

# The Ø 40 x 33 km Pilbara Crater near Port Hedland ( NW-Australia )

- **RAMAN Spectra of selected Rock Samples** - by Harry K. Hahn, 30.6.2021 -

Raman spectra of quartz samples collected at the sample sites **25, 11** and **10** provide first evidence for this Ø40x33km elliptical Impact Crater and for the secondary impact-structures produced by this crater

The impact crater is located near the town Port Hedland in Western Australia. Because of the elliptical shape of the crater it is the result of an oblique impact. That means the impactor which formed the crater impacted in a very shallow angle of probably less than 10°. → **Here my more detailed : [Study](#)**

Because of the shallow impact angle, fragments of the impactor were ejected from the crater and caused complex secondary impact structures 40 km and 80 km further east of this elliptical crater.

One of the secondary impact structures is Mount Goldsworthy which is a famous Iron Ore Mine that contained the world's richest deposits of ferrous (iron)-ore with a share of up to 68 % iron.

Beside the Raman spectra which I present as evidence and first verification for this elliptical crater and its secondary impact structures, there is additional geo-physical evidence coming from the magnetic anomaly map ( see image below ), which clearly indicates the elliptical crater, including a center-line structure in the crater, and which shows the secondary impact structures in detail.

The shifts of the main Raman bands ( peaks ) to the lower frequencies **463, 261, 198/205** and **125 cm<sup>-1</sup>** in a quartz sample from the sample site 25 ( Stone 2 ), which was collected inside the crater area, clearly indicates that the quartz was exposed to a **shock pressure of around 22 GPa**. ( see explanation in the Appendix at **page 19** ). Further evidence for an impact event is provided by quartz samples from sample sites 10 & 11 which are located in the area of the secondary impact-structure Mt Goldsworthy.

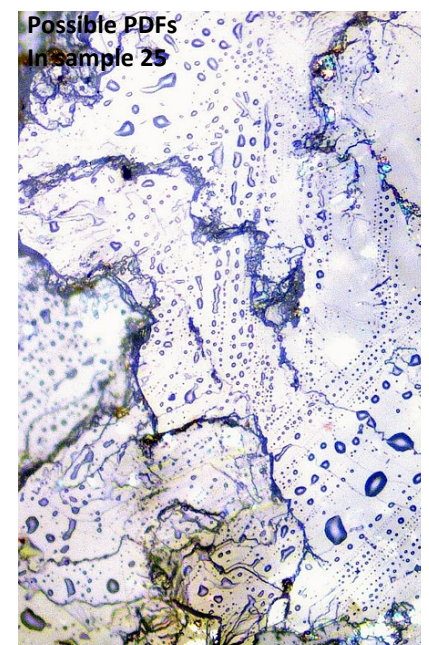
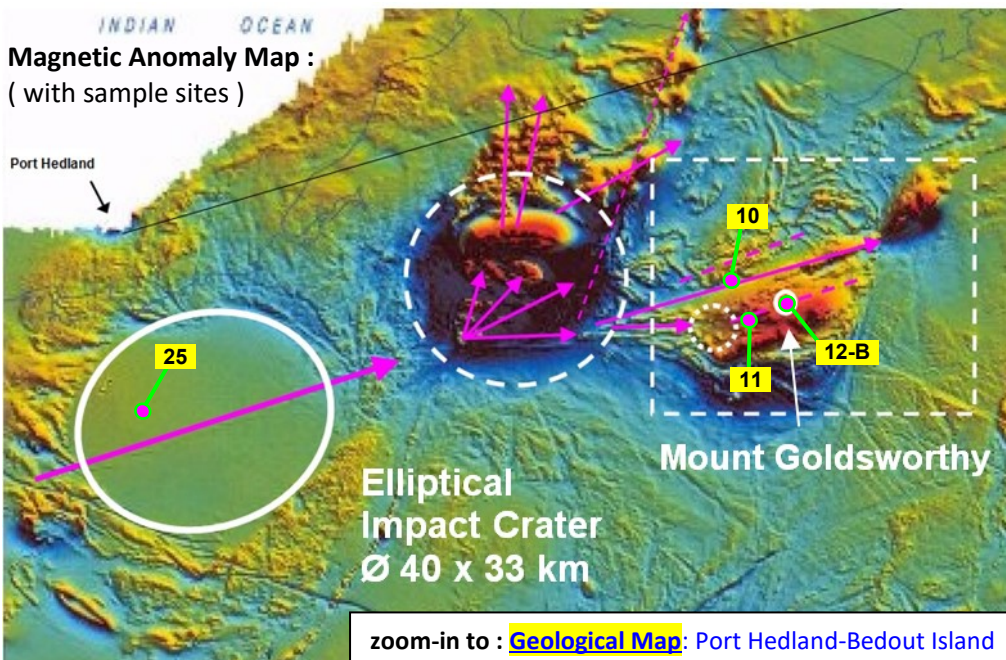
These quartz samples show shifts of the main Raman bands ( peaks ) to the lower frequencies **463, 260, 204** and **126 cm<sup>-1</sup>** which also indicates a **shock pressure of around 22 GPa**. Further evidence comes from a microscopic image of sample 25 (stone 3) which indicates planar deformation features (PDFs). All spectra were made with a **BRUKER Senterra-II Raman Microscope** (wavenumber precision <0.1cm<sup>-1</sup>)

