79 5.39 5.97	153.0 159.0 148.0 164.0	1570 1880 1590 1860	1.03 1.07 0.95 1.15	2.89 2.97 2.77 3.09	3.98 4.13 3.84 4.27	<0.02 <0.02 <0.02 0.04	83.8 88.8 82.0 90.6	193.0 200 186.5 206	37 38 35 40	0.78 0.84 0.72 0.90	2970 3090 2920 3140	15.00 15.70 14.55 16.15	18.35 18.55 17.50 19.40
GRM-20 DUP Target Range – Lower Bound Upper Bound																
GRM-21 DUP Target Range – Lower Bound Upper Bound																
ELV_07 DUP Target Range – Lower Bound Upper Bound		0.08 0.09 0.07 0.10	3.89 3.94 3.71 4.12	1.7 1.6 1.4 1.9	140 140 120 160	0.38 0.39 0.32 0.45	0.09 0.10 0.08 0.11	0.29 0.30 0.27 0.32	0.03 0.03 <0.02 0.04	68.3 65.1 63.4 70.0	43.6 42.0 40.6 45.0	29 28 26 31	0.57 0.57 0.49 0.65	185.5 188.0 180.0 193.5	2.34 2.36 2.22 2.48	8.95 9.01 8.48 9.48
ELV_10 DUP Target Range – Lower Bound Upper Bound																
ELV_11 DUP Target Range – Lower Bound Upper Bound																
ELV_30 DUP Target Range – Lower Bound Upper Bound																
ELV_31 DUP Target Range – Lower Bound Upper Bound																



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DUPLICATES																
GRM-01 DUP Target Range – Lower Bound Upper Bound		0.21 0.18 0.13 0.26	3.5 3.7 3.3 3.9	0.109 0.129 0.108 0.130	3.32 3.45 3.21 3.56	84.0 90.6 82.4 92.2	18.4 18.9 17.5 19.8	1.10 1.15 1.06 1.19	2380 2460 2290 2550	64.6 65.0 61.5 68.1	1.42 1.50 1.38 1.54	5.6 5.8 5.3 6.1	73.5 78.7 72.1 80.1	730 760 700 790	5.6 6.9 5.4 7.1	113.0 121.5 111.5 123.0
GRM-20 DUP Target Range – Lower Bound Upper Bound																
GRM-21 DUP Target Range – Lower Bound Upper Bound																
ELV_07 DUP Target Range – Lower Bound Upper Bound		0.11 0.11 <0.05 0.17	1.7 1.8 1.6 1.9	0.022 0.019 0.014 0.027	0.40 0.41 0.37 0.44	37.6 38.1 35.5 40.2	14.3 14.5 13.5 15.3	0.56 0.57 0.53 0.60	137 138 126 149	1.94 1.89 1.77 2.06	0.65 0.66 0.61 0.70	3.4 3.2 3.0 3.6	37.5 36.8 35.1 39.2	60 70 50 80	6.4 6.5 5.6 7.3	20.8 20.5 19.5 21.8
ELV_10 DUP Target Range – Lower Bound Upper Bound																
ELV_11 DUP Target Range – Lower Bound Upper Bound																
ELV_30 DUP Target Range – Lower Bound Upper Bound																
ELV_31 DUP Target Range – Lower Bound Upper Bound																



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Sample Description	Method Analyte Units LOD	ME-MS61 Re ppm 0.002	ME-MS61 S %	ME-MS61 Sb ppm 0.05	ME-MS61 Sc ppm 0.1	ME-MS61 Se ppm 1	ME-MS61 Sn ppm 0.2	ME-MS61 Sr ppm 0.2	ME-MS61 Ta ppm 0.05	ME-MS61 Te ppm 0.05	ME-MS61 Th ppm 0.01	ME-MS61 Ti %	ME-MS61 Tl ppm 0.02	ME-MS61 U ppm 0.1	ME-MS61 V ppm 1	ME-MS61 W ppm 0.1
DUPLICATES																
GRM-01 DUP Target Range – Lower Bound Upper Bound		0.030 0.031 0.027 0.034	0.94 0.98 0.90 1.02	3.19 3.43 3.01 3.61	16.6 17.8 16.2 18.2	2 2 <1 3	4.5 4.6 4.1 5.0	103.0 108.5 100.5 111.0	0.43 0.44 0.36 0.51	0.36 0.36 0.29 0.43	8.43 8.04 7.81 8.66	0.440 0.461 0.423 0.478	0.25 0.26 0.22 0.29	17.4 18.0 16.7 18.7	240 252 233 259	42.8 44.4 40.2 47.0
GRM-20 DUP Target Range – Lower Bound Upper Bound																
GRM-21 DUP Target Range – Lower Bound Upper Bound																
ELV_07 DUP Target Range – Lower Bound Upper Bound		<0.002 <0.002 <0.002 0.004	0.23 0.23 0.21 0.25	0.27 0.25 0.19 0.33	5.4 5.1 4.9 5.6	1 <1 <1 2	0.8 0.8 0.6 1.0	18.8 18.4 17.5 19.7	0.31 0.28 0.23 0.36	0.12 0.14 0.07 0.19	4.79 4.78 4.54 5.03	0.170 0.174 0.158 0.186	0.11 0.11 0.08 0.14	9.2 9.5 8.8 9.9	41 42 38 45	0.9 0.8 0.7 1.0
ELV_10 DUP Target Range – Lower Bound Upper Bound																
ELV_11 DUP Target Range – Lower Bound Upper Bound																
ELV_30 DUP Target Range – Lower Bound Upper Bound																
ELV_31 DUP Target Range – Lower Bound Upper Bound																



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Sample Description	Method Analyte Units LOD	ME-MS61 Y ppm 0.1	ME-MS61 Zn ppm 2	ME-MS61 Ba ppm 0.5	ME-MS81 Ce ppm 0.1	ME-MS81 Cr ppm 5	ME-MS81 Cs ppm 0.01	ME-MS81 Dy ppm 0.05	ME-MS81 Er ppm 0.03	ME-MS81 Eu ppm 0.02	ME-MS81 Ga ppm 0.1	ME-MS81 Cd ppm 0.05	ME-MS81 Hf ppm 0.05	ME-MS81 Ho ppm 0.01	ME-MS81 La ppm 0.1
GRM-01 DUP Target Range – Lower Bound Upper Bound		20.5 22.2 20.2 22.5	23 24 20 27	136.5 141.5 128.0 150.0											
GRM-20 DUP Target Range – Lower Bound Upper Bound				139.5 136.0 130.5 145.0	22.8 22.1 21.2 23.7	2530 2500 2380 2650	6.57 6.50 6.20 6.87	2.14 2.45 2.13 2.46	1.50 1.23 1.27 1.46	0.66 0.75 0.65 0.76	11.3 11.6 10.8 12.1	2.36 2.32 2.17 2.51	1.85 1.62 1.60 1.87	0.44 0.41 0.39 0.46	12.1 12.2 11.4 12.9
GRM-21 DUP Target Range – Lower Bound Upper Bound															
ELV_07 DUP Target Range – Lower Bound Upper Bound		15.7 15.0 14.5 16.2	15 15 12 18	59.3 54.1 51.9 61.5											
ELV_10 DUP Target Range – Lower Bound Upper Bound				160.0 161.5 152.0 169.5	146.0 139.5 135.5 150.0	85 79 73 91	1.28 1.08 1.11 1.25	7.64 6.67 6.75 7.56	4.61 4.31 4.21 4.71	1.44 1.44 1.35 1.53	29.6 28.1 27.3 30.4	8.55 7.99 7.81 8.73	2.96 2.70 2.64 3.02	1.36 1.35 1.28 1.43	106.0 101.0 98.2 109.0
ELV_11 DUP Target Range – Lower Bound Upper Bound															
ELV_30 DUP Target Range – Lower Bound Upper Bound				179.0 175.5 168.0 186.5	178.0 173.5 167.0 184.5	59 59 51 67	1.24 1.10 1.10 1.24	7.03 6.09 6.18 6.94	4.27 3.81 3.81 4.27	1.60 1.46 1.43 1.63	23.8 22.9 22.1 24.6	8.26 8.18 7.76 8.68	3.79 3.36 3.35 3.80	1.16 1.24 1.13 1.27	124.5 120.5 116.5 128.5
ELV_31 DUP Target Range – Lower Bound Upper Bound															



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Sample Description	Method Analyte Units LOD	ME-MS81 Lu ppm 0.01	ME-MS81 Nb ppm 0.05	ME-MS81 Nd ppm 0.1	ME-MS81 Pr ppm 0.02	ME-MS81 Rb ppm 0.2	ME-MS81 Sc ppm 0.5	ME-MS81 Sm ppm 0.03	ME-MS81 Sn ppm 0.5	ME-MS81 Sr ppm 0.1	ME-MS81 Ta ppm 0.1	ME-MS81 Tb ppm 0.01	ME-MS81 Th ppm 0.05	ME-MS81 Ti % 0.01	ME-MS81 Tm ppm 0.01	ME-MS81 U ppm 0.05
GRM-01 DUP Target Range – Lower Bound Upper Bound																
GRM-20 DUP Target Range – Lower Bound Upper Bound		0.19 0.17 0.16 0.20	2.94 3.21 2.87 3.28	11.1 10.7 10.3 11.5	2.92 2.65 2.63 2.94	79.3 81.1 76.0 84.4	32.8 34.3 31.4 35.7	2.20 2.33 2.12 2.41	8.7 6.7 6.8 8.6	51.8 51.2 48.8 54.2	0.2 0.2 <0.1 0.3	0.35 0.41 0.35 0.41	4.92 4.77 4.55 5.14	0.24 0.24 0.22 0.26	0.17 0.18 0.16 0.19	1.54 1.48 1.38 1.64
GRM-21 DUP Target Range – Lower Bound Upper Bound																
ELV_07 DUP Target Range – Lower Bound Upper Bound																
ELV_10 DUP Target Range – Lower Bound Upper Bound		0.57 0.69 0.59 0.67	6.44 6.47 6.08 6.83	44.7 45.0 42.5 47.2	14.05 13.25 12.95 14.35	31.1 32.8 30.2 33.7	16.1 16.8 15.1 17.8	8.43 8.53 8.03 8.93	5.3 4.4 4.1 5.6	26.1 26.5 24.9 27.7	0.5 0.4 0.3 0.6	1.05 1.16 1.04 1.17	7.83 7.09 7.04 7.88	0.25 0.24 0.22 0.27	0.60 0.55 0.54 0.61	42.8 41.0 39.8 44.0
ELV_11 DUP Target Range – Lower Bound Upper Bound																
ELV_30 DUP Target Range – Lower Bound Upper Bound		0.56 0.50 0.49 0.57	6.85 6.91 6.49 7.27	55.0 51.8 50.6 56.2	16.90 16.55 15.85 17.60	29.3 31.1 28.5 31.9	13.8 14.0 12.7 15.1	9.67 9.54 9.09 10.10	3.1 4.0 2.9 4.2	45.1 44.4 42.4 47.1	0.4 0.4 0.3 0.5	1.12 1.10 1.04 1.18	6.03 5.74 5.54 6.23	0.28 0.28 0.26 0.30	0.53 0.57 0.51 0.59	28.1 27.6 26.4 29.3
ELV_31 DUP Target Range – Lower Bound Upper Bound																



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Sample Description	Method Analyte Units LOD	pXRF-34									
		ME-MS81	ME-MS81	ME-MS81	ME-MS81	ME-MS81	ME-MS81	ME-MS81	pXRF-34	pXRF-34	pXRF-34
		V	W	Y	Yb	Zr	Si	Ti	Zr		
		ppm	ppm	ppm	ppm	ppm	%	%	ppm		
		5	0.5	0.1	0.03	1	0.5	0.1	5		
DUPLICATES											
GRM-01											
DUP											
Target Range – Lower Bound											
Upper Bound											
GRM-20											
DUP											
Target Range – Lower Bound											
Upper Bound											
GRM-21											
DUP											
Target Range – Lower Bound											
Upper Bound											
ELV_07											
DUP											
Target Range – Lower Bound											
Upper Bound											
ELV_10											
DUP											
Target Range – Lower Bound											
Upper Bound											
ELV_11											
DUP											
Target Range – Lower Bound											
Upper Bound											
ELV_30											
DUP											
Target Range – Lower Bound											
Upper Bound											
ELV_31											
DUP											
Target Range – Lower Bound											
Upper Bound											



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DUPLICATES																
ELV_43		0.85	6.11	12.4	170	0.62	1.52	1.51	0.12	217	48.9	37	1.22	1590	6.46	19.80
DUP		0.95	6.34	13.3	170	0.64	1.56	1.55	0.13	225	52.8	39	1.28	1660	6.68	20.1
Target Range – Lower Bound		0.85	5.90	12.0	150	0.55	1.45	1.44	0.10	210	48.2	35	1.14	1570	6.23	18.90
Upper Bound		0.96	6.55	13.7	190	0.71	1.63	1.62	0.15	232	53.5	41	1.36	1680	6.91	21.0
ELV_44																
DUP																
Target Range – Lower Bound																
Upper Bound																
ELV_45																
DUP																
Target Range – Lower Bound																
Upper Bound																
ELV_64																
DUP																
Target Range – Lower Bound																
Upper Bound																
ELV_65																
DUP																
Target Range – Lower Bound																
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Target Range – Lower Bound																
Upper Bound																



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Sample Description	Method Analyte Units LOD	ME-MS61 Ge ppm 0.05	ME-MS61 Hf ppm 0.1	ME-MS61 In ppm 0.005	ME-MS61 K % 0.01	ME-MS61 La ppm 0.5	ME-MS61 Li ppm 0.2	ME-MS61 Mg % 0.01	ME-MS61 Mn ppm 5	ME-MS61 Mo ppm 0.05	ME-MS61 Na % 0.01	ME-MS61 Nb ppm 0.1	ME-MS61 Ni ppm 0.2	ME-MS61 P ppm 10	ME-MS61 Pb ppm 0.5	ME-MS61 Rb ppm 0.1
DUPLICATES																
ELV_43		0.17	2.5	0.140	0.65	141.0	29.9	2.65	497	24.3	1.46	4.7	56.0	620	42.9	23.2
DUP		0.20	2.7	0.152	0.67	150.5	31.0	2.74	519	25.0	1.51	5.1	59.5	630	44.6	25.2
Target Range – Lower Bound		0.12	2.4	0.134	0.62	138.0	28.7	2.55	478	23.4	1.40	4.6	54.7	580	41.1	22.9
Upper Bound		0.25	2.8	0.158	0.70	153.5	32.2	2.84	538	25.9	1.57	5.2	60.8	670	46.4	25.5
ELV_44																
DUP																
Target Range – Lower Bound																
Upper Bound																
ELV_45																
DUP																
Target Range – Lower Bound																
Upper Bound																
ELV_64																
DUP																
Target Range – Lower Bound																
Upper Bound																
ELV_65																
DUP																
Target Range – Lower Bound																
Upper Bound																
ORIGINAL																
DUP																
Target Range – Lower Bound																
Upper Bound																
ORIGINAL																
DUP																
Target Range – Lower Bound																
Upper Bound																



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Sample Description	Method Analyte Units LOD	ME-MS61 Re ppm 0.002	ME-MS61 S %	ME-MS61 Sb ppm 0.05	ME-MS61 Sc ppm 0.1	ME-MS61 Se ppm 1	ME-MS61 Sn ppm 0.2	ME-MS61 Sr ppm 0.2	ME-MS61 Ta ppm 0.05	ME-MS61 Te ppm 0.05	ME-MS61 Th ppm 0.01	ME-MS61 Ti %	ME-MS61 Tl ppm 0.02	ME-MS61 U ppm 0.1	ME-MS61 V ppm 1	ME-MS61 W ppm 0.1
DUPLICATES																
ELV_43		<0.002	0.22	0.69	8.5	1	2.9	50.0	0.38	1.44	4.78	0.184	0.11	36.6	68	6.3
DUP		<0.002	0.23	0.77	8.6	1	3.1	51.5	0.40	1.48	5.04	0.191	0.10	37.3	69	6.9
Target Range – Lower Bound		<0.002	0.20	0.63	8.0	<1	2.7	48.0	0.32	1.34	4.65	0.173	0.08	35.0	64	6.0
Upper Bound		0.004	0.25	0.83	9.1	2	3.4	53.5	0.46	1.58	5.17	0.202	0.13	38.9	73	7.2
ELV_44																
DUP																
Target Range – Lower Bound																
Upper Bound																
ELV_45																
DUP																
Target Range – Lower Bound																
Upper Bound																
ELV_64																
DUP																
Target Range – Lower Bound																
Upper Bound																
ELV_65																
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Target Range – Lower Bound																
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Sample Description	Method Analyte Units LOD	ME-MS61 Y ppm 0.1	ME-MS61 Zn ppm 2	ME-MS61 Zr ppm 0.5	ME-MS81 Ba ppm 0.5	ME-MS81 Ce ppm 0.1	ME-MS81 Cr ppm 5	ME-MS81 Cs ppm 0.01	ME-MS81 Dy ppm 0.05	ME-MS81 Er ppm 0.03	ME-MS81 Eu ppm 0.02	ME-MS81 Ga ppm 0.1	ME-MS81 Cd ppm 0.05	ME-MS81 Hf ppm 0.05	ME-MS81 Ho ppm 0.01	ME-MS81 La ppm 0.1
ELV_43 DUP Target Range – Lower Bound Upper Bound		27.9 28.9 26.9 29.9	56 58 52 62	91.3 100.0 88.0 103.5												
ELV_44 DUP Target Range – Lower Bound Upper Bound		165.5 164.5 156.5 174.0			111.5 112.5 106.5 117.5	0.79 0.88 0.78 0.89	74 72 64 82		4.99 5.22 4.80 5.41	3.14 3.06 2.92 3.29	1.18 1.26 1.14 1.30	20.7 21.2 19.8 22.1	5.24 5.31 4.96 5.59	3.09 3.56 3.11 3.54	0.99 0.98 0.93 1.04	76.1 77.6 72.9 80.8
ELV_45 DUP Target Range – Lower Bound Upper Bound																
ELV_64 DUP Target Range – Lower Bound Upper Bound		177.0 170.0 164.5 182.5			110.5 112.0 105.5 117.0	1.12 1.02 1.01 1.13	61 61 53 69		5.05 5.07 4.76 5.36	3.38 2.95 2.98 3.35	1.18 1.14 1.08 1.24	19.4 18.4 17.9 19.9	5.42 5.75 5.26 5.91	4.62 4.71 4.38 4.95	1.01 1.06 0.97 1.10	77.7 77.8 73.8 81.7
ELV_65 DUP Target Range – Lower Bound Upper Bound																
ORIGINAL DUP Target Range – Lower Bound Upper Bound		308 305 291 322			42.0 40.1 38.9 43.2	12.75 12.85 12.15 13.45	44 43 36 51		3.24 3.93 3.36 3.81	2.24 2.83 2.38 2.69	0.57 0.51 0.49 0.59	18.4 18.2 17.3 19.3	2.96 2.89 2.73 3.12	6.04 6.31 5.82 6.53	0.67 0.80 0.69 0.78	28.0 27.4 26.2 29.2
ORIGINAL DUP Target Range – Lower Bound Upper Bound		461 438 427 472			92.4 86.5 84.9 94.0	608 565 557 616	64 59 53 70		5.46 4.80 4.82 5.44	3.18 3.00 2.91 3.27	1.32 1.23 1.19 1.36	17.1 16.9 16.1 18.0	6.60 5.28 5.59 6.29	6.44 6.14 5.93 6.65	0.98 1.00 0.93 1.05	45.1 41.8 41.2 45.7



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		ME-MS81 Lu ppm 0.01	ME-MS81 Nb ppm 0.05	ME-MS81 Nd ppm 0.1	ME-MS81 Pr ppm 0.02	ME-MS81 Rb ppm 0.2	ME-MS81 Sc ppm 0.5	ME-MS81 Sm ppm 0.03	ME-MS81 Sn ppm 0.5	ME-MS81 Sr ppm 0.1	ME-MS81 Ta ppm 0.1	ME-MS81 Tb ppm 0.01	ME-MS81 Th ppm 0.05	ME-MS81 Ti % 0.01	ME-MS81 Tm ppm 0.01	ME-MS81 U ppm 0.05	
ELV_43 DUP Target Range – Lower Bound Upper Bound																	
ELV_44 DUP Target Range – Lower Bound Upper Bound																	
ELV_45 DUP Target Range – Lower Bound Upper Bound																	
ELV_64 DUP Target Range – Lower Bound Upper Bound																	
ELV_65 DUP Target Range – Lower Bound Upper Bound																	
ORIGINAL DUP Target Range – Lower Bound Upper Bound																	
ORIGINAL DUP Target Range – Lower Bound Upper Bound																	



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ELV_43 DUP Target Range – Lower Bound Upper Bound		100	4.9	29.9	3.10	126			
		100	8.1	28.6	3.25	126			
		90	5.7	27.7	2.99	119			
		110	7.3	30.8	3.36	133			
ELV_45 DUP Target Range – Lower Bound Upper Bound							16.6	0.2	92
							16.9	0.3	86
							14.6	<0.1	75
							18.9	0.4	103
ELV_64 DUP Target Range – Lower Bound Upper Bound		86	5.3	30.4	3.02	186			
		85	5.7	29.6	2.91	184			
		76	4.7	28.4	2.79	175			
		95	6.3	31.6	3.14	195			
ELV_65 DUP Target Range – Lower Bound Upper Bound							21.9	0.2	120
							21.8	0.2	156
							19.2	<0.1	119
							24.5	0.3	157
ORIGINAL DUP Target Range – Lower Bound Upper Bound		68	11.8	21.6	2.58	214			
		69	10.0	27.1	3.43	229			
		60	9.9	23.0	2.82	209			
		77	11.9	25.7	3.19	234			
ORIGINAL DUP Target Range – Lower Bound Upper Bound		68	4.6	27.9	2.98	239			
		61	4.5	27.4	2.81	246			
		56	3.8	26.2	2.72	229			
		73	5.3	29.1	3.07	256			

DUPPLICATES



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ALS Brisbane is a NATA Accredited Testing Laboratory. Corporate Accreditation
No: 825, Corporate Site No: 818.

QC CERTIFICATE OF ANALYSIS BR23315396

CERTIFICATE COMMENTS

Applies to Method:

REEs may not be totally soluble in this method.
ME-MS61

Applies to Method:

NATA Accreditation covers the performance of this service but does not cover the performance of ALS Brisbane Sample Preparation. Corporate
Accreditation No: 825, Corporate Site No: 818. The Technical Signatory is David Jones, ICPMS Supervising Chemist
ME-MS61

Applies to Method:

Processed at ALS Brisbane located at 32 Shand Street, Stafford, Brisbane, QLD, Australia. Processed at ALS Brisbane Sample Preparation at 23
Pineapple Street, Zillmere, QLD, 4034, Australia
BAG-01
LEV-01
ME-MS81
SPL-21
BAG-21
LOG-22
PUL-23
TRA-21
CRU-21
LOG-24
PUL-QC
WEI-21
DRY-22
ME-MS61
pXRF-34

LABORATORY ADDRESSES



Australian Laboratory Services Pty. Ltd.
32 Shand Street
Stafford
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Phone: +61 7 3243 7222 Fax: +61 7 3243 7218
www.alsglobal.com/geochemistry

To: UNIVERSITY OF QUEENSLAND
MINERAL RESEARCH CENTRE
40 ISLE ROAD
INDOOROOPILLY QLD 4068

Page: 1
Total # Pages: 3 (A)
Plus Appendix Pages
Finalized Date: 8-JAN-2024
Account: UNIQUE

QC CERTIFICATE BR23359697

Project: UQ-23-094 - Elverdton (WA)
P.O. No.: 4280008329
This report is for 78 samples of Tailings submitted to our lab in Brisbane, QLD,
Australia on 13-DEC-2023.

The following have access to data associated with this certificate:

KAMINI BHOWANY

ANITA PARBHAKAR-FOX

SAMPLE PREPARATION	
ALS CODE	DESCRIPTION
LOG-20	Sample login - Additional Analysis

ANALYTICAL PROCEDURES	
ALS CODE	DESCRIPTION
Au-AA25	Ore Grade Au 30g FA AA finish
	INSTRUMENT
	AAS

This is the Final Report and supersedes any preliminary report with this certificate number. Results apply to samples as submitted. All pages of this report have been checked and approved for release.

***** See Appendix Page for comments regarding this certificate *****

Signature:

Peter Neville, Laboratory Manager



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Page: 2 – A
Total # Pages: 3 (A)
Plus Appendix Pages
Finalized Date: 8–JAN–2024
Account: UNIQUE

Project: UQ-23-094 – Elverdton (WA)

QC CERTIFICATE OF ANALYSIS BR23359697

Sample Description	Method Analyte Units LOD	Au-AA25 Au ppm 0.01
STANDARDS		
CT-22		2.61
Target Range – Lower Bound		2.42
Upper Bound		2.74
G918-8		33.5
Target Range – Lower Bound		31.5
Upper Bound		35.6
G919-7		4.83
Target Range – Lower Bound		4.65
Upper Bound		5.27
OREAS L11		0.30
Target Range – Lower Bound		0.28
Upper Bound		0.33
BLANKS		
BLANK		<0.01
BLANK		<0.01
Target Range – Lower Bound		<0.01
Upper Bound		0.02
DUPLICATES		
ORIGINAL		0.46
DUP		0.33
Target Range – Lower Bound		0.37
Upper Bound		0.42
ELV_14		1.63
DUP		2.02
Target Range – Lower Bound		1.72
Upper Bound		1.93



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Project: UQ-23-094 – Elverdton (WA)

Page: 3 – A
Total # Pages: 3 (A)
Plus Appendix Pages
Finalized Date: 8-JAN-2024
Account: UNIQUE

QC CERTIFICATE OF ANALYSIS BR23359697

Sample Description	Method Analyte Units LOD	Au-AA25 Au ppm 0.01
DUPLICATES		
ELV_52 DUP Target Range – Lower Bound Upper Bound		1.40 1.65 1.44 1.61
ELV_72 DUP Target Range – Lower Bound Upper Bound		0.22 0.17 0.18 0.21
ORIGINAL DUP Target Range – Lower Bound Upper Bound		<0.01 <0.01 <0.01 0.02
ORIGINAL DUP Target Range – Lower Bound Upper Bound		0.31 0.31 0.28 0.34



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Project: UQ-23-094 – Elverdton (WA)

Page: Appendix 1
Total # Appendix Pages: 1
Finalized Date: 8-JAN-2024
Account: UNIQUE

QC CERTIFICATE OF ANALYSIS BR23359697

CERTIFICATE COMMENTS	
Applies to Method: Applies to Method:	LABORATORY ADDRESSES Processed at ALS Townsville located at 14-15 Desma Court, Bohle, Townsville, QLD, Australia. Au-AA25 Processed at ALS Brisbane located at 32 Shand Street, Stafford, Brisbane, QLD, Australia. Processed at ALS Brisbane Sample Preparation at 23 Pineapple Street, Zillmere, QLD, 4034, Australia LOG-20

Appendix C

For quality control and quality assurance (QAQC) purposes, standards were inserted into the geochemical assay runs. Standards OREAS 601c was selected as an In- and Sn-bearing skarn tungsten-magnetite ore, and a base metal-bearing sulphide ore. The results are investigated here to assess the results for selected elements of interest. The certified and measured values were compared for the enriched base and precious metals Cu, Pb, Au and Ag, and the critical metals Te, Se, Bi, Mo, Co, Re, W, La and Ce (Figure A1 to Figure A12). The measured values from ME-MS61 analysis were used for most elements reported here, while ME-MS81 values were used for La and Ce, and Au-AA25 for Au.

