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Customer Ref : CMT/011/16/2025
Lab ID : G2803-2
Date of Sample Analysis :17/10/2025
Date of Reporting :23/10/2025

MINERALOGY TEST REPORT

1.60 KW POWDER X RAY DIFRACTOMETER METHOD

INTRODUCTION: X-ray diffraction (XRD) and petrology studies are both valuable techniques used in geology and materials science for analysing minerals and rocks, but they serve different purposes and offer unique advantages. Here's how XRD is superior to petrology studies in certain aspects. XRD excels in identifying crystalline minerals present in a sample. It provides precise information about the crystal structure and lattice parameters of minerals, which can be challenging to ascertain solely through petrological observations. XRD allows for quantitative analysis of mineral phases present in a sample, providing accurate estimates of mineral composition based on peak intensities. Petrology studies, while descriptive, may not always provide quantitative data on mineral abundance. XRD is highly sensitive and can detect trace amounts of minerals present in a sample, even at concentrations as low as a few percent. Powder Diffraction (XRD) Database, contains a comprehensive collection of more than 6000 diffraction patterns for various materials. Researchers use this resource for identifying unknown substances, confirming crystal structures, and conducting material characterization. Shiva Analyticals team has decades of experience on XRD studies. Accurate chemical assay coupled with reliable mineralogy information is vital in resource characterisation.

Sample Code: G2803-2 (CMT/011/16/2025)

Instruments: WDXRF – Bruker S8 Tiger Series 2 (4 kW); XRD – Bruker D8 Advance (1.6 kW).
2θ Scan Range: 5–80° | Crystallinity: 63.70% | Amorphous: 36.30% |

Bulk Oxides by WDXRF:

Oxide	Wt.%
Al2O3	9.19
BaO	<0.05
CaO	9.29
Cr2O3	0.32
Fe2O3	12.08
K2O	0.44
MgO	20.36
MnO	0.13
Na2O	1.17
P2O5	0.19
SiO2	43.43
SO3	<0.05
SrO	<0.05
TiO2	1.54
V2O5	<0.05
ZrO2	<0.05
HfO2	<0.05
CuO	<0.05
NiO	0.11
PbO	<0.05
ZnO	<0.05
LOI	1.66

Mineral Phases by XRD:

Sl.no	Mineral Phase	Chemical Formula	XRD Wt.%	XRD Crystalline Wt % (XRD Wt.% ×0.637)	Molecular Weight (g/mol)
1	Andesine An50	$(Na,Ca)Al(Si,Al)_3O_8$	34.3	21.85	268.3
2	Labradorite	$(Ca,Na)(Al,Si)_4O_8$	2.74	1.75	271.8
3	Forsterite	Mg_2SiO_4	6.33	4.03	140.7
4	Olivine	$(Mg,Fe)_2SiO_4$	0.15	0.10	153.3
5	Diopside	$CaMgSi_2O_6$	24.00	15.29	216.6
6	Augite	$(Ca,Na)(Mg,Fe,Al)(Si,Al)_2O_6$	3.63	2.31	236.4
7	Analcime	$NaAlSi_2O_6·H_2O$	1.89	1.20	220.1

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Sl.no	Mineral Phase	Chemical Formula	XRD Wt.%	(XRD Wt.% ×0.637)	Molecular Weight (g/mol)
8	Clinoenstatite	$MgSiO_3$	0.46	0.29	100.40
9	Hydrogarnet	$Ca_3Al_2(SiO_4)_{3-x}(OH)_{4x}$	0.47	0.30	377.00
10	Dolomite	$CaMg(CO_3)_2$	1.00	0.64	184.40
11	Lizardite-1T	$Mg_3Si_2O_5(OH)_4$	0.01	0.01	277.10
12	Muscovite 2M1	$KAl_2(AlSi_3O_{10})(OH)_2$	13.33	8.49	398.30
13	Quartz	SiO_2	1.37	0.87	60.10
14	Chlorite	$(Mg,Fe)_3(Si,Al)_4O_{10}(OH)_2\cdot(Mg,Fe)_3(OH)_6$	2.35	1.50	595.20
15	Canadinite	$Na_4Ca_2Si_{16}O_{38}(OH)_2\cdot 10H_2O$	2.91	1.85	1407.50
16	Antigorite	$Mg_3Si_2O_5(OH)_4$	1.48	0.94	277.10
17	Fassaite	$Ca(Mg,Fe,Al)(Si,Al)_2O_6$	0.74	0.47	226.70
18	Topaz	$Al_2(SiO_4)(F,OH)_2$	0.22	0.14	182.20
19	Titanite	$CaTiSiO_5$	0.71	0.45	196.00
20	Magnetite	Fe_3O_4	1.37	0.87	231.50
21	Kaolinite	$Al_2Si_2O_5(OH)_4$	0.54	0.34	258.20
		Total	**100**	**63.70**	

