SHIVA ANALYTICALS INDIA PRIVATE LIMITED

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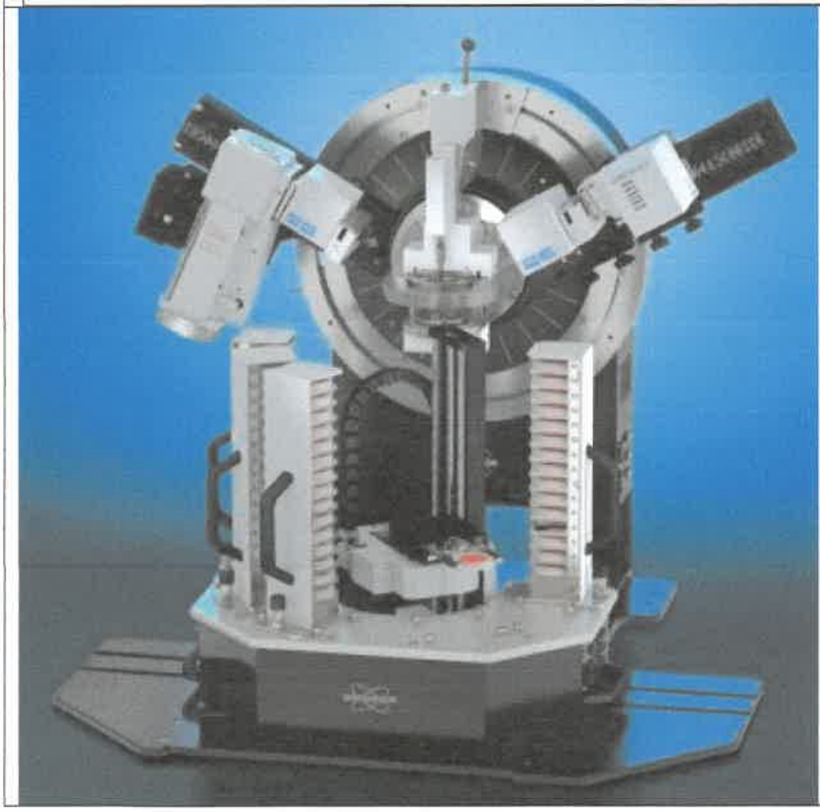
Customer Ref : CMT/011/10/2025
Lab ID : G2803-1
Date of Sample Analysis :17/10/2025
Date of Reporting :23/10/2025

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: G2803-1(CMT/011/10/2025)

Instruments: WDXRF – Bruker S8 Tiger Series 2 (4 kW); XRD – Bruker D8 Advance (1.6 kW).
2θ Scan Range: 5–80° | Crystallinity: 78.50% | Amorphous: 21.50% |

Bulk Oxides by WDXRF:

Oxide	Wt.%
Al2O3	13.62
BaO	<0.05
CaO	9.62
Cr2O3	0.06
Fe2O3	11.37
K2O	1.82
MgO	7.18
MnO	0.12
Na2O	2.35
P2O5	0.31
SiO2	51.01
SO3	<0.05
SrO	<0.05
TiO2	1.98
V2O5	<0.05
ZrO2	<0.05
HfO2	<0.05
CuO	<0.05
NiO	<0.05
PbO	<0.05
ZnO	<0.05
LOI	0.36

Mineral Phases by XRD:

Sl. No.	Mineral	Chemical Formula	XRD Wt.%	XRD Crystalline Wt % (XRD Wt% x 0.785)	Molecular Weight (g/mol)
1	Andesine (An50)	$(Na,Ca)(Al,Si)_4O_8$	23.73	18.63	266.35
2	Labradorite	$(Ca,Na)(Al,Si)_4O_8$	1.99	1.56	271.84
3	Albite	$NaAlSi_3O_8$	2.04	1.60	262.22
4	Diopside	$CaMgSi_2O_6$	42.4	33.28	216.55
5	Aegirine	$NaFeSi_2O_6$	0.46	0.36	235.99
6	Augite	$(Ca,Mg,Fe)Si_2O_6$	0.55	0.43	230.00
7	Jadeite	$NaAlSi_2O_6$	0.67	0.53	202.99
8	Forsterite	Mg_2SiO_4	0.89	0.70	140.69
9	Aegirine-augite	$(Na,Ca)(Fe,Mg)Si_2O_6$	1.39	1.09	235.00