The Cu values (Figure A1) are within two standard deviations (SD), generally on the lower side of the certified value. The Pb and Ag values (Figure A2, Figure A3) are well within 2 SD. The Au values are at the high end of 2 SD, with one value exceeding 2 SD, but the values are all well within 3 SD and therefore the measurements are deemed valid (Figure A4). The measurements for Te (Figure A5), Se (Figure A6), and Bi (Figure A7) are all within two SD. The Mo (Figure A8), Co (Figure A9) and W (Figure A10) values are generally on the lower side of the certified value, but remain within 2 SD. The La and Ce values (Figure A11, Figure A12), as measured by ME-MS81, also lie around the certified value and within 2 SD. Therefore, the standard analysis demonstrated that the geochemical assay data is accurate and reliable.

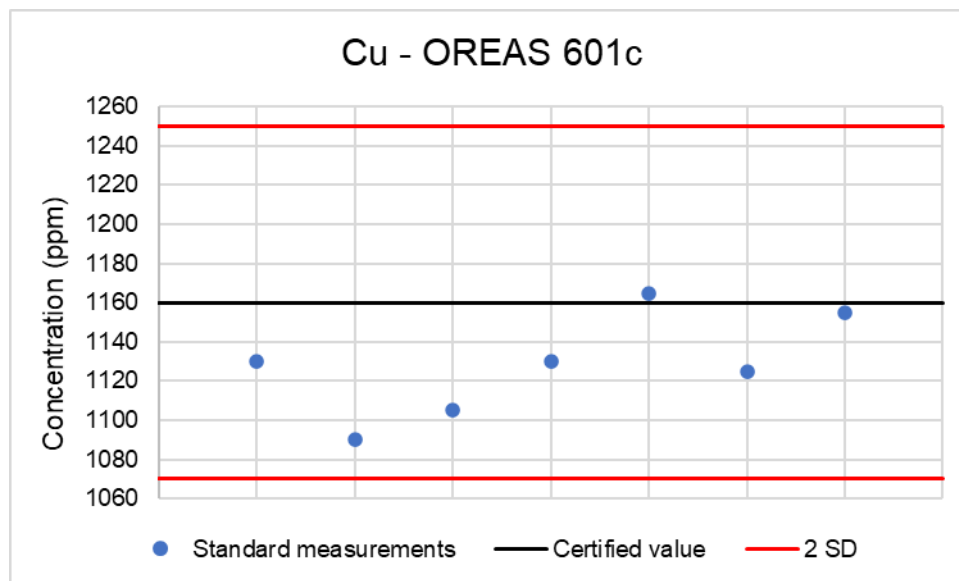


Figure A1. Comparison between the certified reference material OREAS 601c Cu measurements and the certified values with two standard deviations (SD).

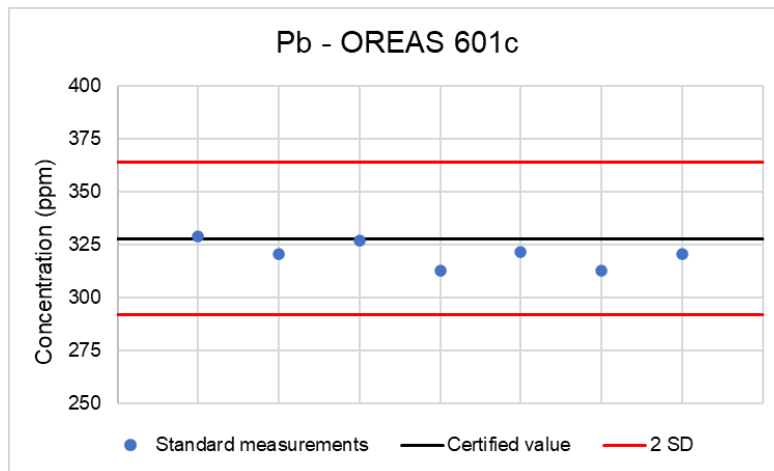


Figure A2. Comparison between the certified reference material OREAS 601c Pb measurements and the certified values with two standard deviations (SD).

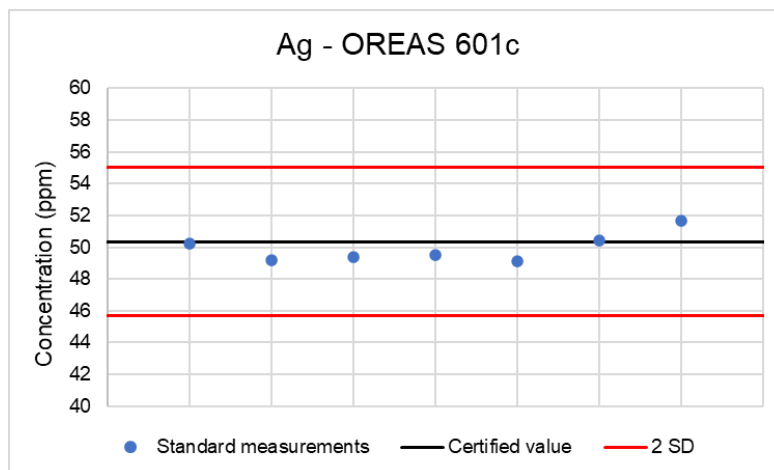


Figure A3. Comparison between the certified reference material OREAS 601c Ag measurements and the certified values with two standard deviations (SD).

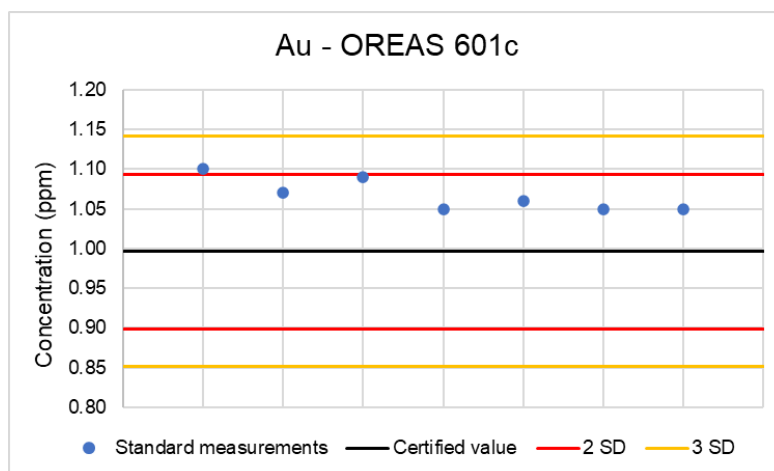


Figure A4. Comparison between the certified reference material OREAS 601c Au measurements and the certified values with two and three standard deviations (SD).

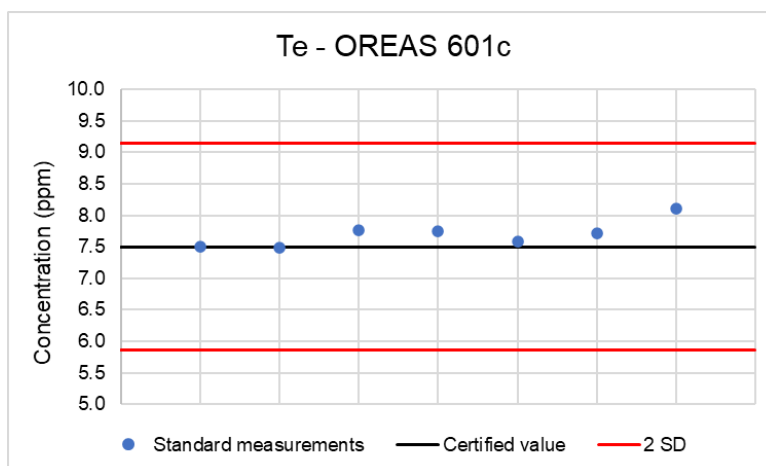


Figure A5. Comparison between the certified reference material OREAS 601c Te measurements and the certified values with two standard deviations (SD).

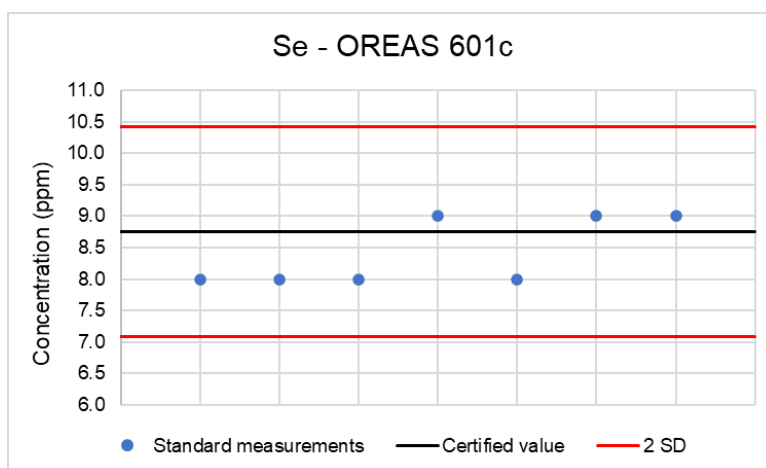


Figure A6. Comparison between the certified reference material OREAS 601c Se measurements and the certified values with two standard deviations (SD).

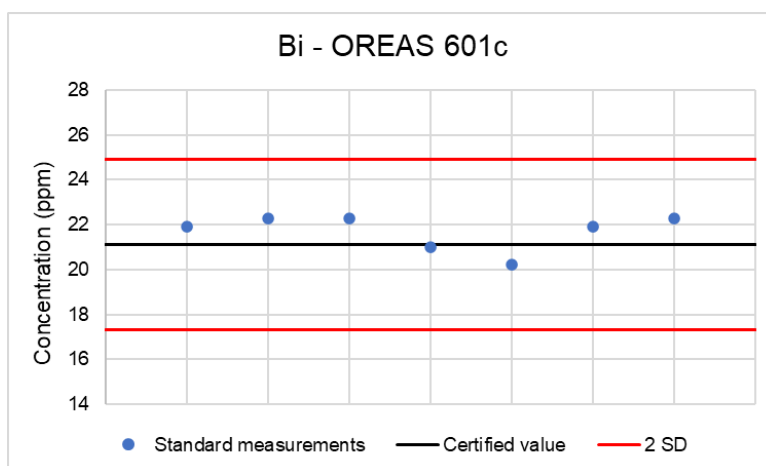


Figure A7. Comparison between the certified reference material OREAS 601c Bi measurements and the certified values with two standard deviations (SD).

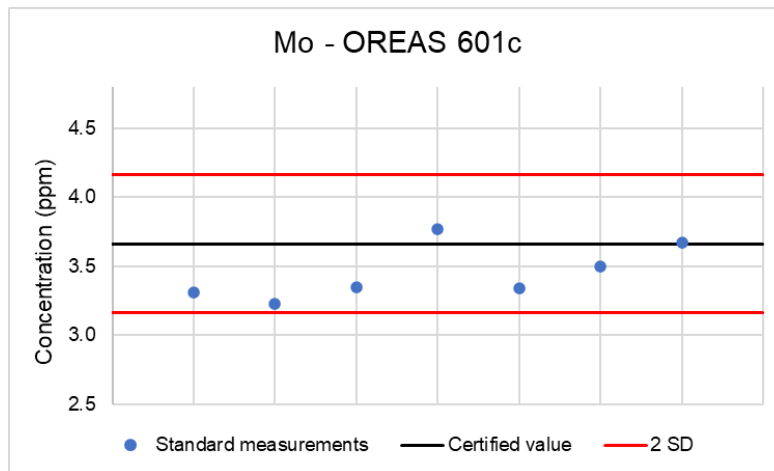


Figure A8. Comparison between the certified reference material OREAS 601c Mo measurements and the certified values with two standard deviations (SD).

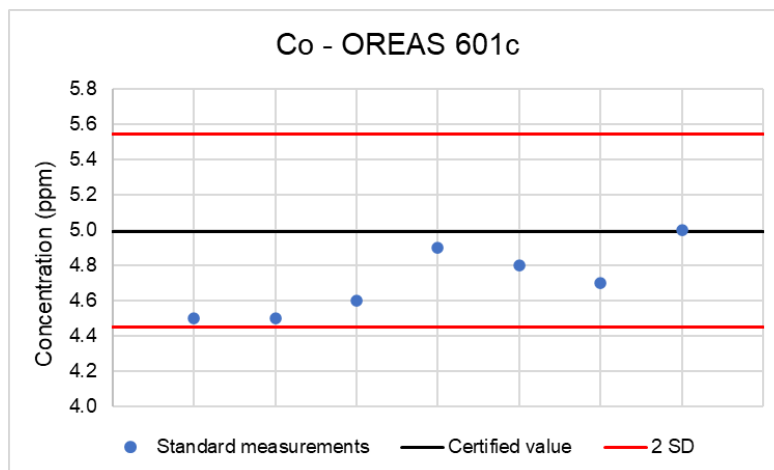


Figure A9. Comparison between the certified reference material OREAS 601c Co measurements and the certified values with two standard deviations (SD).

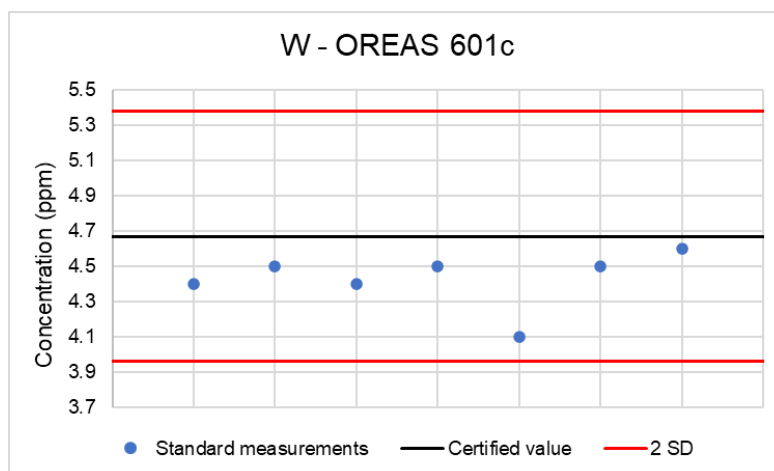


Figure A10. Comparison between the certified reference material OREAS 601c W measurements and the certified values with two standard deviations (SD).

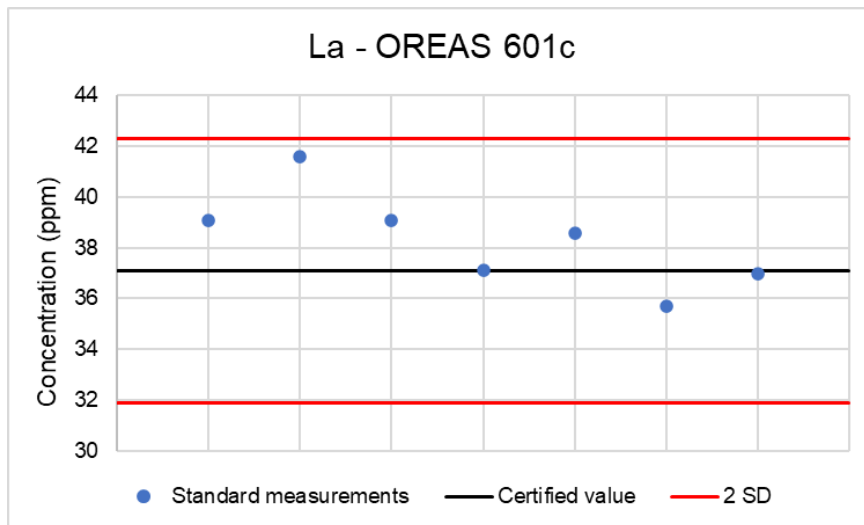


Figure A11. Comparison between the certified reference material OREAS 601c La measurements and the certified values with two standard deviations (SD).

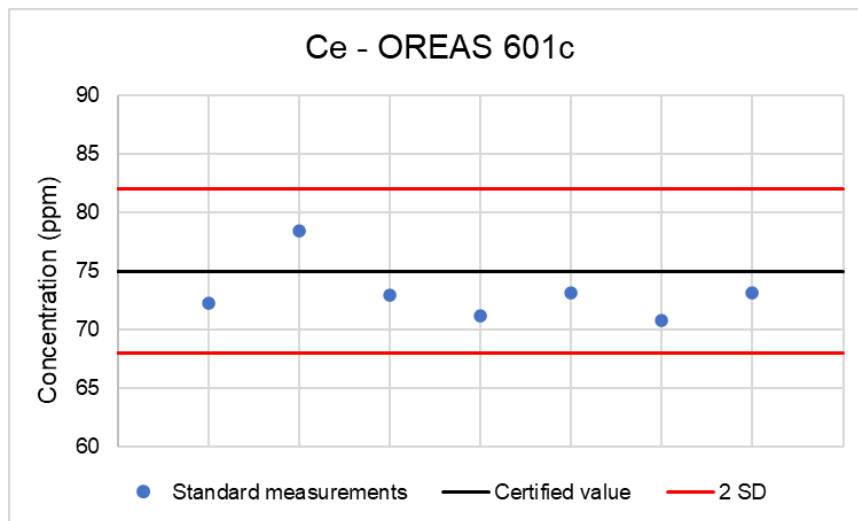


Figure A12. Comparison between the certified reference material OREAS 601c Ce measurements and the certified values with two standard deviations (SD).

Appendix D

XRD results.



Central Analytical
Research Facility

QUT Central Analytical Research Facility

Materials Characterisation Report

CLIENT	Anita Parbhakar-Fox UQ SMI
REPORT DATE	2024-06-19
PREPARED BY	Henry Spratt
ANALYSIS REQUESTED	Quantitative XRD, Clay Analysis
OUR REFERENCE	X24132
YOUR REFERENCE	Elverdton
QUT CONTACTS	<p>Mr Ashley Locke, X-ray Analysis Coordinator Ph: 0400128230 email: a.locke@qut.edu.au</p> <p>Dr Henry Spratt, Senior X-ray Technologist (Geoscience) Ph: 07 3138 9526 email: henry.spratt@qut.edu.au</p> <p>X-ray and Particles Laboratory enquiries: xandp@qut.edu.au</p>

RESULTS

Phase Identification / Quantification – Bulk Samples

The powder X-ray diffraction patterns show the presence of crystalline phases. Graphics of the collected diffraction patterns along with the phases identified are included at the end of this report. The estimated normalised abundance of the corundum internal standard in the samples is higher than 20 wt%. This means there is an unaccounted for component in the samples (i.e., the samples contain non-diffracting and/or unidentified material). This component is frequently referred to as amorphous.

Table of phase abundances (nominal wt%, absolute)

X24132 Elverdton	1 ELV_10	2 ELV_14	3 ELV_23	4 ELV_25	5 ELV_37
Quartz	22.8	26.0	22.4	24.4	15.5
Hematite	0.8	1.0			
Magnetite		3.1	0.9		
Calcite		1.3	0.1		
Bassanite					1.2
Bloedite					27.3
Jarosite (TOTAL)		10.2	0.4		0.7
Hexahydrite					15.6
Starkeyite					3.5
Goethite	0.4		0.9	2.3	
Pyralspite garnet		0.9			
Amphibole	1.7	8.0	7.9	4.2	2.5
Ampibhole (low Ca)		2.7			
Plagioclase	10.6	22.0	21.1	8.0	7.2
K-Feldspar	1.1				
Halite					0.9
Chlorite/clinochlore	33.8	5.7	17.2	29.6	2.6
Illite/mica	5.2	4.7	6.3	8.8	0.7
Amorphous	23.6	14.6	23.0	22.8	22.4

X24132 Elverdton	6 ELV_48	7 ELV_53	8 ELV_55	9 ELV_69	10 ELV_73
Quartz	28.1	34.8	26.8	33.1	26.7
Anatase					0.7
Magnetite			3.3	1.8	1.0
Pyrite	5.8	8.5			
Chalcopyrite	0.5	1.0			
Bassanite	3.0				
Dolomite		0.5		0.1	
Gypsum	1.1	1.1			1.3
Jarosite (TOTAL)	0.1	1.1	10.3	0.1	3.7
Hexahydrite				0.6	
Goethite			4.8		
Pyrralospite garnet	0.7			0.1	0.5
Amphibole			17.3	9.3	11.4
Ampibhole (low Ca)			1.9		1.7
Plagioclase	2.5	3.3	11.5	19.1	16.0
K-Feldspar	0.7			1.8	1.6
Halite				1.2	2.0
Kaolinite	2.6				
Chlorite/clinochlore	16.2	21.2	3.8	6.8	15.7
Illite/mica	12.6	10.9	2.2	7.0	3.8
Amorphous	26.1	17.8	18.1	19.2	14.0

Table of fine fraction (clay phases) identifications (qualitative, nominal)

X24132 Elverdton	1 ELV_10	2 ELV_14	3 ELV_23	4 ELV_25	5 ELV_37
Chlorite	major	minor	major	major	trace
Illite/mica	minor	minor	minor	minor	trace
Smectite			trace		

X24132 Elverdton	6 ELV_48	7 ELV_53	8 ELV_55	9 ELV_69	10 ELV_73
Chlorite	major	major	minor	minor	major
Illite/mica	minor	minor	minor	minor	minor
Kaolinite	minor				

Abundant – nominally > 40 wt%

Major – nominally > 10 wt% but < 40 wt%

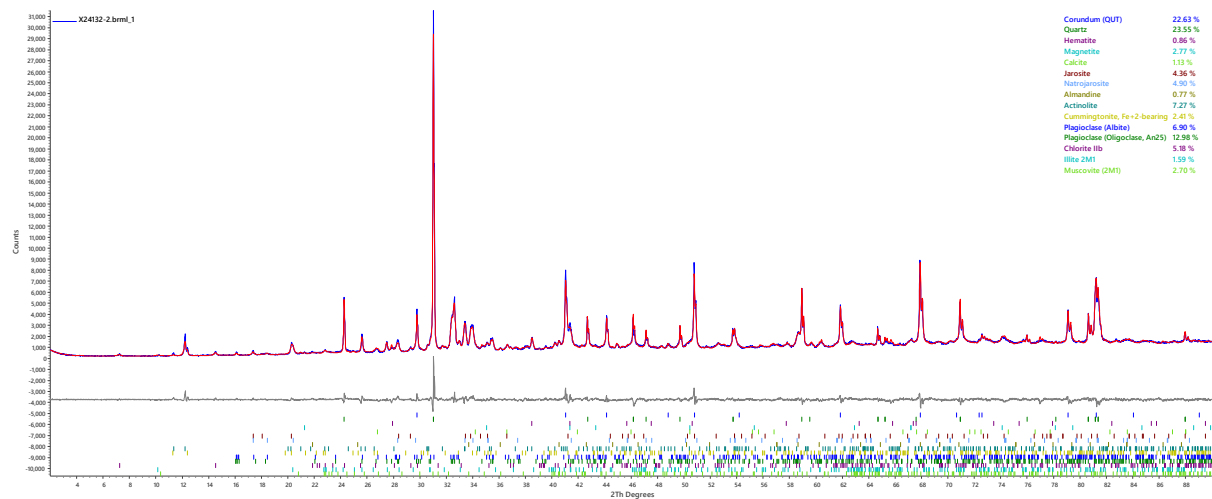
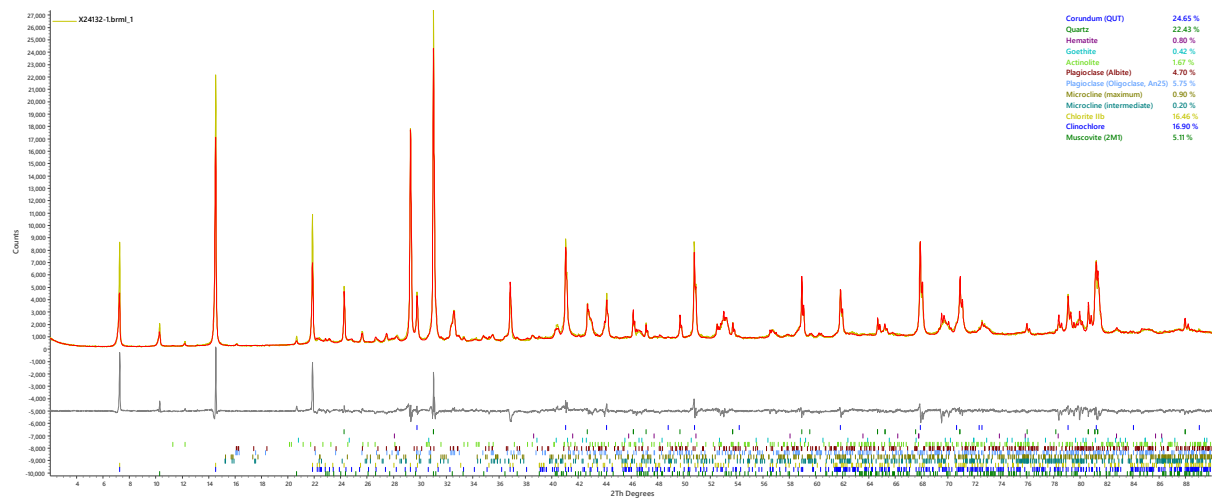
Minor – nominally > 1 wt% but < 10 wt%

