Pioneer Dome Lithium - Waste Rock Assessment

Stage 1 – Information Review

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Mine Earth

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Terms and acronyms commonly used in waste material characterisation

Abbreviation	Description
ABA	Acid-base accounting
ABCC	Acid Buffering Characteristic Curve
AC	Acid consuming
AP	Acid production
Alkalinity	A measure of the buffering capacity of water and capacity to neutralise acidity (kgCaCO3/l)
AMD	Acid and metalliferous drainage
ANC	Acid neutralisation capacity (kg H_2SO_4/t)
ANC_{Lab}	Acid neutralisation capacity measured in the laboratory (kg H_2SO_4/t)
ANC_{Carb}	Acid neutralising capacity estimated from carbonate (total inorganic carbon) (kg H_2SO_4/t)
ANC_{ABCC}	Acid neutralising capacity estimated from ABCC test (kg H_2SO_4/t)
BIF	Banded iron formation
Circum-neutral	pH value near neutral (~pH 7)
EAT	Emerson Aggregate Test
EC	Electrical conductivity (µS/cm)
$EC_{1:2}$	EC of a sample slurry with a solid to water ratio of 1:2 (µS/cm)
ECEC	Effective cation exchange capacity
ESP	Exchangeable sodium percentage
GAI	Geochemical abundance index
HCl	Hydrochloric acid
MPA	Maximum potential acidity (kg H_2SO_4/t)
NAF	Non-acid forming
NAG	Net acid generation
NAG pH	Measured pH of the NAG solution
NAG pH 4.5	NAG acidity to endpoint pH 4.5 (kg H_2SO_4/t)
NAG pH 7.0	NAG acidity to endpoint pH 7.0 (kg H_2SO_4/t)
NAPP	Net acid producing potential (kg H_2SO_4/t)
PAF	Potentially acid forming
PGE	Platinum group
$pH_{1:2}$	pH of a sample slurry with a solid to water ratio of 1:2
PMLU	Post-mining land use
PSD	Particle Size Distribution
QXRD	Quantitative X-ray diffraction
SD	Saline drainage
Sulfate	Oxidised form of sulfur (SO_4^{2-})
Sulfide	Reduced form of sulfur (S^{2-})
Total-C	Total carbon (%).
TDS	Total dissolved solids
TIC	Total inorganic carbon
TOC	Total organic carbon
Total-S	Total sulfur (%)
UC	Uncertain
WRD	Waste Rock Dump

Executive Summary

Mine Earth was asked to undertake a review of the existing database for the Pioneer Dome Lithium Project to provide a preliminary assessment of the waste rock characterisation and identify gaps for further characterisation. The project will include two pits, the Cade pit and the Davy pit, with 2.4 and 1.52 Mbcm of waste rock being extracted for each pit respectively.

The data provided for both pits was reviewed and considered acceptable to provide a preliminary understanding of the sulfur content and associated acid and metalliferous drainage (AMD) risk of the materials. The review showed that the risk of acid and metalliferous drainage for the Davy pit is negligible with 99% of the intervals recorded in the database having a sulfur content below 0.1%, a conservative cut-off value. The findings for the Cade pit differed in that whilst the material extracted from the oxide and transitional zone present a negligible risk of AMD, the material extracted from the fresh zone contained higher sulfur content (median 0.34%S) warranting further testing.

The gap analysis identified that:

- the spatial distribution will have to be improved by collecting material from the edge of the pits, mostly the eastern sections of both pits.
- the number of komatiite intervals should be increased to respect the lithological distribution.

Moving forward, it is recommended to develop a sampling and analysis plan that takes into account the gaps identified and the need to undertake a detailed material characterisation program that assesses the potential for saline and neutral metalliferous drainage as well as the AMD potential of fresh material extracted from the Cade pit.

1. Introduction

The Pioneer Dome Lithium Project (the Project) is located in the eastern goldfields, 150 km south of Kalgoorlie and 70 km north of Norseman in Western Australia. It will initially consist of mining at two open pits (Cade and Davy), with the option to open a third pit (Heller) in the future. The open pits will be mined for approximately 18 months, after which the operation will move to underground mining for five to six years. Other infrastructure will include two waste rock landforms (WLFs), crushing infrastructure and other non-processing infrastructure.

