James Hutton Limited

Report Number: 2018-26370

ANALYTICAL LABORATORY SERVICES
Assured Analytical Excellence
www.claysandminerals.com

Report on the Mineralogy of Five Samples by X-Ray Powder Diffraction (XRPD)

FOR:

Peter Polito
Institute for Geophysics
The University of Texas at Austin
10100 Burnet Rd Stop: 2200
ROC-196, Rm 2.104A
Austin
TEXAS
USA

INVESTORS IN PEOPLE

UKAS TESTING 7541

REPORT AUTHORS:

Ian M Phillips BSc, PhD (Senior Analyst)
(e-mail: ian.phillips@hutton.ac.uk T: 01224 395356)

Job and Sample Information:	
Job No(s):	2018-26370
Client Order No/Reference:	2018A13313
Date Sample(s) Received:	12-March-2018
Lab Code	**Client Code**
1282528	1FB-3
1282529	3FB-2
1282530	3FB-3-1
1282531	4FB-2
1282532	4FB-3-1

Introduction

Five samples were forwarded for whole rock and <2 micron clay fraction mineralogical analysis by X-ray powder diffraction (XRPD).

Methods

Methods	Accreditation Reference
Identification and Quantification of Polycrystalline Material by XRPD	GM003 and GM004
Identification and Semi-Quantification of Clay Minerals	GM001 and GM002

XRPD

The bulk samples were wet ground (in ethanol) in a McCrone mill and spray dried to produce random powders. The X-ray powder diffraction (XRPD) patterns were recorded from 2-75°2θ using Cobalt Kα radiation. Quantitative analysis was done by a normalised full pattern reference intensity ratio (RIR) method. Unless stated otherwise, expanded uncertainty using a coverage factor of 2, i.e. 95% confidence, is given by $\pm X^{0.35}$, where X = concentration in wt.%., e.g. 30 wt.% ±3.3. Note also that for phases present at the trace level (<1%) there may also be uncertainty as to whether or not the phase is truly present in the sample. This is both phase and sample dependent. It arises because at trace concentrations identification is often based on the presence of a single peak and the judgement of the analyst in assigning that peak to a likely mineral.

The clay fractions of <2µm were obtained by timed sedimentation, prepared as an oriented mount using the filter peel transfer technique and scanned from 2-45°2θ in the air-dried state, after glycolation, and after heating to 300°C for one hour. Clay minerals identified were quantified using a mineral intensity factor approach based on calculated XRPD patterns. Unless otherwise stated, for clay minerals present in amounts >10wt.% uncertainty is estimated as better than ±5wt.% at the 95% confidence level.

The XRPD patterns are identified by a labcode and by a name based on customer supplied identifiers, plus the suffix ‘A’ for air-dried, ‘G’ for glycolated, ‘H3’ for heated to 300°C and ‘B’ for bulk sample.

Results

The bulk XRPD results are presented in Table 1 and <2 micron clay fraction are in Table 2. The XRPD patterns, with the main non-clay phases identified in the bulk sample by reference to patterns from the International Centre for Diffraction Database (ICDD), are provided for reference.

Comments and opinions

The whole rock samples are mixtures of quartz, plagioclase, K-feldspar, calcite, dolomite, undifferentiated illite plus illite/smectite, amphibole, kaolinite, chlorite, halite and possible traces of siderite, pyrite and anatase.

The <2 micron clay fractions are dominated by mixed-layer illite/smectite with smaller amounts of illite, chlorite and kaolinite. In all samples the mixed-layer illite/smectite has an expandability estimated as 75%.

Note:
Samples will be stored for a period of eight weeks following completion of analysis and acceptance of analytical report(s) at no extra cost after which samples will be disposed of unless a specific instruction is given (with the sample analysis request/order) to store the sample beyond this period. Extended storage charges will apply.

Table 1: XRPD Bulk Mineralogy (weight %) RIR Method

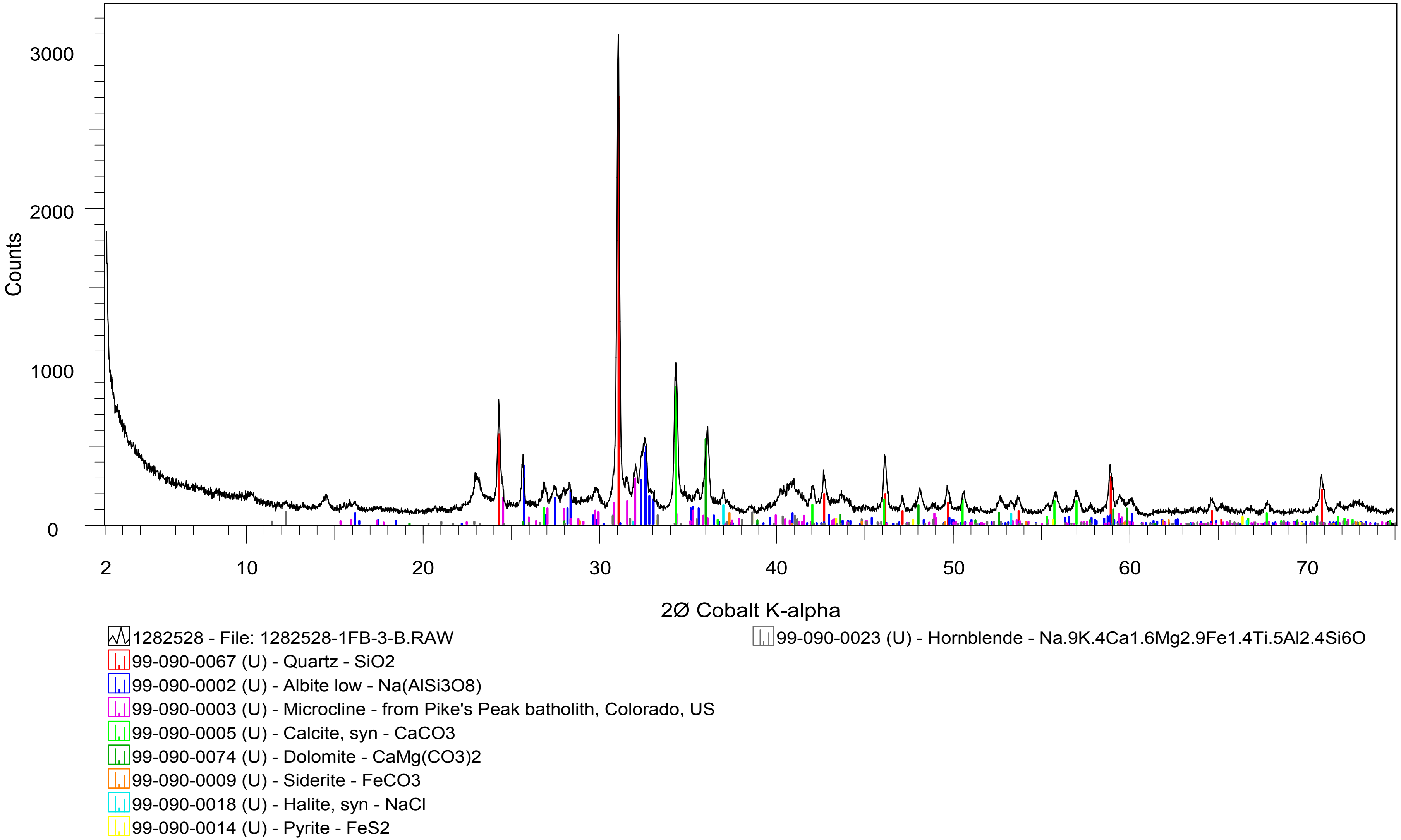
Labcode	Sample ID	Quartz	Plagioclase	K-feldspar	Amphibole	Calcite	Dolomite	Siderite	Pyrite	Anatase	Halite	I+I/S-ML	Chlorite(Tri)	Kaolinite	Total
1282528	1FB-3-B	20.0	15.9	8.4	1.8	11.7	8.4	0.8	0.4	0.0	0.7	26.9	2.9	2.1	100.0
1282529	3FB-2-B	34.4	18.7	7.4	1.3	8.4	10.7	0.5	0.3	0.0	2.0	15.2	0.8	0.3	100.0
1282530	3FB-3-1-B	47.6	20.9	8.4	1.3	5.9	9.7	0.2	0.0	0.0	0.1	5.9	0.0	0.0	100.0
1282531	4FB-2-B	46.7	22.3	8.0	1.0	6.1	9.7	0.2	0.0	0.0	0.0	6.0	trace	trace	100.0
1282532	4FB-3-1-B	25.6	15.0	6.5	1.4	9.7	9.3	0.9	0.2	0.1	0.9	25.8	1.2	3.4	100.0