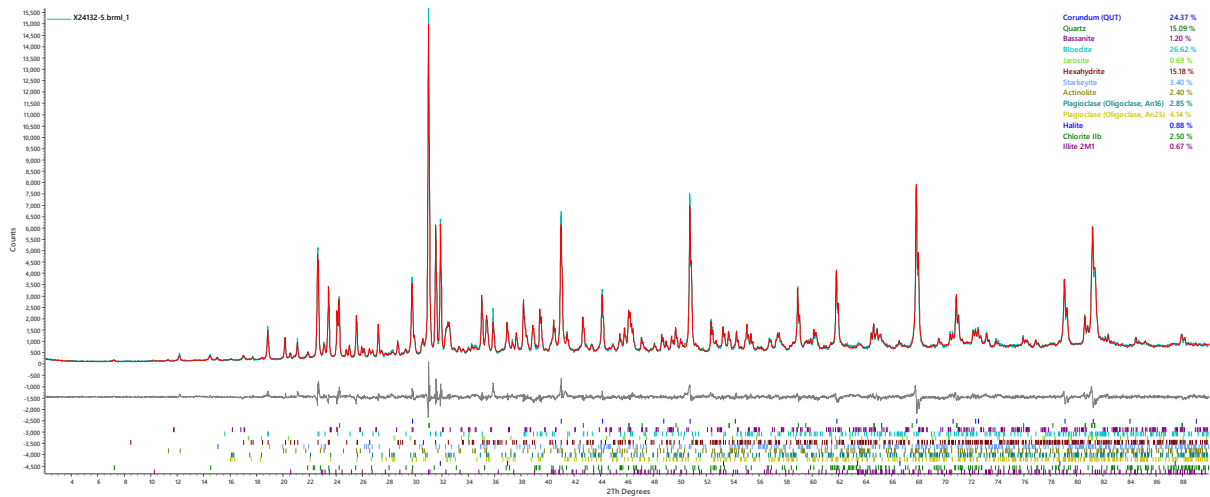
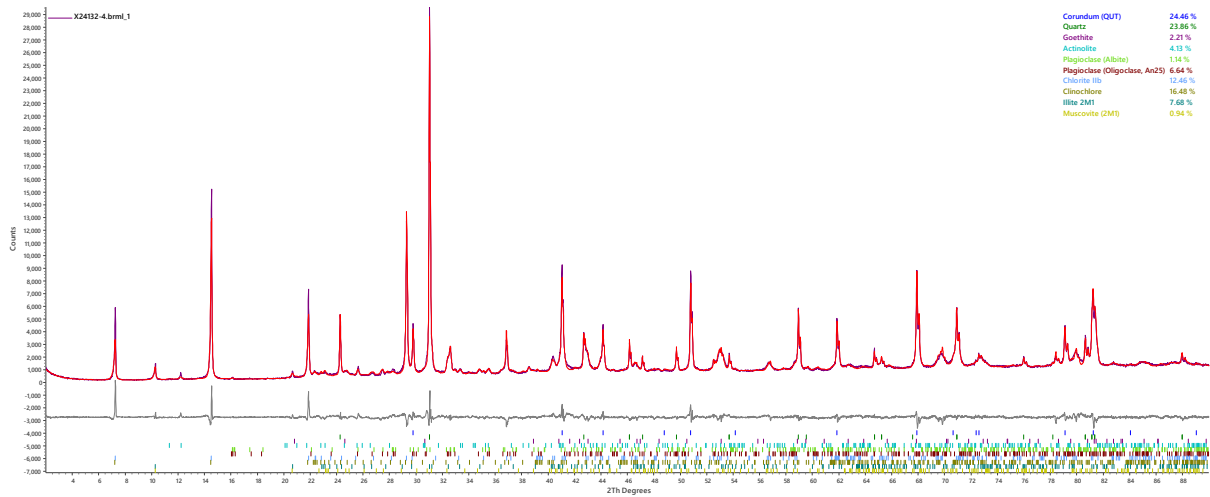
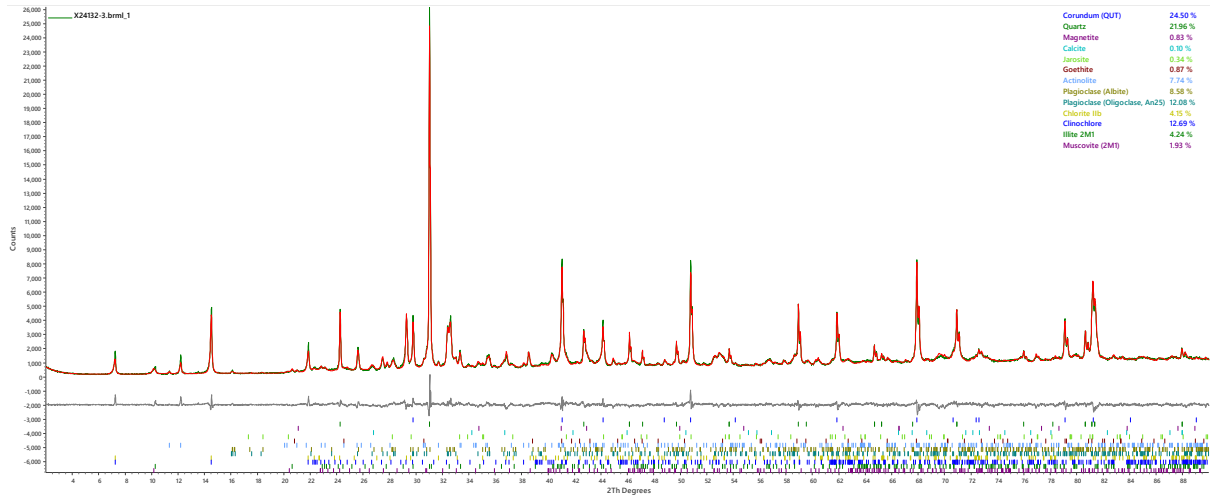
Trace – nominally < 1 wt%

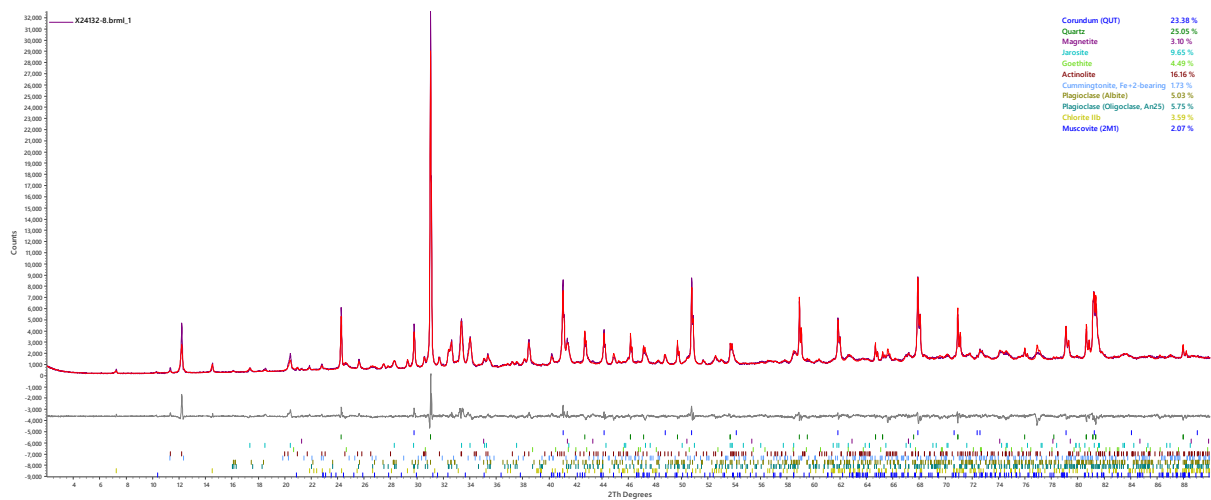
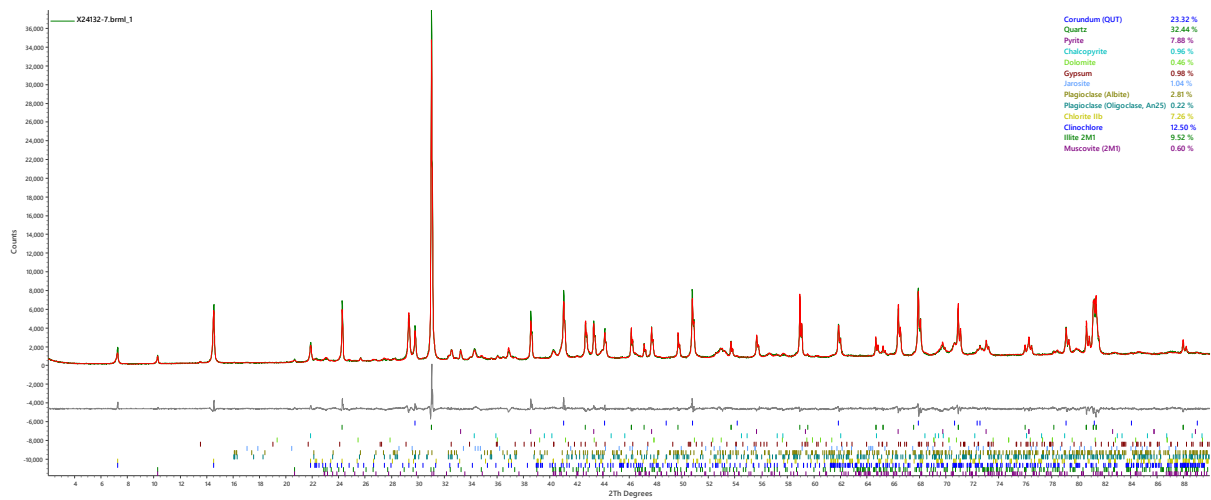
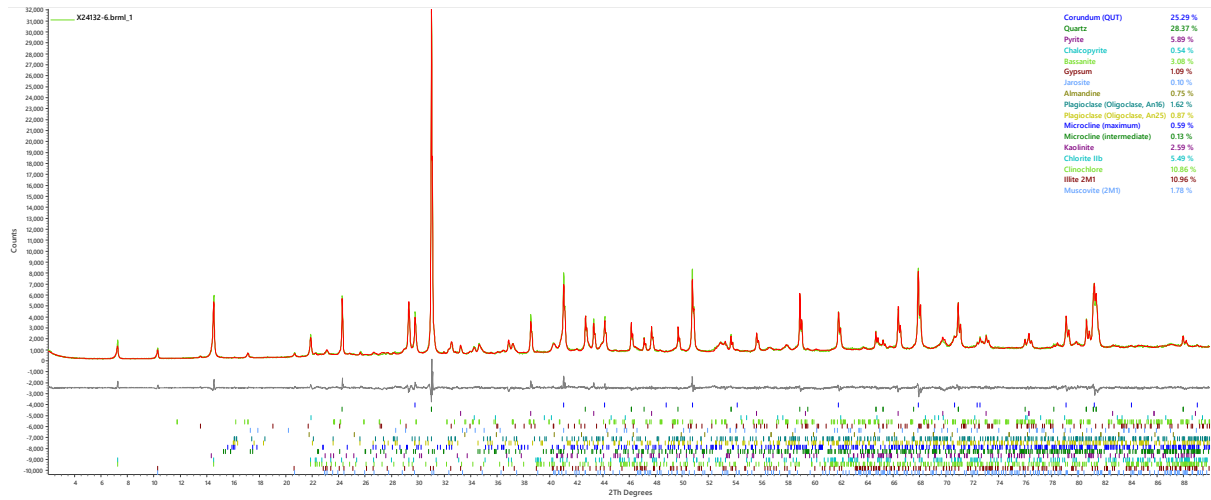
APPENDIX 1 – X-RAY DIFFRACTION DATA AND GRAPHICS

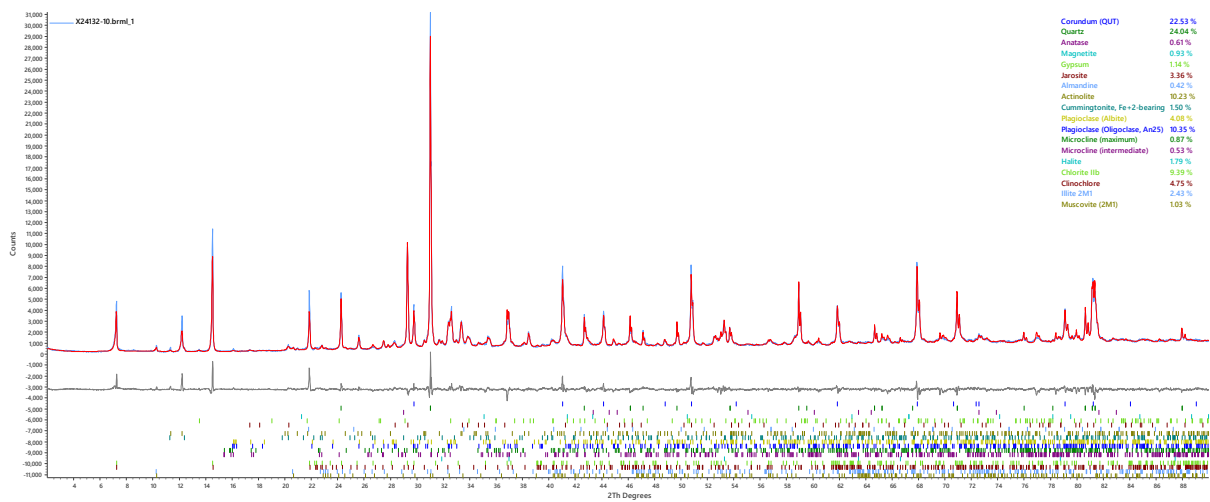
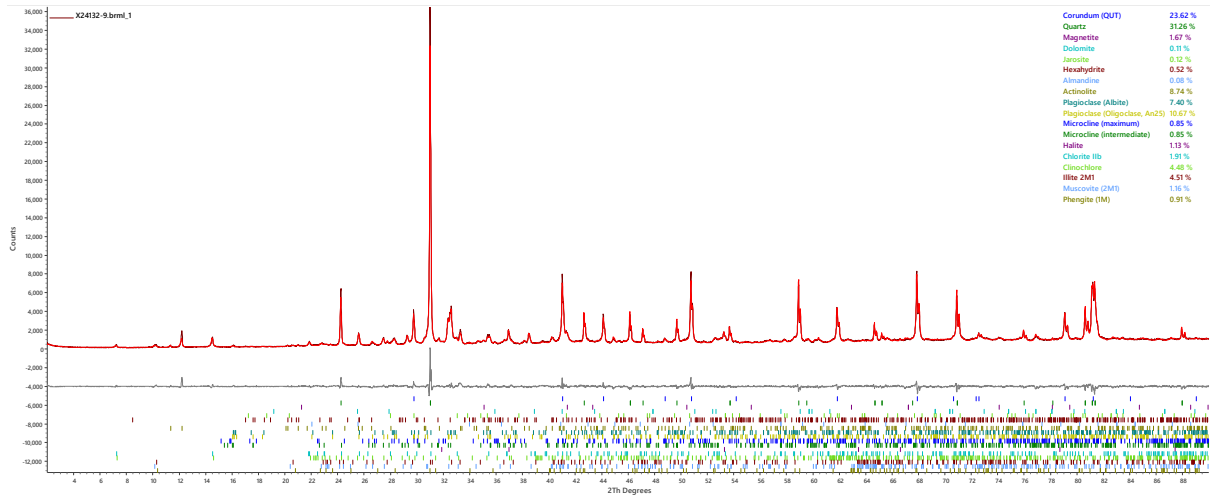
Powder X-ray Diffraction Patterns – Bulk Samples

In the graphics below the red line is the Rietveld refinement model, the coloured line is the collected data, and the grey line is the difference. The abundances on the graphics are before taking into account the known addition of corundum standard. Please use the tabulated abundances (wt% in original sample) which require no further manipulation.

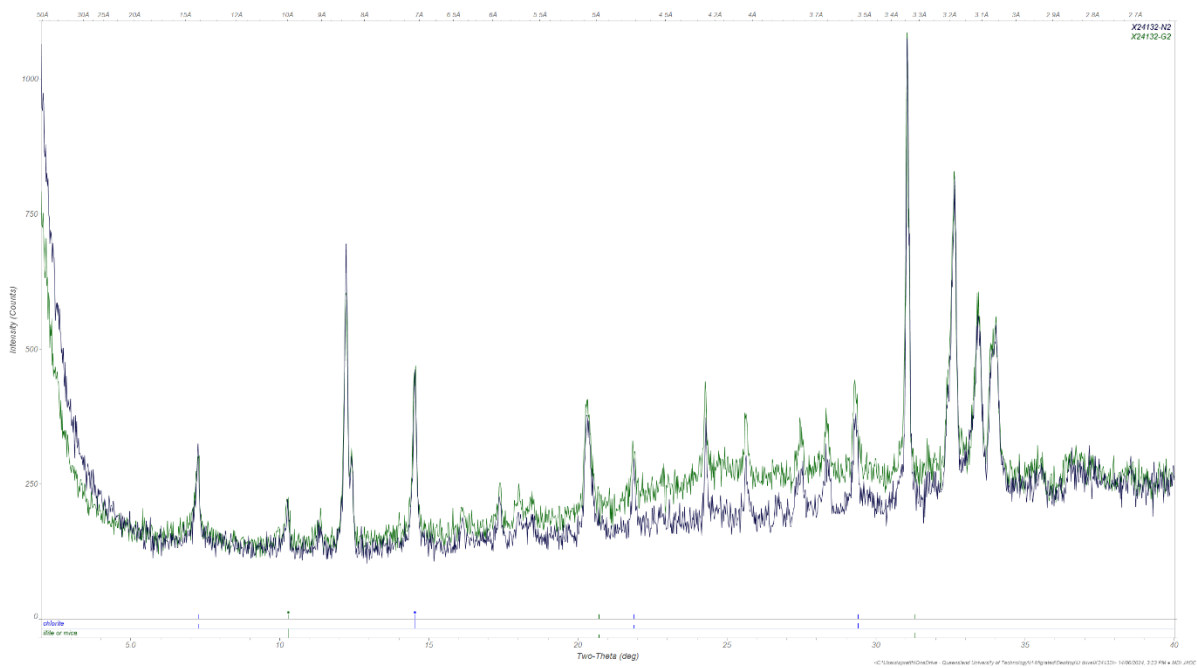
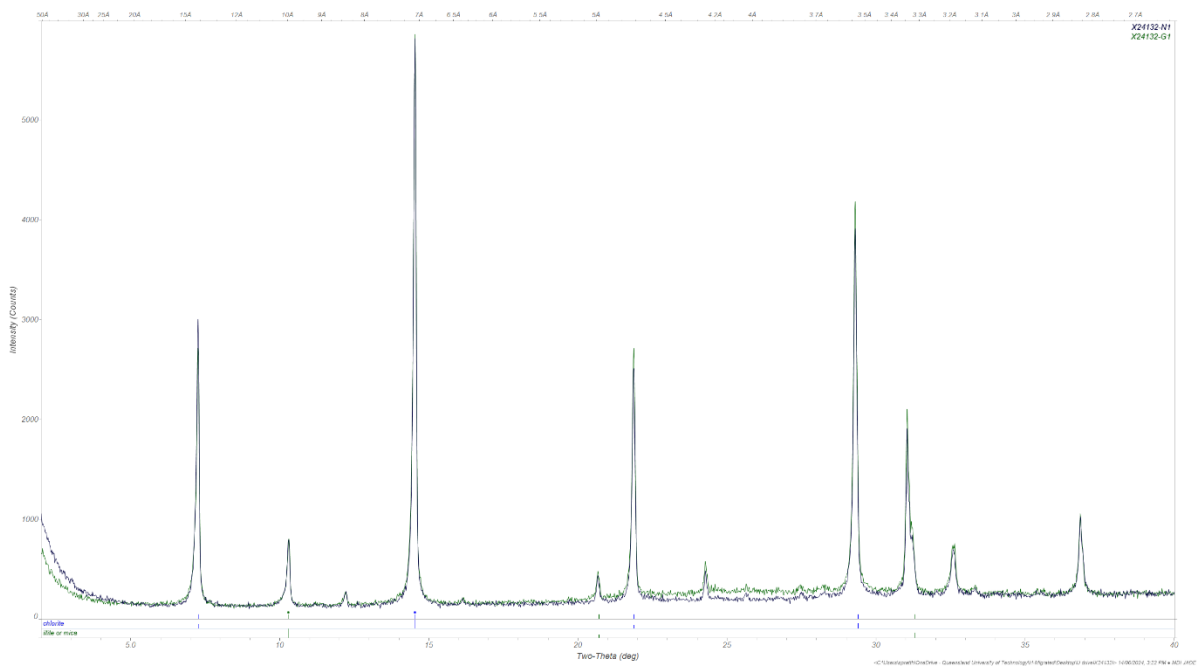


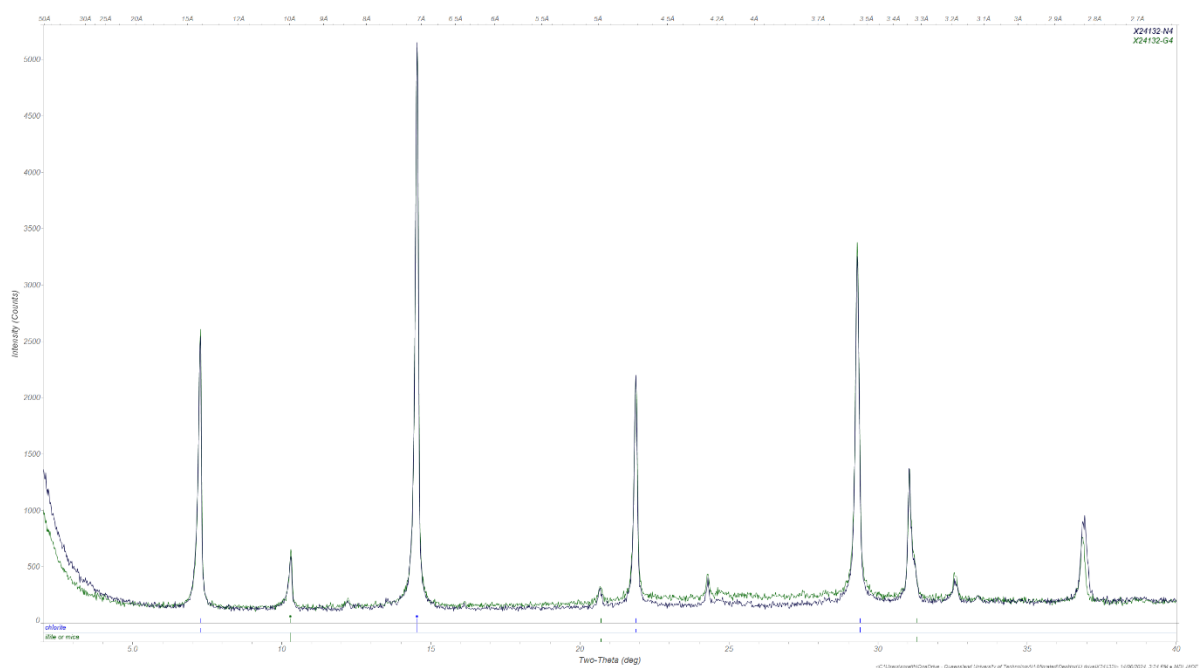
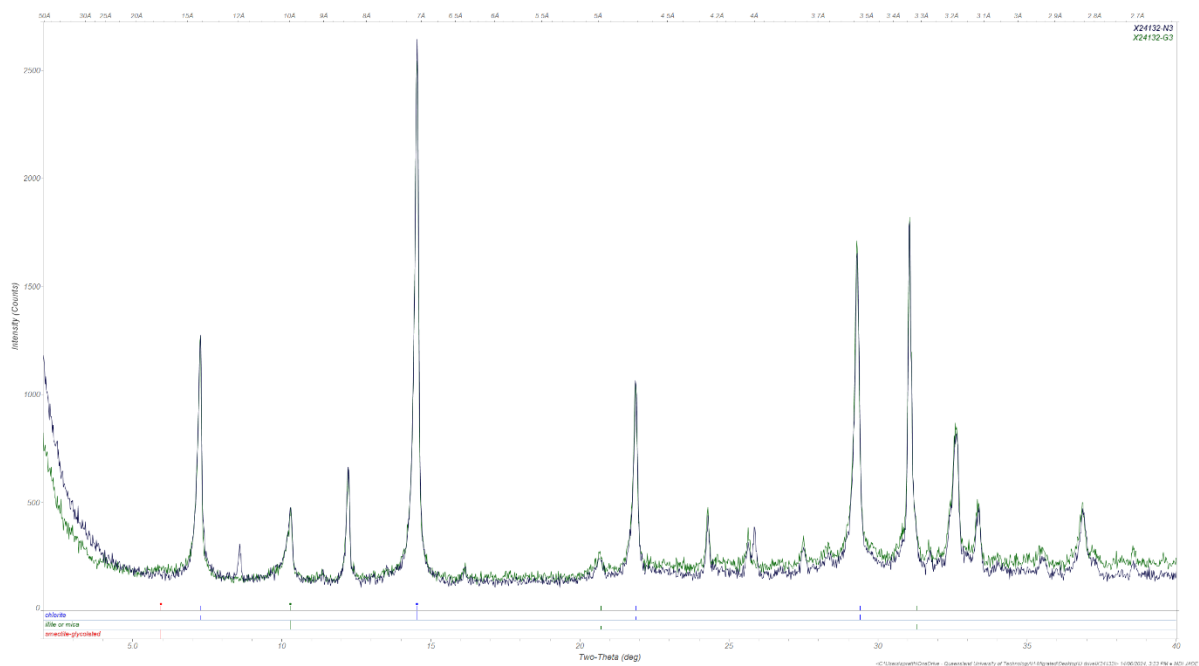