The aim of the broader geochemical assessment (of which this information review is a part of) is to geochemically and physically characterise waste rock materials to be extracted from the Cade and Davy pits so that mine waste management recommendations can be developed to minimise the potential for environmental impacts and enhance long-term closure outcomes.

This initial report presents the findings of the geochemical database review provided by Develop for the Project. It assesses the acid and metalliferous drainage (AMD) potential for key waste rock lithology types and identifies gaps to address for a more complete characterisation.

2. Background information

2.1 Information provided

The following documents were made available by Develop.

- Geology of the granite-greenstone terrane of the Lake Lefroy and Cowan 1:100,000 sheets, Western Australia. Griffin, T. J. (Timothy John), PhD., 1990.
- ASX announcement 20/02/2022– Essentials Metals – Dome North Lithium upgrade boosts Indicated tonnes by 50% https://www.listcorp.com/asx/ess/essential-metals-limited/news/dome-north-resource-upgrade-2816673.html
- Site information, including environmental surveys, presented as pdf: *Pioneer Dome Overview.*
- Waste characterisation databases for both the Cade and the Davy pit (Excel files) including waste rock volumes and geological maps: *Cade Pit Shell 09 Stage 1 WST Assays, PD Waste Characterisation 16_11_23*, and *PD Waste Char 2024_02_09*.
- Drilling database including data for lithium content, sulfur content, lithology, and degree of weathering: *Lithology_Codes*, *PD_DHAssays*, *PD_DHCollars*, *PD_DHLith*, and *PD_DHSurv*.
- Mining surfaces for both pits: *Cade Pit Design 251020023.DXF*, and *Davy Pit Design 251020023.DXF*

The drilling database (as provided by Develop) was imported into Leapfrog Works along with the pit shell files to assist with the interpretation of the data.

2.2 Geology

The Pioneer Dome project is located at the southern end of the Kalgoorlie Terrane and lies on the boundary between the Pioneer Dome and the southern extension of the Norseman-Wiluna greenstone belt (ASX, 2022).

The Pioneer Granitoid Complex is the section of the Pioneer Dome local to the Project area and is comprised of the biotitic Pioneer Monzogranite and the quartzo-feldspathic Fifty Mile Tank Gneiss) (ASX, 2022).

The Archaean greenstone sequence is comprised of tholeiitic basalt, pyroxene spinifex-textured basal, komatiite, peridotite and dolerite, in addition to volcaniclastic, pelitic and psammitic metasedimentary rocks of the Black Flag Group. Carbonaceous shale horizons are commonly present as interflow sediments (ASX, 2022).. The mafic rocks are dominated by tremolite-actinolite-chlorite-plagioclase-carbonate schist, whilst the ultramafic rocks include tremolite-chlorite-carbonate-talc schist (John, 1990). The metasedimentary host rocks of the Black Flag Group are fine grained and largely quartz, mica, amphibole and garnet +/- pyrite and andalusite. The metasediments are strongly deformed and locally folded and sheared (ASX, 2022).

Series of pegmatite dykes and sills, associated with the later stage Pioneer Dome granite, intrude along the strike length of the eastern edge of the granite dome. The pegmatites consist of a thin unmineralised wall zone (typically 0.5-3m) of albite, quartz, muscovite and garnet +/- trace spodumene and a lithium enriched intermediate zone (typically 10-30m) of albite, quartz, muscovite and spodumene +/- potassium feldspar with trace petalite. The pegmatites near the Cade deposit have a geochemical signature associated with the lithium-caesium-tantalum (LCT) subclass of pegmatites (ASX, 2022).

There are five main lithologies identified in the region: granites, mafics, igneous felsic volcanics (IFV), komatiites (KOM) and pegmatite (PEG) the ore-bearing material, all have the potential to contain smaller subsets of other lithologies. The three lithologies identified in the pits include IFV, PEG and KOM, with the latter only being present in the Davy pit.