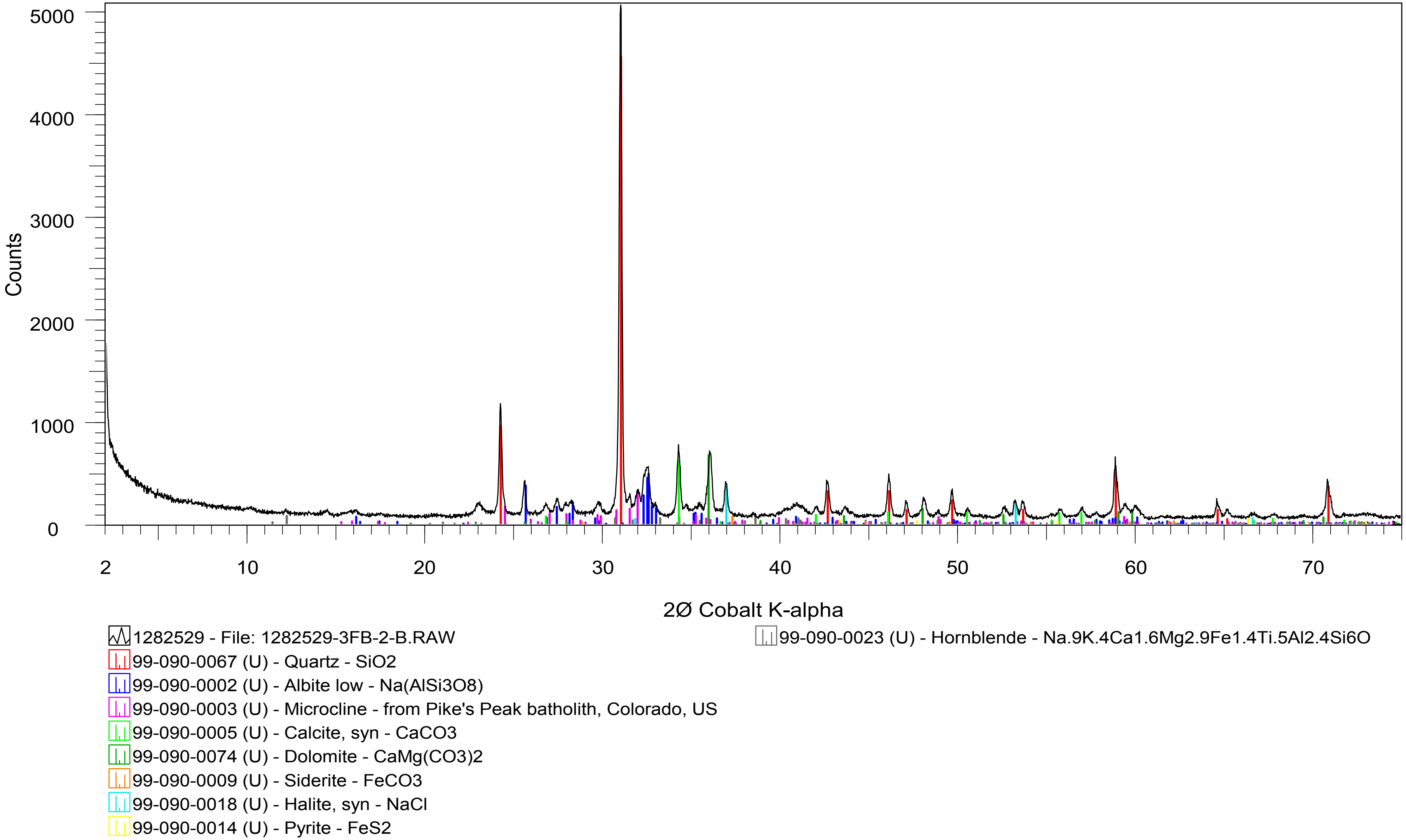
I+I/S = Undifferentiated Illite + Illite/Smectite – Mixed Layered