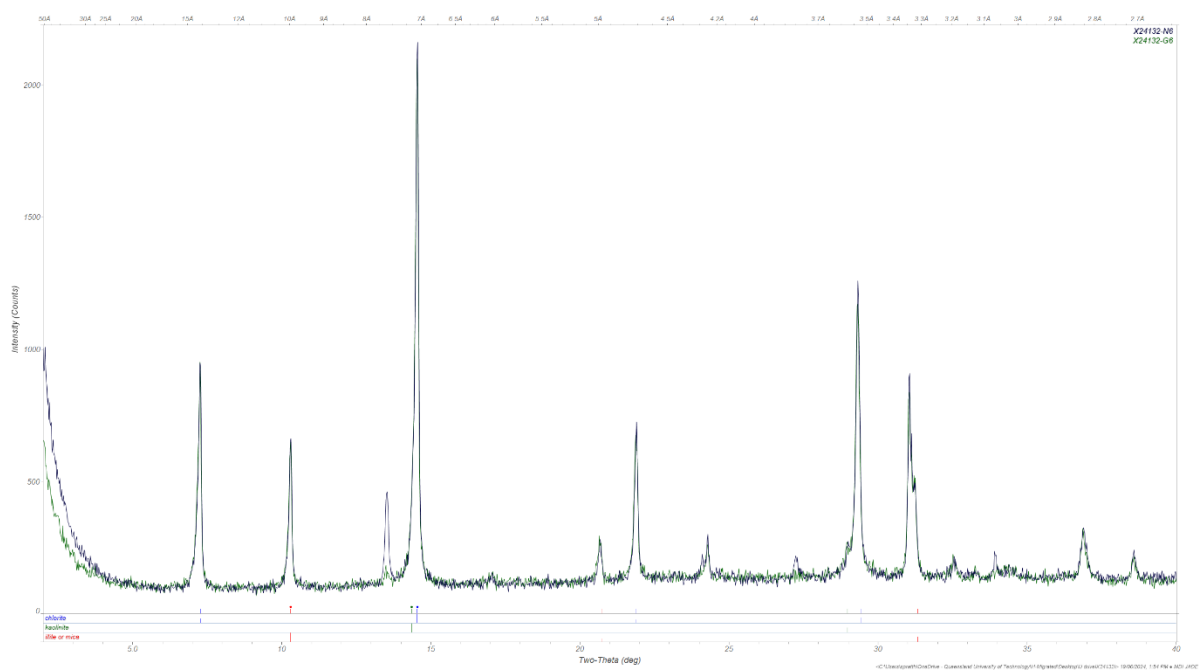
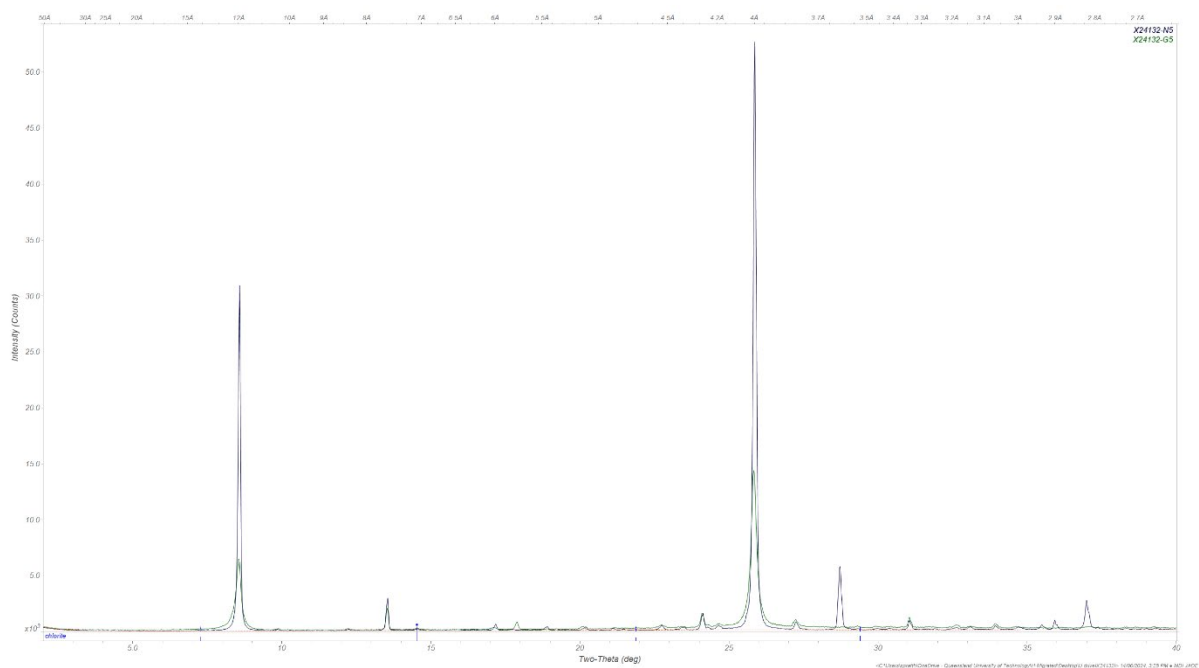


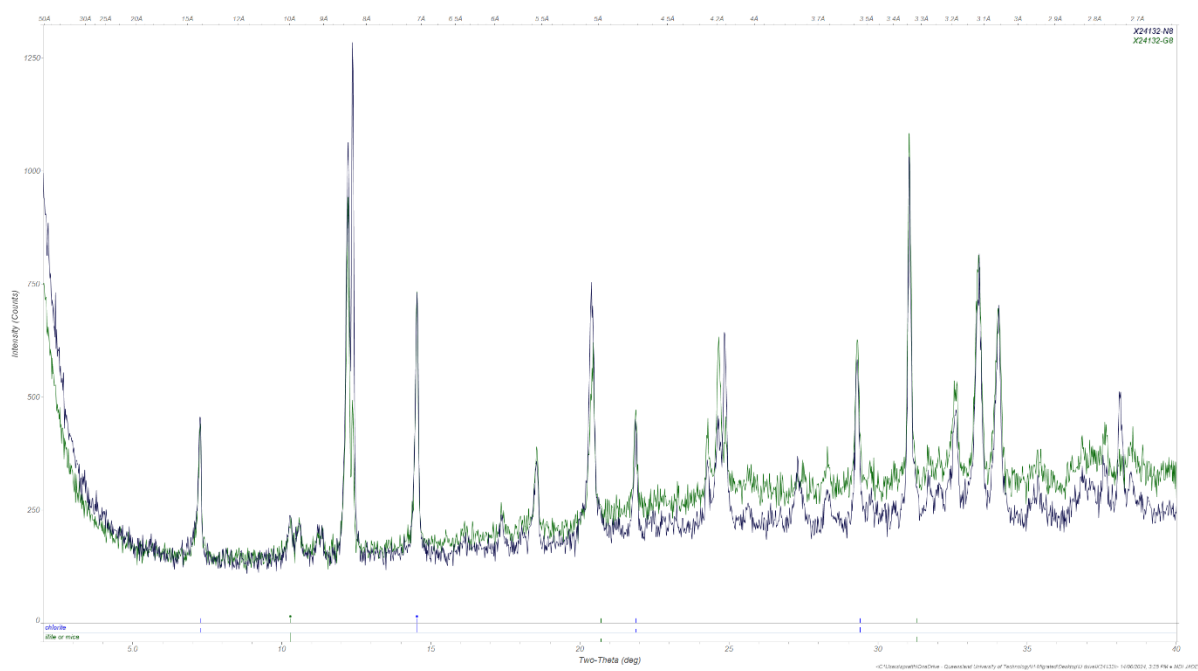
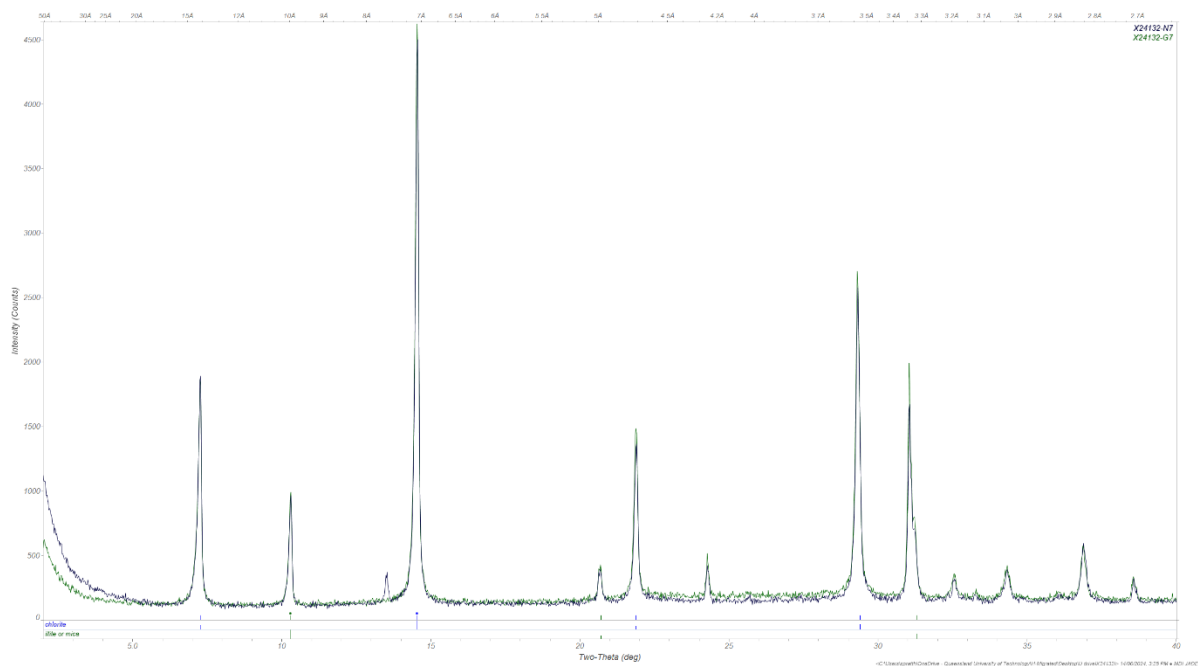


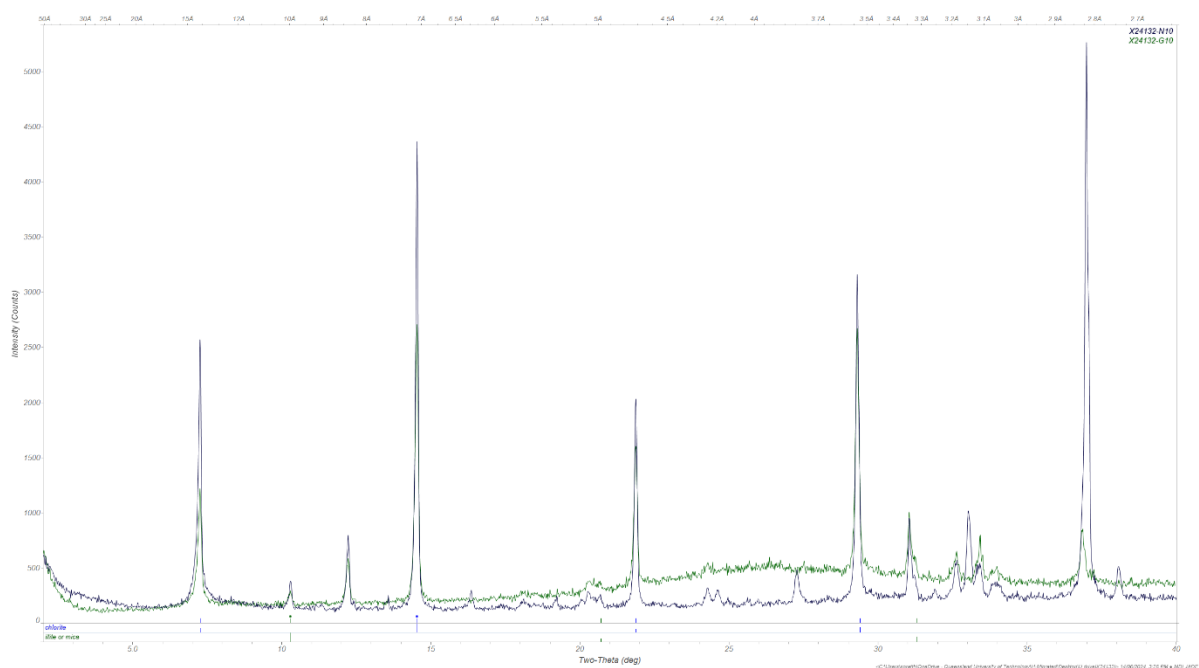
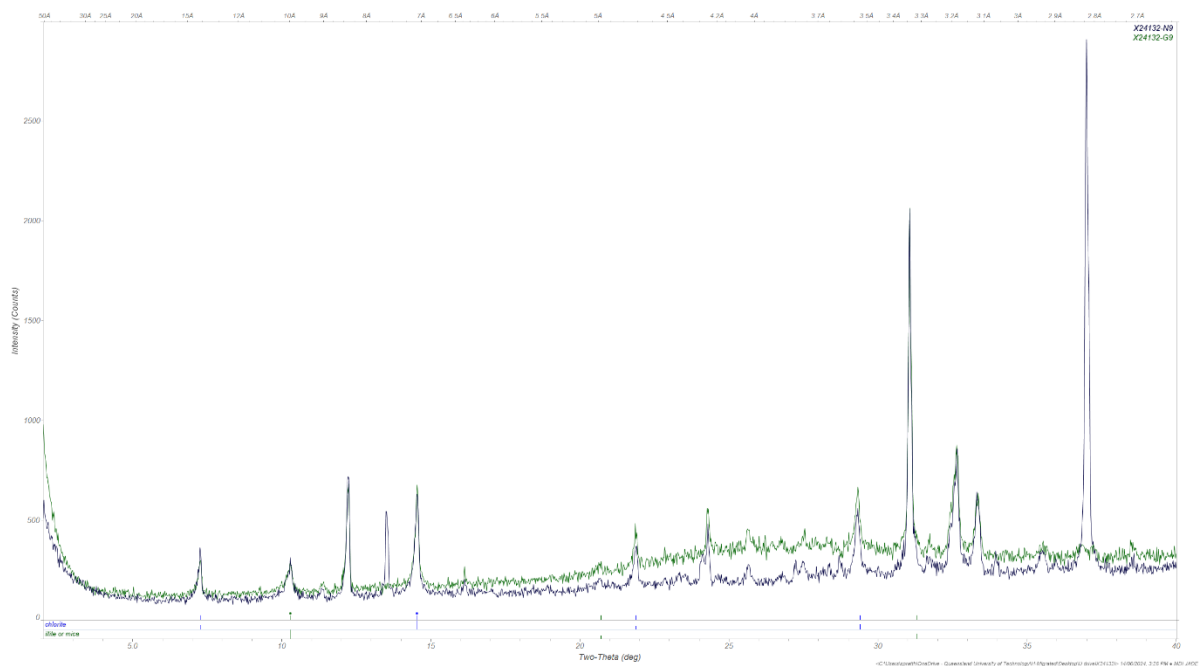
Fine Fraction (Clay) X-ray Diffraction Patterns











APPENDIX 2 – ANALYTICAL TECHNIQUES

Sample preparation

Sub-samples were accurately weighed and specimens prepared for X-ray diffraction analysis by the addition of a corundum (Al_2O_3) internal standard at 20 wt%. The specimens were micronised in a McCrone mill using zirconia beads and ethanol, then dried in an oven overnight at 40 °C. The resultant homogenous powders were back-pressed into sample holders.

A small portion of the crushed samples were dispersed in water. After sonication (5 min) and settling for 5 min, the fine fraction (nominally < 5 μm in suspension) was transferred via pipette to a low background plate and allowed to settle and dry (these samples have the label N in this report). This preparation is used to concentrate the fine (clay dominant) fraction and aids identification of the clays present. This means ratios of the clays and other phases present in this extract may vary from the bulk sample: the fine fraction result is qualitative. The air dried slides were further treated in an ethylene glycol atmosphere (60 °C) for several hours, then immediately re-examined. The ethylene glycol treated samples have the label G in this report.

Sample analysis

Step scanned X-ray diffraction patterns were collected for an hour per sample using a Bruker D8 Advance powder diffractometer and cobalt $\text{K}\alpha$ radiation operating in Bragg-Brentano geometry using the usual conditions. The collected data was analysed using JADE (V2010, Materials Data Inc.), EVA (V5, Bruker) and X'Pert Highscore Plus (V4, PANalytical) with various reference databases (PDF4+, AMCSD, COD) for phase identification. Rietveld refinement was performed using TOPAS (V6, Bruker). The known addition of corundum facilitates reporting of absolute phase abundances for the modelled phases. The sum of the absolute abundances is subtracted from 100 wt% to obtain a residual (called non-diffracting/unidentified, also known as “amorphous”). The residual represents the unexplained portion of the pattern: it may be non-diffracting content but will also contain unidentified phases and the error from poorly modelled phases. It is the least accurate measure as its error is the sum of the errors of the modelled phases. The estimated uncertainties in the reported phase abundances are 20 wt% relative or better for every modelled phase. Due to propagation of errors the uncertainty in the amorphous (non-diffracting/unidentified) content is higher at approximately 30 wt% relative. The detection limit using our method is approximately 0.5 – 1 wt% depending on the phase in question and sample matrix. In general, clay phases (e.g. kaolinite) have higher detection limits and more uncertainty than non-clay phases (e.g. quartz).

Powder X-ray diffraction is bulk phase analysis, it is not bulk chemical analysis or trace phase analysis. Phase abundances may be mis-estimated if an incorrect chemical formula is assigned to a phase. Therefore, the closest matches in the reference phase identification databases were used in the Rietveld refinement model, but other members of the identified mineral groups may be present.

Appendix E

MLA results.

Table A1. Modal mineralogy (wt. %) of Elverdton samples with all minerals detected by MLA.
Trace = <0.01 wt. % detected, BDL = below detection limit.

Mineral	ELV T2_03	ELV GS_01	ELV T3_06	ELV T3_08	ELV GS_06	ELV T6_03	ELV T7_04	ELV GS_10	ELV GS_23	ELV GS_26
Au-Ag minerals	BDL	BDL	BDL	BDL	BDL	Trace	BDL	BDL	BDL	BDL
Pyrite	0.02	Trace	0.02	0.02	0.04	2.65	4.43	0.02	Trace	Trace
Pyrrhotite	0.05	Trace	0.05	0.02	0.02	3.59	5.65	0.05	Trace	Trace
Chalcopyrite	0.04	0.22	0.02	0.03	0.06	0.66	0.80	0.01	Trace	Trace
Bornite	BDL	BDL	Trace	Trace	0.02	0.03	0.01	BDL	BDL	BDL
Covellite	Trace	BDL	Trace	0.01	BDL	0.01	Trace	BDL	BDL	BDL
Stannite	BDL	BDL	BDL	BDL	0.04	Trace	Trace	BDL	BDL	BDL
Tetrahedrite	Trace	BDL	Trace	0.01	0.45	0.01	Trace	BDL	BDL	BDL
Molybdenite	Trace	Trace	Trace	Trace	0.51	Trace	0.01	Trace	0.01	0.01
Galena	BDL	Trace	Trace	Trace	Trace	Trace	BDL	BDL	BDL	BDL
Sphalerite	Trace	BDL	Trace	BDL	BDL	0.01	BDL	BDL	BDL	BDL
Arsenopyrite	BDL	BDL	BDL	BDL	0.01	BDL	BDL	BDL	BDL	BDL
Cobaltite	BDL	BDL	BDL	BDL	BDL	Trace	Trace	BDL	BDL	BDL
Iron oxide	0.36	2.49	0.45	0.37	0.71	0.09	0.18	4.36	2.07	0.69
Rutile	0.09	0.04	0.03	0.07	0.06	0.19	0.21	0.05	0.04	0.13
Ilmenite	0.02	0.21	0.13	0.02	0.11	0.03	Trace	0.15	0.19	0.12
Quartz	17.72	26.13	18.28	19.39	22.80	34.40	40.15	26.43	38.24	28.27
Plagioclase	6.19	22.33	14.36	5.85	11.82	1.79	2.61	11.01	19.27	16.16
Orthoclase	0.93	0.83	0.81	0.87	0.62	0.36	0.67	1.24	0.88	1.58
Augite	0.84	1.84	2.59	0.56	2.72	0.08	0.15	0.47	7.83	1.81
Hornblende	0.93	6.67	6.98	1.21	4.23	0.63	0.62	18.12	4.64	10.56
Garnet	0.25	0.48	0.69	0.19	0.68	0.33	0.89	0.37	1.77	0.40
Calcite	BDL	Trace	Trace	Trace	BDL	0.16	0.86	Trace	Trace	BDL
Dolomite	BDL	BDL	Trace	BDL	Trace	0.36	0.53	Trace	Trace	Trace
Ankerite	BDL	Trace	Trace	Trace	BDL	0.17	0.53	Trace	0.01	Trace
Titanite	0.03	Trace	0.04	0.02	0.06	0.05	0.05	0.01	0.06	0.02
Chlorite-Fe	1.85	4.14	1.91	2.20	1.34	12.17	17.73	2.50	3.70	3.82
Clinocllore	24.29	1.84	6.47	23.84	4.94	3.23	3.99	4.41	4.95	10.89
Chlorite	31.88	10.30	33.13	28.63	3.57	14.31	10.76	4.28	5.94	12.41
Biotite	6.89	0.08	3.15	9.36	1.87	3.87	2.06	0.17	2.91	2.97
Muscovite	3.19	2.41	2.51	3.78	1.59	10.48	4.61	1.20	3.40	1.95
Talc	Trace	0.01	Trace	0.01	0.04	0.01	0.03	Trace	0.01	Trace
Kaolinite	2.72	1.19	7.39	1.71	0.73	6.67	0.78	0.45	0.97	0.69
Jarosite	0.02	13.56	0.02	0.03	0.20	0.80	0.27	8.64	0.01	5.59
Schwertmannite	0.02	2.32	Trace	Trace	0.08	0.04	0.03	8.85	0.01	0.28
Gypsum	Trace	BDL	Trace	Trace	2.81	0.65	0.06	BDL	0.25	Trace
Alunite	Trace	Trace	Trace	Trace	0.08	0.22	0.02	BDL	Trace	0.53
Monazite	0.02	Trace	0.01	0.02	0.01	0.01	Trace	0.01	0.03	0.01
Barite	Trace	BDL	Trace	Trace	BDL	Trace	Trace	BDL	Trace	BDL
Fluorite	BDL	Trace	Trace	Trace	Trace	0.10	0.45	Trace	0.02	Trace
Apatite	0.14	0.02	0.11	0.14	0.29	0.04	0.07	BDL	0.88	0.10
Goethite	1.26	2.63	0.68	1.27	0.53	1.26	0.52	7.01	0.53	0.59
Chromite	Trace	Trace	Trace	0.01	0.02	0.01	0.01	Trace	Trace	0.01
NaCl	Trace	BDL	BDL	BDL	0.63	BDL	Trace	BDL	0.03	0.03
Na-Mg sulphate	BDL	BDL	BDL	Trace	19.85	Trace	0.01	BDL	0.03	Trace
Mg sulphate	BDL	BDL	BDL	0.01	13.58	BDL	BDL	BDL	0.27	Trace