2.3 Pit Geometry and Estimated Waste Rock Volumes

The geometry of the pits and their respective lithologies are shown in Figure 1 and Figure 2. The figures also present the cross- and long-sections showing the distribution of the three weathering zones along the drillholes. The estimated waste rock volumes to be generated for each pit are presented in Table 1. The Cade pit waste material will be mostly composed of IFV material from the oxide horizon whilst the Davy pit waste material will be composed mostly of komatiites in relatively equal proportions from the three weathering zones.

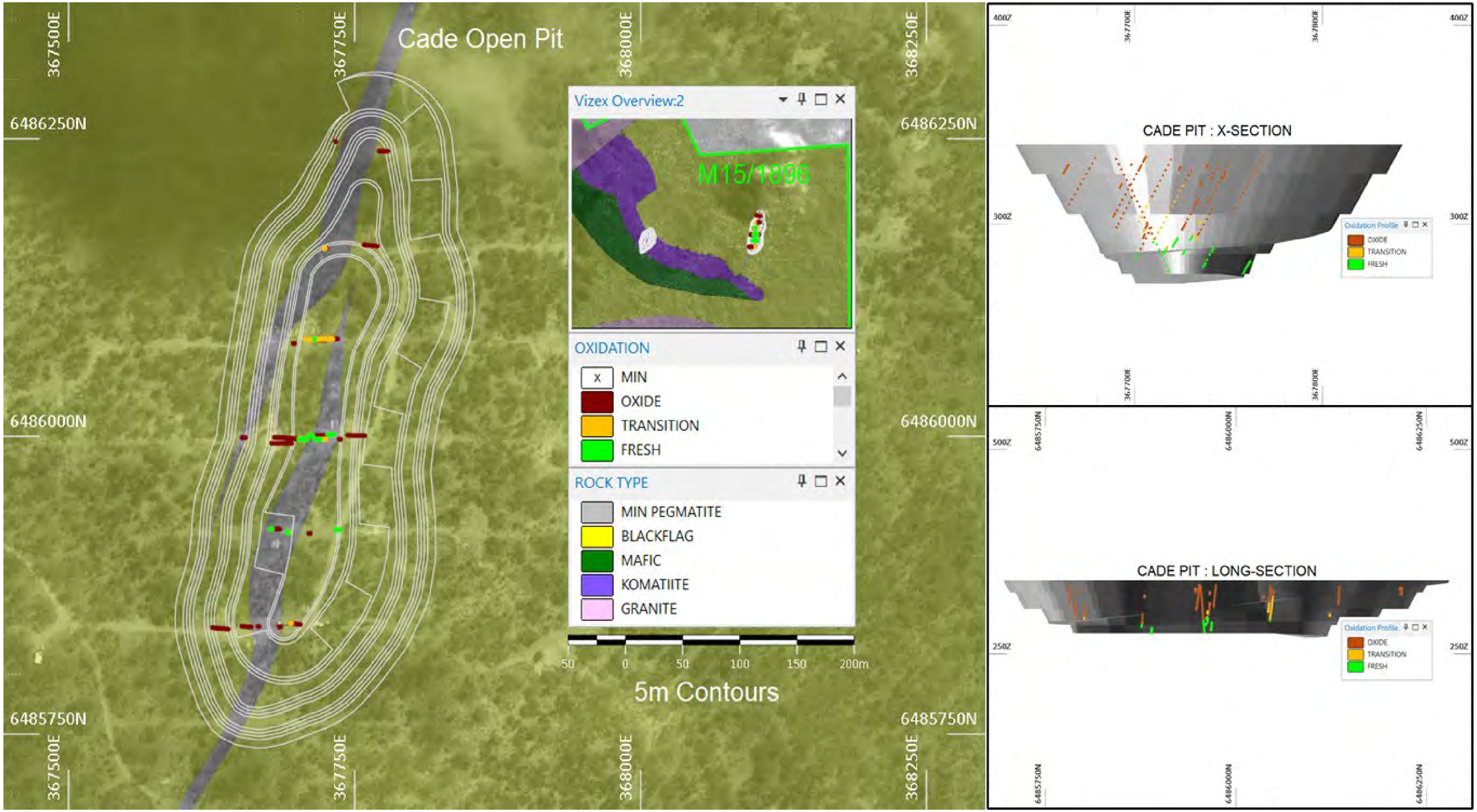

Figure 1: **Cade pit geometry with cross- and long- sections, showing lithologies, drillhole locations, and weathering zones.**