Table 2: Relative percentage of clay minerals in the <2μm clay size fraction

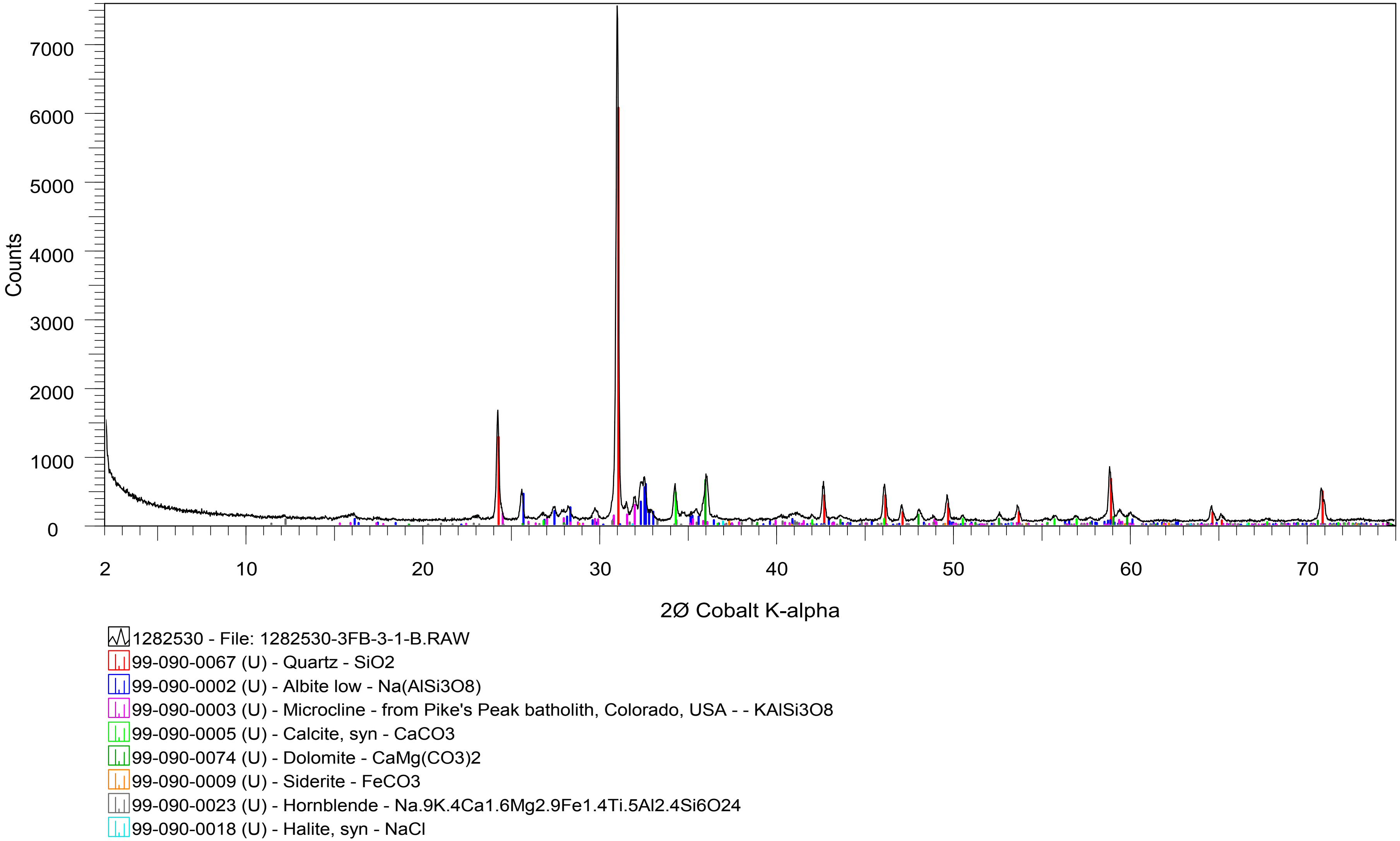
Labcode	Sample ID	XRD pattern name	Chlorite(Tri)©	Kaolinite©	Illite©	I/S-ML©	%Exp©
1282528	1FB-3	1FB-3-A,-G,-H3	10	4	14	72	75
1282529	3FB-2	3FB-2-A,-G,-H3	5	3	15	77	75
1282530	3FB-3	3FB-3-1-A,-G,-H3	3	2	10	85	75
1282531	4FB-2	4FB-2-A,-G,-H3	3	2	9	86	75
1282532	4FB-3-1	4FB-3-1-A,-G,-H3	6	4	13	77	75