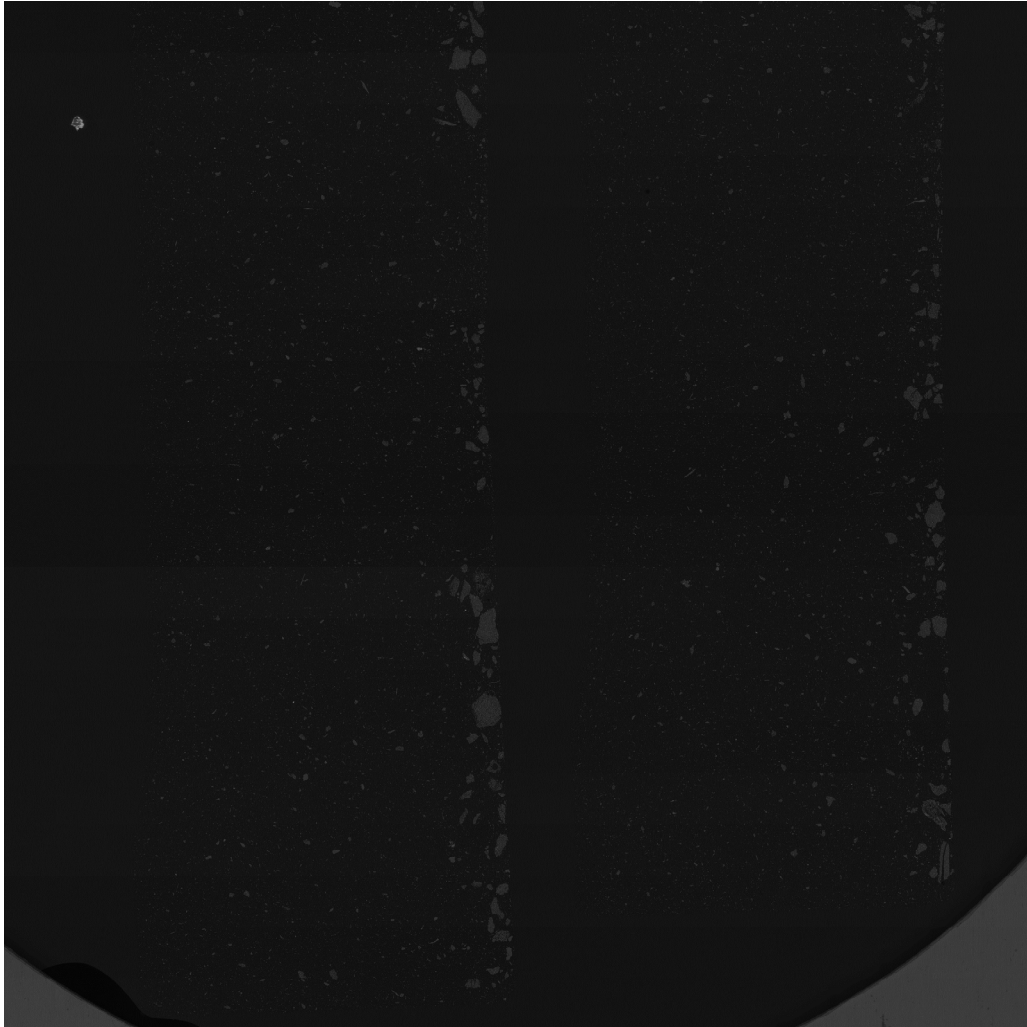
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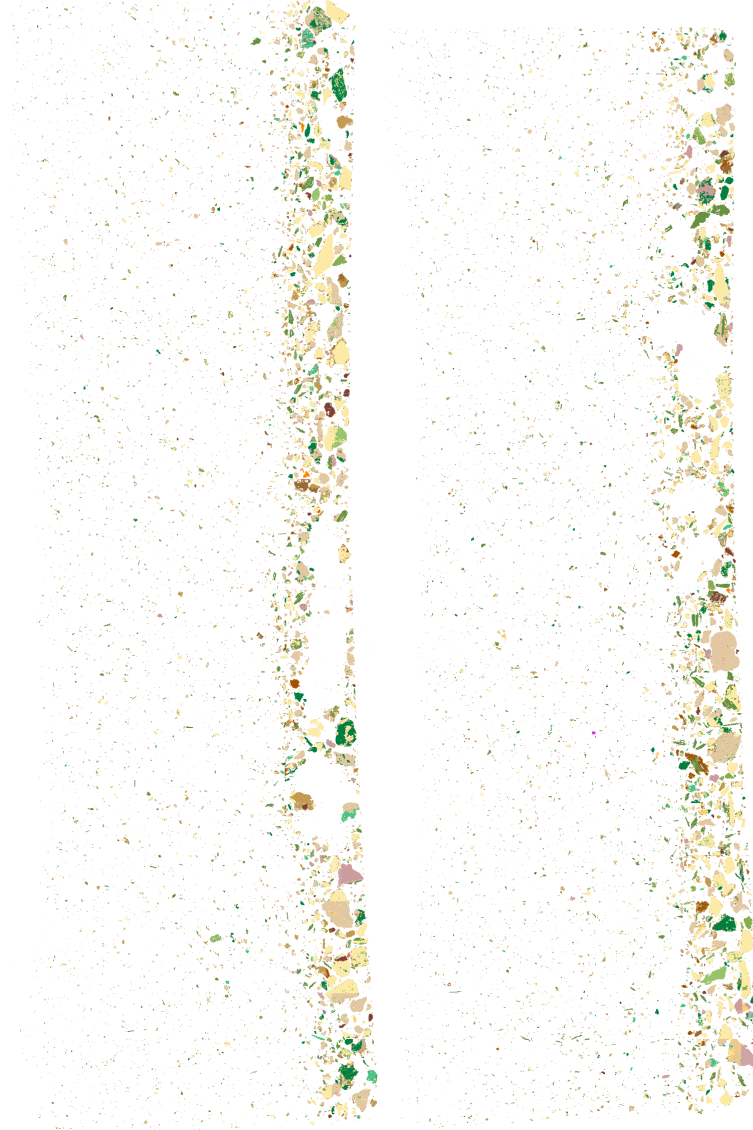
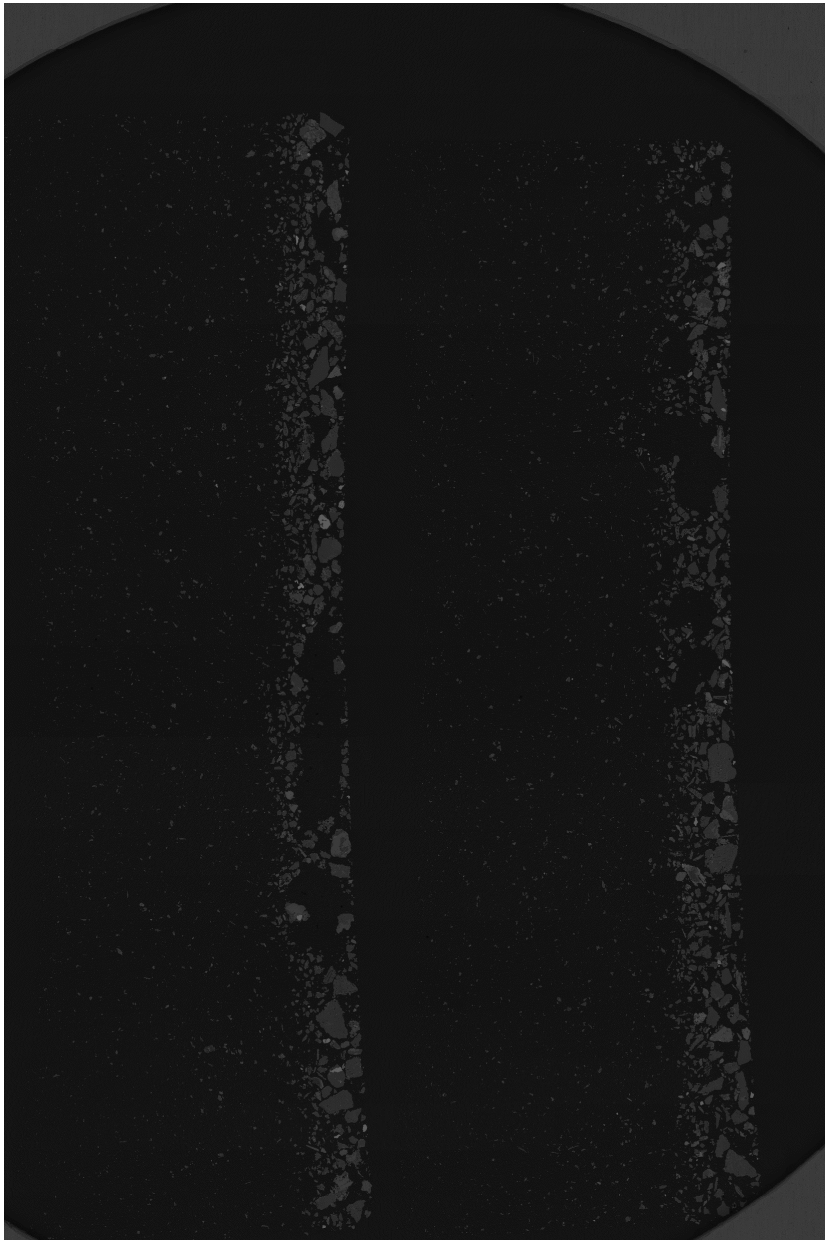
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Elverdton MLA Images

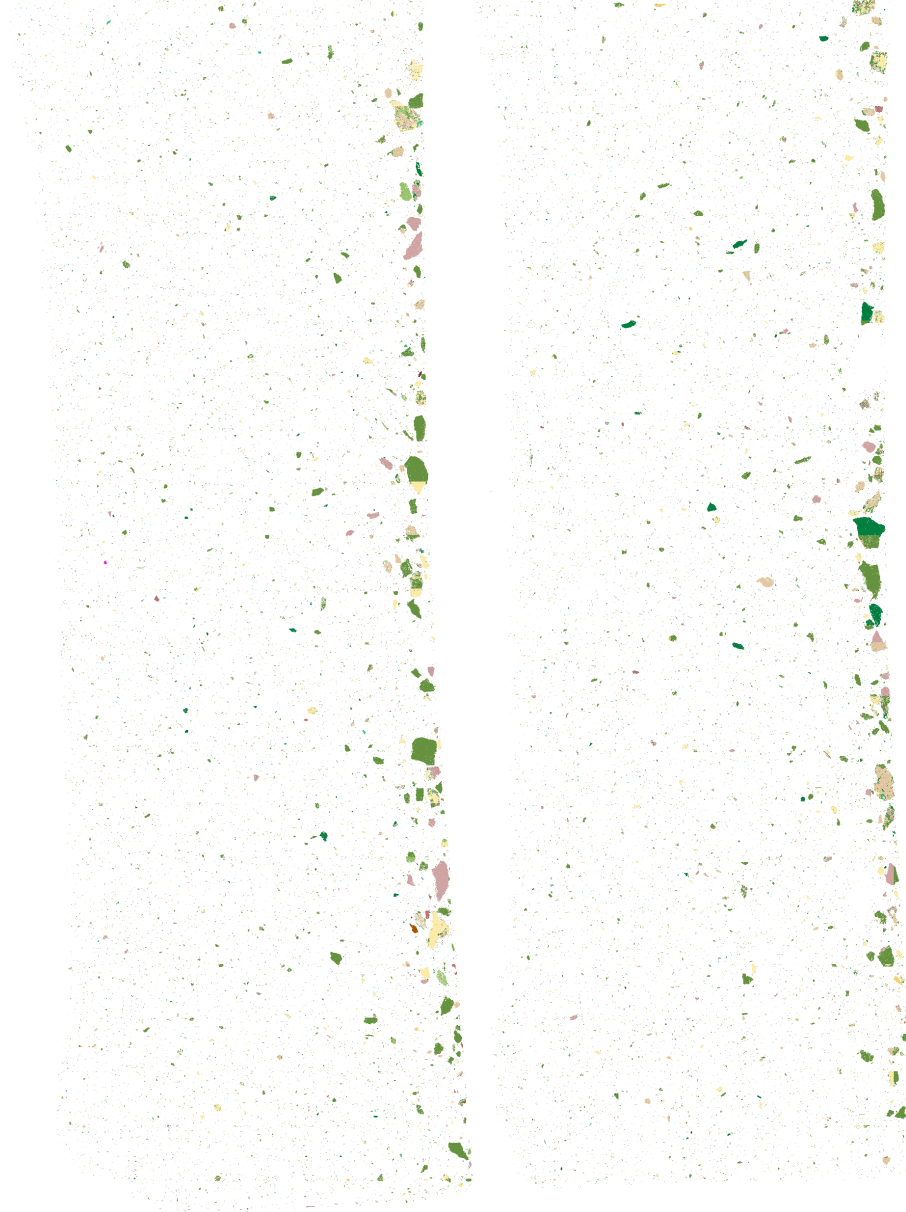
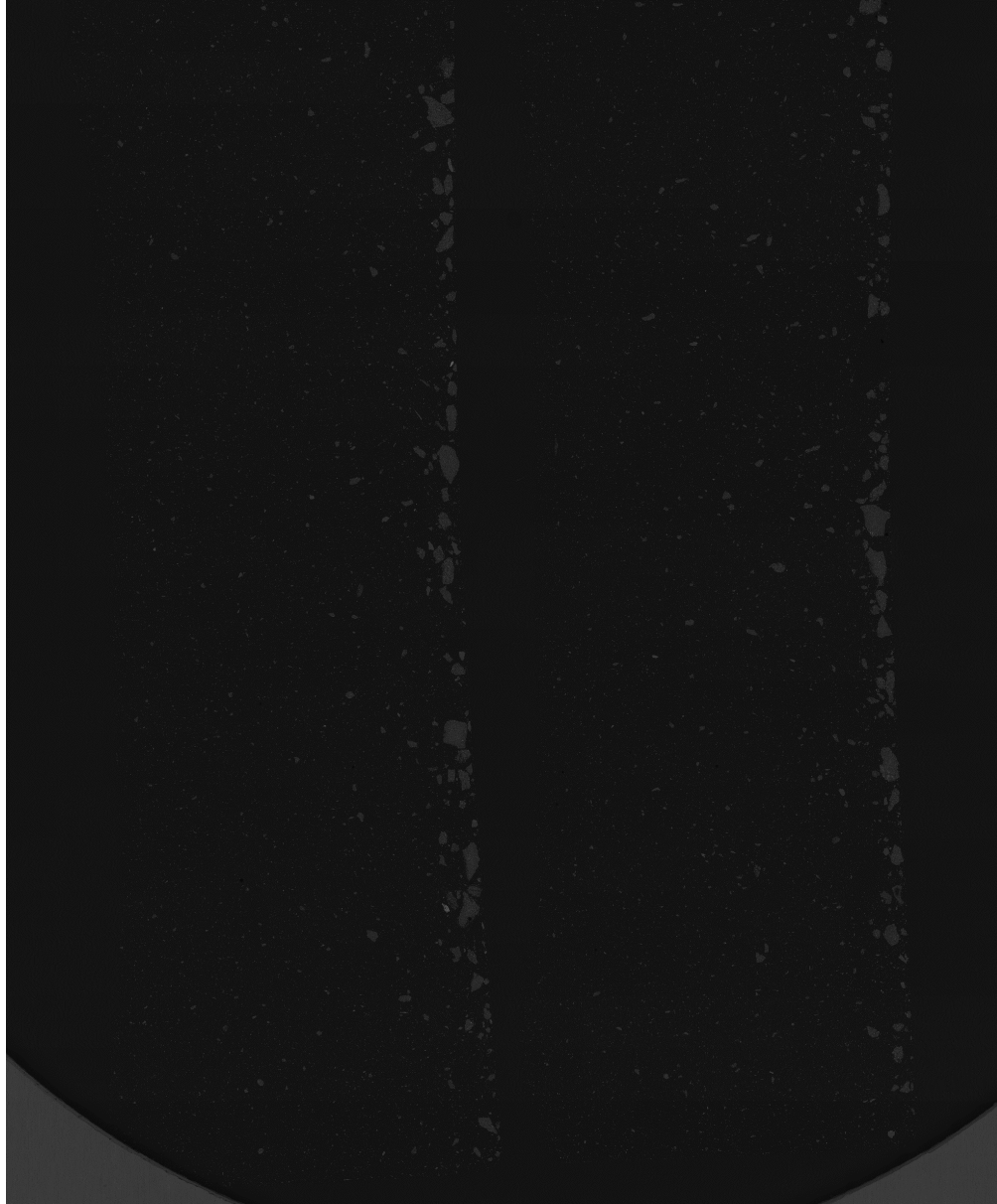
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- Pyrrhotite
- Chalcopyrite
- Bornite
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- Stannite
- Tetrahedrite
- Molybdenite
- Galena
- Sphalerite
- Arsenopyrite
- Cobaltite
- FeOxide
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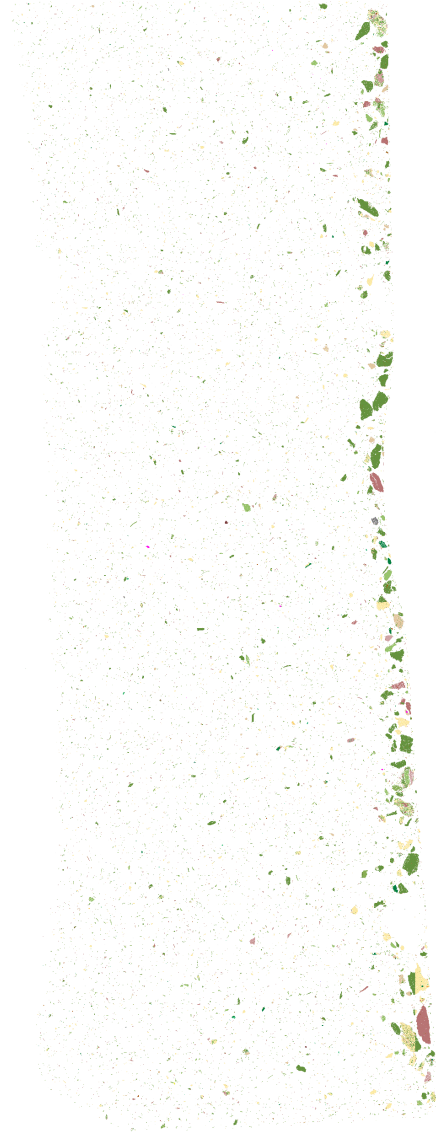
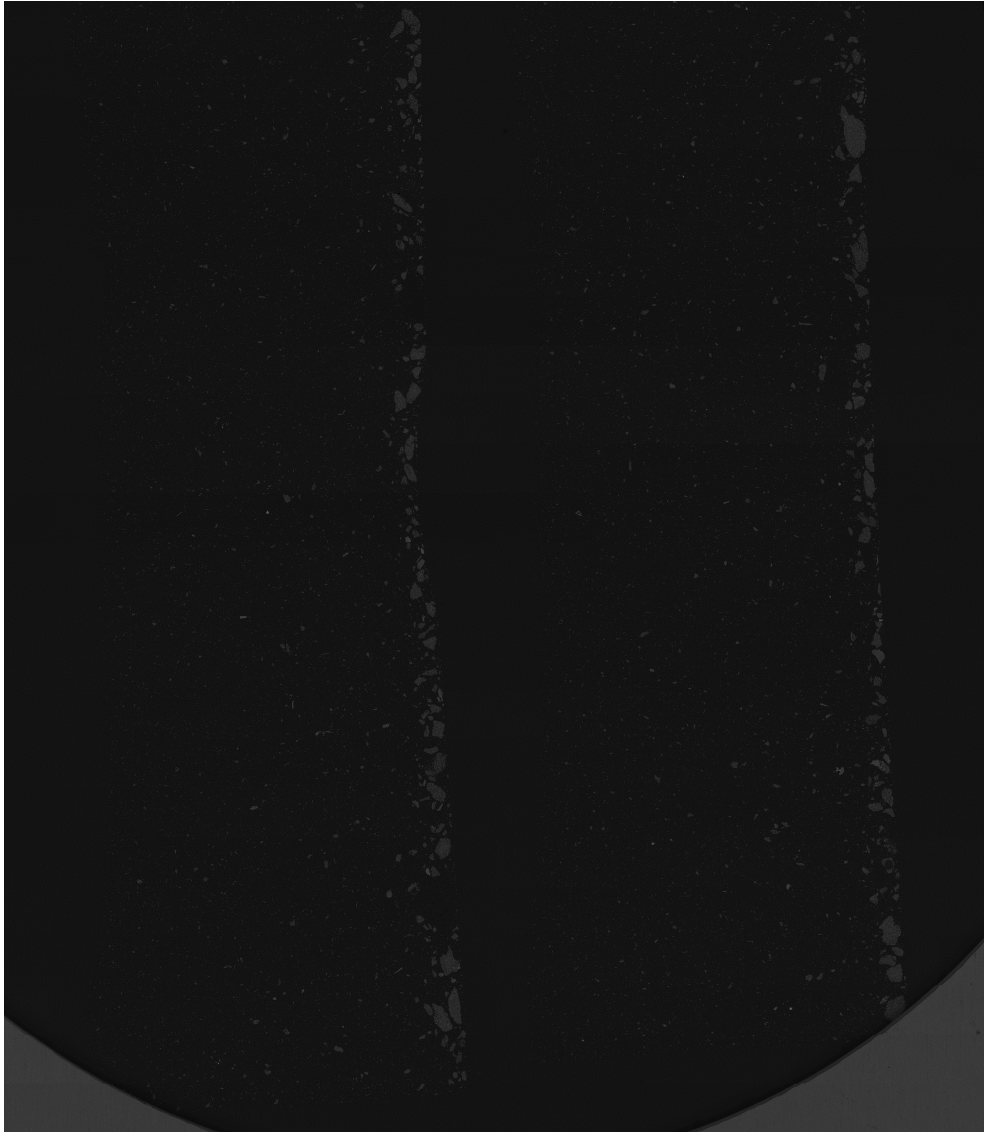




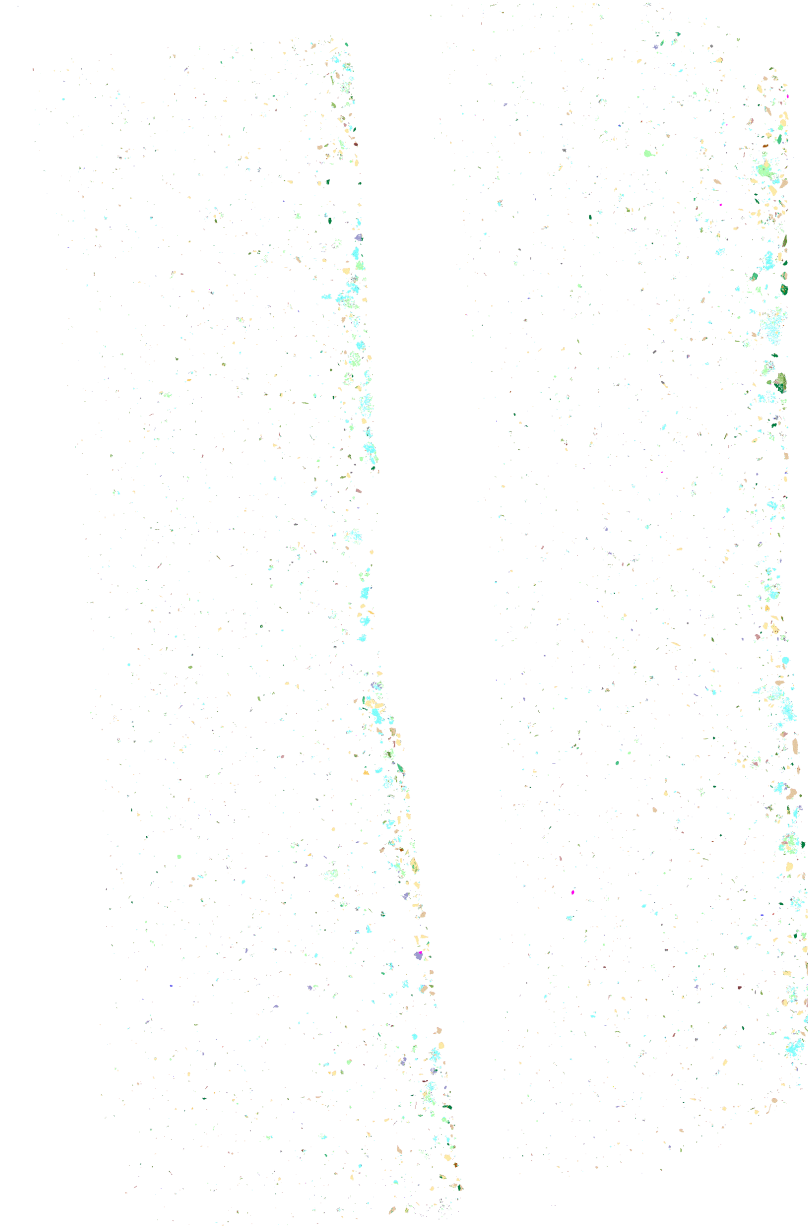
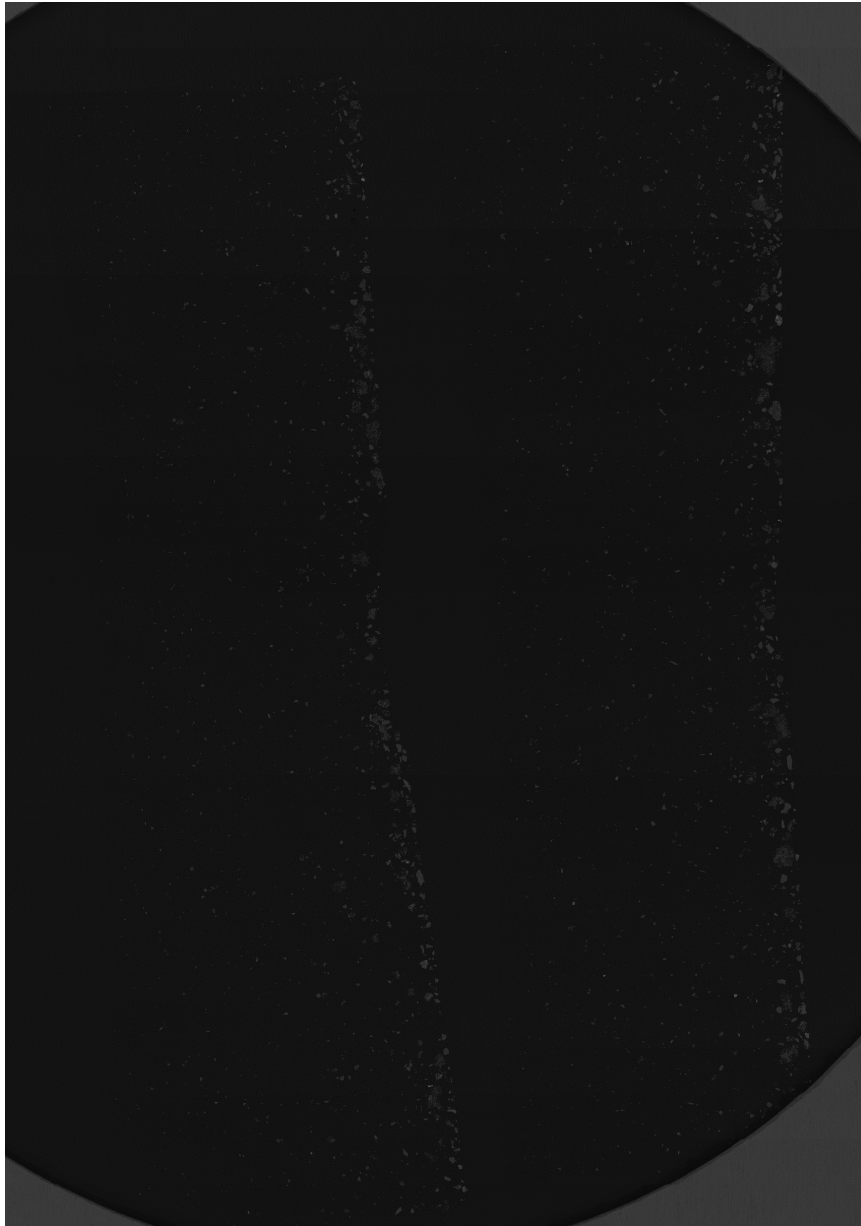
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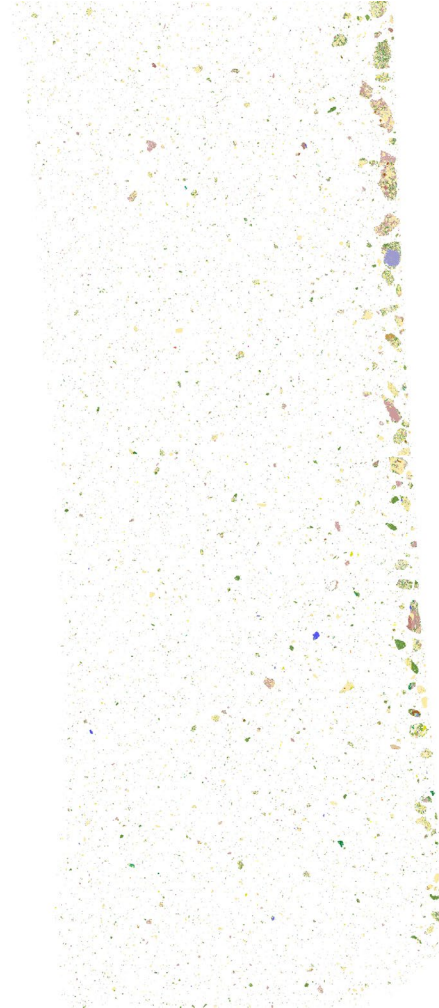
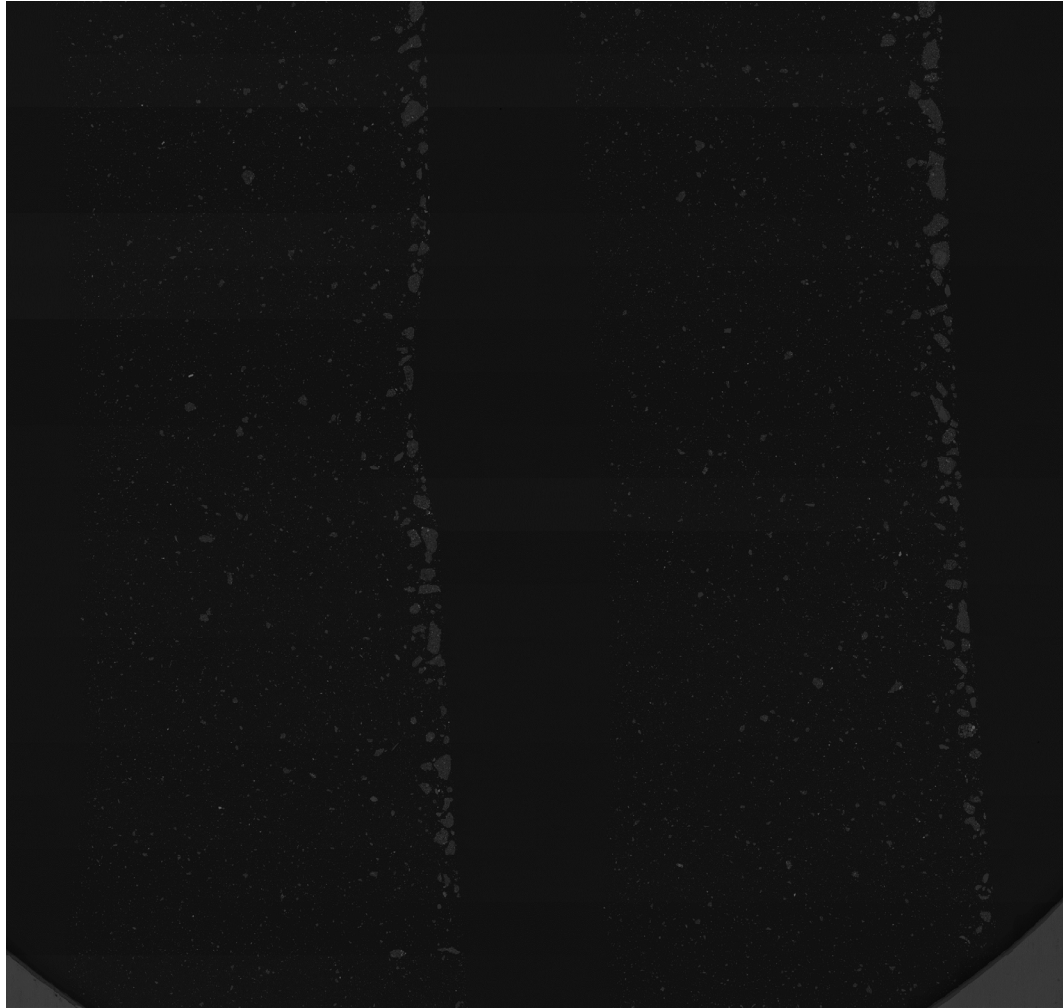