→ Images of the analysed rock samples and photos of the sample sites are in the Appendix at **page 17**.

→ More images of all sample sites are available on [www.permiantriassic.de](http://www.permiantriassic.de) or [www.permiantriassic.at](http://www.permiantriassic.at)

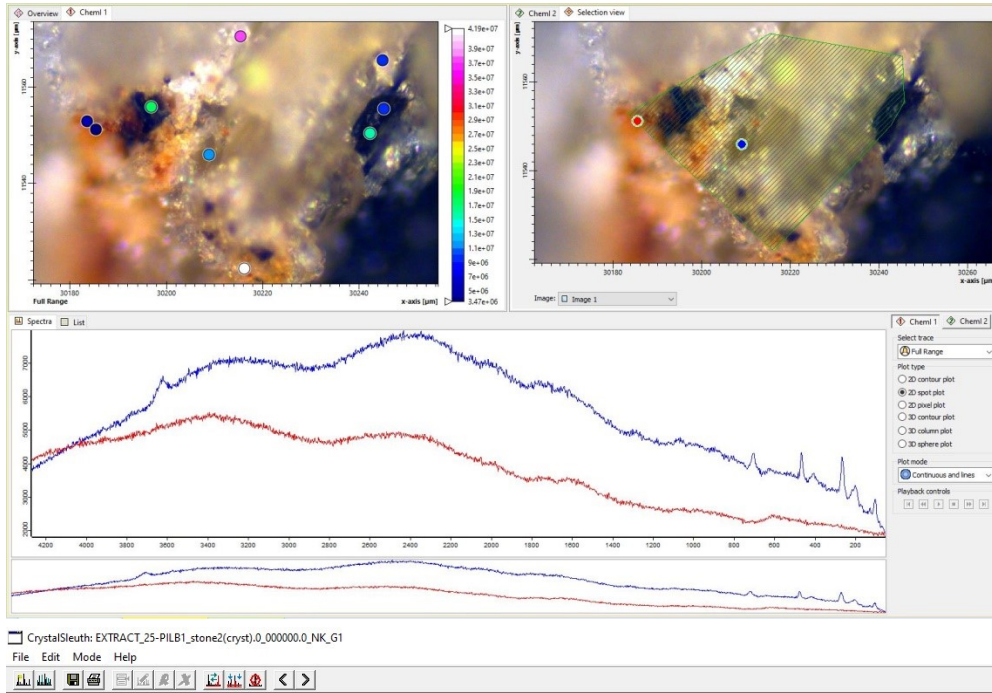
→ **General Summary** of my Analysis : see **Part 6 (P6)** of my **PTI-hypothesis (P1)** / References : **page 20**

