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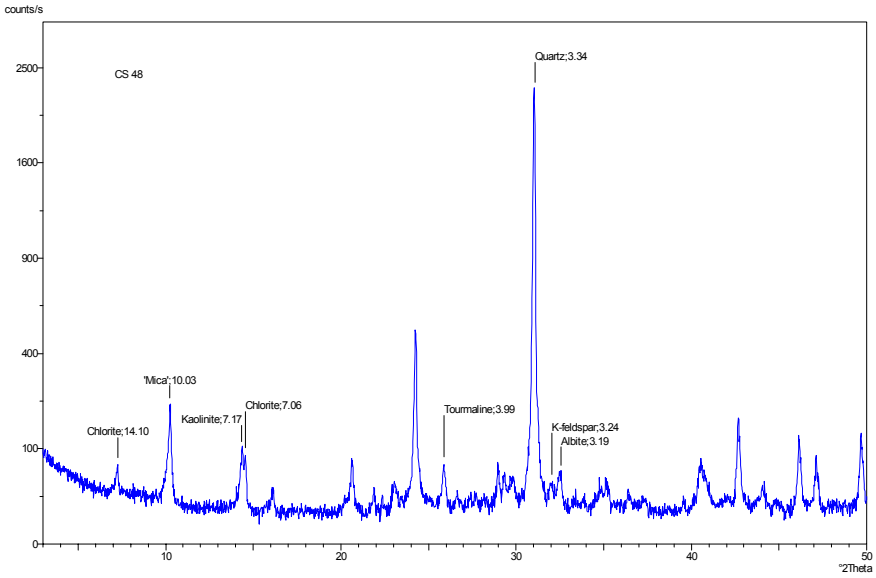
X-ray diffraction analysis of soil samples from abandoned mine sites in Cornwall

Pollution and Waste Management and Extraction Industry Impacts Programme

Internal Report IR/02/137



BRITISH GEOLOGICAL SURVEY

INTERNAL REPORT IR/02/137

X-ray diffraction analysis of soil samples from abandoned mine sites in Cornwall

J A McKervey

Key words

X-ray diffraction, Cornwall, mines, soil samples.

Front cover

XRD trace for the soil sample CS48.

Bibliographical reference

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Parent Body

Natural Environment Research Council, Polaris House, North Star Avenue, Swindon, Wiltshire SN2 1EU

☎ 01793-411500 Fax 01793-411501
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1 Introduction

This report presents the results of qualitative whole-rock X-ray diffraction analysis (XRD) analysis conducted for the project 'Fate and Transport of Heavy Metals'. The object of this project is to examine the environmental transport and fate of heavy metals, particularly in relation to abandoned mining and mineral processing operations. The samples submitted are soils collected from abandoned mine sites in Cornwall (Table 1).

Table 1: Sample list

Sample	Lab code		Sample	Lab code		Sample	Lab code
CS44	H769		CS51	H776		CS58	H783
CS45	H770		CS52	H777		CS59	H784
CS46	H771		CS53	H778		CS60	H785
CS47	H772		CS54	H779		CS61	H786
CS48	H773		CS55	H780		CS62	H787
CS49	H774		CS56	H781		_	_
CS50	H775		CS57	H782		_	_

2 Sample preparation

The samples were received as fine powders from the BGS Sample Preparation Facility. Approximately 3 g of each powder was micronised under water for 10 minutes to provide a finer and more uniform particle size. The powder was then back-loaded into a standard aluminium sample holder for XRD analysis.

3 XRD analysis

XRD analysis was carried out using a Philips PW1700 series diffractometer fitted with a cobalt-target tube and operated at 45 kV and 40 mA. The samples were scanned from 3-50 °2θ at 0.7 °2θ/minute. Diffraction data were analysed using Philips X'Pert software coupled to an International Centre for Diffraction Data (ICDD) database running on a Gateway personal computer system.

4 Results

The results of qualitative XRD analysis are given in Table 2 where a ranking (major (mj), minor (mi) or trace (tr)) is provided on the basis of relative X-ray intensity. A labelled XRD trace for each sample is shown in the Appendix.

The majority of the samples consist predominantly of quartz with minor or trace amounts of 'mica' (undifferentiated mica species) ± chlorite ± kaolinite ± K-feldspar ± albite. In samples CS51 and CS55 pyrite is identified as a major component, as are 'mica' and kaolinite in sample CS49. Sometimes present in minor or trace concentrations are tourmaline, jarosite, pyrite, and, less frequently, calcite, ?hematite, ?halite, ?illite/smectite, pyrrhotite and ?fluorite.

In contrast the samples CS59, 60, 61, and 62 have produced XRD traces with fewer, lower intensity peaks and a higher background (Figure 1). These four samples contain predominantly calcite, and minor quartz, and are all characterised by an orange-brown colour in powdered sample (Note: Although CS52 is not calcareous, it has some of the characteristics of CS59 to CS61 and is also plotted as a red trace on Figure 1).

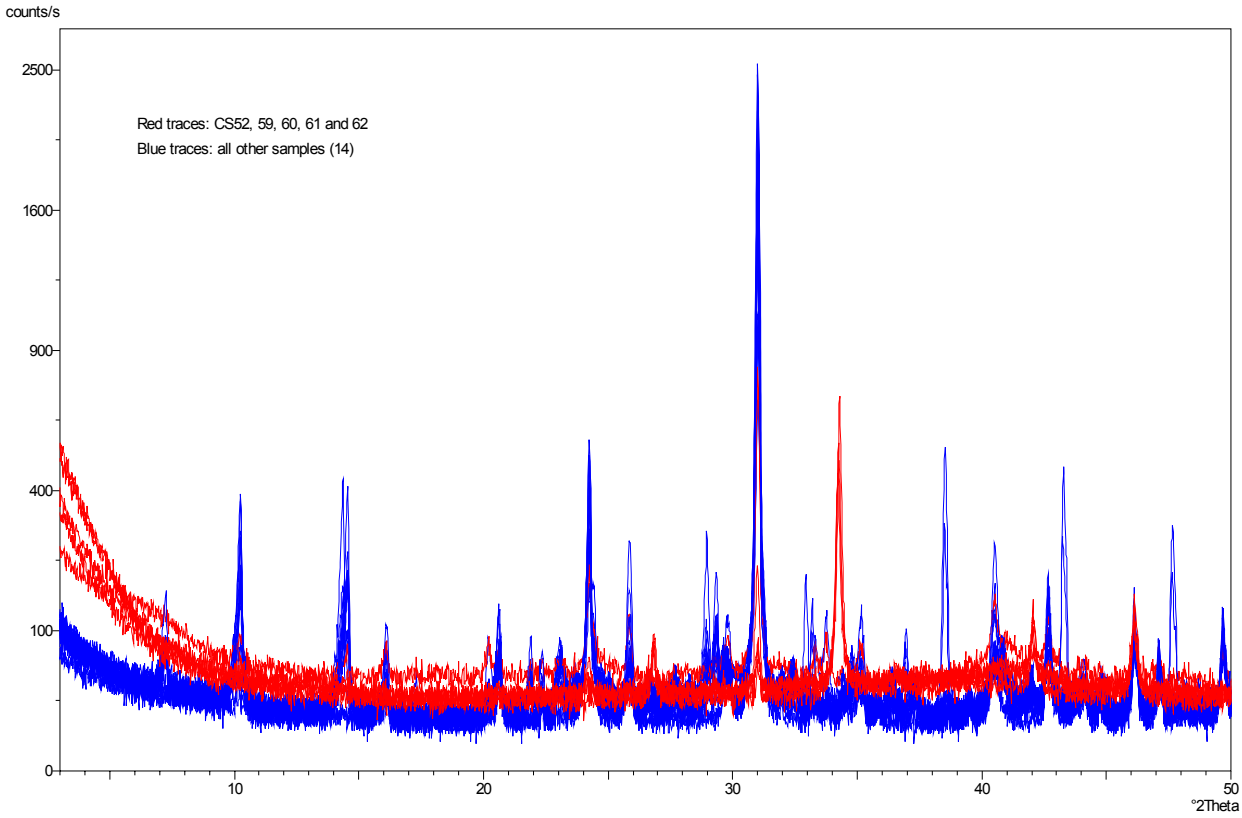


Figure 1: Comparison of the XRD traces for samples CS44 to CS62. Samples CS52, 59, 60, 61 and 62 are in red, and all the remaining samples are in blue. X-axis: °2θ Co-Kα; Y-axis: (Intensity) counts per second.

Table 2 : Summary of the results of qualitative whole-rock XRD analysis

Sample	Lab code	Mineralogy															
		Quartz	'Mica'	Chlorite	Kaolinite	K-feldspar	Albite	Pyrite	Hematite	Halite	Calcite	Tourmaline	Jarosite	Illite/ smectite	Pyrrhotite	Fluorite	Gypsum
CS44	H769	mj	mi	mi	mi	tr	tr	?tr	?tr	?tr	_	_	_	_	_	_	_
CS45	H770	mj	mi	mi	mi	?tr	tr	tr	_	?tr	_	_	_	_	_	_	_
CS46	H771	mj	mi	mi	mi	?tr	tr	?tr	?tr	?mi	tr	tr	_	_	_	_	_
CS47	H772	mj	mi	mi	mi	tr	tr	?tr	?tr	?mi	?tr	tr	_	_	_	_	_
CS48	H773	mj	mi	mi	mi	tr	tr	_	_	_	_	mi	_	_	_	_	_
CS49	H774	mj	mj	_	mj	tr	tr	_	_	_	_	mi	mi	?tr	_	_	_
CS50	H775	mj	mi	?tr	mi	?tr	tr	_	_	_	_	mi	tr	_	_	_	_
CS51	H776	mj	tr	_	_	?tr	_	mj	_	_	_	mi	_	_	tr	_	_
CS52	H777	mj	tr	tr	tr	_	_	_	_	_	_	tr	tr	_	_	_	_
CS53	H778	mj	mi	mi	mi	tr	?tr	_	_	_	_	mi	tr	_	_	_	_
CS54	H779	mj	mi	mi	mi	tr	tr	_	_	_	_	mi	_	_	?tr	?mi	_
CS55	H780	mj	mi	_	_	?tr	?tr	mj	_	_	_	mi	_	_	?tr	_	_
CS56	H781	mj	mi	mi	?tr	_	_	_	_	_	_	mi	tr	_	?tr	_	_
CS57	H782	mj	mi	mi	mi	_	?tr	_	?tr	_	_	tr	tr	_	_	_	_
CS58	H783	mj	mi	mi	mi	tr	tr	_	_	_	_	mi	tr	_	_	_	_
CS59	H784	mi	tr	?tr	?tr	_	_	_	_	_	mj	_	_	_	_	_	?tr
CS60	H785	mi	_	_	_	_	_	_	_	_	mj	_	_	_	_	_	_
CS61	H786	mi	_	_	_	_	_	_	_	_	mj	_	_	_	_	_	_
CS62	H787	mi	_	_	_	_	_	_	_	_	mj	_	_	_	_	_	_