Stoichiometric Comparison Table:

Oxides	XRF (wt%)	XRD crystallinity (wt%)	Amorphous (wt%)
SiO2	43.43	35.31	8.12
Al2O3	9.19	9.24	-0.05
Fe2O3	12.08	1.11	10.97
MgO	20.36	6.66	13.70
CaO	9.29	8.48	0.81
Na2O	1.17	0.82	0.35
K2O	0.44	0.40	0.04
TiO2	1.54	0.18	1.36
CO2	0.00	0.31	-0.31
F	0.00	0.02	-0.02
H2O	0.00	1.16	-1.16
Traces	2.50	0.00	2.50

Interpretation

Integrated bulk-rock chemistry and XRD data indicate a mafic–ultramafic lithology, characterized by high MgO and Fe_2O_3 contents with moderate CaO and low alkalis. The crystalline assemblage comprises plagioclase (andesine–labradorite), clinopyroxene (diopside–augite–fassaite), and forsteritic olivine, consistent with a pyroxenitic to komatiitic composition. Subordinate phases such as muscovite, chlorite, antigorite, and hydrogarnet record retrogressive hydration and metamorphic overprint on the primary silicate framework.

Suggested minor/Secondary mineral phases

- Poorly ordered Mg–Fe silicate gels / proto-serpentines (serpentine-type, lizardite/antigorite precursors): Mg-rich and Fe-bearing amorphous material produced by hydration of olivine/pyroxene.
- Ferruginous amorphous oxides/hydroxides (nano-goethite, poorly crystalline ferrihydrite-like phases) resulting from oxidation of Fe^{2+}.
- Amorphous silica/silica gel (opal/cryptocrystalline SiO_2) produced during silica mobilisation and low-temperature alteration.
- Minor amorphous titanate or Ti-bearing glassy residue (accounts for the TiO_2 deficit).
- Small amounts of carbonate/organic/alkali-bearing non-crystalline phases may also be present (consistent with small Ca, Na deficits).

Potential commercial uses

Component	Application
Refractory material	Furnace linings, foundry crucibles, refractory bricks
Ceramic and glass–ceramic production	Advanced ceramics, glass–ceramic composites
Feedstock for Mg/Fe compounds	Catalysts, flame retardants, adsorbents, magnetic materials
Construction aggregate / stone ·	Dimension stone, road metal, construction aggregate
Pozzolanic / geopolymer additive	Supplementary cementitious materials, geopolymer binders
CO_2 sequestration feedstock	Carbon capture and storage (CCUS), mineral carbonation
Industrial mineral recovery	Pigments, ceramics, mineral fillers
Environmental sorbent	Heavy metal removal, wastewater treatment, soil remediation
Low-grade glass precursor	Glass manufacturing, fiber glass raw mix

Probable origin assessment

The sample most likely represents a Mg-rich, mantle-derived mafic–ultramafic protolith (high-Mg basalt to komatiite or an ultramafic cumulate) that has undergone significant post-magmatic hydrothermal/low-grade metamorphic alteration (serpentinization, chloritization, silica mobilization, local carbonation and Fe-oxidation).

Final Results:

- The integrated WDXRF and XRD datasets indicate a compositionally Mg- and Fe-rich mafic–ultramafic rock that has undergone significant low-grade alteration.
- The bulk oxide chemistry (SiO_2 = 43.43 wt%, MgO = 20.36 wt%, Fe_2O_3 = 12.08 wt%, CaO = 9.29 wt%, Al_2O_3 = 9.19 wt%) reflects a dominantly mafic to ultramafic character with subordinate alkalis (Na_2O = 1.17 wt%, K_2O = 0.44 wt%).
- XRD mineralogical quantification reveals that the crystalline fraction (63.70 wt%) is dominated by plagioclase (andesine–labradorite; 37%), clinopyroxenes (diopside–augite–fassaite; 28%), and forsteritic olivine (6%), along with muscovite (13%), chlorite, analcime, and minor quartz and magnetite.
- These assemblages define a mineralogically evolved but compositionally primitive system, with alteration signatures evident in the presence of muscovite, chlorite, antigorite, and hydrogarnet.
- The stoichiometric balance between XRF and XRD data indicates an amorphous component of 36.31 wt%,