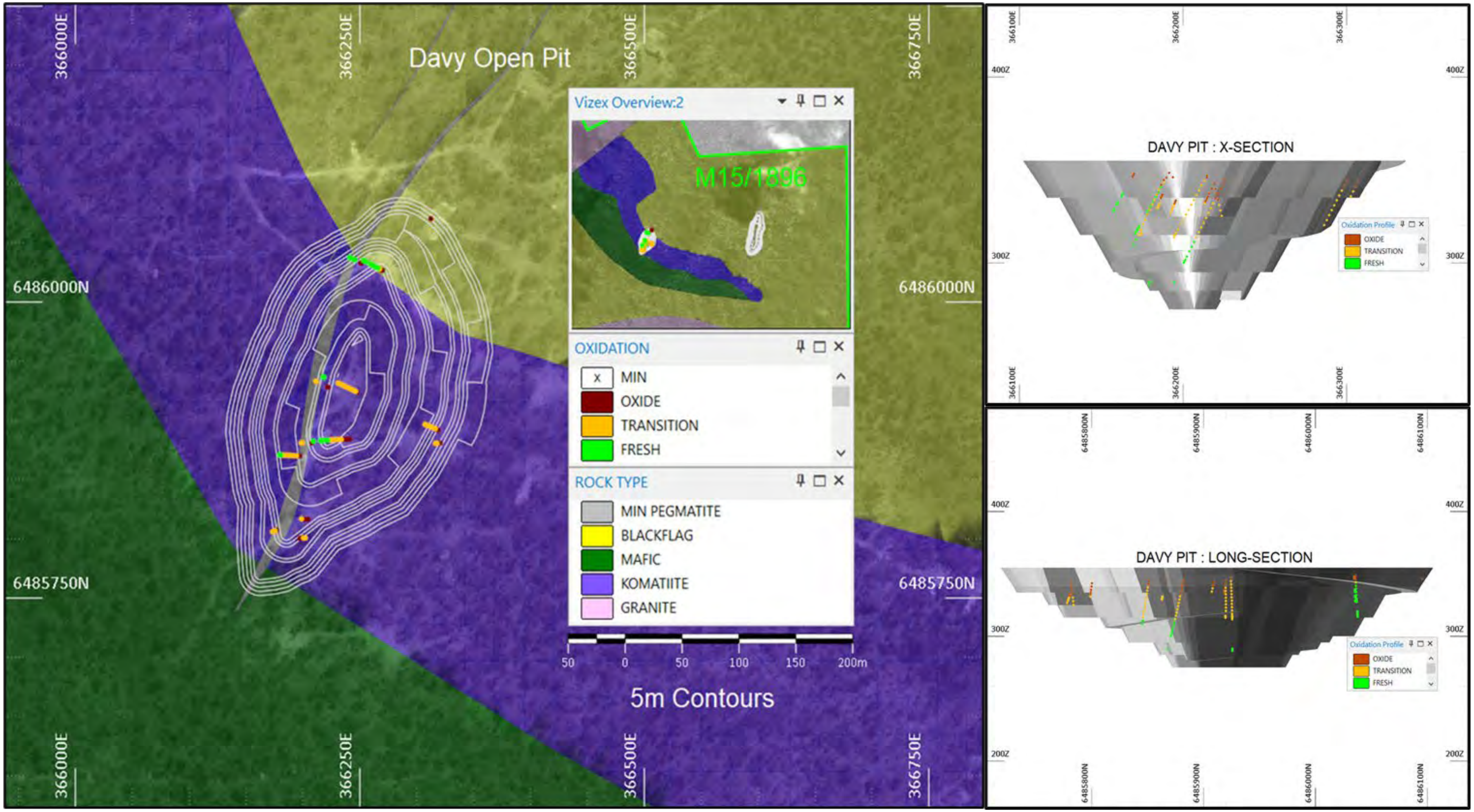

Figure 2: Davy pit geometry with cross- and long- sections, showing lithologies, drillhole locations, and weathering zones.