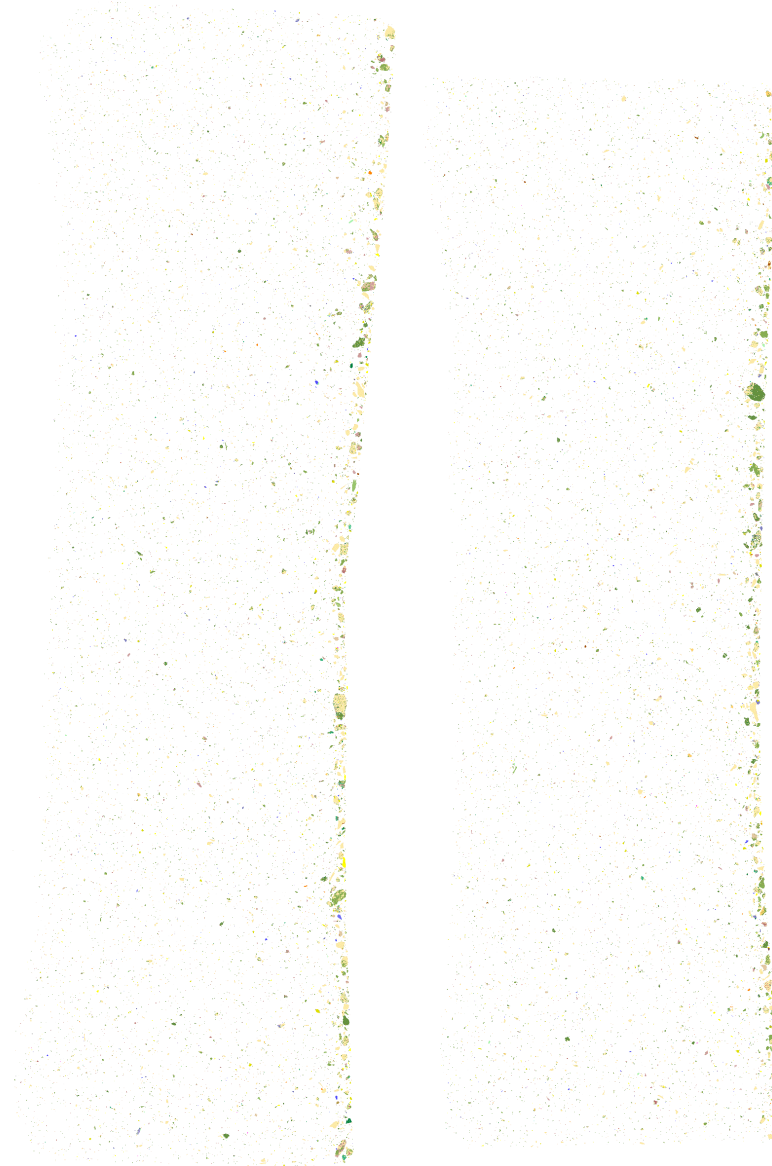
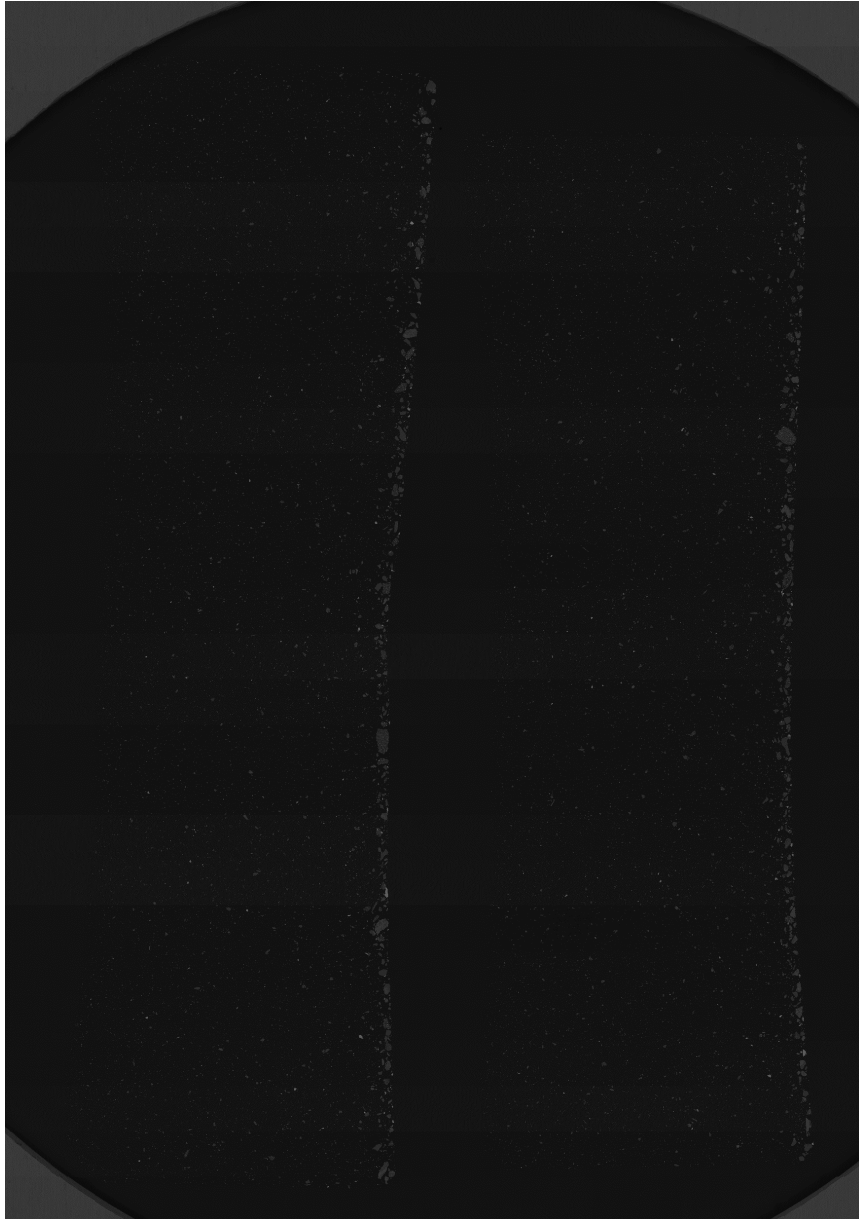
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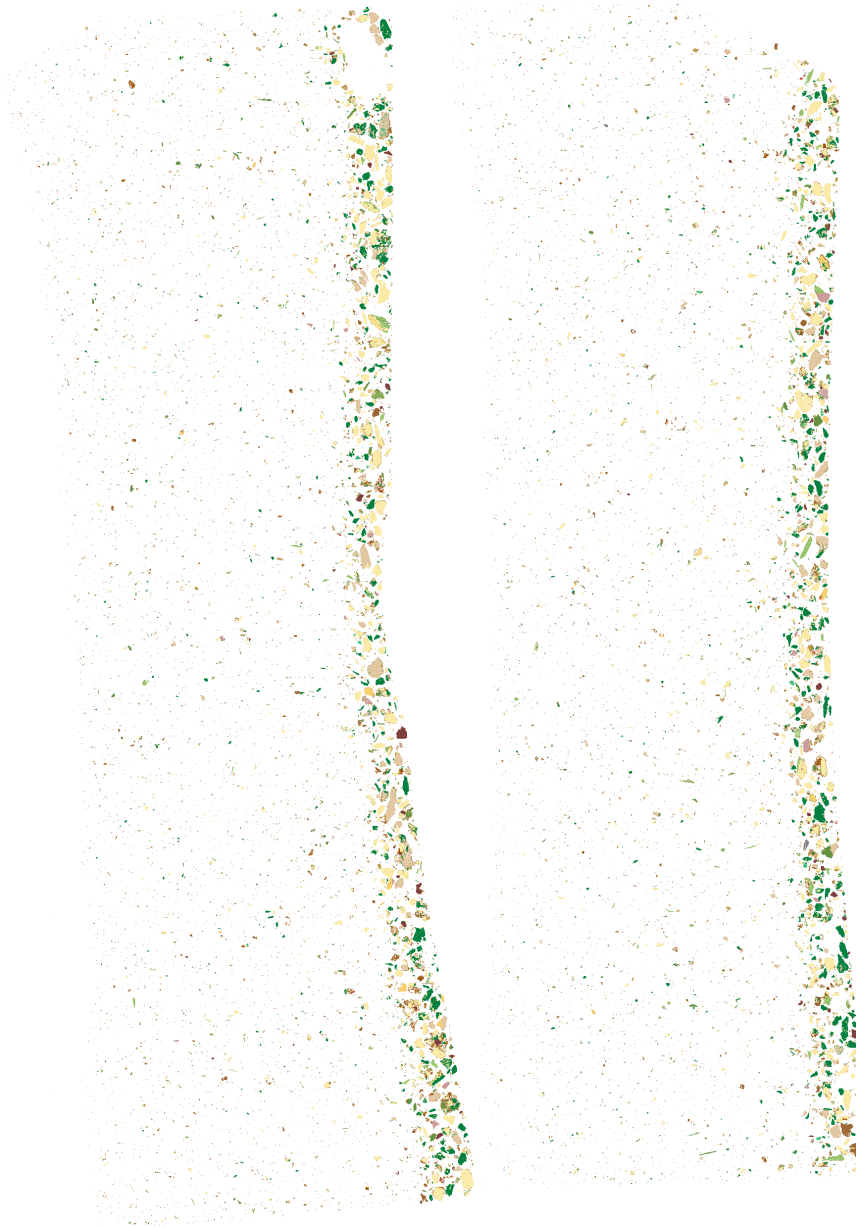
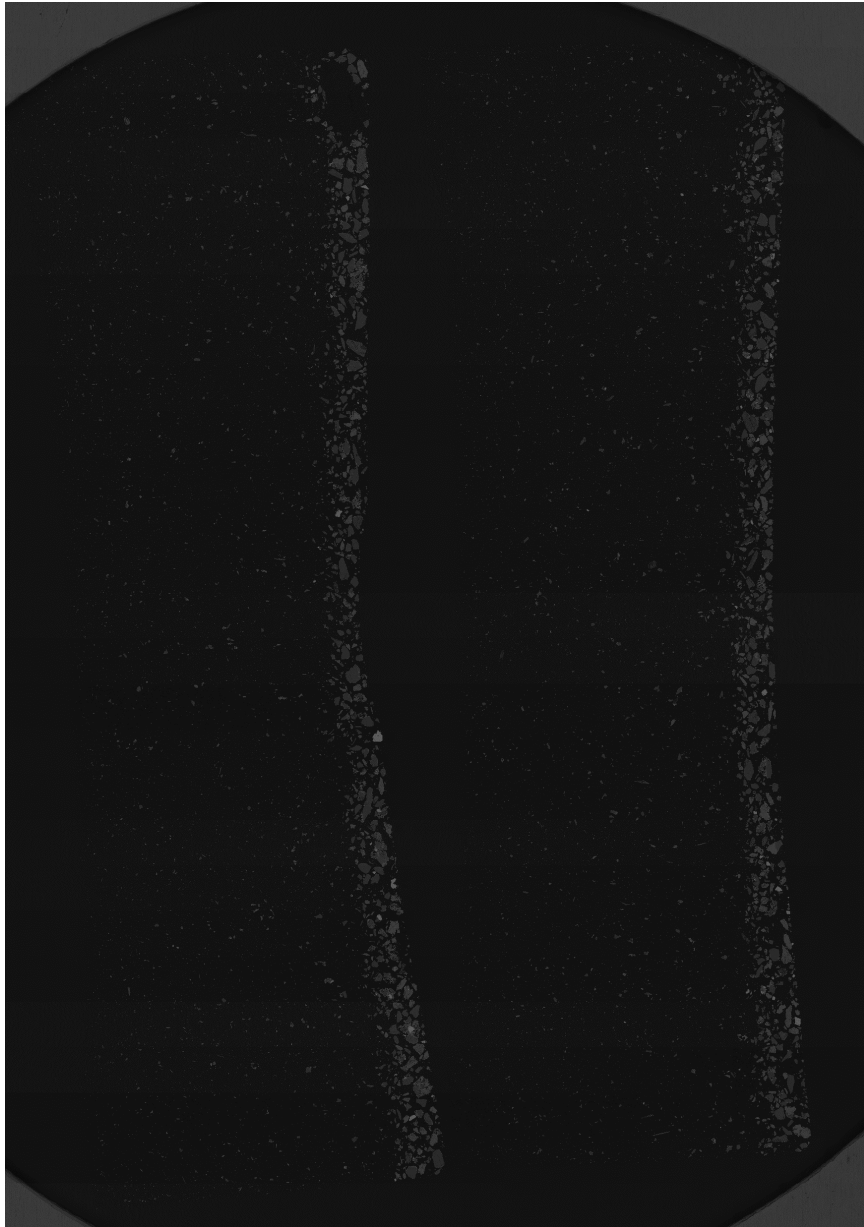
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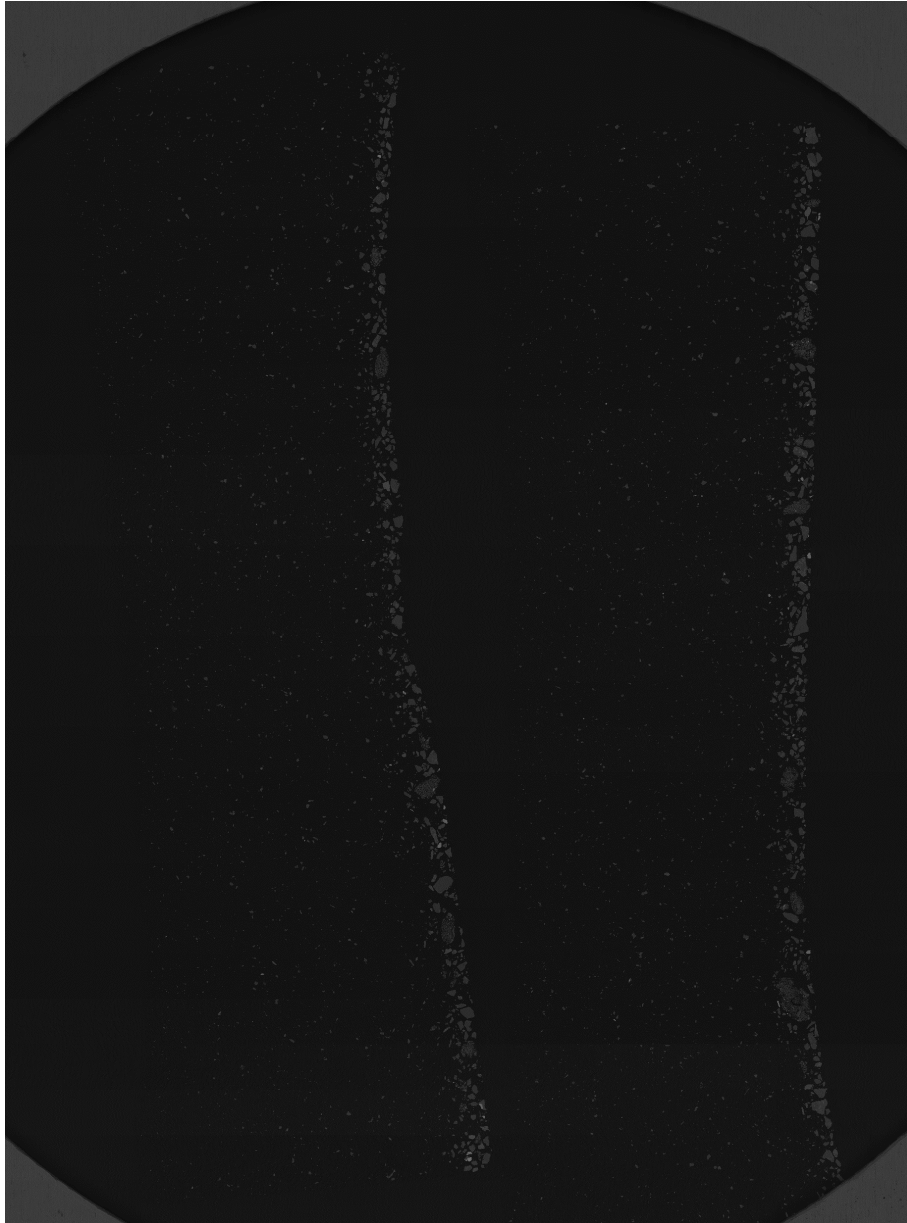




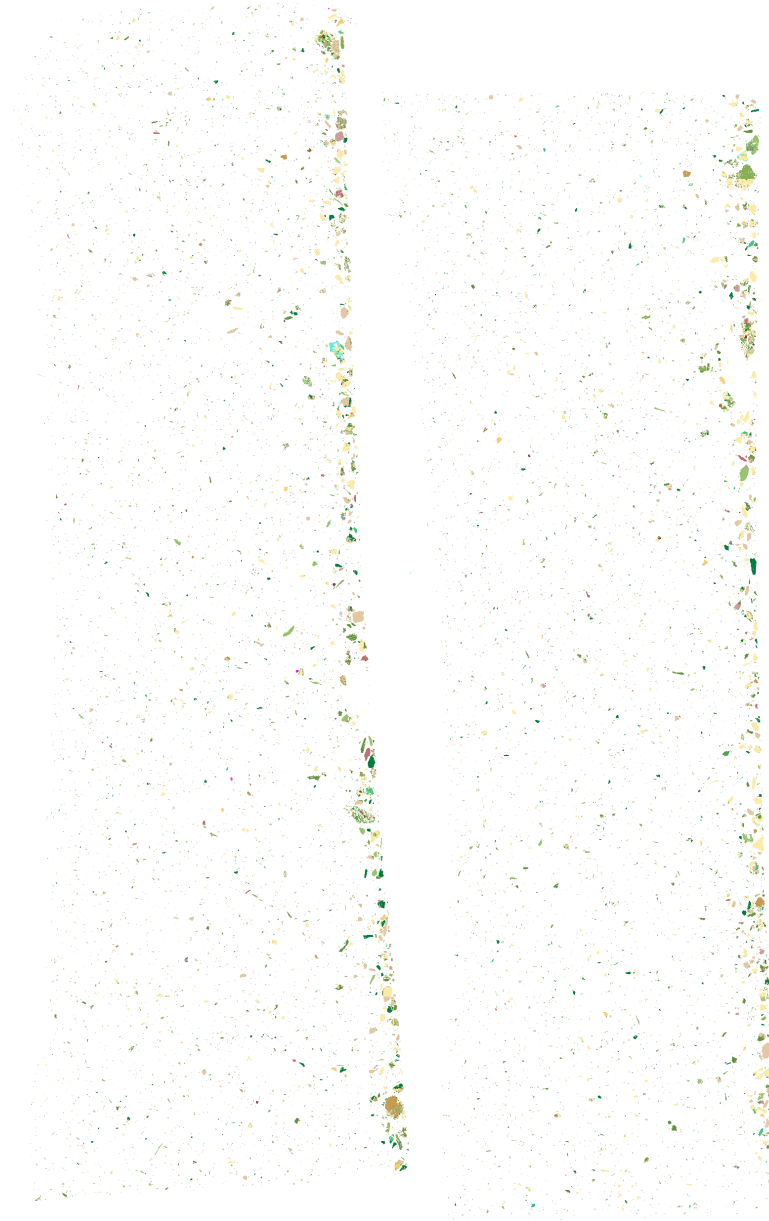
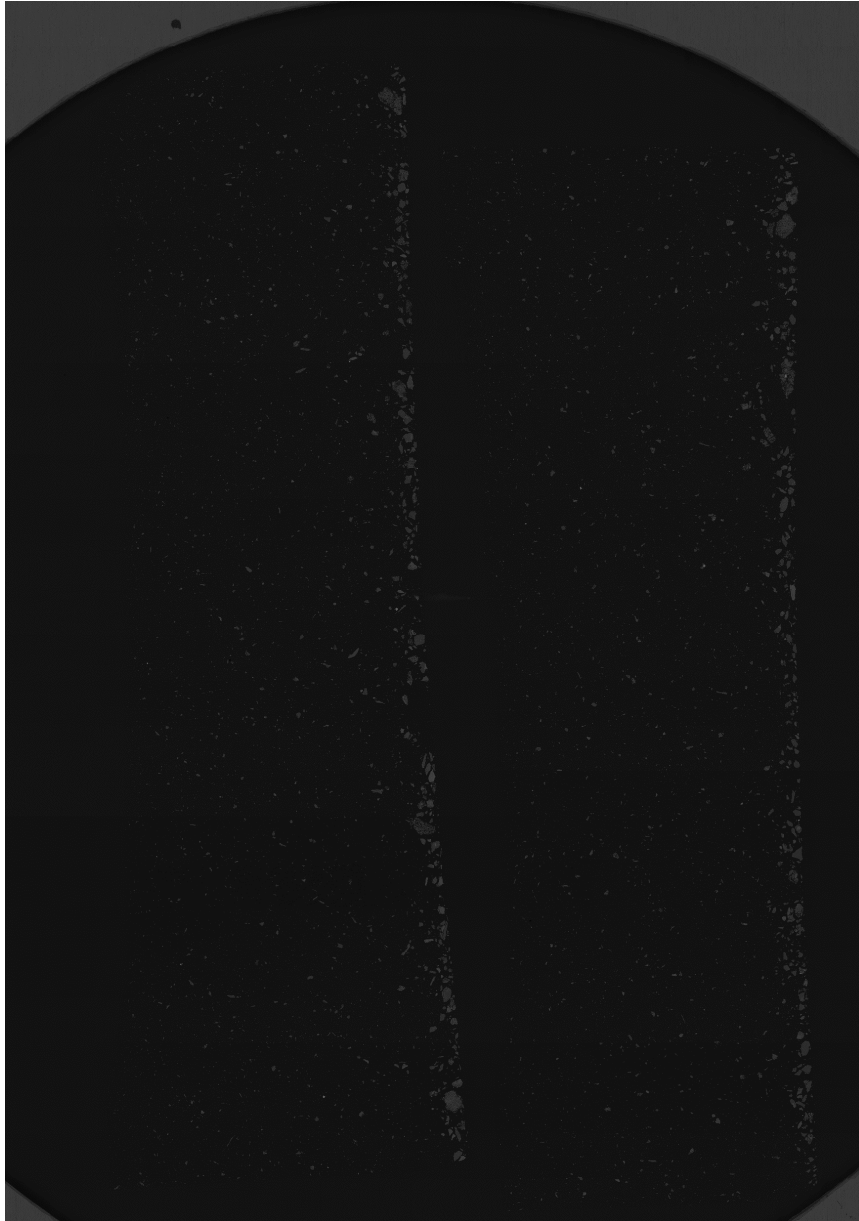
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- Chromite
- NaCl
- NaMg-sulfate
- Mg-sulfate
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Appendix F

LA-ICP-MS maps.