Appendix

Key to the whole-rock X-ray diffraction traces:

X-axis: °2θ Co-Kα

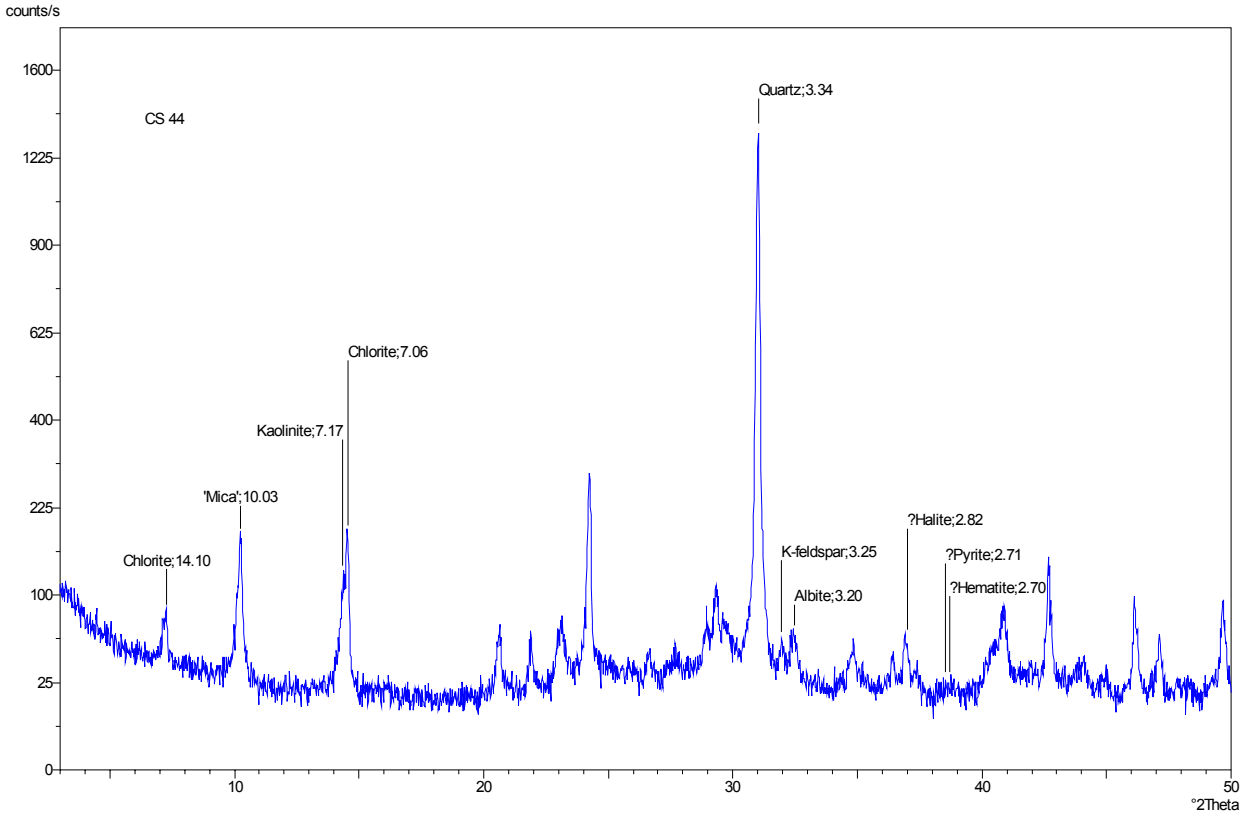
Y-axis: (Intensity) counts per second

Peak Labels: mineral and d-spacing (Å)

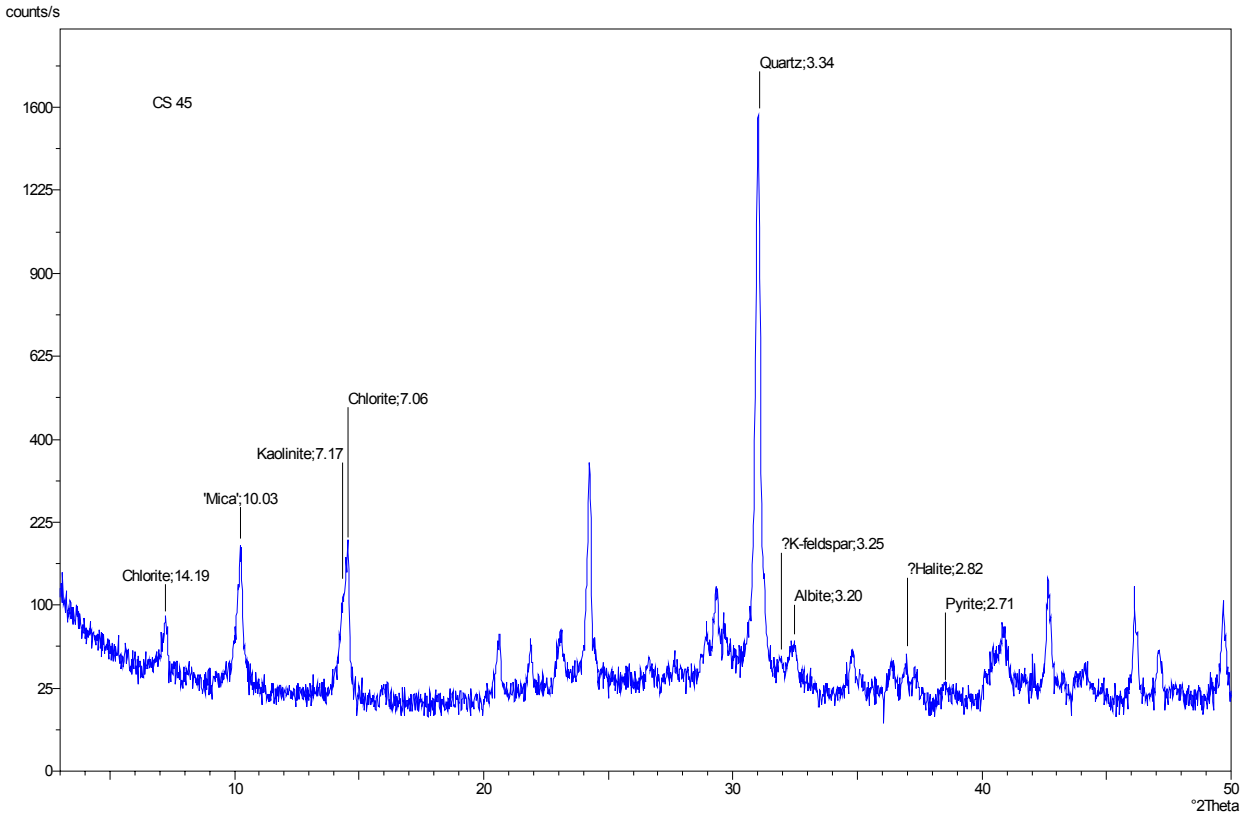
Blue trace: whole-rock powder

Only the most intense/characteristic peak is labelled for each mineral.