**Note:** A shock pressure of 22 GPa far exceeds all pressures caused by normal terrestrial metamorphism. Therefore the quartz from the sample sites 25, 11 and 10 was clearly shocked by an impact event. The indicated shock pressure of ≈ 22 GPa is lower than the shock pressure that occurred in other circular impact craters on Earth, which can reach 100 GPa. This points towards an oblique impact. That means the impactor which formed the impact crater ( → possibly a fragment of the PTI-Impactor ) impacted in a very shallow angle of probably less than 10 degree, with a relatively low impact velocity of < 10 km/s.

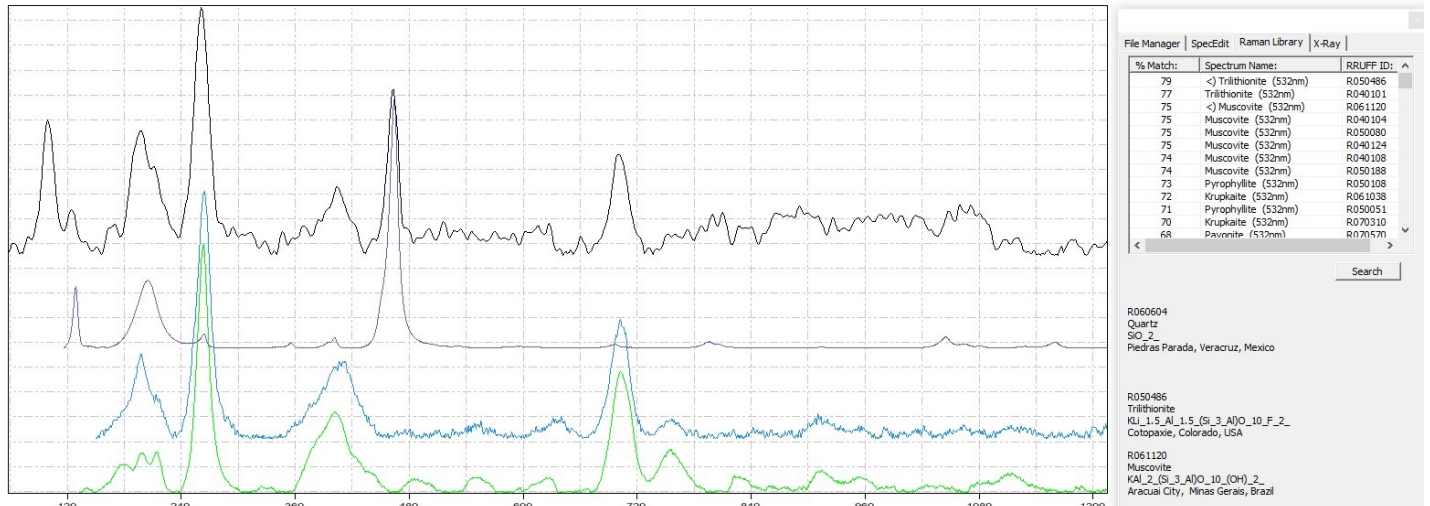


Sample Site 25 : Stone 2\_spectra 2 indicates : Quartz & Trilithionite, Muscovite (→ see RRUFF\_CS results )