Stoichiometric Oxide Table

Sl. No.	Mineral Name	Simplified Mineral Formula	XRD Wt%	SiO2	Al2O3	Fe2 O3	MgO	CaO	Na2O	K2O	TiO2	CO2	F	H2O
1	Andesine (An50)	$(Na,Ca)Al(Si,Al)_3O_8$	21.85	12.99	5.34	0.00	0.00	3.12	0.40	0.00	0.00	0.00	0.00	0.00
2	Labradorite	$(Ca,Na)(Al,Si)_4O_8$	1.75	0.92	0.52	0.00	0.00	0.21	0.10	0.00	0.00	0.00	0.00	0.00
3	Forsterite	Mg_2SiO_4	4.03	1.72	0.00	0.00	2.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	Olivine	$(Mg,Fe)_2SiO_4$	0.10	0.04	0.00	0.01	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	Diopside	$CaMgSi_2O_6$	15.29	8.49	0.00	0.00	2.85	3.95	0.00	0.00	0.00	0.00	0.00	0.00
6	Augite	$(Ca,Na)(Mg,Fe,Al)(Si,Al)_2O_6$	2.31	1.15	0.22	0.15	0.26	0.48	0.05	0.00	0.00	0.00	0.00	0.00
7	Analcime	$NaAlSi_2O_6 \cdot H_2O$	1.20	0.66	0.28	0.00	0.00	0.00	0.16	0.00	0.00	0.00	0.00	0.10
8	Clinoenstatite	$MgSiO_3$	0.29	0.17	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	Hydrogarnet	$Ca_3Al_2(SiO_4)_{3-x}(OH)_{4x}$	0.30	0.08	0.07	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.03
10	Dolomite	$CaMg(CO_3)_2$	0.64	0.00	0.00	0.00	0.14	0.19	0.00	0.00	0.00	0.31	0.00	0.00
11	Lizardite01T	$Mg_3Si_2O_5(OH)_4$	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
12	Muscovite02M1	$KAl_2(AlSi_3O_{10})(OH)_2$	8.49	5.36	2.35	0.00	0.00	0.00	0.00	0.40	0.00	0.00	0.00	0.38
13	Quartz	SiO_2	0.87	0.87	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	Chlorite	$(Mg,Fe)_3(Si,Al)_4O_{10}(OH)_2 \cdot (Mg,Fe)_3(OH)_6$	1.50	0.64	0.10	0.08	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.18
15	Canadinite	$Na_4Ca_2Si_{16}O_{38}(OH)_2 \cdot 10H_2O$	1.85	1.32	0.00	0.00	0.00	0.15	0.11	0.00	0.00	0.00	0.00	0.27
16	Antigorite	$Mg_3Si_2O_5(OH)_4$	0.94	0.41	0.00	0.00	0.41	0.00	0.00	0.00	0.00	0.00	0.00	0.12
17	Fassaite	$Ca(Mg,Fe,Al)(Si,Al)_2O_6$	0.47	0.13	0.19	0.00	0.02	0.13	0.00	0.00	0.00	0.00	0.00	0.00
18	Topaz	$Al_2(SiO_4)(F,OH)_2$	0.14	0.06	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02
19	Titanite	$CaTiSiO_5$	0.45	0.14	0.00	0.00	0.00	0.13	0.00	0.00	0.18	0.00	0.00	0.00
20	Magnetite	Fe_3O_4	0.87	0.00	0.00	0.87	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	Kaolinite	$Al_2Si_2O_5(OH)_4$	0.34	0.16	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05
			63.70	**35.31**	**9.24**	**1.11**	**6.66**	**8.48**	**0.82**	**0.40**	**0.18**	**0.31**	**0.02**	**1.16**

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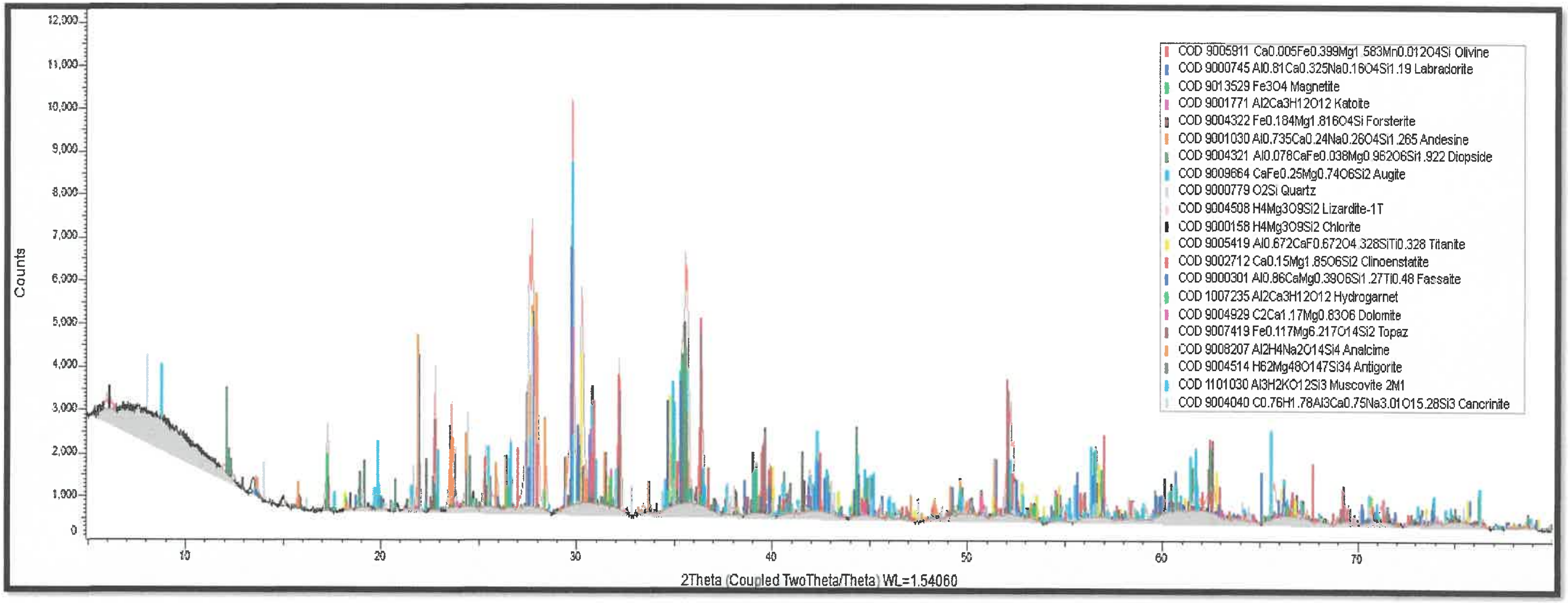