Table 1: **Estimated waste rock volumes (in Mbcm) by lithology for the Cade and Davy pits, with proportions in brackets (Pioneer Dome Lithium, 2024).**

	Oxide (Mbcm)	Transitional (Mbcm)	Fresh (Mbcm)	Total Waste (Mbcm)
Cade Pit				**2.4**
Igneous Felsic Volcanics	2.02 (91.6%)	0.19 (4.2%)	0.19 (4.2%)	2.4
Davy Pit				**1.52**
Igneous Felsic Volcanics	0.08 (5%)	0.01 (0.6%)	0.03 (2.0%)	0.12
Mafics	<0.01	-	-	<0.01
Komatiites	0.48 (32%)	0.61 (40%)	0.31 (20%)	1.4

3. Data analysis and interpretation

3.1 Data review

The updated geological and geochemical database provided by Develop was reviewed and analysed. For interpretation purposes, the database was filtered to reference only samples representative of the waste rock from the pit shells. The main steps used to filter the data are presented below:

- Drillholes considered:
  - Cade Pit : PDAC375, 376, -384, -385, -386, PDD-600, PDRC-263, -264, -266, -269, -270, -589, -590, -591, -592, PDRCD-292.
  - Davy Pit : PDAC461, PDRC310, -323, -324, -325, -326, -337, -518, -519, -588.
- Intervals from holes not intersecting the proposed pit were excluded.
- Intervals without stratigraphy/lithological data were excluded.
- Intervals with a lithium content above 1400 ppm were excluded.
- Intervals from holes predominantly drilled through the ore zone were excluded.
- Intervals with pegmatite were excluded as they are considered as part of the mineralisation zone.
- Intervals with no sulfur content data were excluded.
- A conservative cut-off value of 0.1% S was applied.

A summary of the lithological distribution in the geochemical database is presented in Table 2. For both pits, the table summarises the number of intervals available for each lithology and weathering zone, along with the corresponding distribution percentage. For this preliminary study, the number of intervals for which data is available is considered acceptable for all lithologies and weathering zones, except for the Komatiite in the transition zone (KOM-TR) of the Davy pit. The volume of KOM-TR waste is estimated at 40% whilst the number of intervals available is limited to 10%.

Table 2: Data Analysis, number of intervals and % distribution.

No intervals	Code	Cade Pit		Davy Pit	
		No Intervals	%Distribution	No Intervals	% Distribution
Total Nº intervals with sulfur data		159		89	
Nº intervals with S>0.1%		37			
IFV - Oxide	IFV-OX	120	75%	3	3%
IFV - Transition	IFV-TR	17	11%	1	1%
IFV - Fresh	IFV-FR	22	14%	5	6%
KOM- Oxide	KOM-OX			52	58%
KOM-Transition	KOM-TR			9	10%
KOM-Fresh	KOM-FR			19	21%

In green, the % of intervals is acceptable to represent the waste, in red the % of intervals should be increased,

3.2 Total sulfur and acid and metalliferous drainage (AMD)

Total sulfur is used as an indication of the maximum potential acidity (MPA) that can be generated by a sample. It assumes that all sulfur is present as pyrite and can be oxidised into sulfuric acid, where 1% S generates 30.6 kg of H_2SO_4/t. This method overestimates acidity as sulfur can be present in a variety of forms, such as sulfides (including pyrite, pyrrhotite, chalcopyrite etc.), sulfates (including non-acid generating forms such as gypsum and acid-generating forms such as alunite) or organics forms. When there is no data for sulfur speciation or acid neutralisation capacity (ANC), a sulfur value of 0.1% is considered a conservative cut-off value indicating the potential for acid generation. The interpretation of the sulfur content for the two pit shells is presented below:

- The sulfur distribution for the different geological units and weathering zones is presented as box plots in Figure 3 for the Cade pit and in Figure 6 for the Davy pit.
- The sulfur distribution with depth is presented in Figure 4 for the Cade pit and in Figure 7 for the Davy pit.
- The sulfur distribution across the pit and along the existing drillholes using the drilling database has been plotted using Leapfrog Works and is presented in Figure 5 for the Cade pit and Figure 8 for the Davy pit.