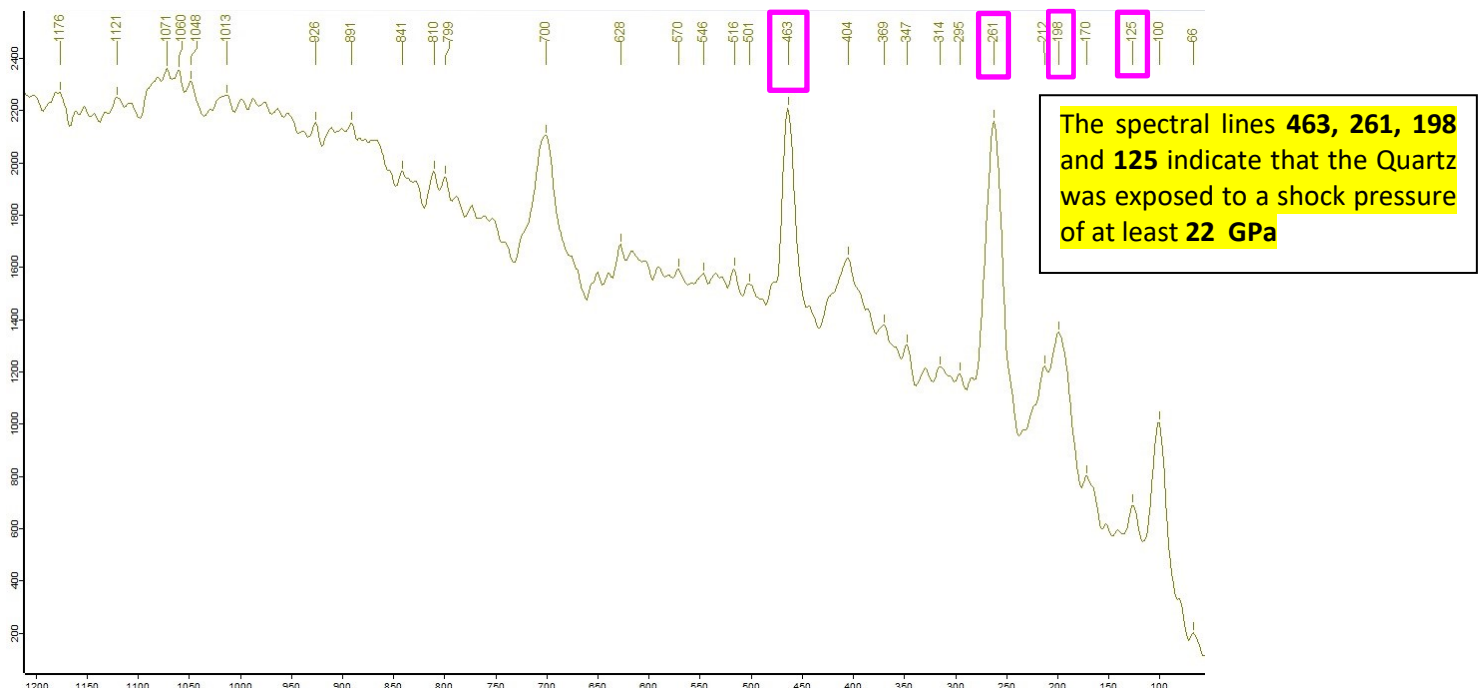
The Spectrum indicates a mixture of Quartz and Trilithionite / Muscovite



Sample :