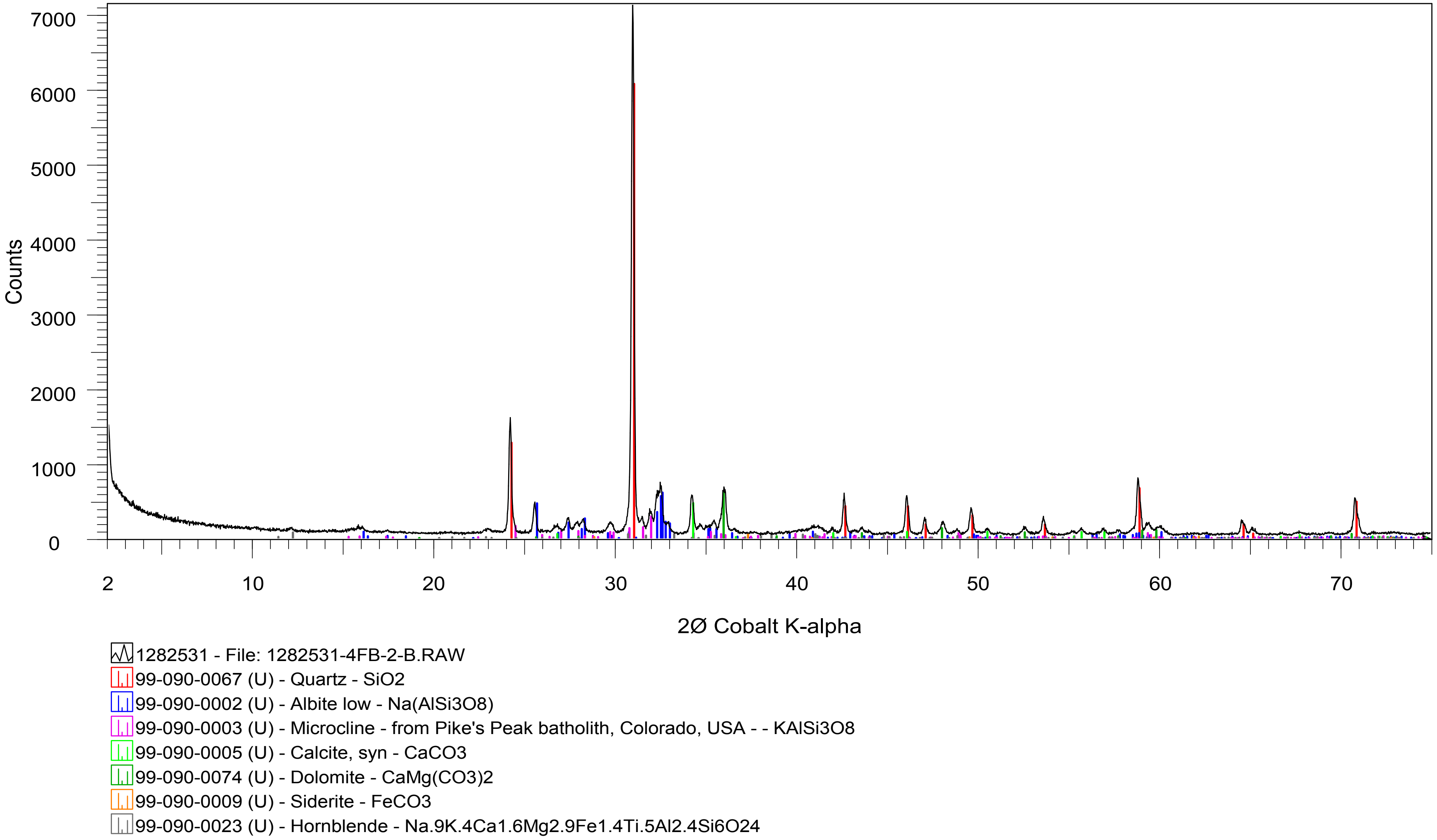
I+I/S© = Undifferentiated Illite + Illite/Smectite – Mixed Layered
Exp%© = Percent Expandability of Illite/Smectite – Mixed Layered

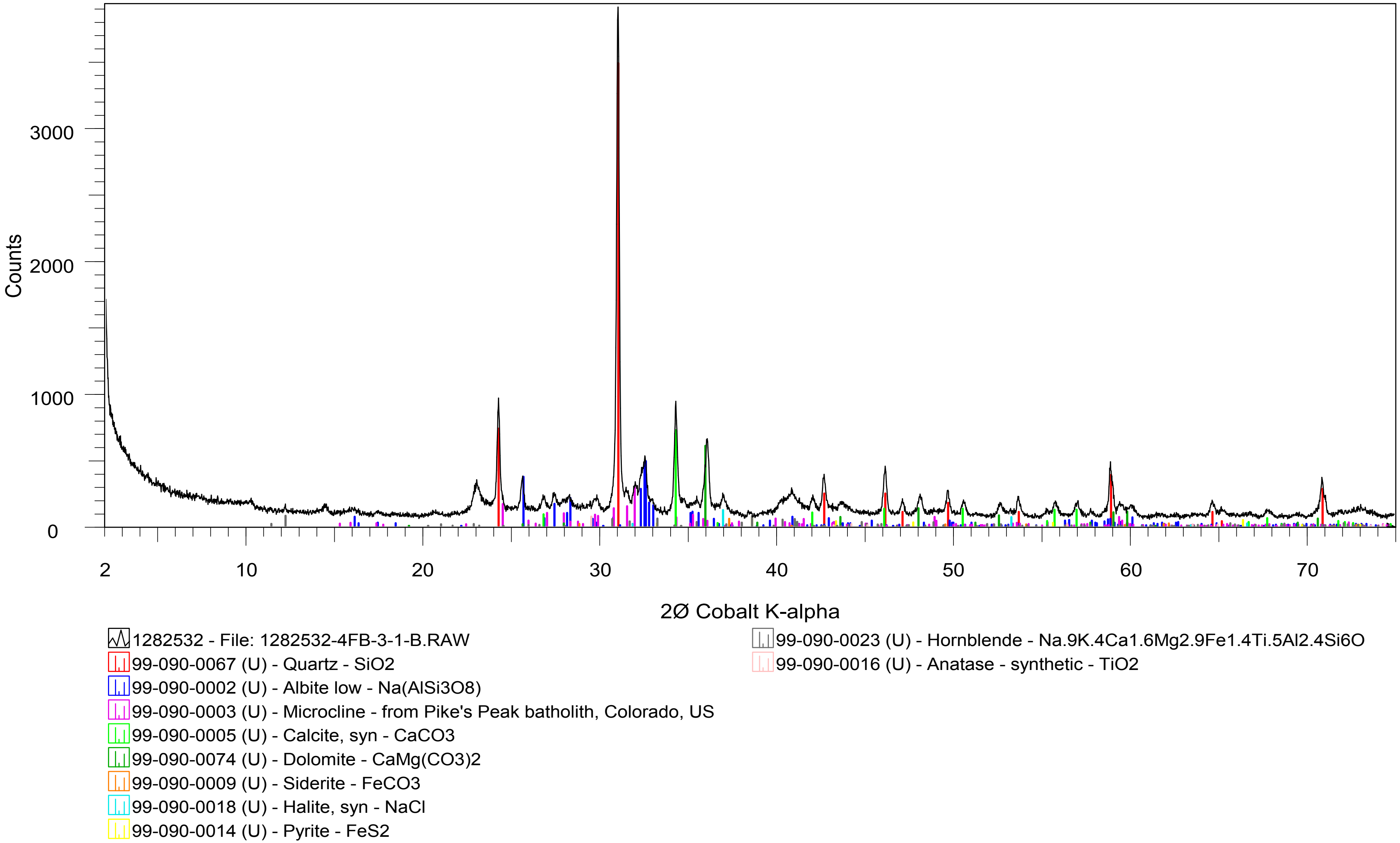

Counts
3000
2000
1000
0
2
10
20
30
40
50
60
70
2Ø Cobalt K-alpha
1282528 - File: 1282528-1FB-3-B.RAW
99-090-0067 (U) - Quartz - SiO2
99-090-0002 (U) - Albite low - Na(AlSi3O8)
99-090-0003 (U) - Microcline - from Pike's Peak batholith, Colorado, US
99-090-0005 (U) - Calcite, syn - CaCO3
99-090-0074 (U) - Dolomite - CaMg(CO3)2
99-090-0009 (U) - Siderite - FeCO3
99-090-0018 (U) - Halite, syn - NaCl
99-090-0014 (U) - Pyrite - FeS2
99-090-0023 (U) - Hornblende - Na.9K.4Ca1.6Mg2.9Fe1.4Ti.5Al2.4Si6O