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Elverdton LA-ICP-MS Images

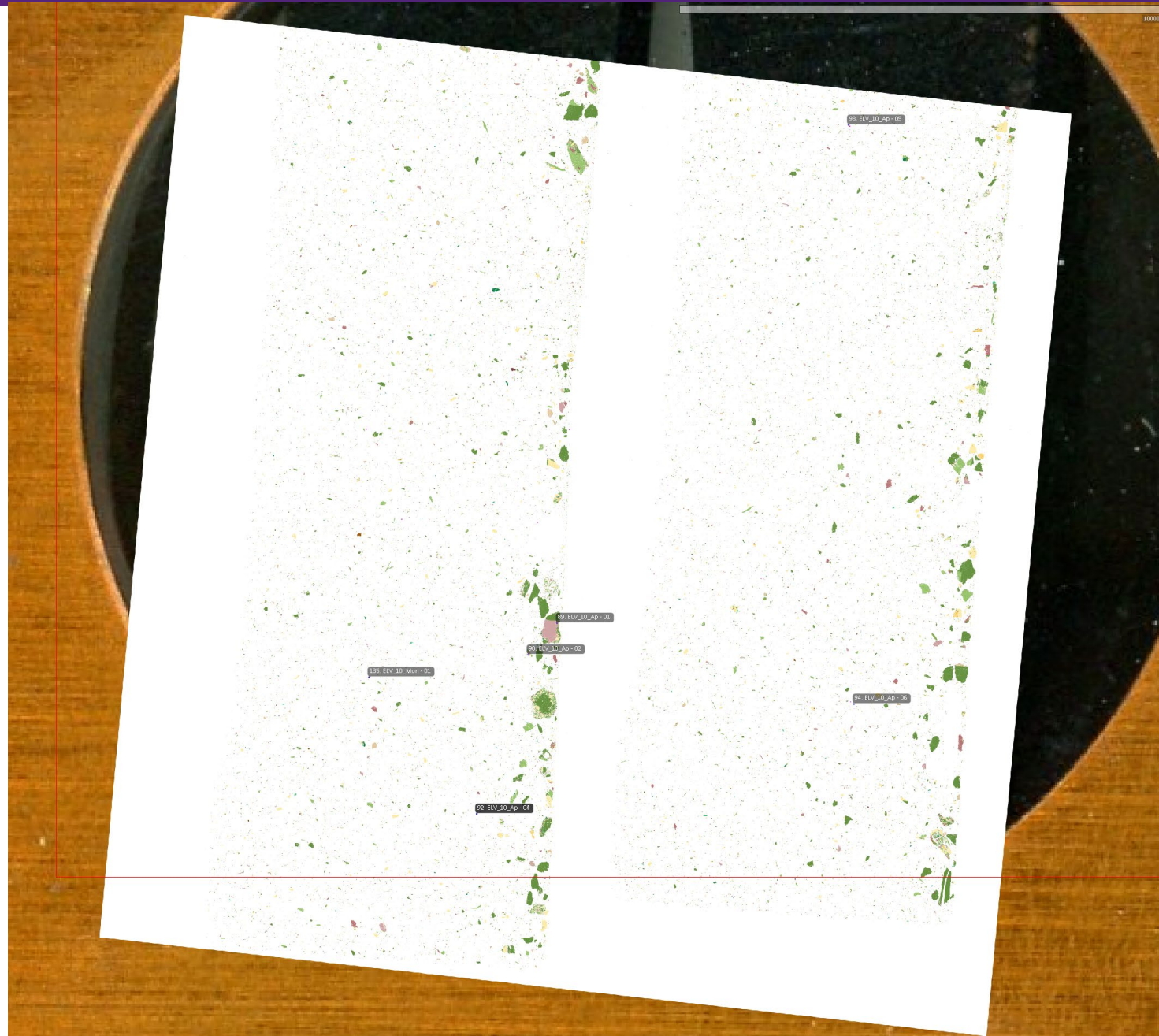
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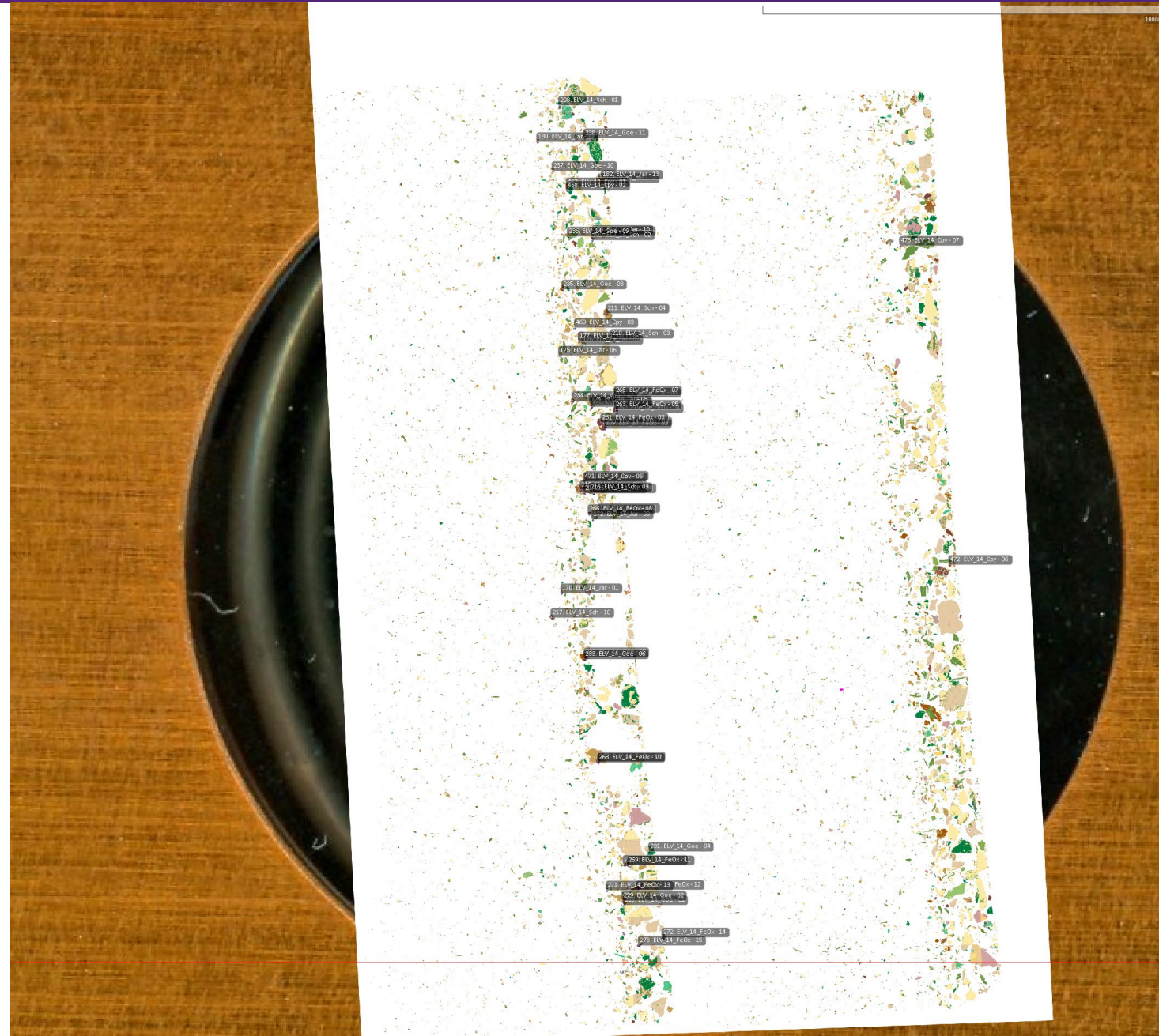


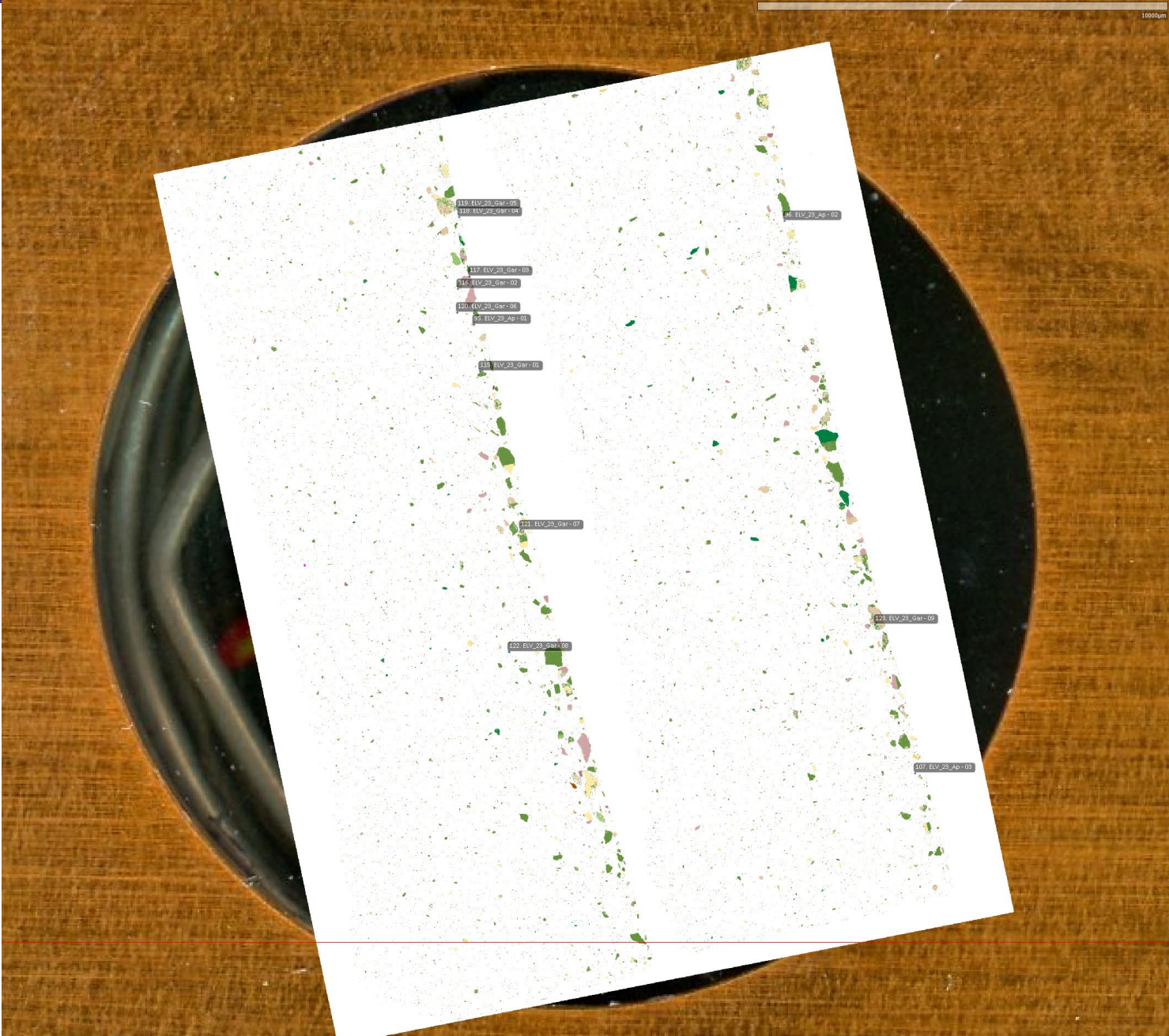
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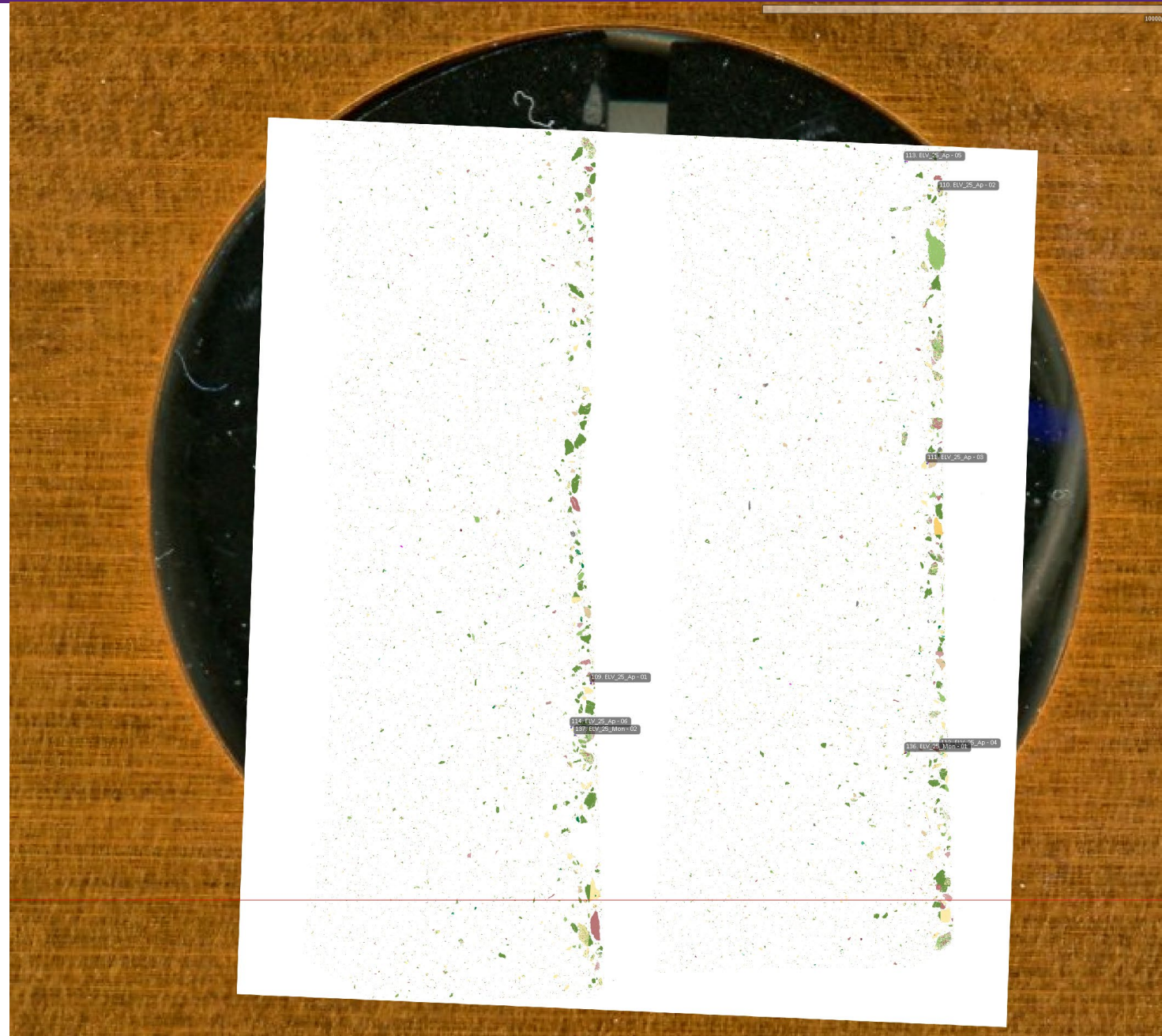
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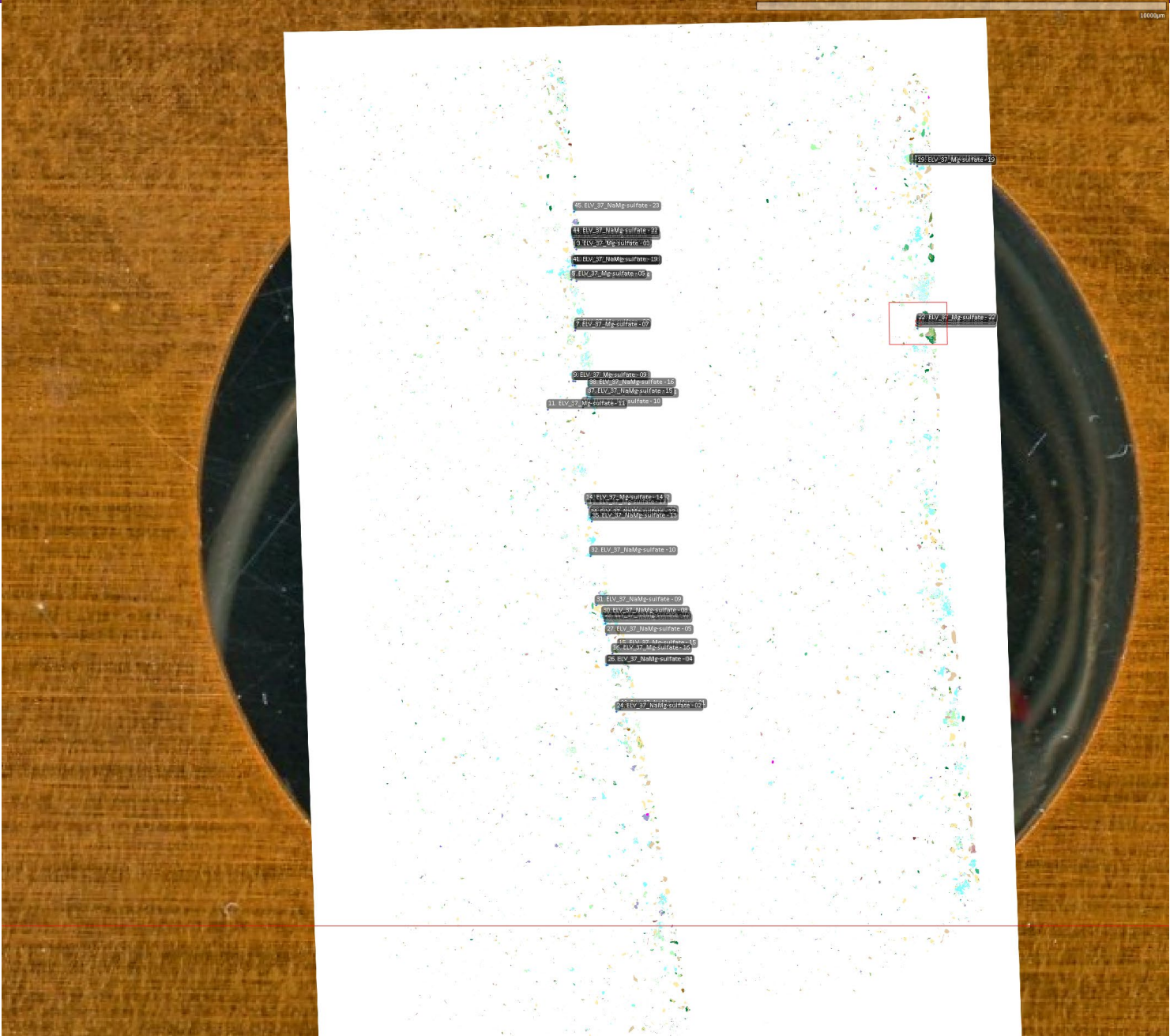
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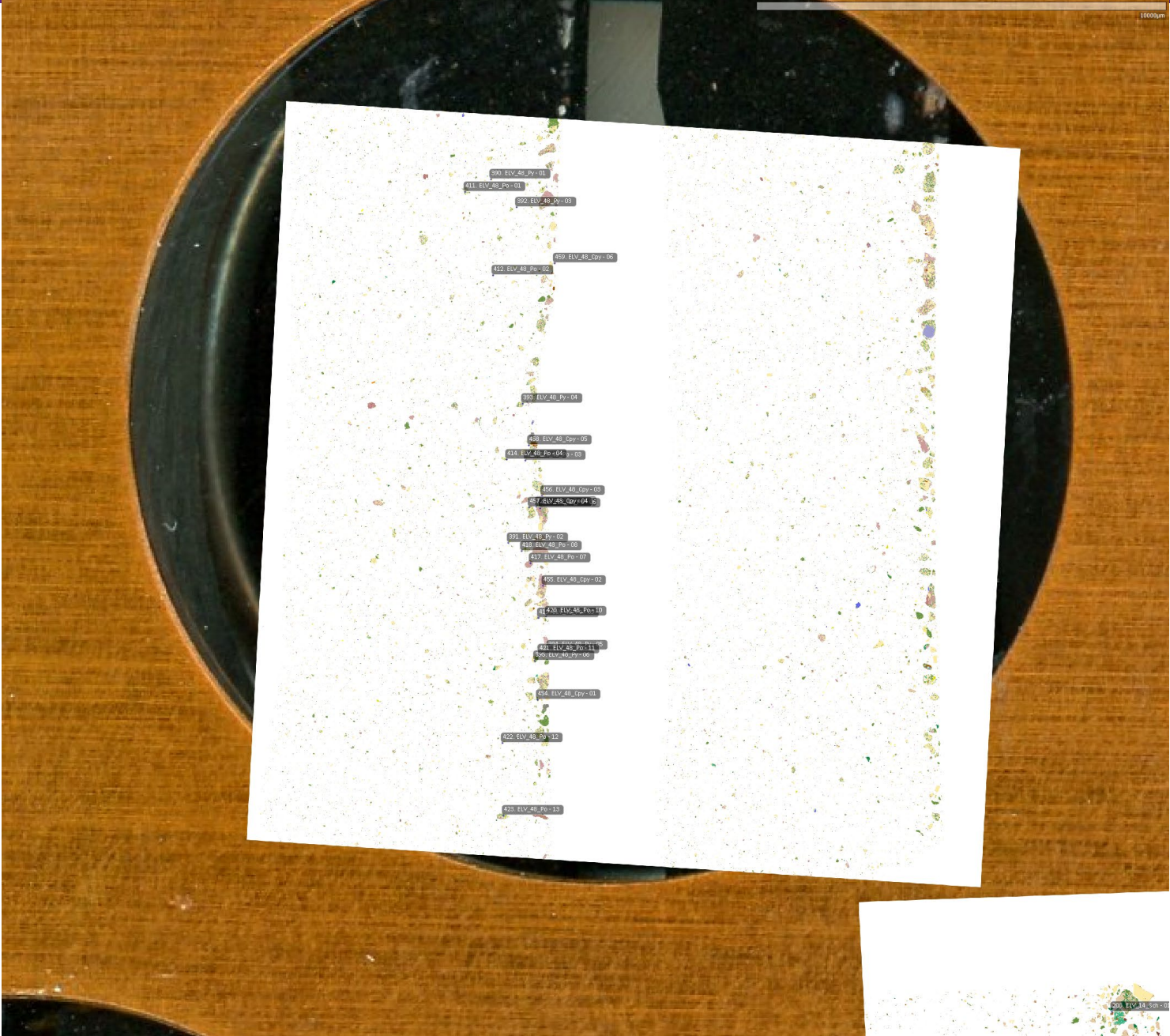