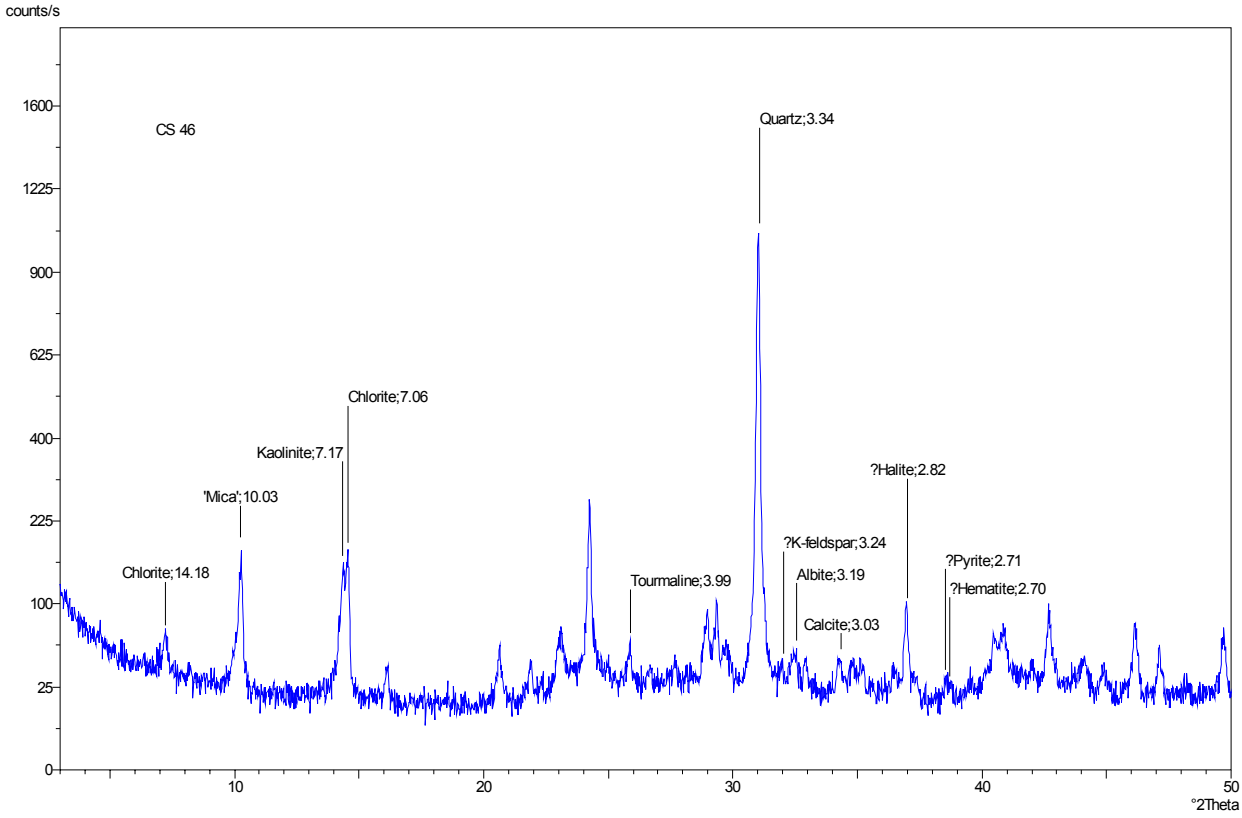
CS44


counts/s
CS 44
Quartz;3.34
Chlorite;7.06
Kaolinite;7.17
'Mica';10.03
?Halite;2.82
K-feldspar;3.25
?Pyrite;2.71
Chlorite;14.10
Albite;3.20
?Hematite;2.70
°2Theta

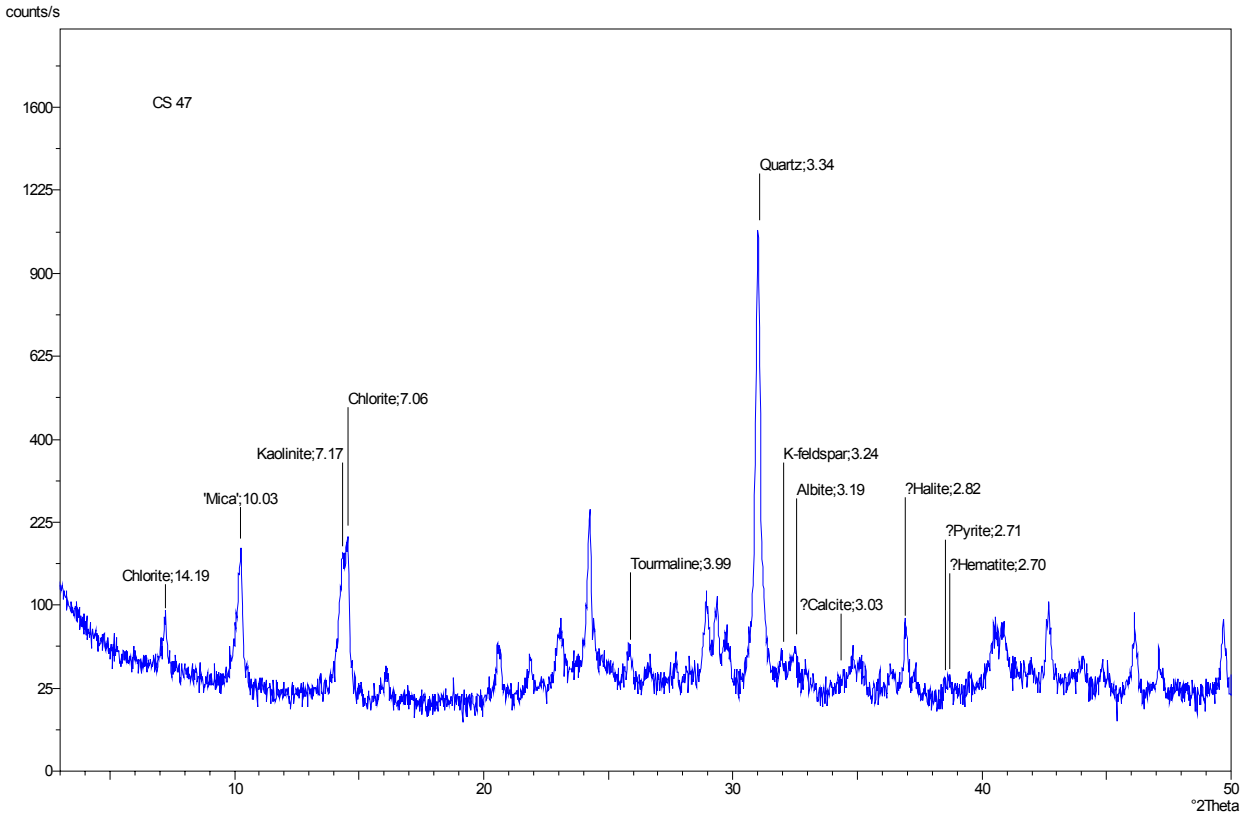
CS45


counts/s
CS 45
Quartz;3.34
Chlorite;7.06
Kaolinite;7.17
'Mica';10.03
?K-feldspar;3.25
?Halite;2.82
Chlorite;14.19
Albite;3.20
Pyrite;2.71
°2Theta

CS46


counts/s
CS 46
Quartz;3.34
Chlorite;7.06
Kaolinite;7.17
?Halite;2.82
'Mica';10.03
?K-feldspar;3.24
?Pyrite;2.71
Albite;3.19
Chlorite;14.18
Tourmaline;3.99
?Hematite;2.70
Calcite;3.03
1600
1225
900
625
400
225
100
25
0
10
20
30
40
50
°2Theta

CS47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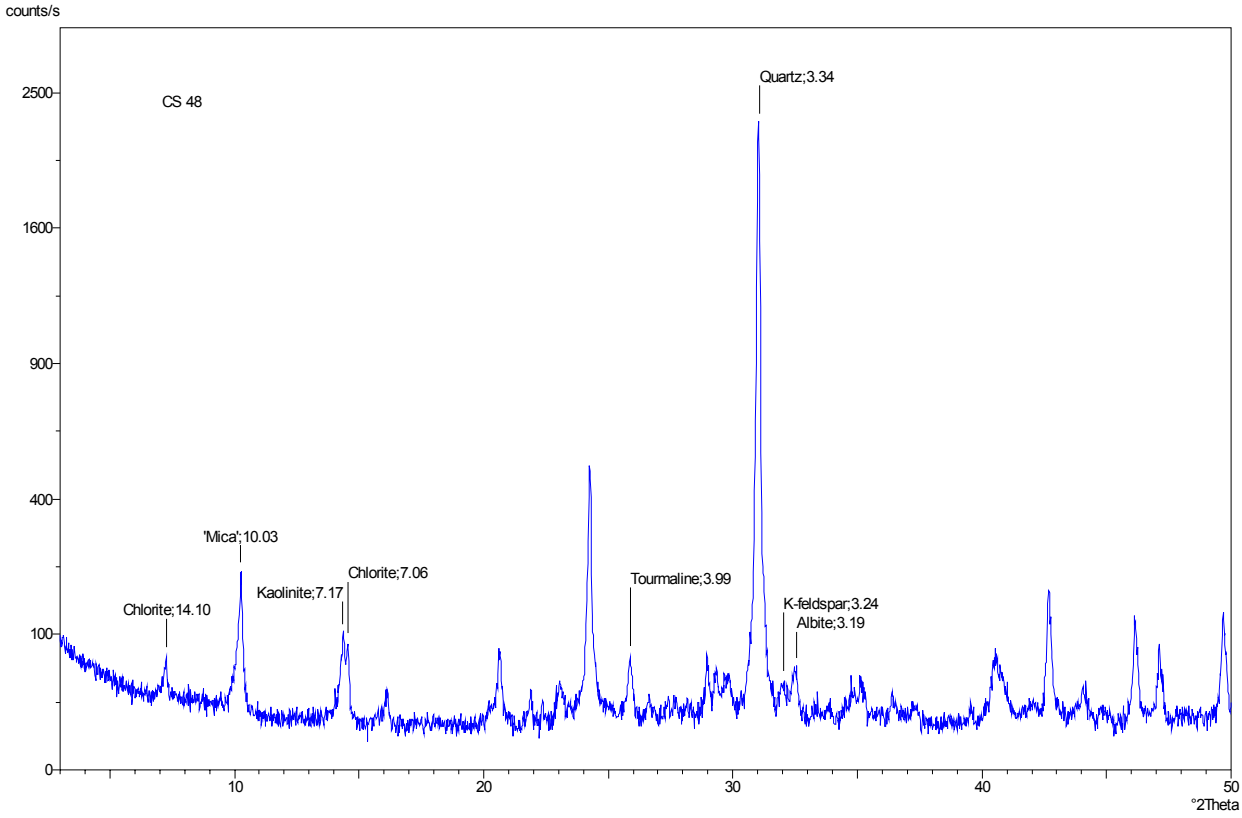
Quartz;3.34
Chlorite;7.06
K-feldspar;3.24
Kaolinite;7.17
Albite;3.19
?Halite;2.82
'Mica';10.03
?Pyrite;2.71
Tourmaline;3.99
?Hematite;2.70
Chlorite;14.19
?Calcite;3.03
1600
1225
900
625
400
225
100
25
0
10
20
30
40
50
°2Theta