3.3 Data analysis

The review of the information and data available for analysis shows that:

- For both pits:
  - the risk of AMD produced by the waste rock is negligible for the oxide and transition zones across the different geology units.
- For the Cade pit (Figure 3, Figure 4, and Figure 5)
  - 84% of the samples have less than 0.1%S (a conservative cut-off value), these are all from the oxide and transition zones.
  - The IFV-FR material presents the highest risk of AMD, with all sulfur measurements above 0.1%S except for one. The median sulfur content is 0.34%. These values are all recorded at depth below 48 m.
  - Total sulfur content shows more variability in the IFV-OX, this is associated to weathering and leaching.
  - The higher values in the IFV-OX, are found at surface and could be linked to sulfate minerals such as gypsum.
- For the Davy pit, (Figure 6, Figure 7, and Figure 8)
  - The total sulfur content is consistently below 0.1% except for two samples, indicating that the risk of AMD is negligible.
  - The spatial coverage is limited in particular for the northeast and southeast sections of the pit.
  - The number of intervals for the komatiite in the transition zone is not representative of the lithological distribution.

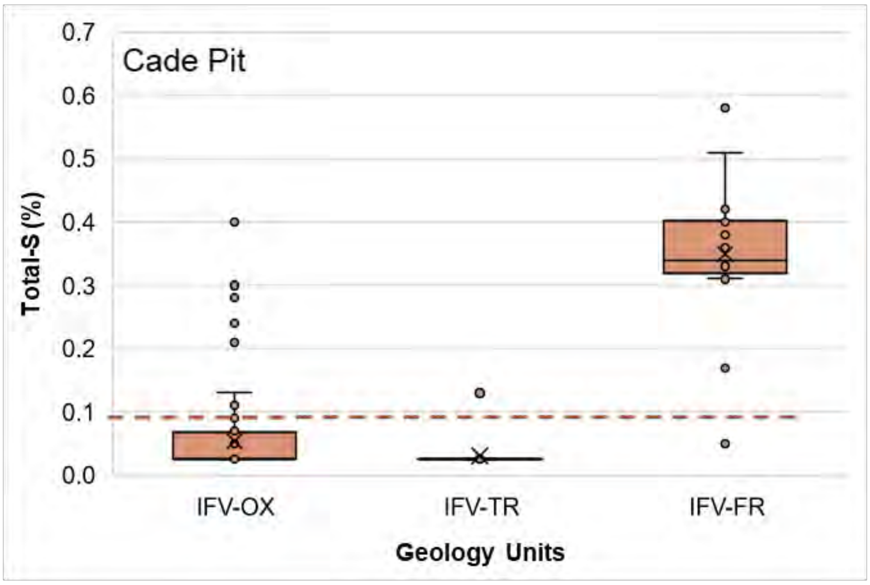

Figure 3: Cade Pit: sulfur Box and Whiskers plot for the different geological units and weathering zones.