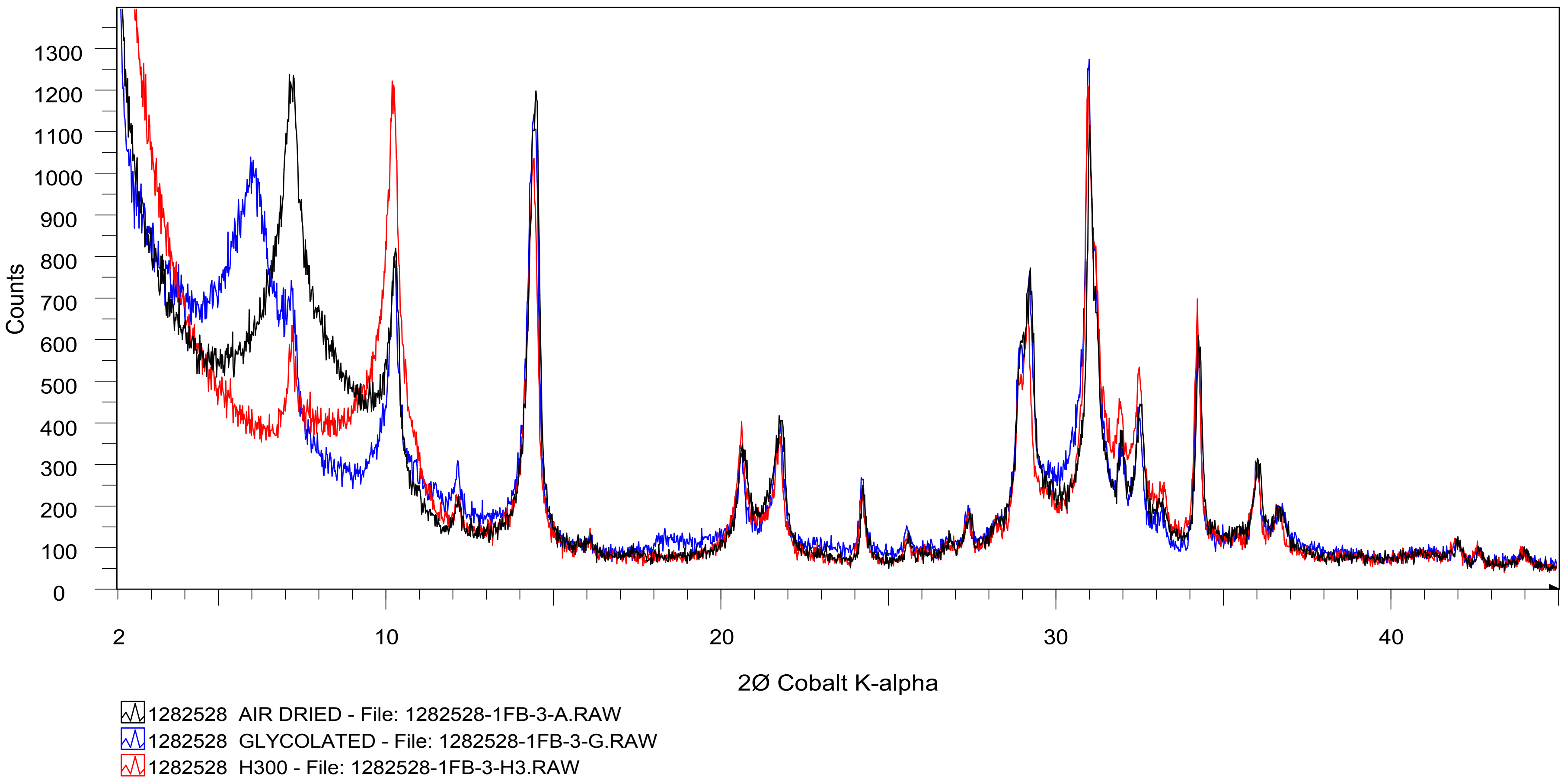


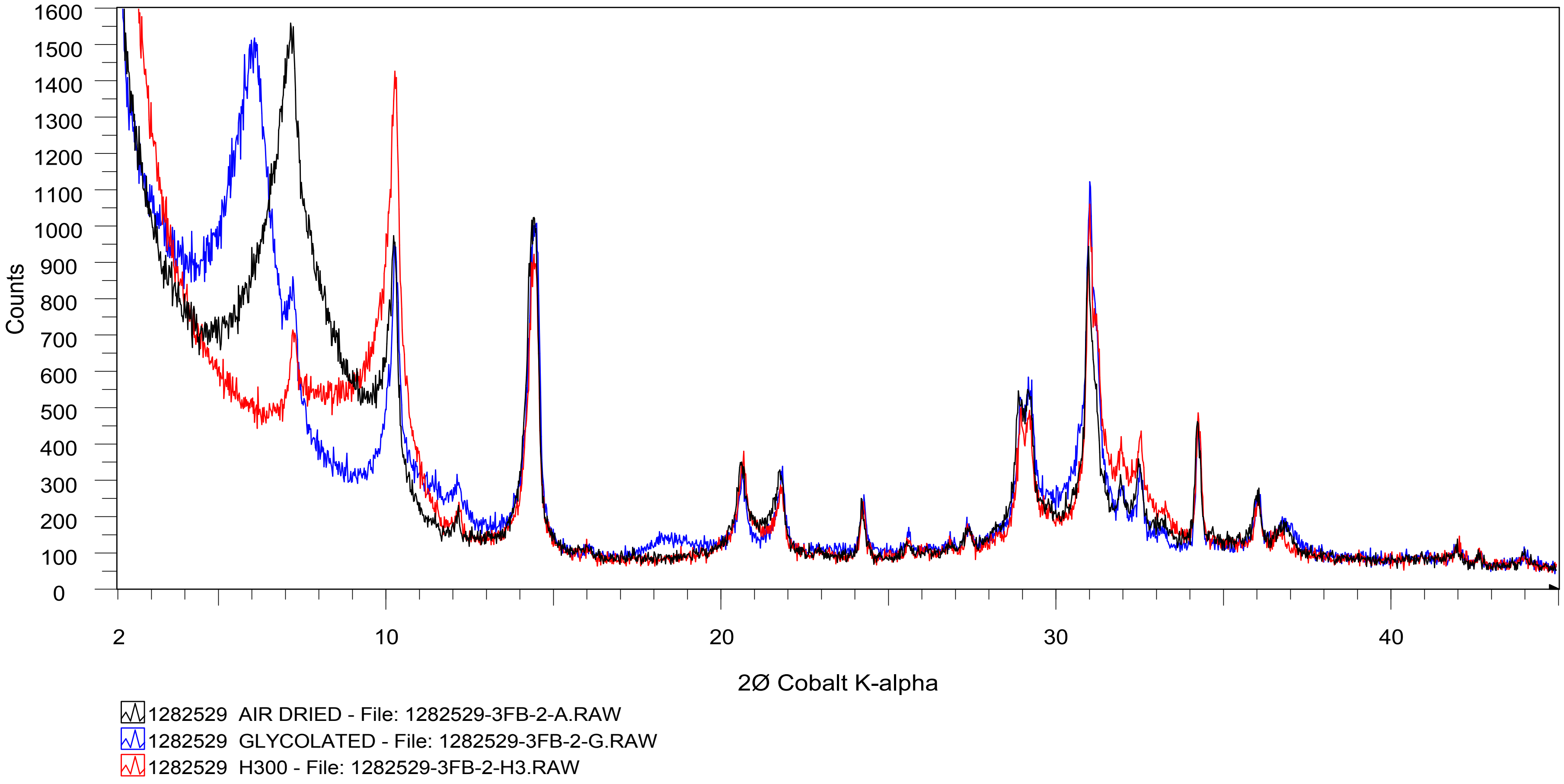
5000
4000
3000
2000
1000
0
Counts
2
10
20
30
40
50
60
70
2Ø Cobalt K-alpha
1282529 - File: 1282529-3FB-2-B.RAW
99-090-0067 (U) - Quartz - SiO2
99-090-0002 (U) - Albite low - Na(AlSi3O8)
99-090-0003 (U) - Microcline - from Pike's Peak batholith, Colorado, US
99-090-0005 (U) - Calcite, syn - CaCO3
99-090-0074 (U) - Dolomite - CaMg(CO3)2
99-090-0009 (U) - Siderite - FeCO3
99-090-0018 (U) - Halite, syn - NaCl
99-090-0014 (U) - Pyrite - FeS2
99-090-0023 (U) - Hornblende - Na.9K.4Ca1.6Mg2.9Fe1.4Ti.5Al2.4Si6O


7000
6000
5000
4000
3000
2000
1000
0
Counts
2
10
20
30
40
50
60
70
2Ø Cobalt K-alpha
1282530 - File: 1282530-3FB-3-1-B.RAW
99-090-0067 (U) - Quartz - SiO2
99-090-0002 (U) - Albite low - Na(AlSi3O8)
99-090-0003 (U) - Microcline - from Pike's Peak batholith, Colorado, USA - - KAlSi3O8
99-090-0005 (U) - Calcite, syn - CaCO3
99-090-0074 (U) - Dolomite - CaMg(CO3)2
99-090-0009 (U) - Siderite - FeCO3
99-090-0023 (U) - Hornblende - Na.9K.4Ca1.6Mg2.9Fe1.4Ti.5Al2.4Si6O24
99-090-0018 (U) - Halite, syn - NaCl