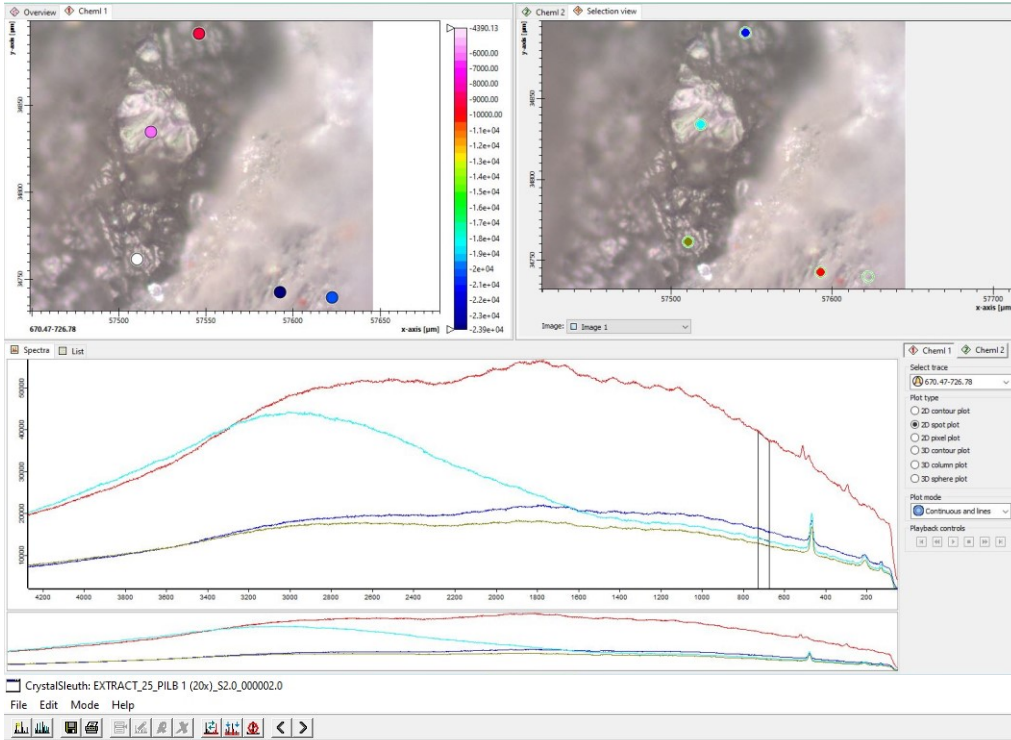


Indication for a shock event are the shifts of the marked Quartz spectral lines towards 463, 261, 198 and 125

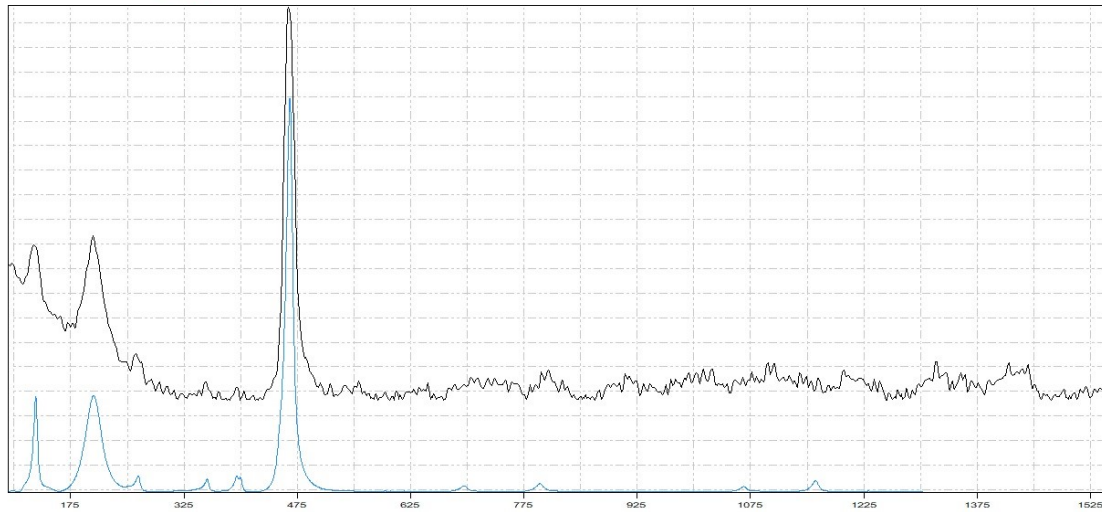


The spectral lines 463, 261, 198 and 125 indicate that the Quartz was exposed to a shock pressure of at least 22 GPa

