Quantitative X-Ray Diffraction by Rietveld Refinement

Report Prepared for:	*SGS Greece S.A.*
Project Number/ LIMS No.	*Custom XRD/MI4527-FEB22*
Sample Receipt:	*February 24, 2022*
Sample Analysis:	*February 25, 2022*
Reporting Date:	*February 25, 2022*

Instrument:	BRUKER AXS D8 Advance Diffractometer
Test Conditions:	Co radiation, 35 kV, 40 mA; Detector: LYNXEYE Regular Scanning: Step: 0.02°, Step time: 0.75s, 2θ range: 6-80°
Interpretations :	PDF2/PDF4 powder diffraction databases issued by the International Center for Diffraction Data (ICDD). DiffracPlus Eva and Topas software.
Detection Limit :	0.5-2%. Strongly dependent on crystallinity.

Contents:

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ACCREDITATION: SGS Natural Resources Lakefield is accredited to the requirements of ISO/IEC 17025 for specific tests as listed on our scope of accreditation, including geochemical, mineralogical and trade mineral tests. To view a list of the accredited methods, please visit the following website and search SGS Canada Inc. - Minerals: https://www.scc.ca/en/search/palcan.

Method Summary

The Rietveld Method of Mineral Identification by XRD (ME-LR-MIN-MET-MN-D05) method used by SGS Natural Resources is accredited to the requirements of ISO/IEC 17025.

Mineral Identification and Interpretation:

Mineral identification and interpretation involves matching the diffraction pattern of an unknown material to patterns of single-phase reference materials. The reference patterns are compiled by the Joint Committee on Powder Diffraction Standards - International Center for Diffraction Data (JCPDS-ICDD) database and released on software as Powder Diffraction Files (PDF).

Interpretations do not reflect the presence of non-crystalline and/or amorphous compounds, except when internal standards have been added by request. Mineral proportions may be strongly influenced by crystallinity, crystal structure and preferred orientations. Mineral or compound identification and quantitative analysis results should be accompanied by supporting chemical assay data or other additional tests.

Quantitative Rietveld Analysis:

Quantitative Rietveld Analysis is performed by using Topas 4.2 (Bruker AXS), a graphics based profile analysis program built around a non-linear least squares fitting system, to determine the amount of different phases present in a multicomponent sample. Whole pattern analyses are predicated by the fact that the X-ray diffraction pattern is a total sum of both instrumental and specimen factors. Unlike other peak intensity-based methods, the Rietveld method uses a least squares approach to refine a theoretical line profile until it matches the obtained experimental patterns.

Rietveld refinement is completed with a set of minerals specifically identified for the sample. Zero values indicate that the mineral was included in the refinement calculations, but the calculated concentration was less than 0.05wt%. Minerals not identified by the analyst are not included in refinement calculations for specific samples and are indicated with a dash.

Summary of Rietveld Quantitative Analysis X-Ray Diffraction Results

Mineral/Compound	Zeolite Sample FEB4527-1 (wt %)
Stilbite	7.8
Clinoptilolite	81.2
Muscovite	4.5
Orthoclase	2.8
Quartz	1.3
Albite	2.4
TOTAL	100

The weight percent quantities indicated have been normalized to a sum of 100%.

The quantity of amorphous material has not been determined.

Mineral/Compound	Formula
Stilbite	$CaAl_2Si_7O_{18}\cdot 7H_2O$
Clinoptilolite	$(Na,K,Ca)_2^{-}3Al_3(Al,Si)_2Si_{13}O_{36}\cdot 12(H_2O)$
Muscovite	$KAl_2(AlSi_3O_{10})(OH)_2$
Orthoclase	$KAlSi_3O_8$
Quartz	SiO_2
Albite	$NaAlSi_3O_8$

Zeolite Sample