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Sl. No.	Mineral	Chemical Formula	XRD Wt.%	XRD Crystalline Wt % (XRD Wt% x 0.785)	Molecular Weight (g/mol)
10	Magnesioferrite	$MgFe_2O_4$	0.23	0.18	199.94
11	Jacobsite	$MnFe_2O_4$	0.12	0.09	230.60
12	Pyrope	$Mg_3Al_2Si_3O_{12}$	0.33	0.26	403.11
13	Ankerite	$Ca(Fe,Mg)(CO_3)_2$	0.1	0.08	221.97
14	Muscovite-2M1	$KAl_2(AlSi_3O_{10})(OH)_2$	14.46	11.35	398.32
15	Titanite	$CaTiSiO_5$	0.64	0.50	196.99
16	Magnetite	Fe_3O_4	1.2	0.94	231.53
17	Ilmenite	$FeTiO_3$	0.43	0.34	151.71
18	Lizardite-1T	$Mg_3Si_2O_5(OH)_4$	2.34	1.84	277.11
19	Quartz	SiO_2	0.07	0.05	60.08
20	Olivine	$(Mg,Fe)_2SiO_4$	5.96	4.68	154
		Total		**78.50**	

Stoichiometric Comparison Table:

Oxides	XRF wt%	XRD wt%	Amorphous Wt%
SiO_2	51.01	43.09	7.92
Al_2O_3	13.62	12.24	1.38
FeO	11.37	2.85	8.52
MgO	7.18	7.70	-0.52
CaO	9.62	8.59	1.03
Na_2O	2.35	1.49	0.86
K_2O	1.82	1.51	0.31
TiO_2	1.98	0.33	1.65
MnO	0.12	0.05	0.07
CO_2	0.00	0.02	-0.02
H_2O	0.00	0.62	-0.62
Traces	0.93	0.00	0.93

Interpretation

The sample is 78.50% crystalline and 21.50% amorphous, indicating that most of the material is well-ordered minerals with a notable amorphous fraction. Diopside (33.28%) and Andesine (18.63%) are the dominant crystalline phases, with Muscovite (11.35%) and minor feldspars and pyroxenes present. Trace oxides (Magnetite, Ilmenite) and garnet occur in small amounts. The amorphous portion likely consists of glassy silicates or poorly crystalline clays, reflecting partial disorder or rapid cooling. Overall, the assemblage suggests a silicate-rich sample with minor accessory oxides and micas.

Suggested minor / secondary mineral phases

The sample contains 21.50% amorphous material, primarily composed of SiO_2-rich glassy silicates (7.92%) and Fe-rich poorly crystalline oxides/hydroxides (8.87%), with minor contributions from Al_2O_3 (2.38%), CaO (1.03%), TiO_2 (1.26%), K_2O (0.50%), and MnO (0.11%).

These amorphous phases likely include:

- Glassy silicates or volcanic glass contributing to the silica fraction.
- Nanophase Fe-oxides or ferrihydrite contributing to the Fe fraction.
- Poorly crystalline aluminosilicates or clay minerals (related to Muscovite, Lizardite, or feldspars).
- Minor amorphous titanates or carbonates (from Titanite or Ankerite) contributing to TiO_2 and CaO.