CS48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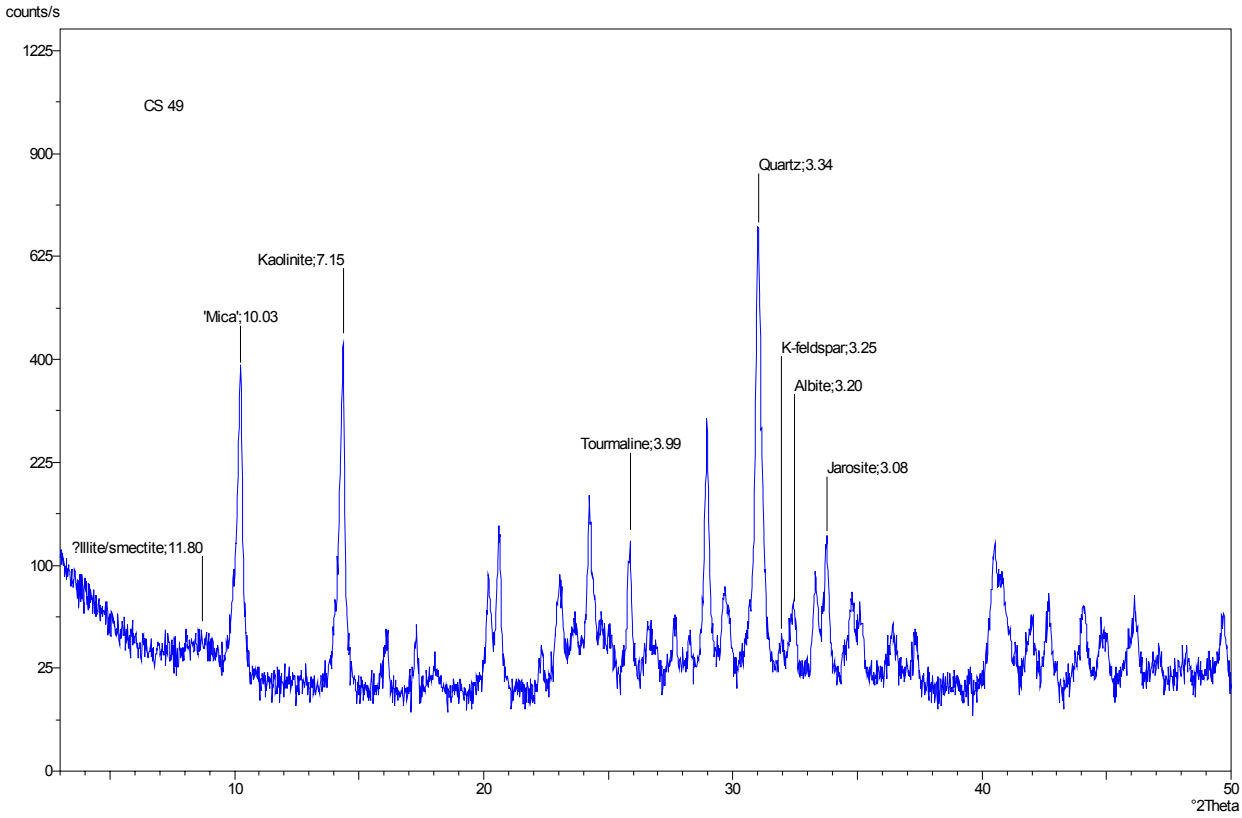
'Mica';10.03
Chlorite;7.06
Kaolinite;7.17
Chlorite;14.10
Tourmaline;3.99
K-feldspar;3.24
Albite;3.19
°2Theta

CS49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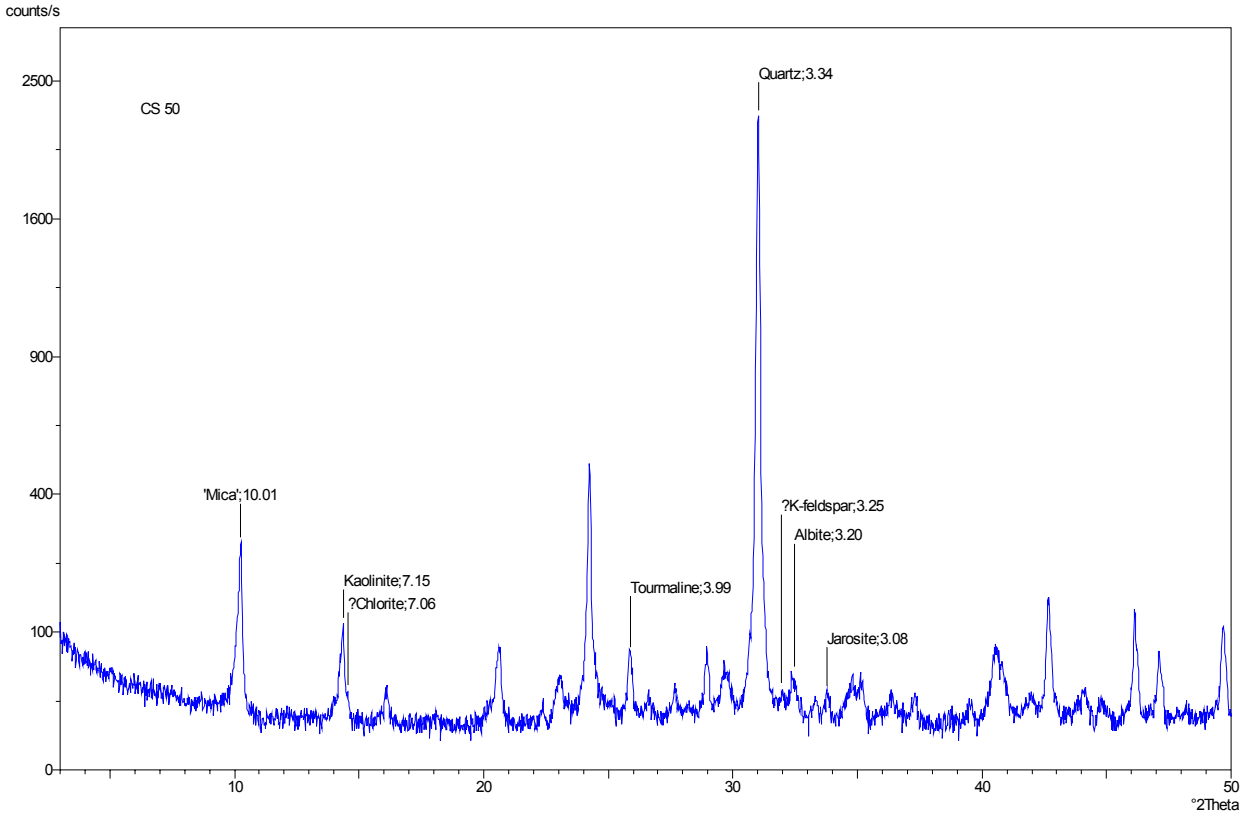
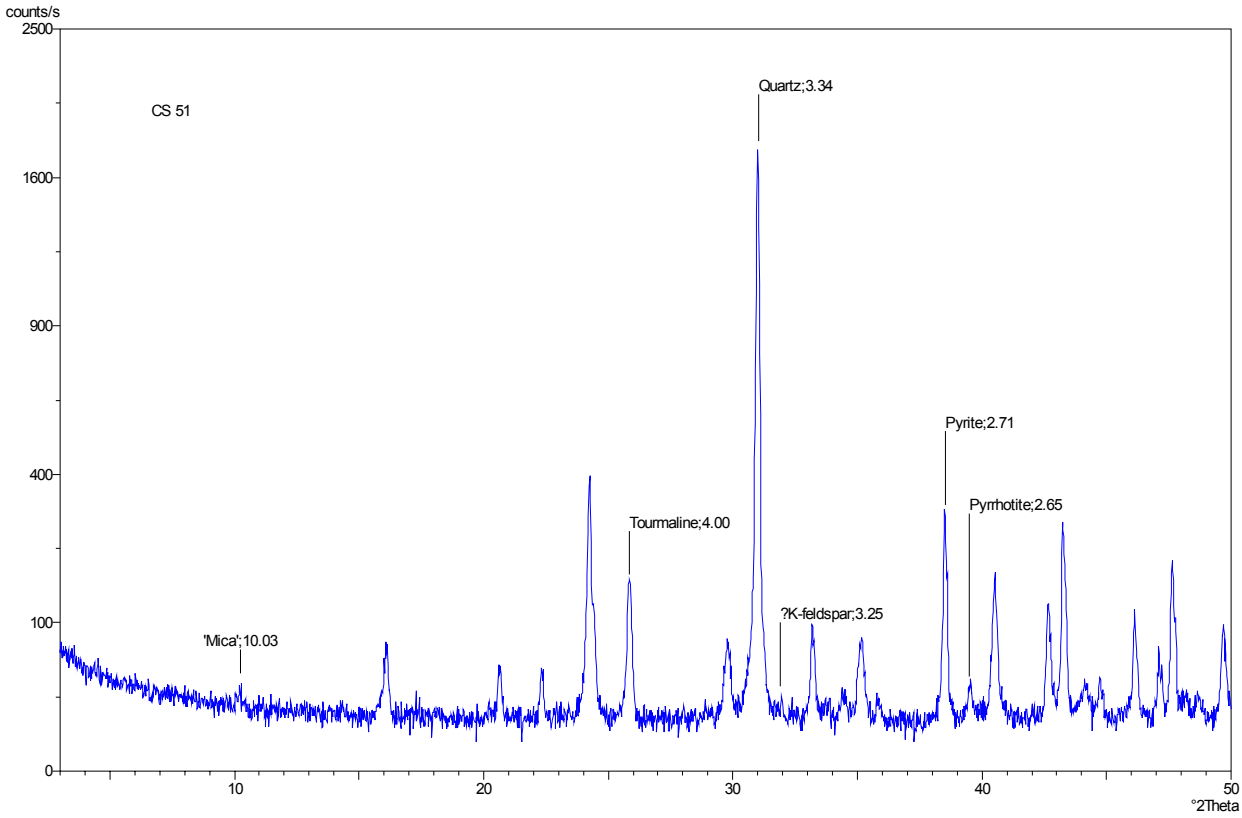
CS 49
Quartz;3.34
Kaolinite;7.15
'Mica';10.03
K-feldspar;3.25
Albite;3.20
Tourmaline;3.99
Jarosite;3.08
?Illite/smectite;11.80
°2Theta