Sample-Site **25** : Stone 2\_spectra 3 indicates : **Quartz** (→ see RRUFF\_CS results )



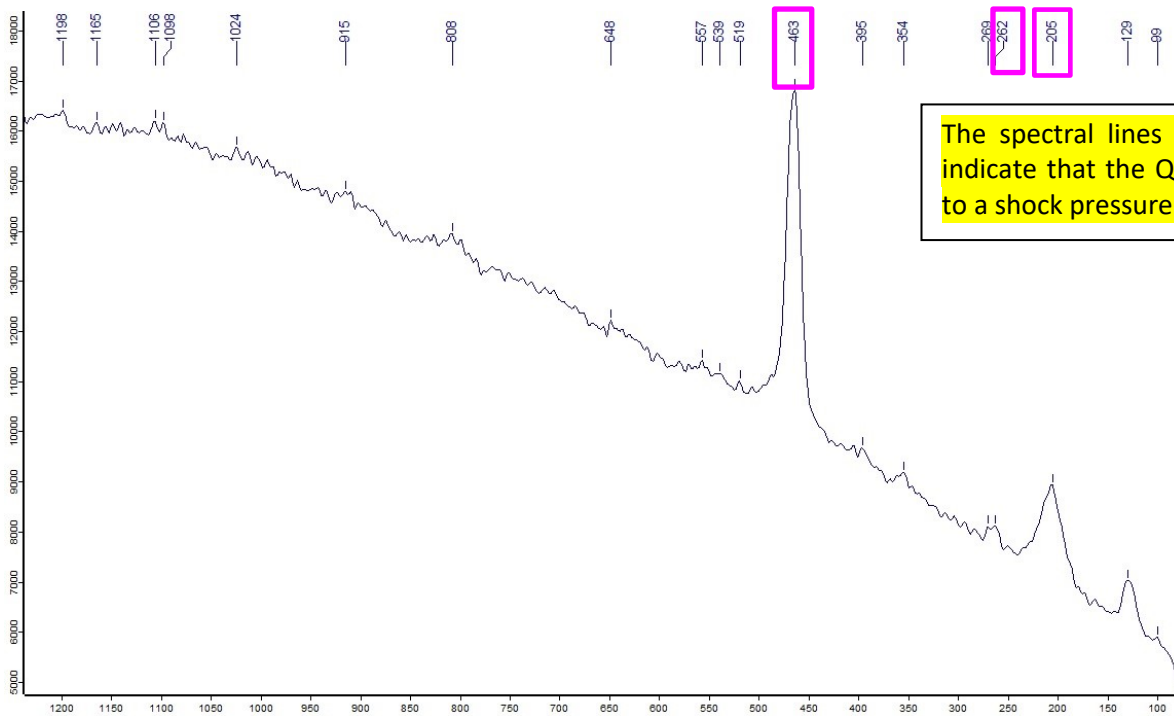
Sample :



% Match:	Spectrum Name:	RRUFF ID:
83	<- Quartz (532nm)	X080016
83	Quartz (532nm)	X080015
83	Quartz (532nm)	R060604
82	Quartz (532nm)	R040031
81	Quartz (532nm)	R050125
80	Amicite (532nm)	R080066
78	Dachardite-Na (532nm)	R061116
76	Edgarballeite (532nm)	R060500
75	Sugilite (532nm)	R070684
71	Sodalite (532nm)	R060405
71	Sodalite (532nm)	R060435
71	Malayaite (532nm)	R061131
70	Sorlaite (532nm)	R060154

X080016  
Quartz  
SiO<sub>2</sub>  
Synthetic

Indication for a shock event are the shifts of the marked Quartz spectral lines towards 463, 262 and 205