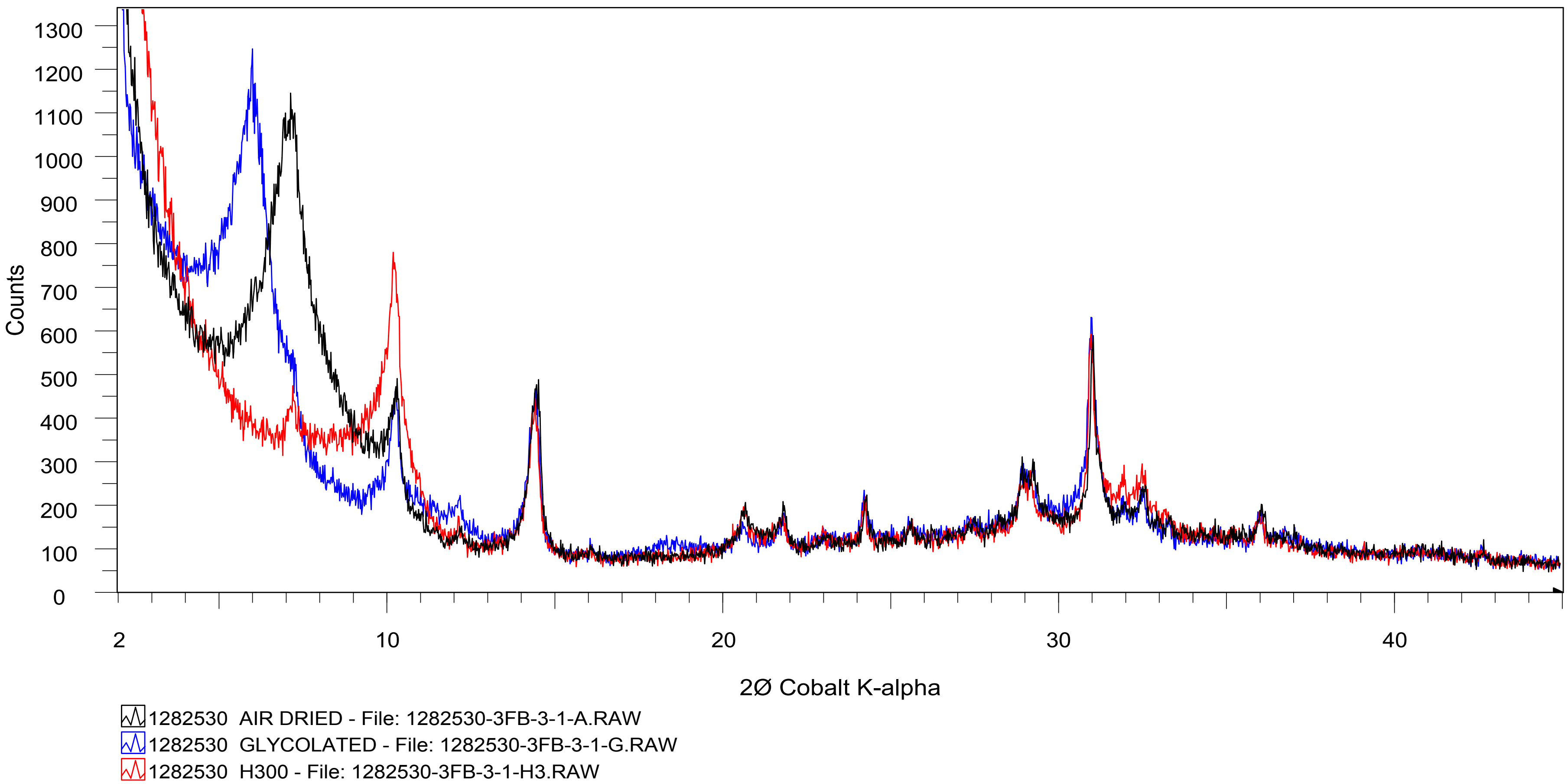

7000
6000
5000
4000
3000
2000
1000
0
Counts
2
10
20
30
40
50
60
70
2Ø Cobalt K-alpha
1282531 - File: 1282531-4FB-2-B.RAW
99-090-0067 (U) - Quartz - SiO2
99-090-0002 (U) - Albite low - Na(AlSi3O8)
99-090-0003 (U) - Microcline - from Pike's Peak batholith, Colorado, USA - - KAlSi3O8
99-090-0005 (U) - Calcite, syn - CaCO3
99-090-0074 (U) - Dolomite - CaMg(CO3)2
99-090-0009 (U) - Siderite - FeCO3
99-090-0023 (U) - Hornblende - Na.9K.4Ca1.6Mg2.9Fe1.4Ti.5Al2.4Si6O24

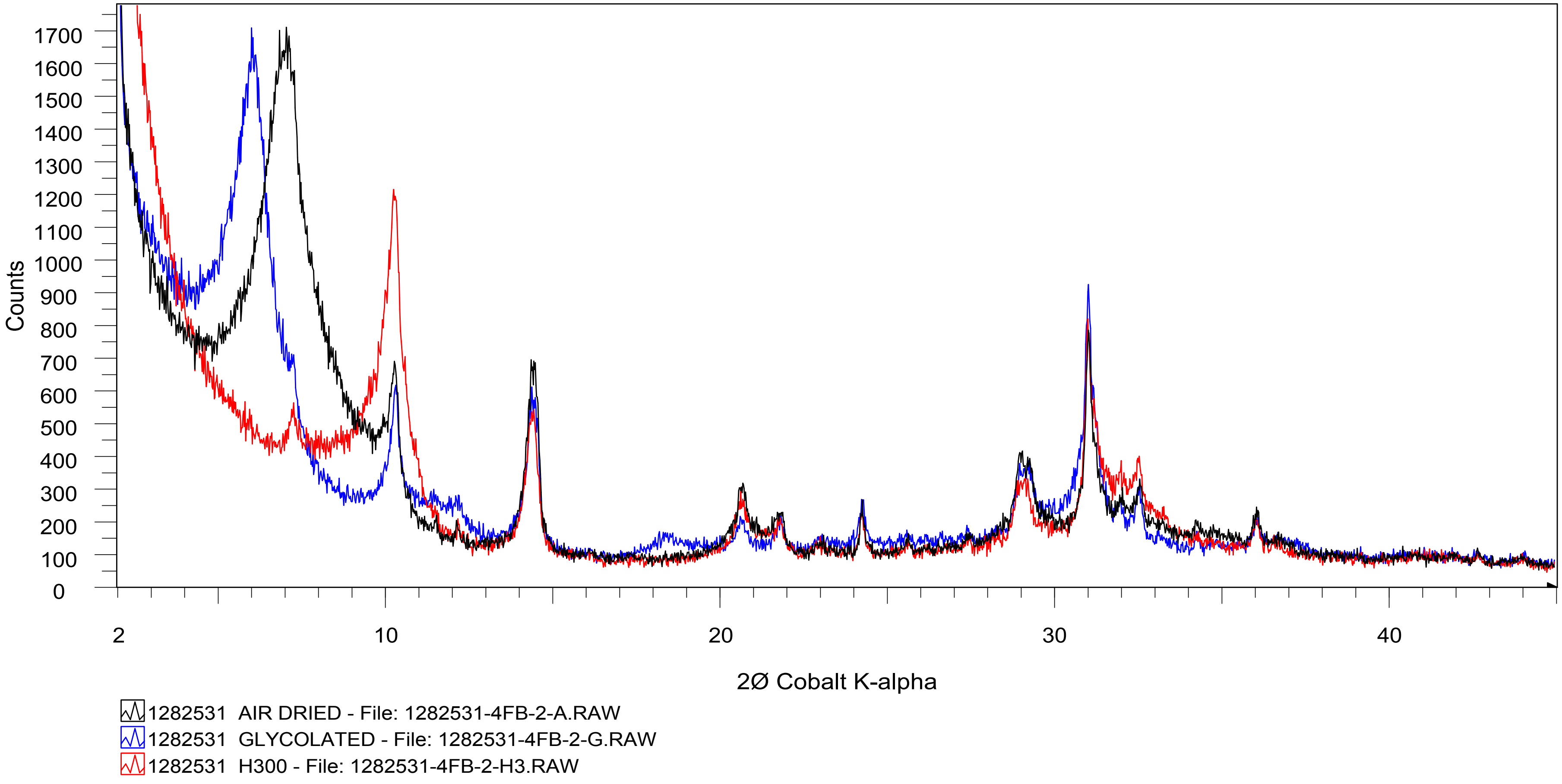

Counts
3000
2000
1000
0
2
10
20
30
40
50
60
70
2Ø Cobalt K-alpha
1282532 - File: 1282532-4FB-3-1-B.RAW
99-090-0067 (U) - Quartz - SiO2
99-090-0002 (U) - Albite low - Na(AlSi3O8)
99-090-0003 (U) - Microcline - from Pike's Peak batholith, Colorado, US
99-090-0005 (U) - Calcite, syn - CaCO3
99-090-0074 (U) - Dolomite - CaMg(CO3)2
99-090-0009 (U) - Siderite - FeCO3
99-090-0018 (U) - Halite, syn - NaCl
99-090-0014 (U) - Pyrite - FeS2
99-090-0023 (U) - Hornblende - Na.9K.4Ca1.6Mg2.9Fe1.4Ti.5Al2.4Si6O
99-090-0016 (U) - Anatase - synthetic - TiO2