CS50


counts/s
CS 50
Quartz;3.34
'Mica';10.01
?K-feldspar;3.25
Albite;3.20
Kaolinite;7.15
?Chlorite;7.06
Tourmaline;3.99
Jarosite;3.08
2500
1600
900
400
100
0
10
20
30
40
50
°2Theta

CS51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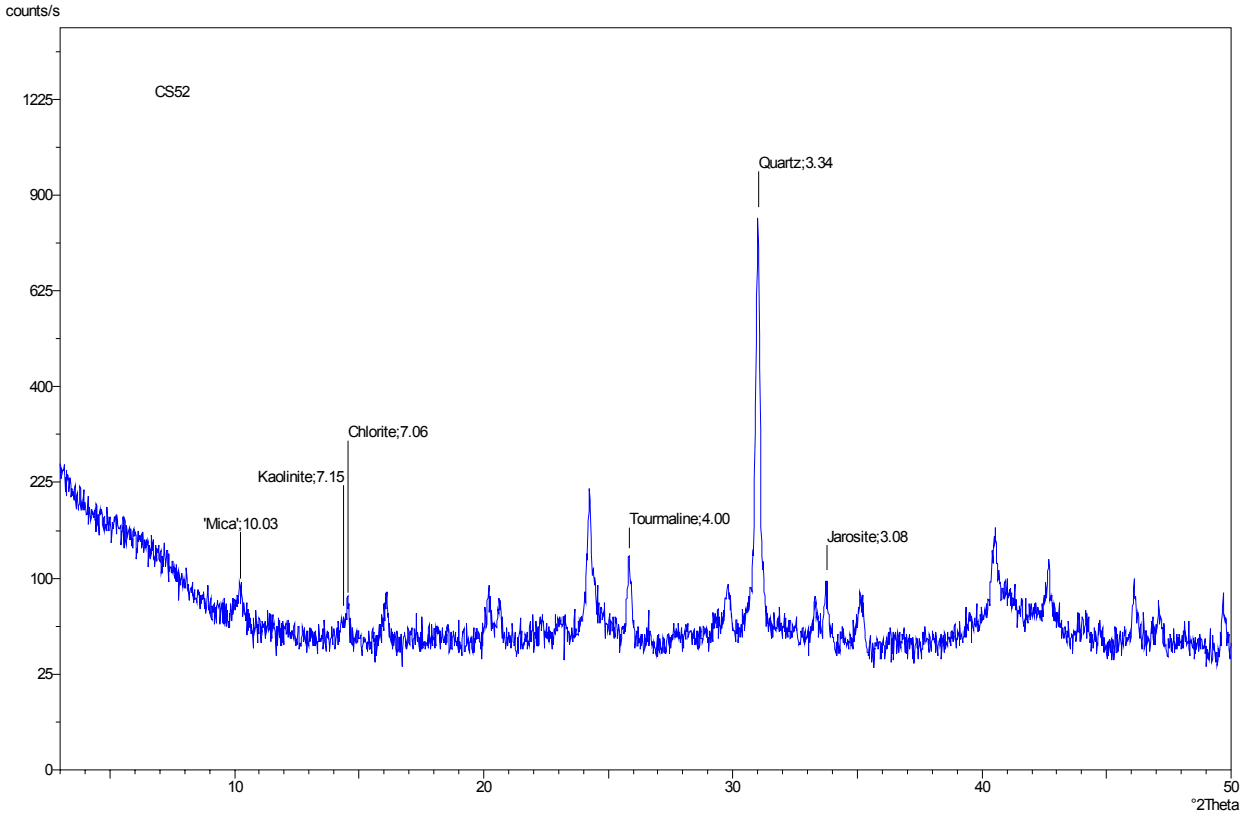
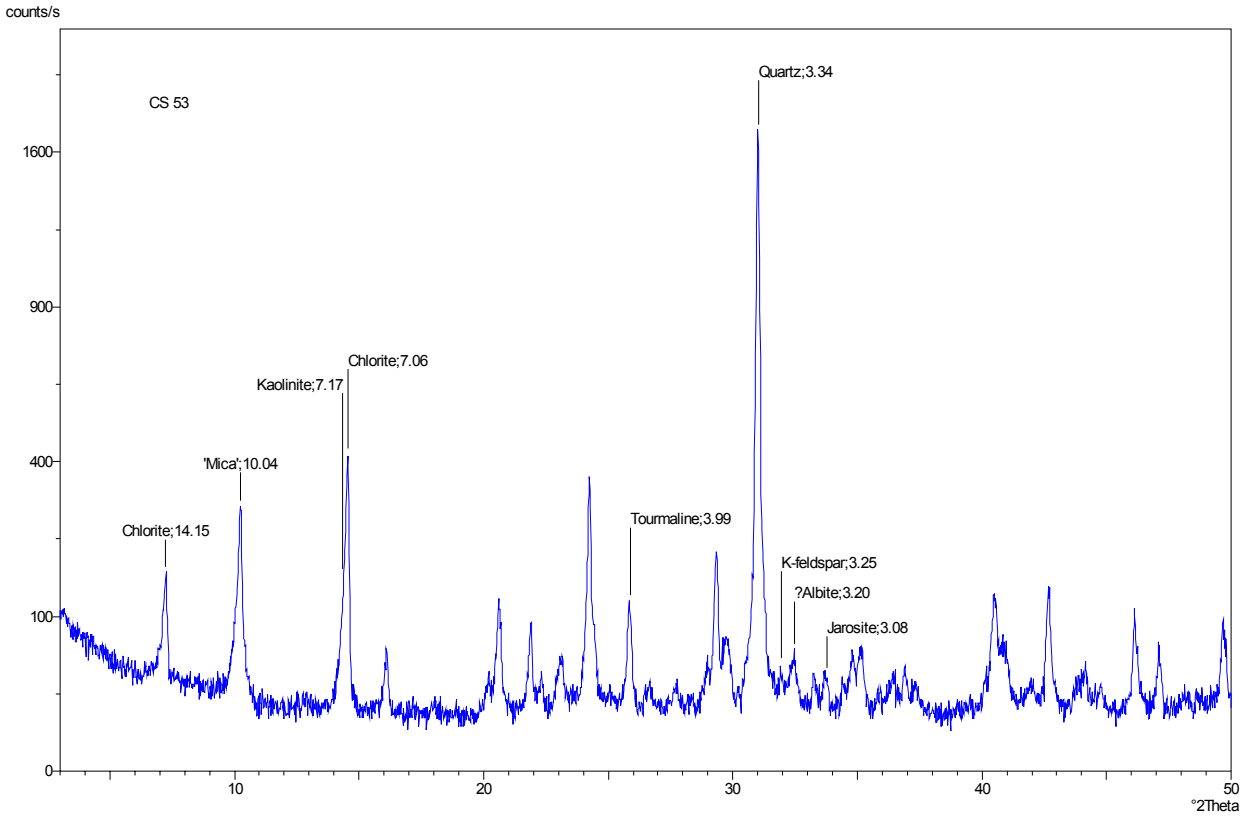
CS 51
Quartz;3.34
Pyrite;2.71
Pyrrhotite;2.65
Tourmaline;4.00
?K-feldspar;3.25
'Mica';10.03
2500
1600
900
400
100
0
10
20
30
40
50
°2Theta

CS52


counts/s
CS52
1225
900
625
400
225
100
25
0
Quartz;3.34
Chlorite;7.06
Kaolinite;7.15
'Mica';10.03
Tourmaline;4.00
Jarosite;3.08
10
20
30
40
50
°2Theta

CS53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CS 53
1600
900
400
100
0
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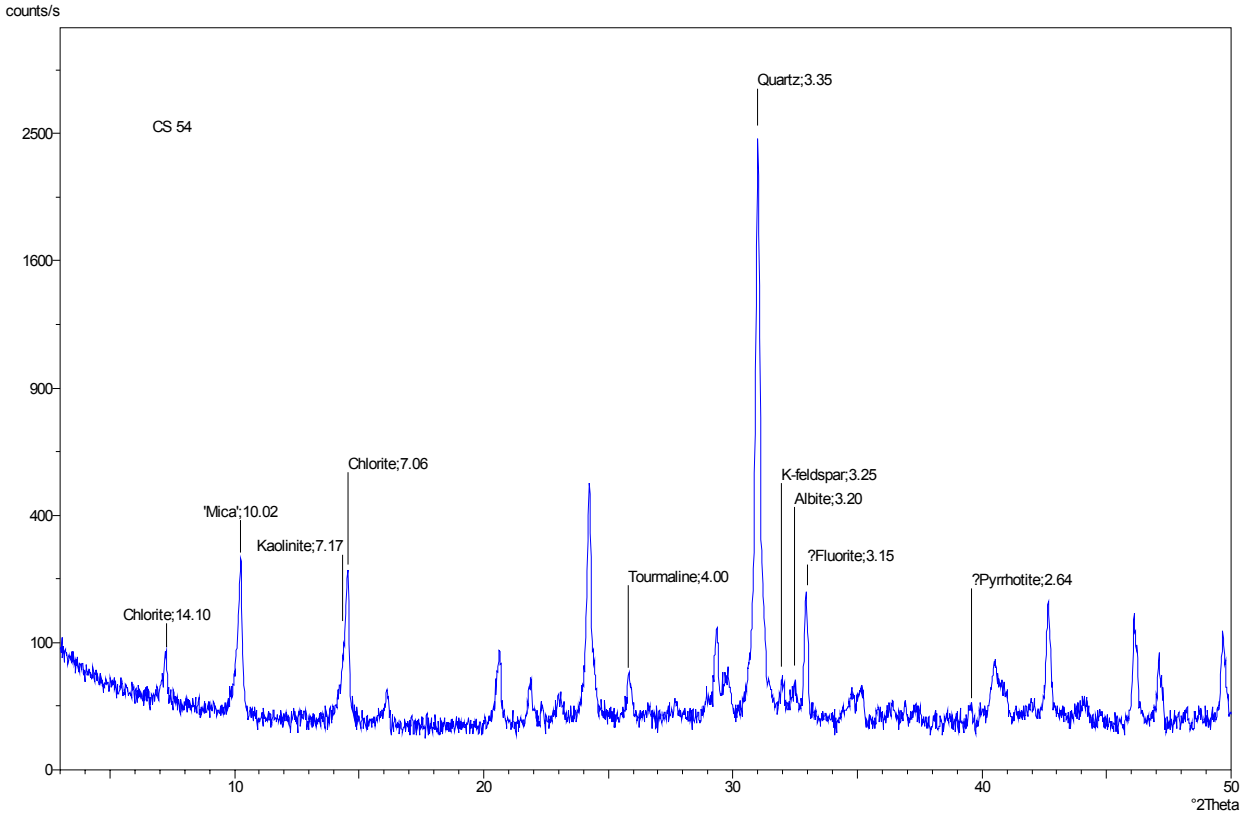
Kaolinite;7.17
'Mica';10.04
Chlorite;14.15
Tourmaline;3.99
K-feldspar;3.25
?Albite;3.20
Jarosite;3.08
10
20
30
40
50
°2Theta