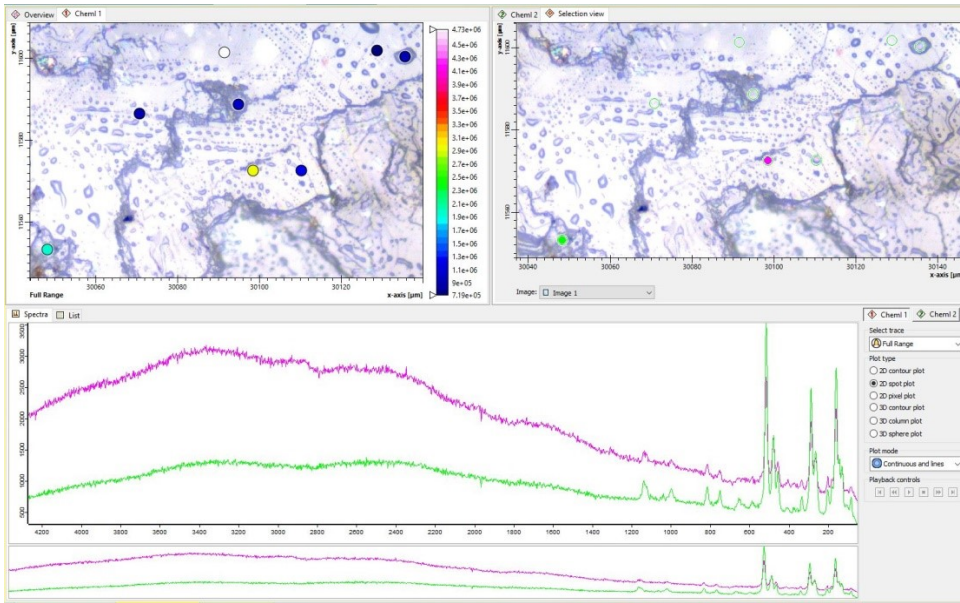
The spectral lines 463, 262 and 205 indicate that the Quartz was exposed to a shock pressure of around 22 GPa

Sample Site 25 : Stone 3\_spectra 2 indicates : **Microcline**

(→ see RRUFF\_CS results )

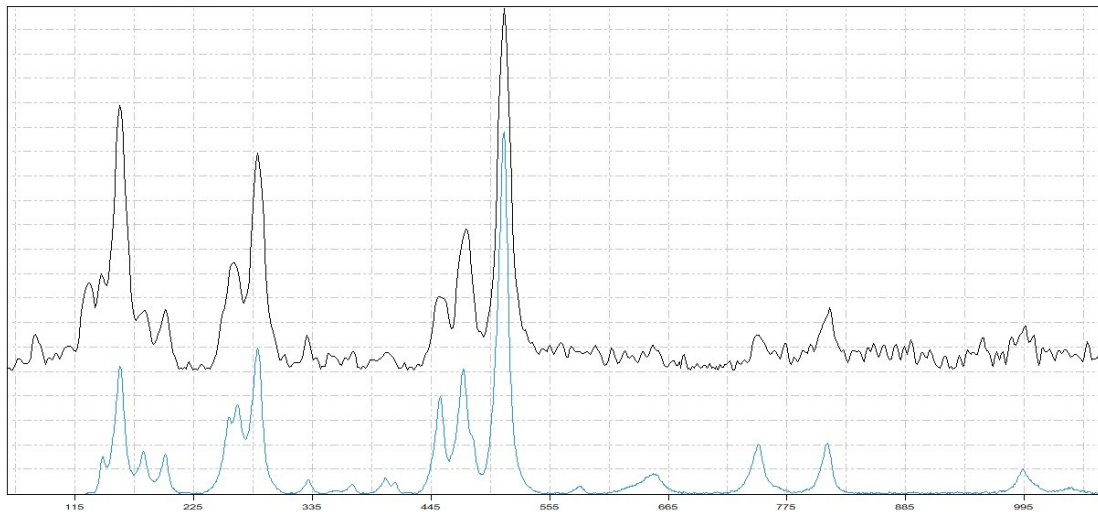
Note the sets of parallel fractures in the microscopic image, which are orientated in defined angles to each other ! This indicates PDFs (Planar Deformation Features) in the sample