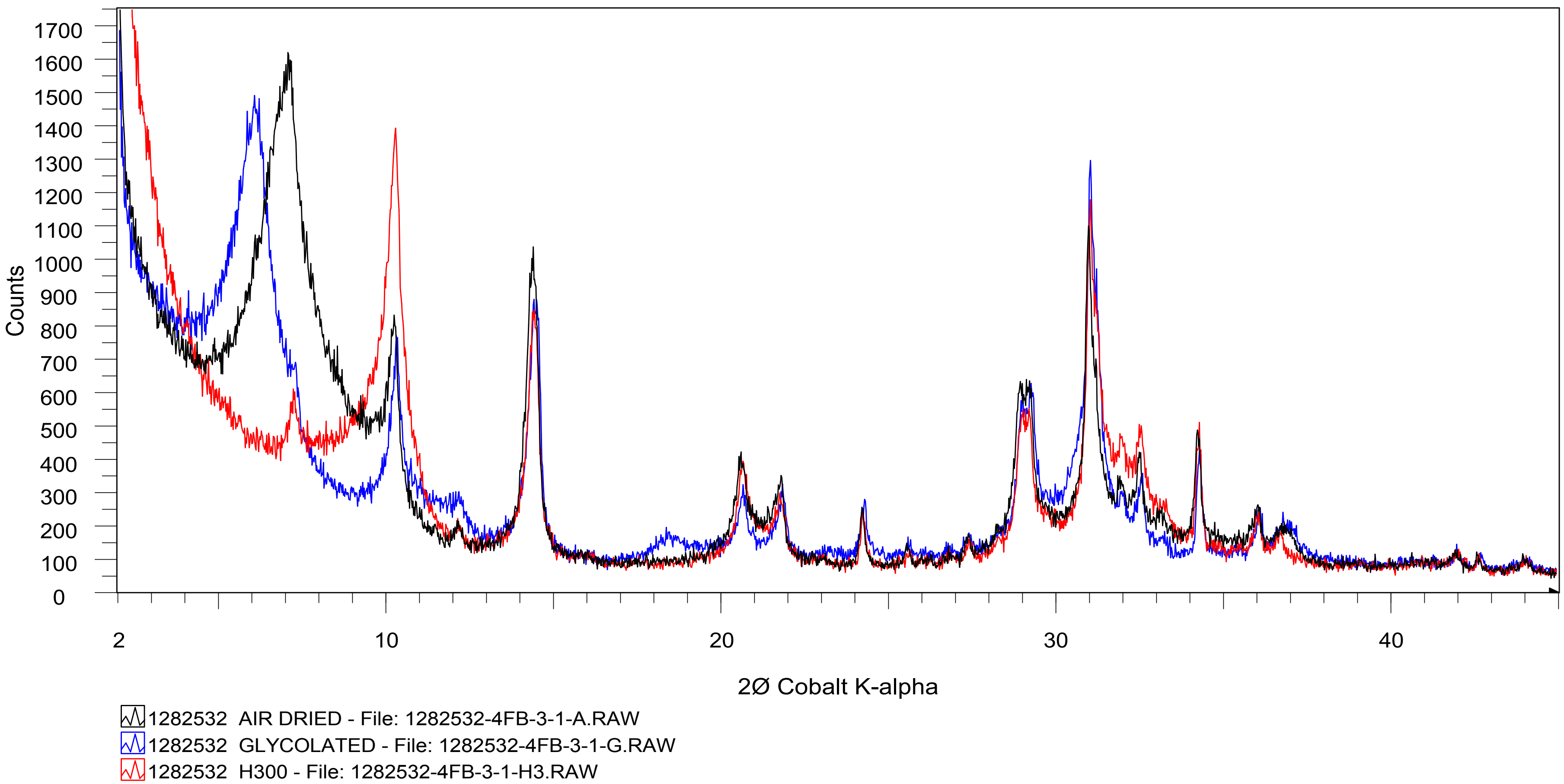

Counts
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
2
10
20
30
40
2Ø Cobalt K-alpha
1282528 AIR DRIED - File: 1282528-1FB-3-A.RAW
1282528 GLYCOLATED - File: 1282528-1FB-3-G.RAW
1282528 H300 - File: 1282528-1FB-3-H3.RAW



Counts
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
2
10
20
30
40
2Ø Cobalt K-alpha
1282529 AIR DRIED - File: 1282529-3FB-2-A.RAW
1282529 GLYCOLATED - File: 1282529-3FB-2-G.RAW
1282529 H300 - File: 1282529-3FB-2-H3.RAW


Counts
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
2
10
20
30
40
2Ø Cobalt K-alpha
1282530 AIR DRIED - File: 1282530-3FB-3-1-A.RAW
1282530 GLYCOLATED - File: 1282530-3FB-3-1-G.RAW
1282530 H300 - File: 1282530-3FB-3-1-H3.RAW


Counts
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
2
10
20
30
40
2Ø Cobalt K-alpha
1282531 AIR DRIED - File: 1282531-4FB-2-A.RAW
1282531 GLYCOLATED - File: 1282531-4FB-2-G.RAW
1282531 H300 - File: 1282531-4FB-2-H3.RAW



Counts
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
2
10
20
30
40
2Ø Cobalt K-alpha
1282532 AIR DRIED - File: 1282532-4FB-3-1-A.RAW
1282532 GLYCOLATED - File: 1282532-4FB-3-1-G.RAW
1282532 H300 - File: 1282532-4FB-3-1-H3.RAW