CS54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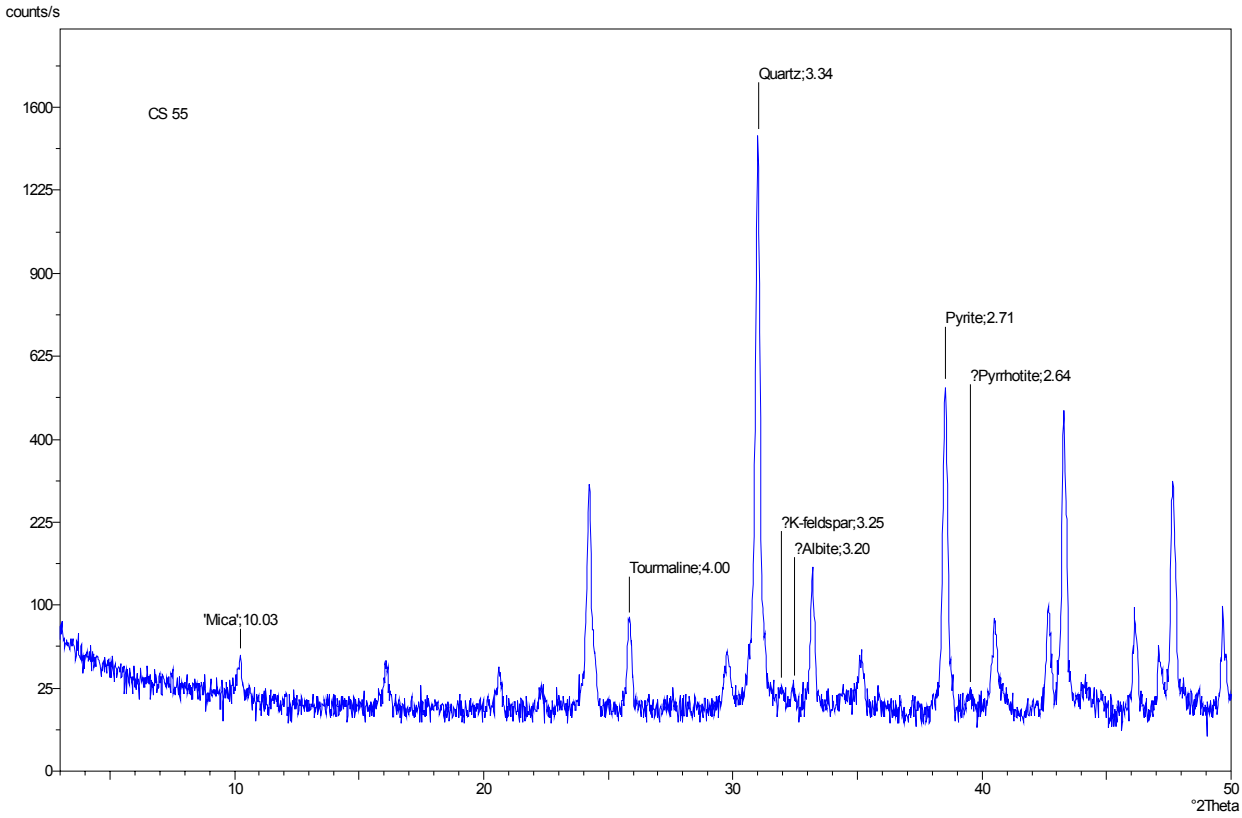
Quartz;3.35
Chlorite;7.06
'Mica';10.02
Kaolinite;7.17
K-feldspar;3.25
Albite;3.20
?Fluorite;3.15
Tourmaline;4.00
?Pyrrhotite;2.64
Chlorite;14.10
2500
1600
900
400
100
0
10
20
30
40
50
°2Theta

CS55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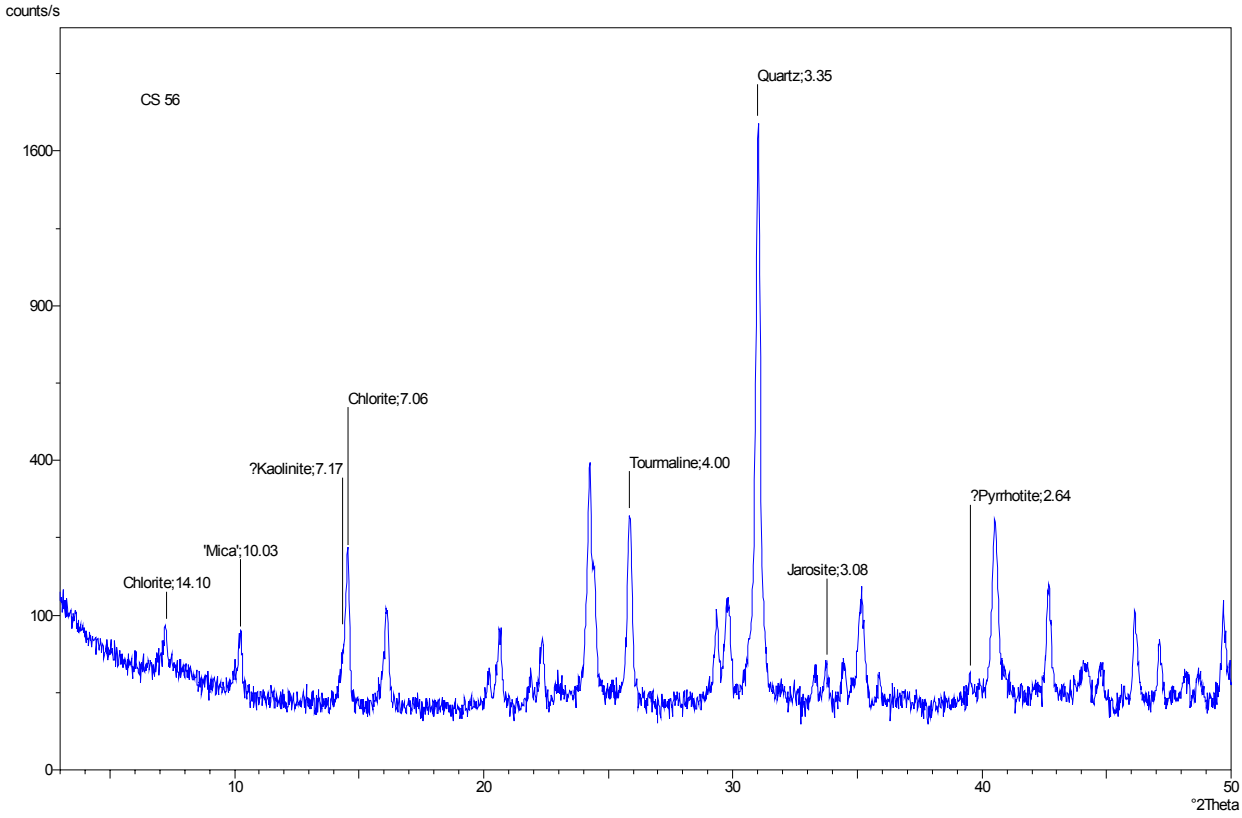
Pyrite;2.71
?Pyrrhotite;2.64
?K-feldspar;3.25
?Albite;3.20
Tourmaline;4.00
'Mica';10.03
1600
1225
900
625
400
225
100
25
0
10
20
30
40
50
°2Theta