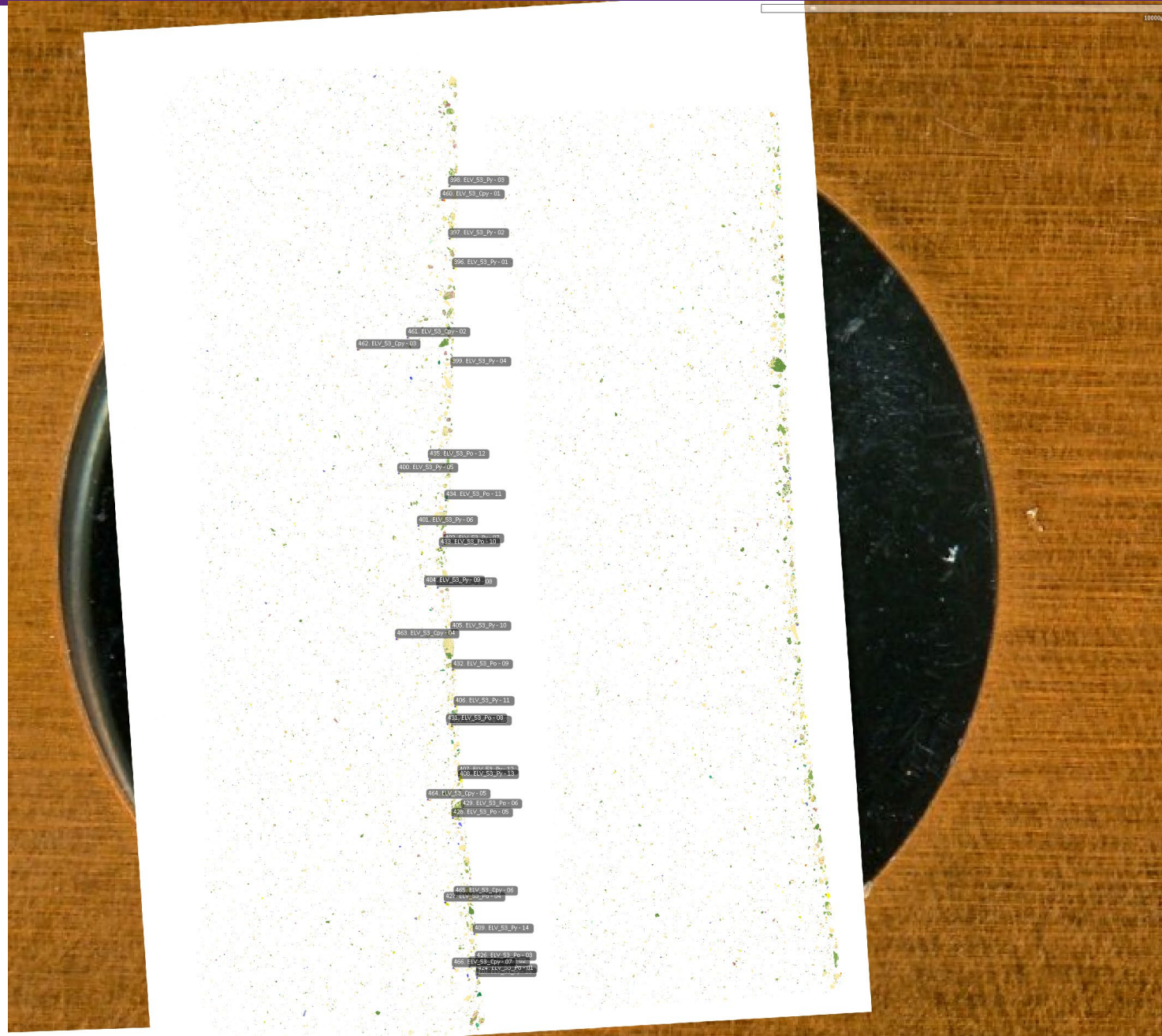




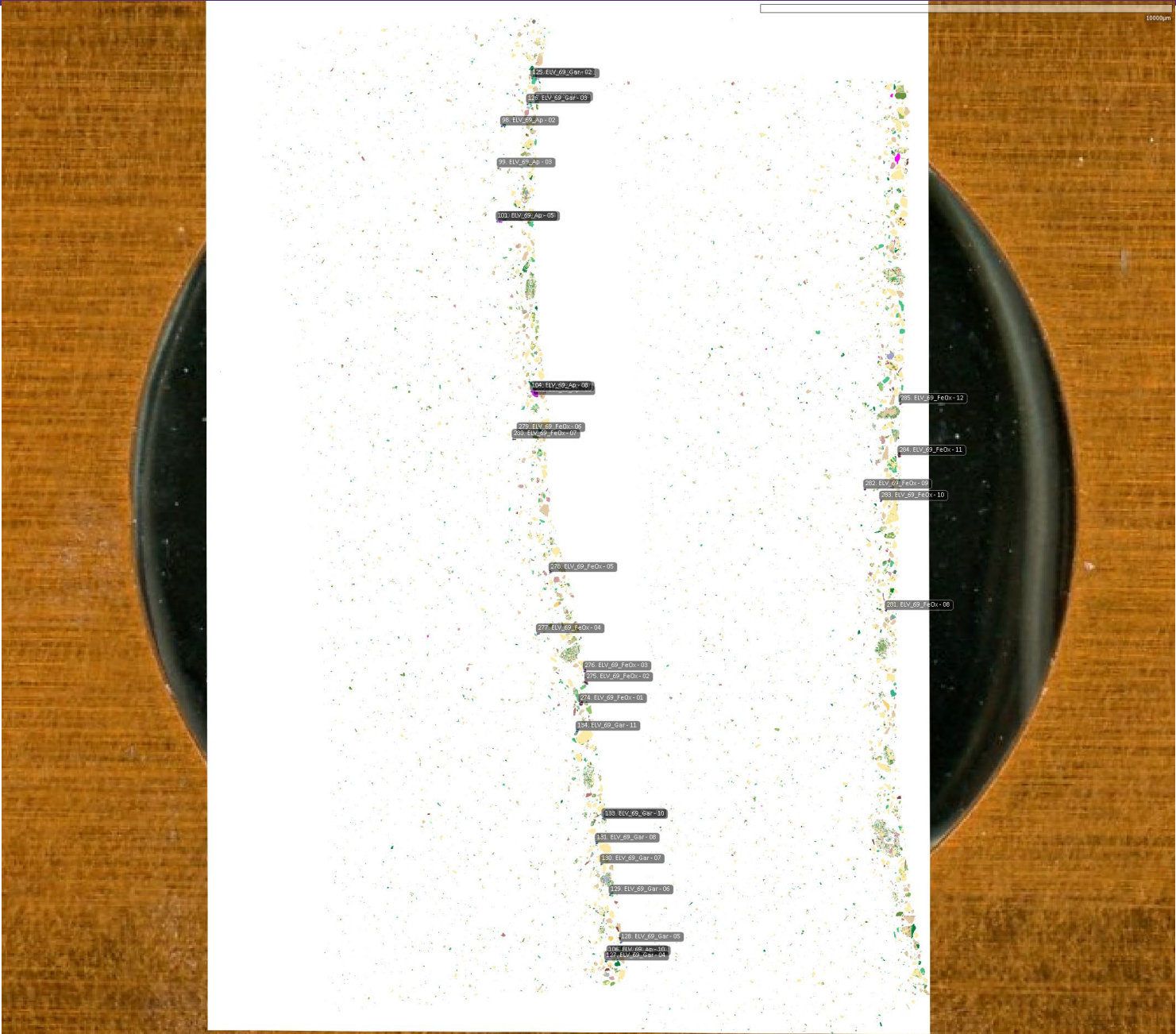


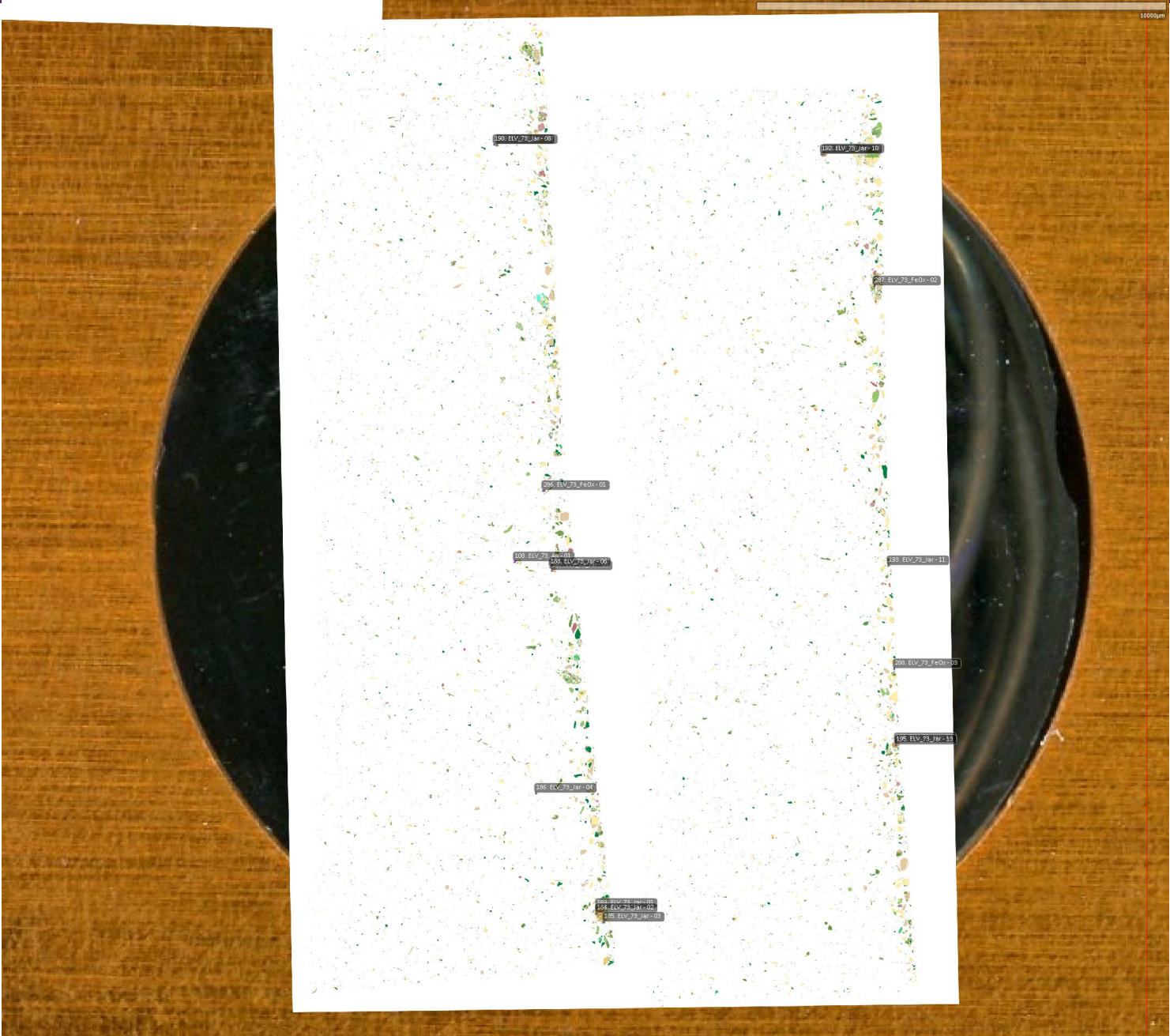










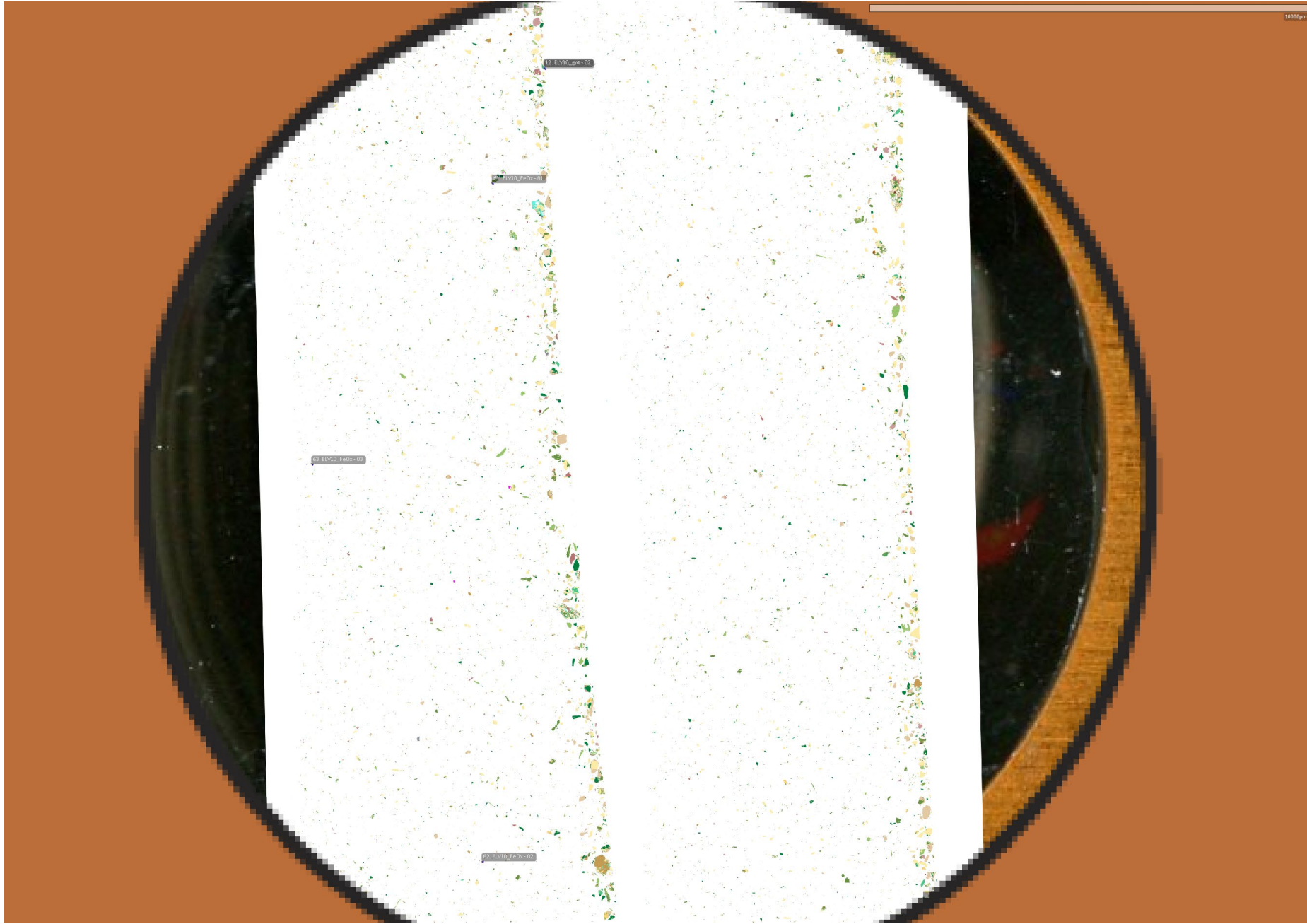


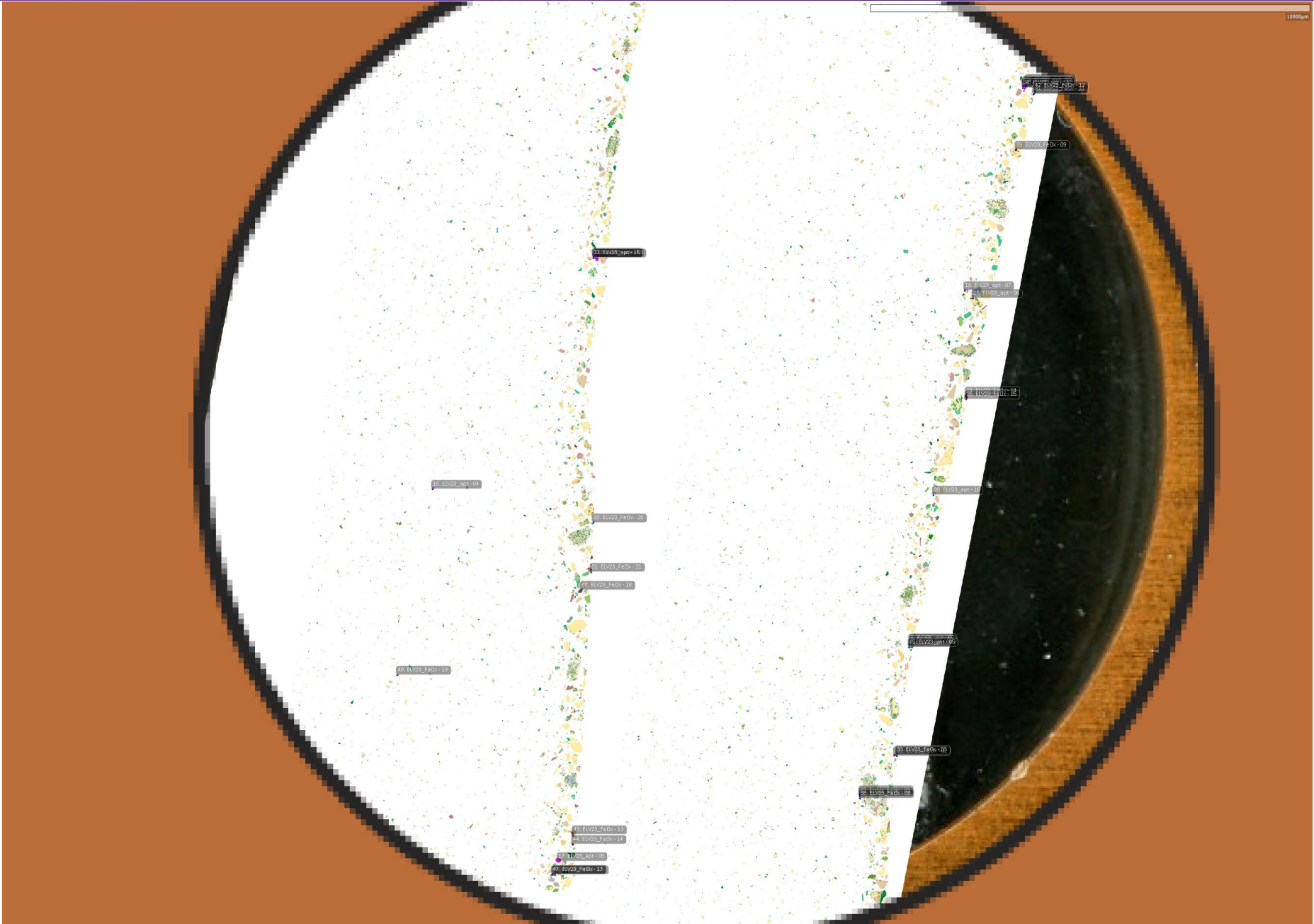


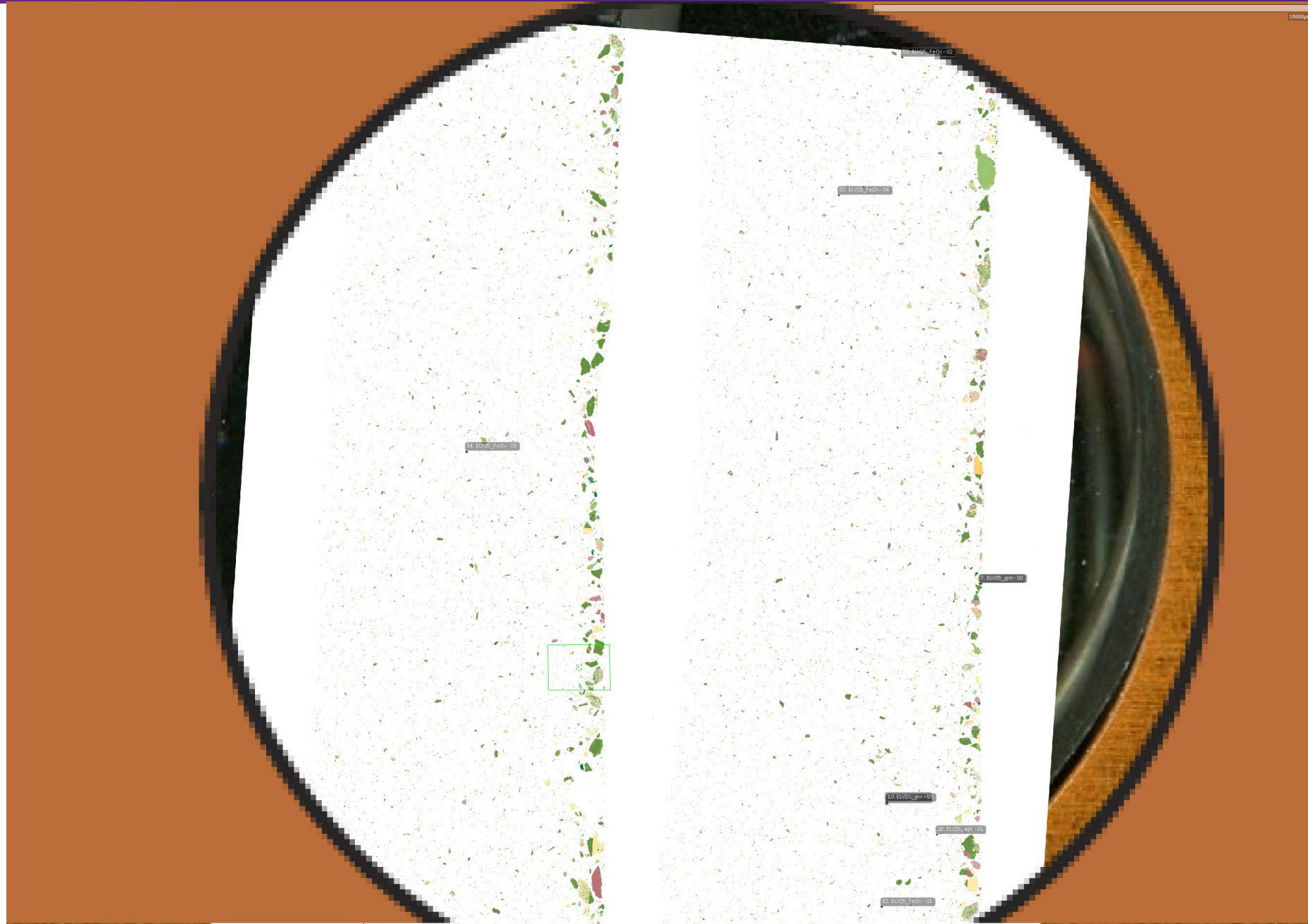
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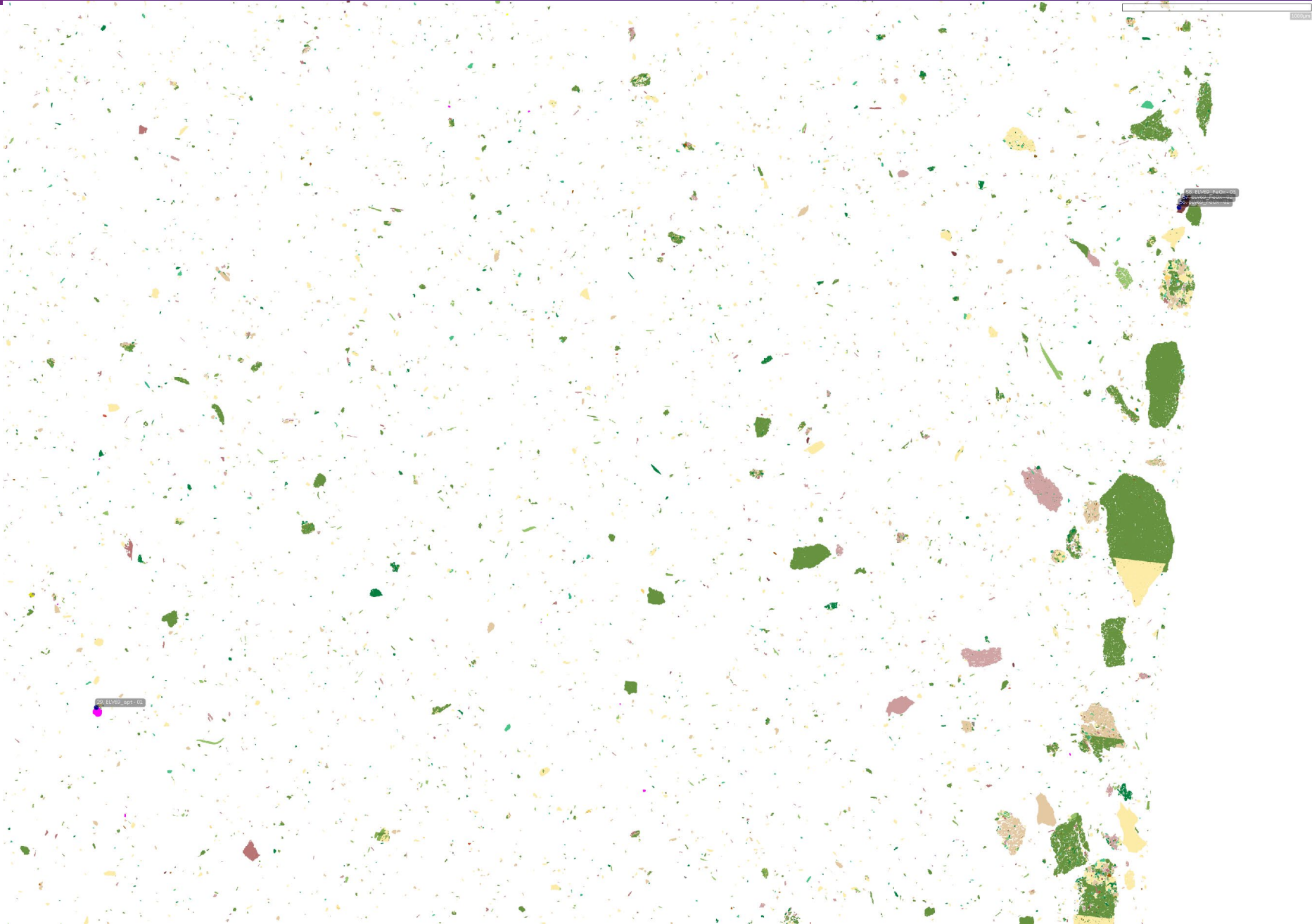
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Garnet, apatite and iron oxide measurements for REEs











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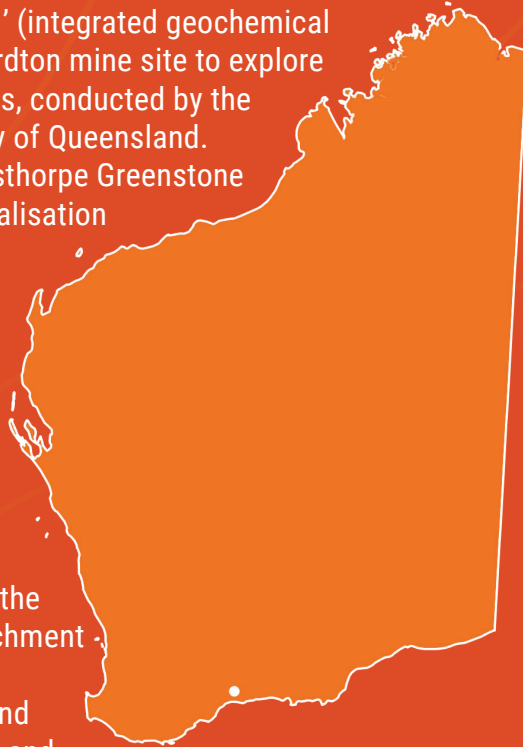
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REPORT 258

MINE WASTE SAMPLING AND CHARACTERISATION IN WESTERN AUSTRALIA: ELVERDTON TAILINGS

MIWATCH, SUSTAINABLE MINERALS INSTITUTE

This Report presents the results of a 'stream 1' (integrated geochemical and mineralogical) study at the historical Elverdton mine site to explore for critical metal endowment of mined residues, conducted by the Sustainable Minerals Institute at the University of Queensland. The Elverdton site is located within the Ravensthorpe Greenstone Belt in the southern Yilgarn Craton, with mineralisation hosted in copper-bearing quartz veins in a north-trending shear zone. The Elverdton deposit was mined for copper, silver and gold between 1957 and 1971, and the processing of ore from nearby Kundip took place from 1988 to 1992. The tailings from these periods were deposited on site in two tailings storage facilities (TSFs), which are uncontained and subject to erosion. Sampling of the two TSFs, the tailings fan, hardpans and salt forming on the tailings show that on average, significant enrichment is seen in Cu, Mo, U and Se at $> 10 \times$ crustal abundance, Au at $> 100 \times$ crustal abundance and Te at $> 1,000 \times$ crustal abundance. The critical and strategic metals in the Elverdton tailings are hosted by multiple mineral phases, including primary sulphides and secondary sulphates. Further mineralogical and microanalytical work (e.g. SEM, EPMA) is recommended to better constrain metal deportment. If any economic potential were to be identified, minerals processing test work (e.g. flotation or leaching) could be performed to investigate potential processing routes for the recovery of metals from the mined residues.



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