Potential commercial uses

Component	Applications
Silica-rich phases (Quartz, Glass)	Glass, ceramics, silica fillers, cement, construction materials
Feldspars (Andesine, Albite, Labradorite)	Ceramics and porcelain (flux), glass manufacturing, industrial fillers
Mica (Muscovite)	Electrical insulation, heat-resistant materials, decorative fillers
Pyroxenes (Diopside, Augite, Jadeite)	Refractory materials, ceramics, steel slag additives
Olivine / Forsterite	Refractory bricks, slag conditioners, metallurgical applications
Iron & Titanium Oxides (Magnetite, Ilmenite, Titanite, Magnesioferrite)	Pigments, magnetic materials, Fe/Ti extraction, coatings
Amorphous fraction	Pozzolanic cement additive, adsorbents, catalyst supports
Garnet (Pyrope, minor)	Abrasives, waterjet cutting
Carbonates (Ankerite, minor)	Cement additives, soil conditioners
Trace oxides (BaO, SrO, V_2O_5, ZrO_2, NiO, PbO, ZnO)	Specialized industrial applications, pigments, alloy additives

Probable origin assessment

The mineral assemblage and oxide chemistry indicate a primary igneous origin, likely intermediate to mafic volcanic or hypabyssal rock, modified by secondary alteration (hydration, mica formation, and partial amorphization). The combination of crystalline feldspars and pyroxenes with 21.50 wt.% amorphous material is consistent with volcanic rocks that have experienced rapid cooling and minor hydrothermal alteration.

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Final Results:

- **Rock Type / Nature:** Mafic–intermediate silicate rock (likely Diopside–andesine–muscovite)
- **Texture and Alteration:** Partially crystalline with ~21.50wt.% amorphous content, indicating glassy or altered component.
- **Probable Origin:** Igneous (basaltic or doleritic) material subjected to slight metamorphic or metasomatic alteration.

Stoichiometric Oxide Table

Sl. No.	Mineral	Chemical Formula	XRD Wt.%	SiO_2	Al_2O_3	Fe2O3	MgO	CaO	Na_2O	K_2O	TiO_2	MnO	CO_2	H_2O
1	Andesine (An50)	$(Na,Ca)(Al,Si)_4O_8$	18.63	8.66	6.70	0.00	0.00	2.83	0.44	0.00	0.00	0.00	0.00	0.00
2	Labradorite	$(Ca,Na)(Al,Si)_4O_8$	1.56	0.35	0.33	0.00	0.00	0.49	0.39	0.00	0.00	0.00	0.00	0.00
3	Albite	$NaAlSi_3O_8$	1.60	1.02	0.40	0.00	0.00	0.00	0.18	0.00	0.00	0.00	0.00	0.00
4	Diopside	$CaMgSi_2O_6$	33.28	23.04	0.00	0.00	5.39	4.85	0.00	0.00	0.00	0.00	0.00	0.00
5	Aegirine	$NaFeSi_2O_6$	0.36	0.13	0.00	0.07	0.00	0.00	0.16	0.00	0.00	0.00	0.00	0.00
6	Augite	$(Ca,Mg,Fe)Si_2O_6$	0.43	0.19	0.00	0.07	0.06	0.11	0.00	0.00	0.00	0.00	0.00	0.00
7	Jadeite	$NaAlSi_2O_6$	0.53	0.23	0.13	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.00
8	Forsterite	Mg_2SiO_4	0.70	0.34	0.00	0.00	0.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	Aegirine-Augite	$(Na,Ca)(Fe,Mg)Si_2O_6$	1.09	0.46	0.00	0.22	0.11	0.15	0.15	0.00	0.00	0.00	0.00	0.00
10	Magnesioferrite	$MgFe_2O_4$	0.18	0.00	0.00	0.14	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	Jacobsite	$MnFe_2O_4$	0.09	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00
12	Pyrope	$Mg_3Al_2Si_3O_{12}$	0.26	0.09	0.09	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	Ankerite	$Ca(Fe,Mg)(CO_3)_2$	0.08	0.00	0.00	0.03	0.01	0.02	0.00	0.00	0.00	0.00	0.02	0.00
14	Muscovite-2M1	$KAl_2(AlSi_3O_{10})(OH)_2$	11.35	4.89	4.59	0.00	0.00	0.00	0.00	1.51	0.00	0.00	0.00	0.36
15	Titanite	$CaTiSiO_5$	0.50	0.22	0.00	0.00	0.00	0.14	0.00	0.00	0.14	0.00	0.00	0.00
16	Magnetite	Fe_3O_4	0.94	0.00	0.00	0.94	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	Ilmenite	$FeTiO_3$	0.34	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.19	0.00	0.00	0.00
18	Lizardite-1T	$Mg_3Si_2O_5(OH)_4$	1.84	0.96	0.00	0.00	0.62	0.00	0.00	0.00	0.00	0.00	0.00	0.26
19	Quartz	SiO_2	0.05	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	Olivine	$(Mg,Fe)_2SiO_4$	4.68	2.46	0.00	1.19	1.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total		**78.50**	**43.09**	**12.24**	**2.85**	**7.70**	**8.59**	**1.49**	**1.51**	**0.33**	**0.05**	**0.02**	**0.62**