CS56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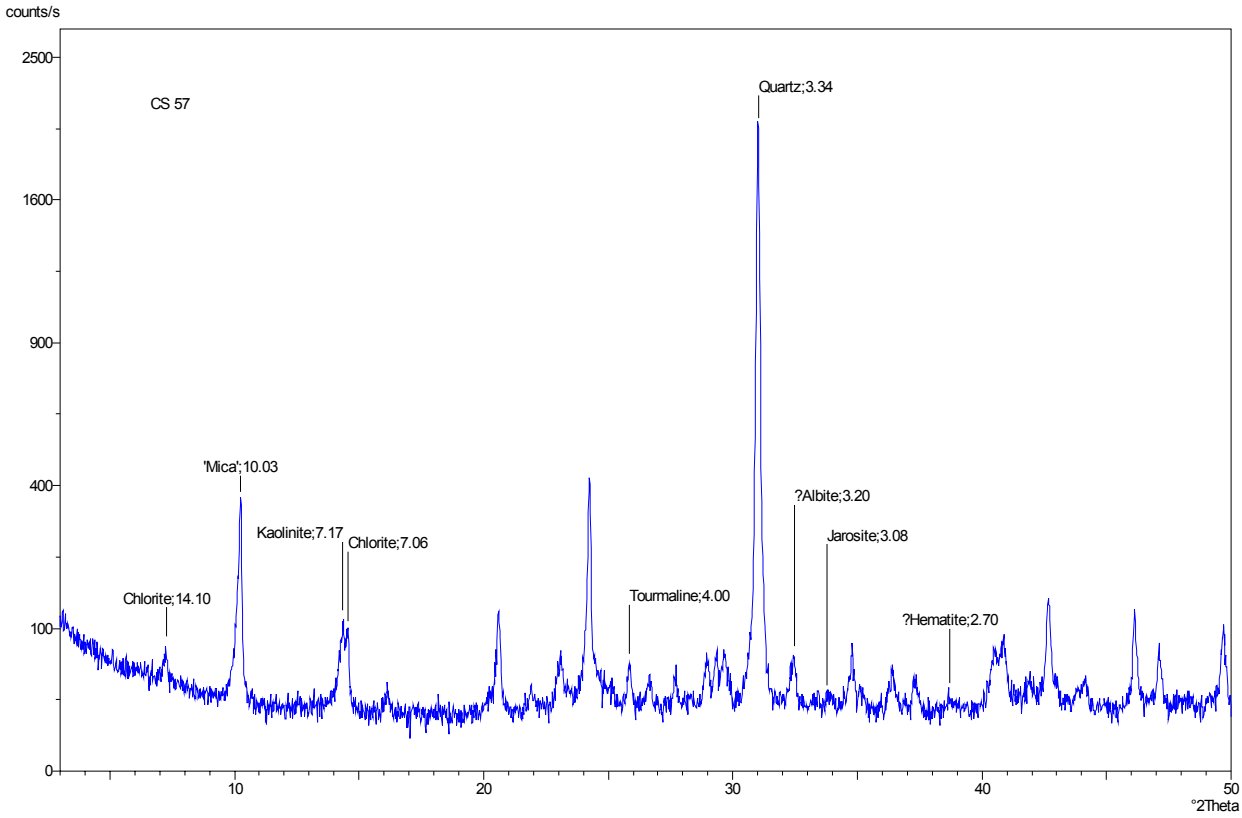
Tourmaline;4.00
?Pyrrhotite;2.64
'Mica';10.03
Jarosite;3.08
Chlorite;14.10
1600
900
400
100
0
10
20
30
40
50
°2Theta

CS57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CS 57
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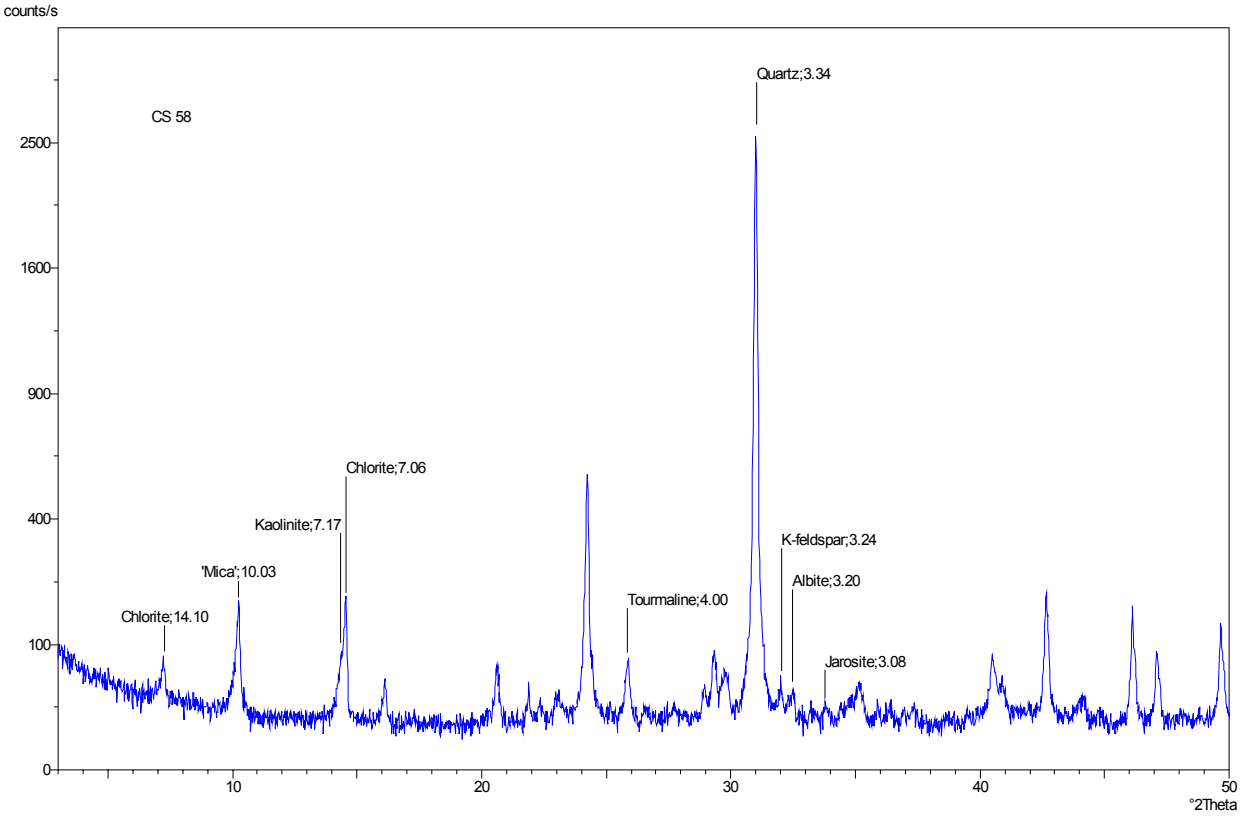
'Mica';10.03
?Albite;3.20
Kaolinite;7.17
Chlorite;7.06
Jarosite;3.08
Chlorite;14.10
Tourmaline;4.00
?Hematite;2.70
2500
1600
900
400
100
0
10
20
30
40
50
°2Theta

CS58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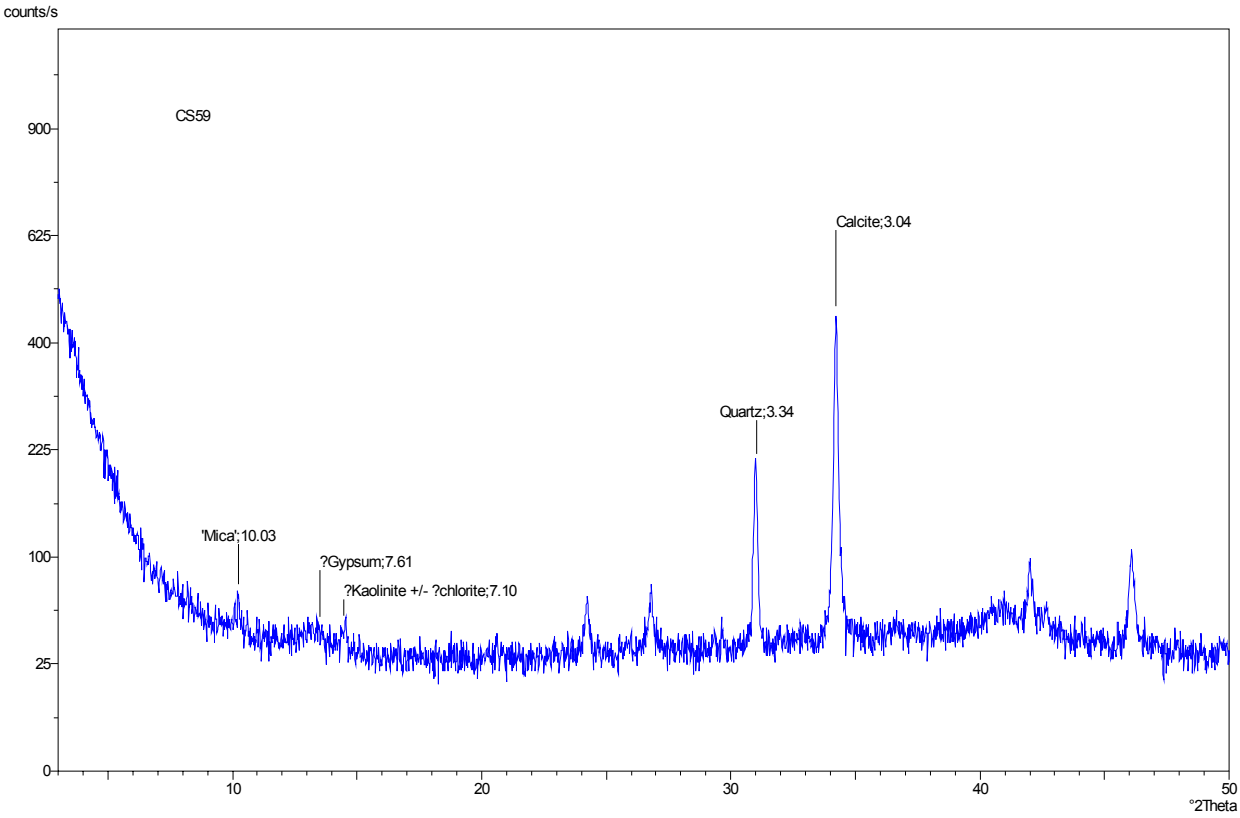
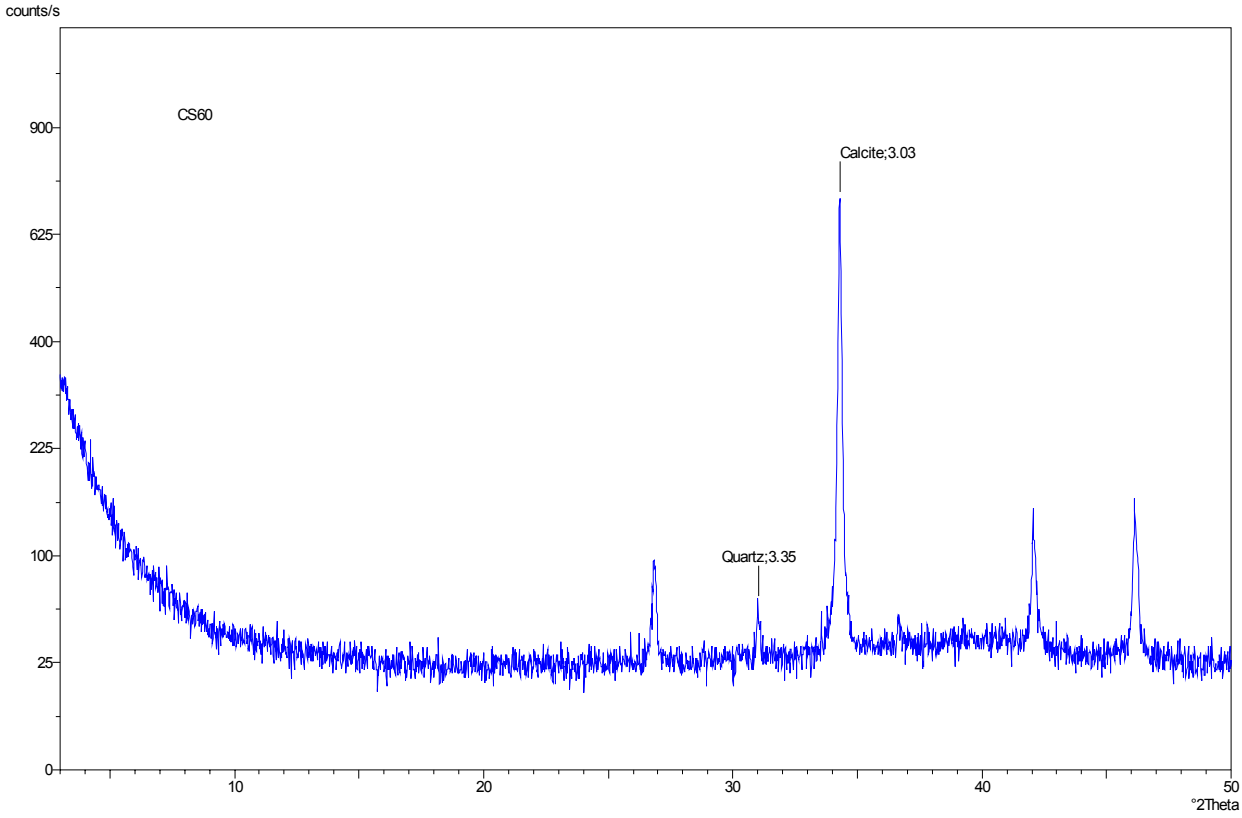
Kaolinite;7.17
K-feldspar;3.24
'Mica';10.03
Albite;3.20
Tourmaline;4.00
Chlorite;14.10
Jarosite;3.08
2500
1600
900
400
100
0
10
20
30
40
50
°2Theta