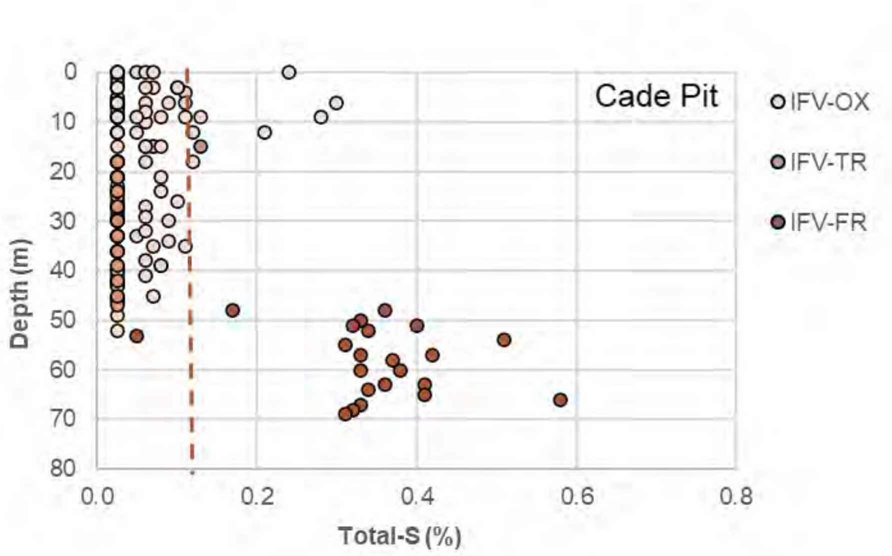

Figure 4: Cade Pit: sulfur content based on depth for the different geological units.

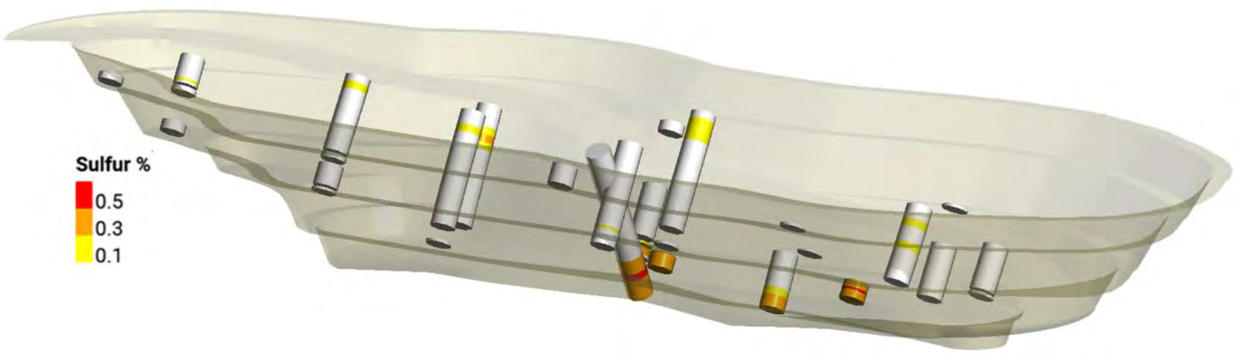

Figure 5: Cade pit: sulfur content across the pit (drilling database).

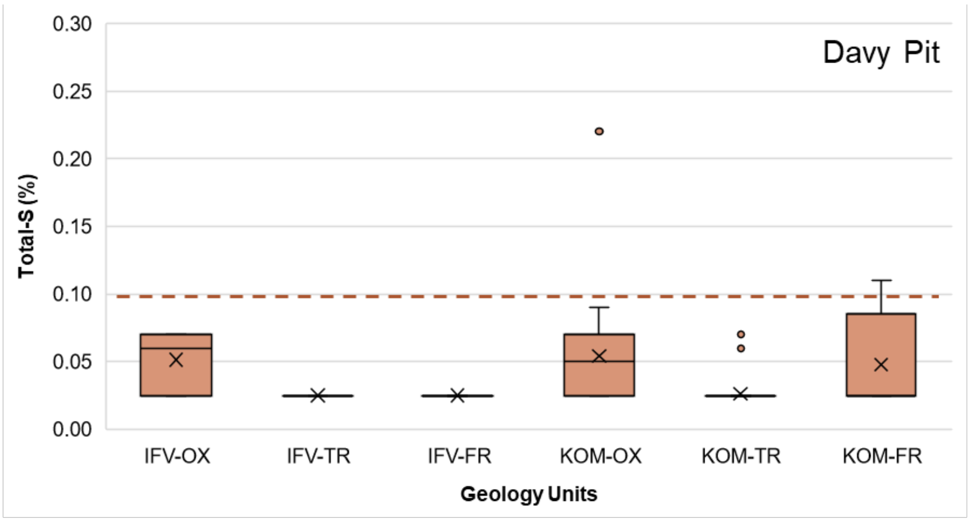

Figure 6: Davy Pit: sulfur Box and Whiskers plot for the different geological units and weathering zones.