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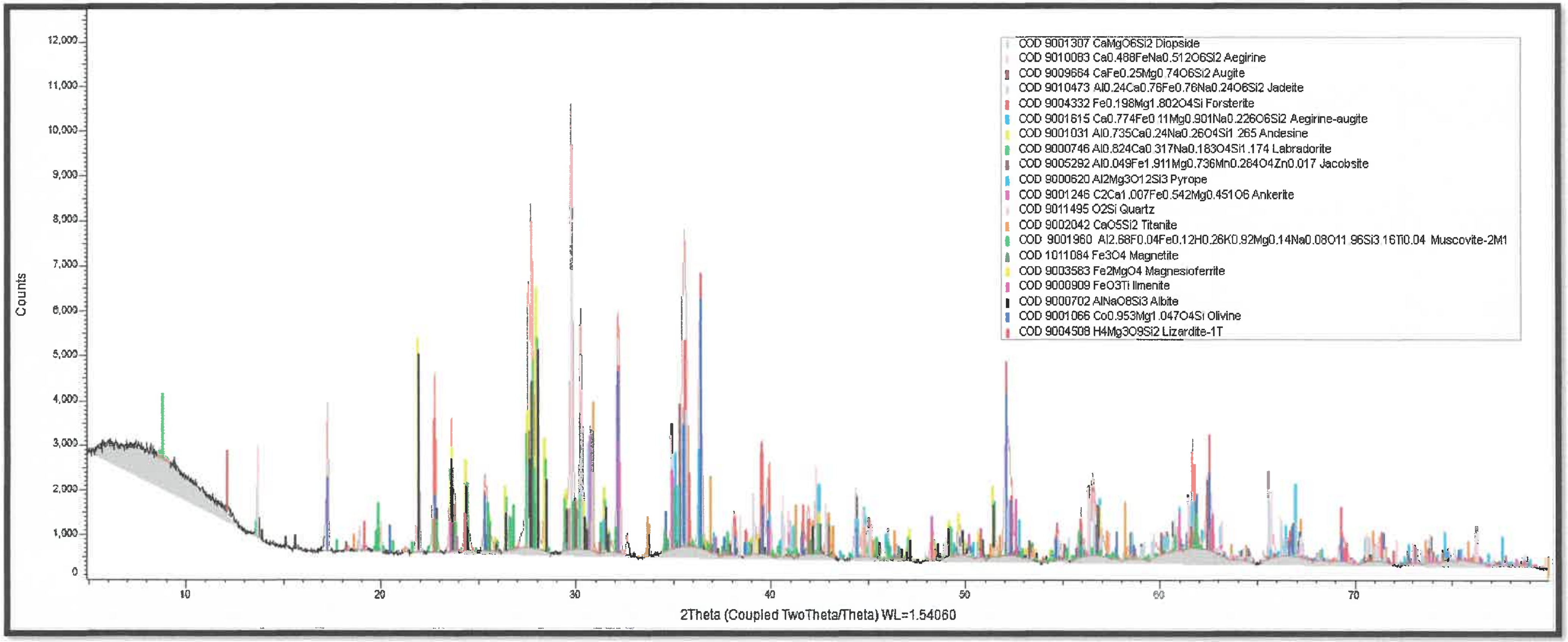
BRUKER D8 ADVANCE XRD TEST DATA