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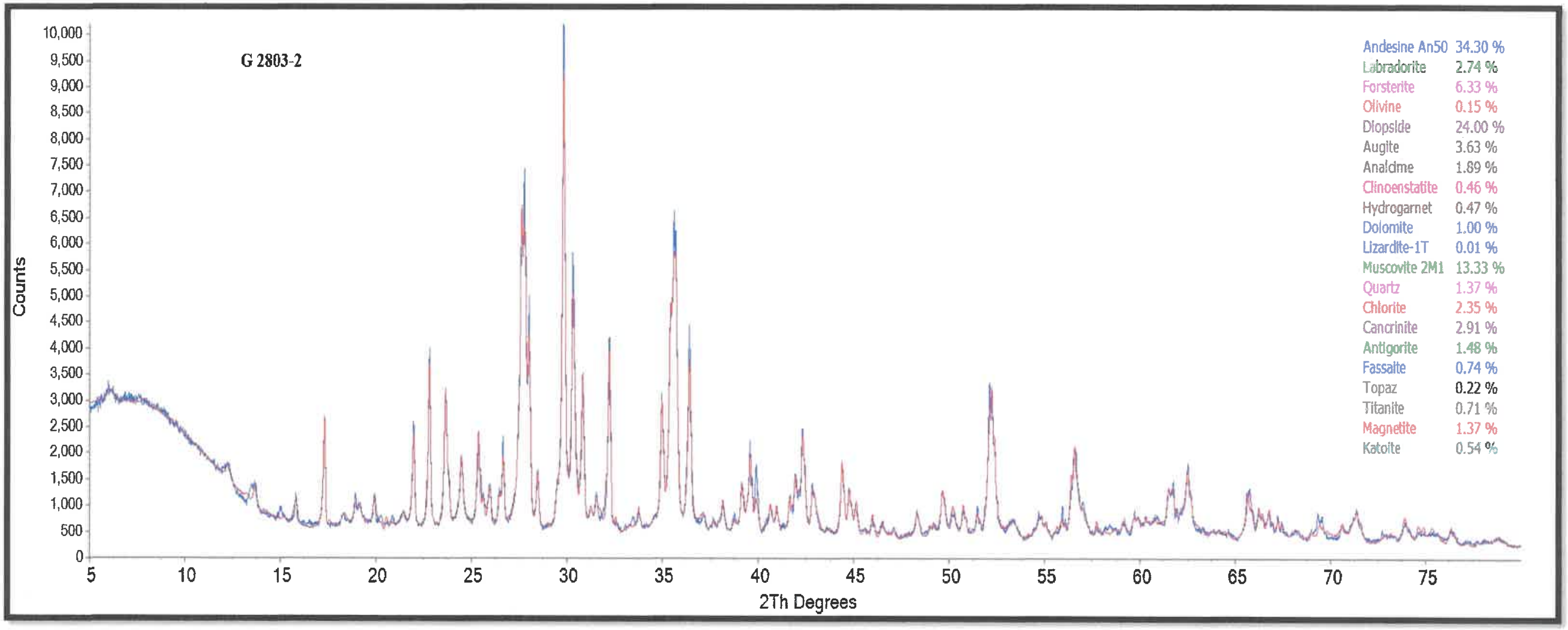
G2803-2	CMT/011/16/2025	XRD Scan Report_2 of 2



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