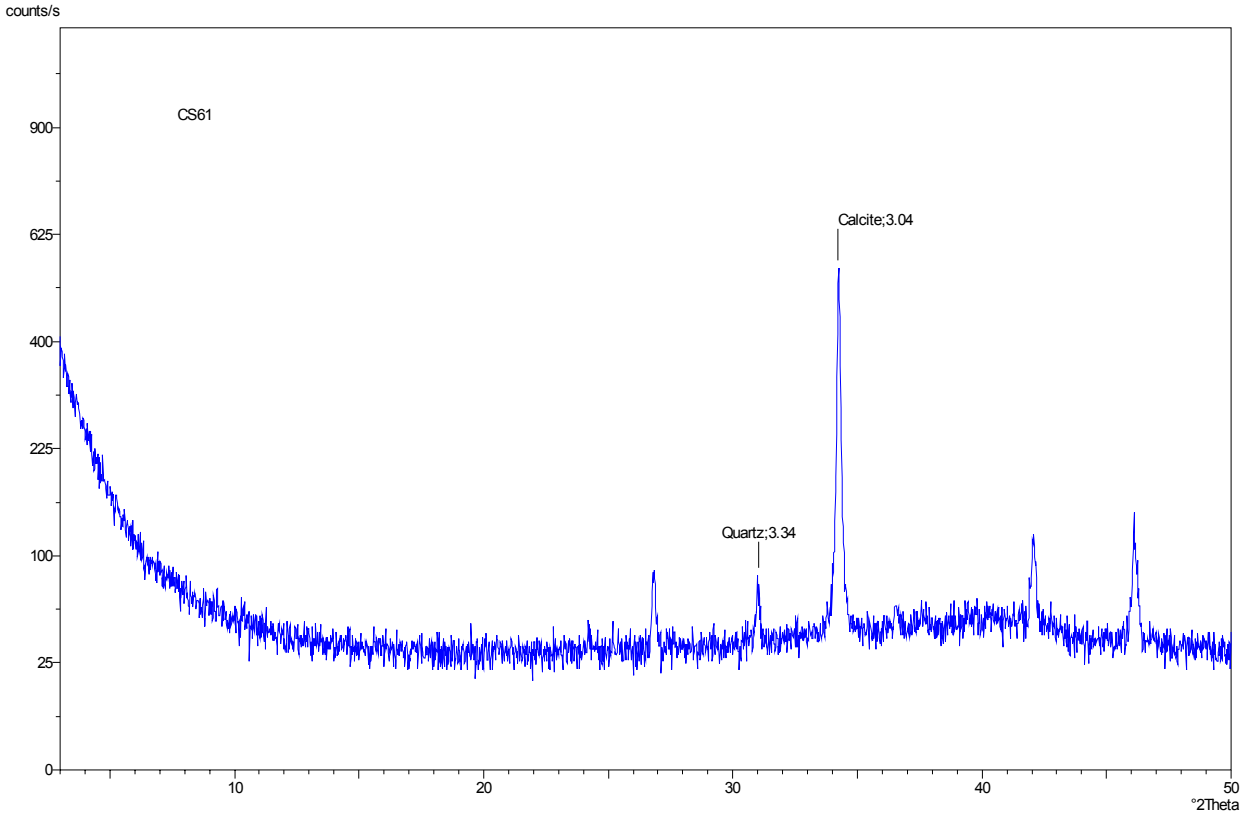
CS59


counts/s
CS59
Calcite;3.04
Quartz;3.34
'Mica';10.03
?Gypsum;7.61
?Kaolinite +/- ?chlorite;7.10
900
625
400
225
100
25
0
10
20
30
40
50
°2Theta

CS60


counts/s
CS60
Calcite;3.03
Quartz;3.35
900
625
400
225
100
25
0
10
20
30
40
50
°2Theta

CS61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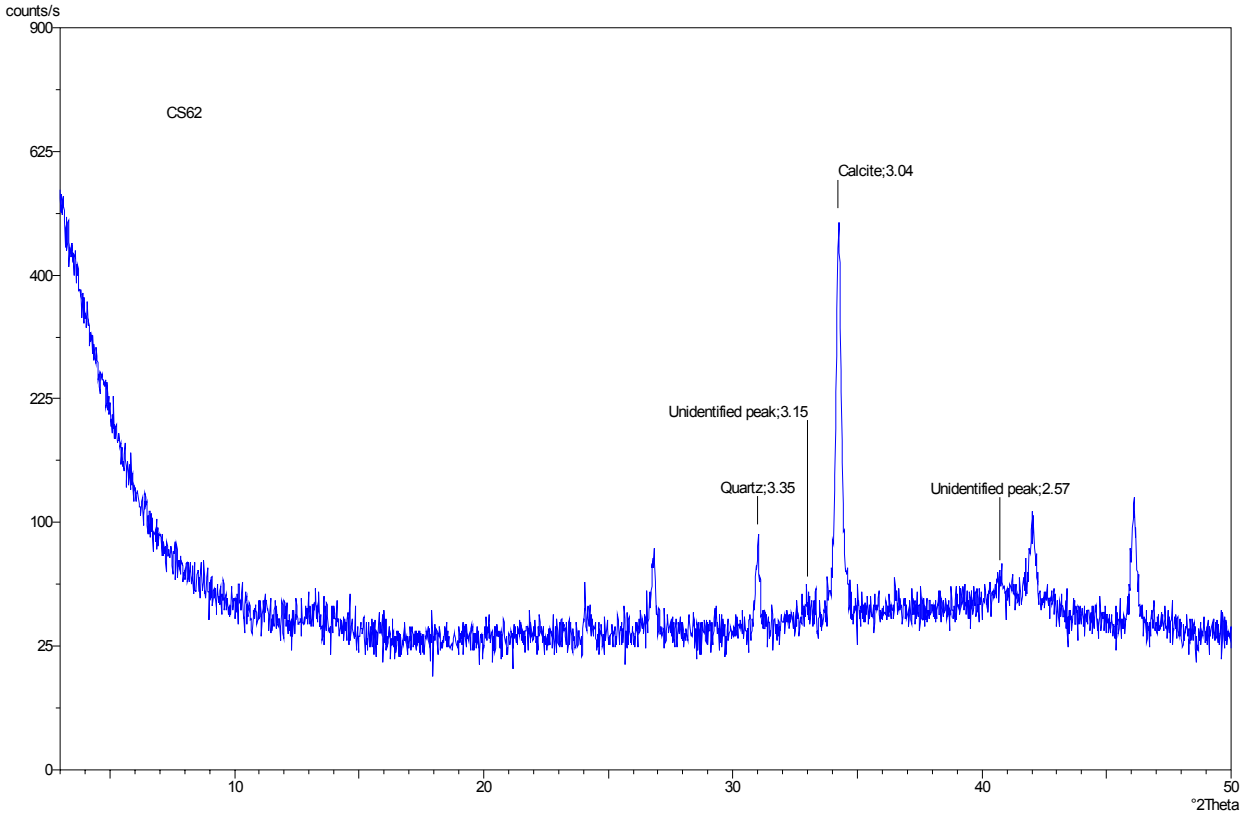
CS61
Calcite;3.04
Quartz;3.34
900
625
400
225
100
25
0
10
20
30
40
50
°2Theta

CS62


counts/s
900
625
400
225
100
25
0
CS62
Calcite;3.04
Unidentified peak;3.15
Quartz;3.35
Unidentified peak;2.57
10
20
30
40
50
°2Theta