G2803-1 CMT/011/10/2025 XRD Scan Report_1 of 2



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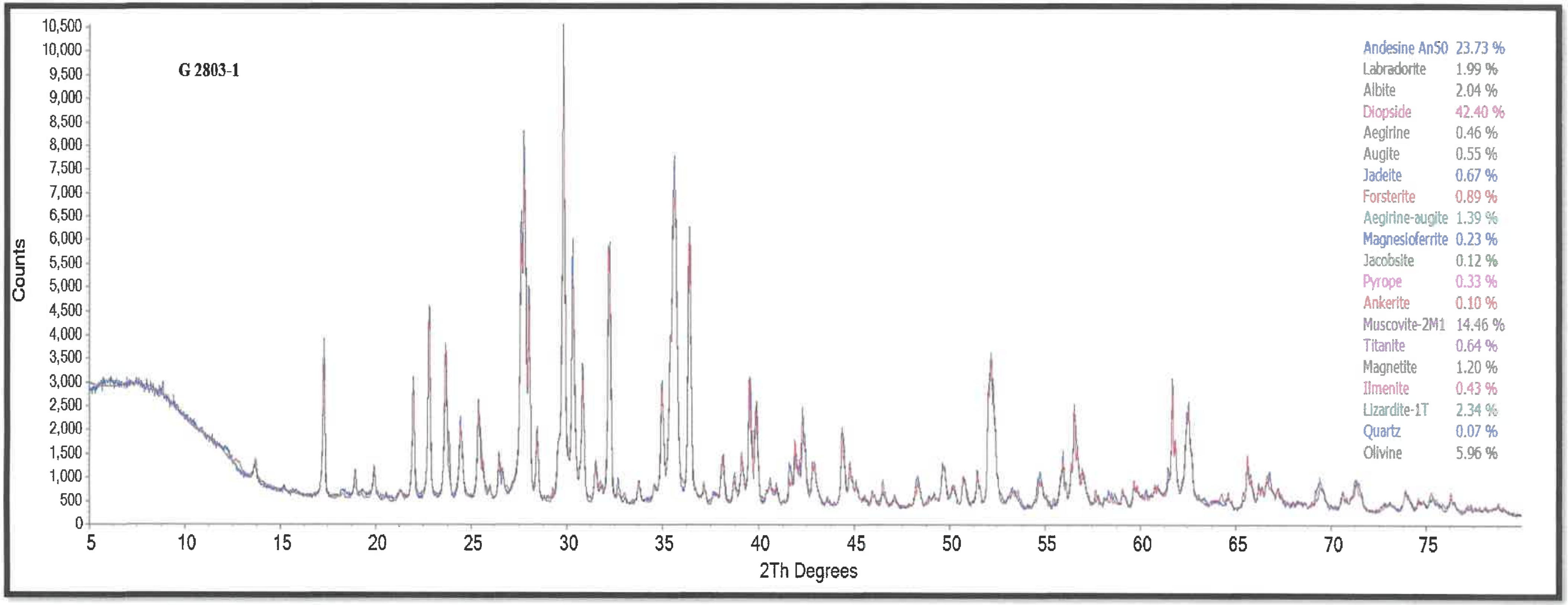
BRUKER D8 ADVANCE XRD TEST DATA

G2803-1	CMT/011/10/2025	XRD Scan Report_2 of 2



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