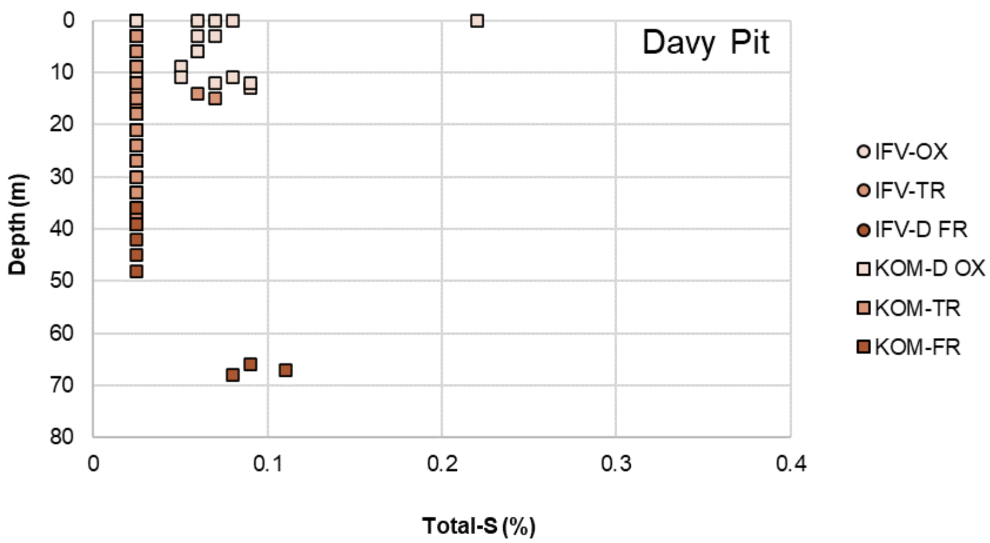

Figure 7: Davy Pit: sulfur content based on depth for the different geological units.

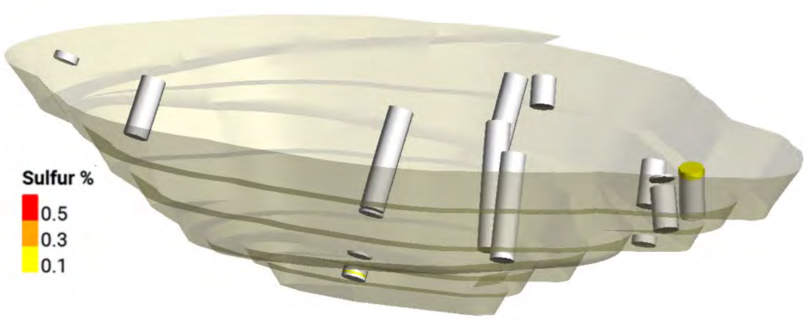

Figure 8: Davy pit: sulfur content across the pit (drilling database).

4. Conclusions and recommendations

4.1 Conclusions

The findings and recommendations from the review of waste rock information are summarised below:

- The coverage of drillholes and downhole multi-element assay data for both the Cade and Davy pits is considered acceptable to provide a preliminary understanding of the sulfur content and associated AMD risk of the materials.
- For the Cade pit:
    - The waste rock extracted from the Cade pit is composed of one lithology (igneous felsic volcanic) across three weathering zones.
    - The AMD risk is limited to the material extracted from the fresh weathering zone with a median sulfur content of 0.34%.
- For the Davy pit:
    - The major lithologies extracted from the Davy pit are igneous felsic volcanic (7.6%) and komatiite (92.4%).
    - The AMD risk is considered negligible with only 1 sample out 89 having a TS content above 0.1%.

4.2 Recommendations

The recommendations for both pits are to address the gaps related to spatial distribution and assess the potential for saline and metalliferous drainage.

Recommendations for the Cade pit include:

- Improve the spatial distribution of the pit by collecting and testing samples from the edges of the pit shell.
- Improve understanding of the spatial extent of the fresh material and the sulfur speciation (sulfide verses sulfate).

Recommendations for the Davy pit include:

- Improve the spatial distribution of the pit by collecting and testing samples from the edges of the pit shell.
- Increase the number of komatiite intervals analysed, to respect the lithological distribution.