Sample :



CrystalSleuth: EXTRACT\_25-PILB1\_stone3.0\_000004.0\_NK\_Y

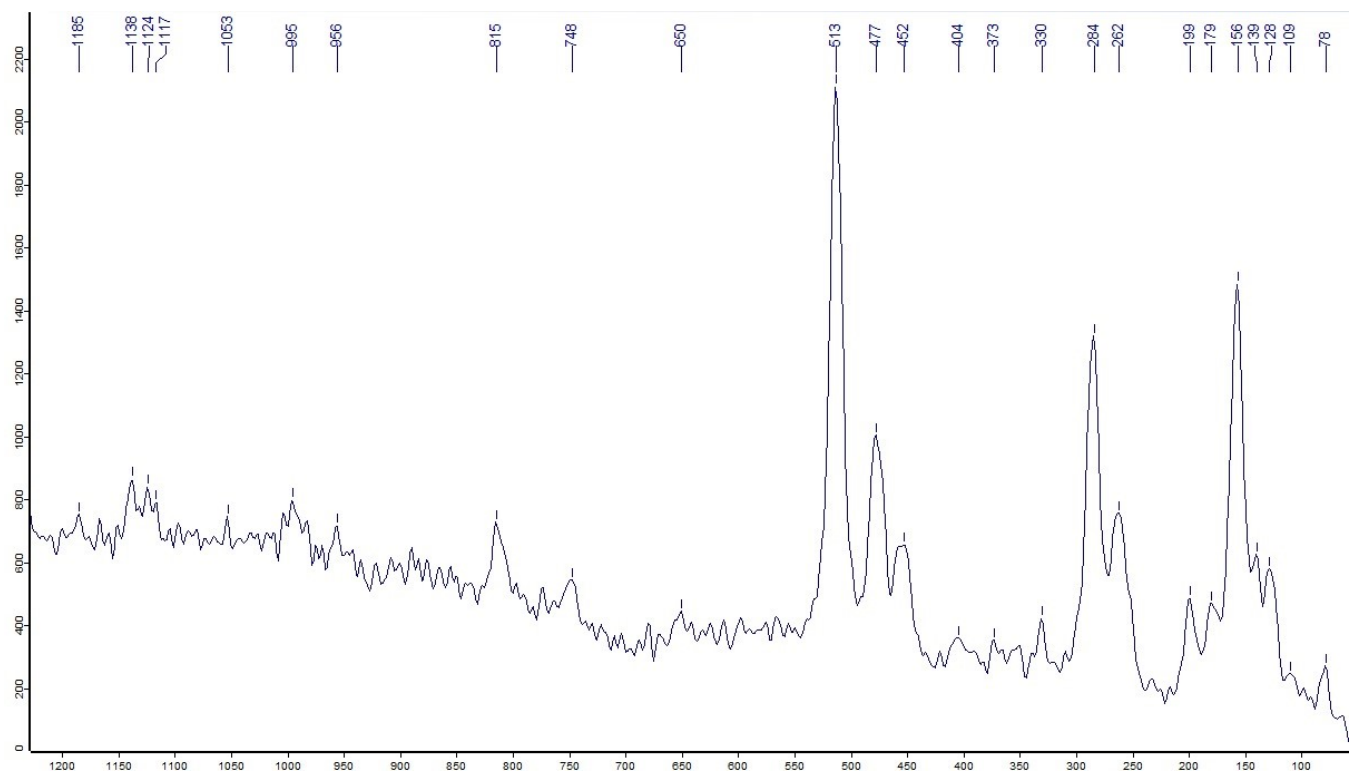
File Edit Mode Help



File Manager SpecEdit Raman Library X-Ray

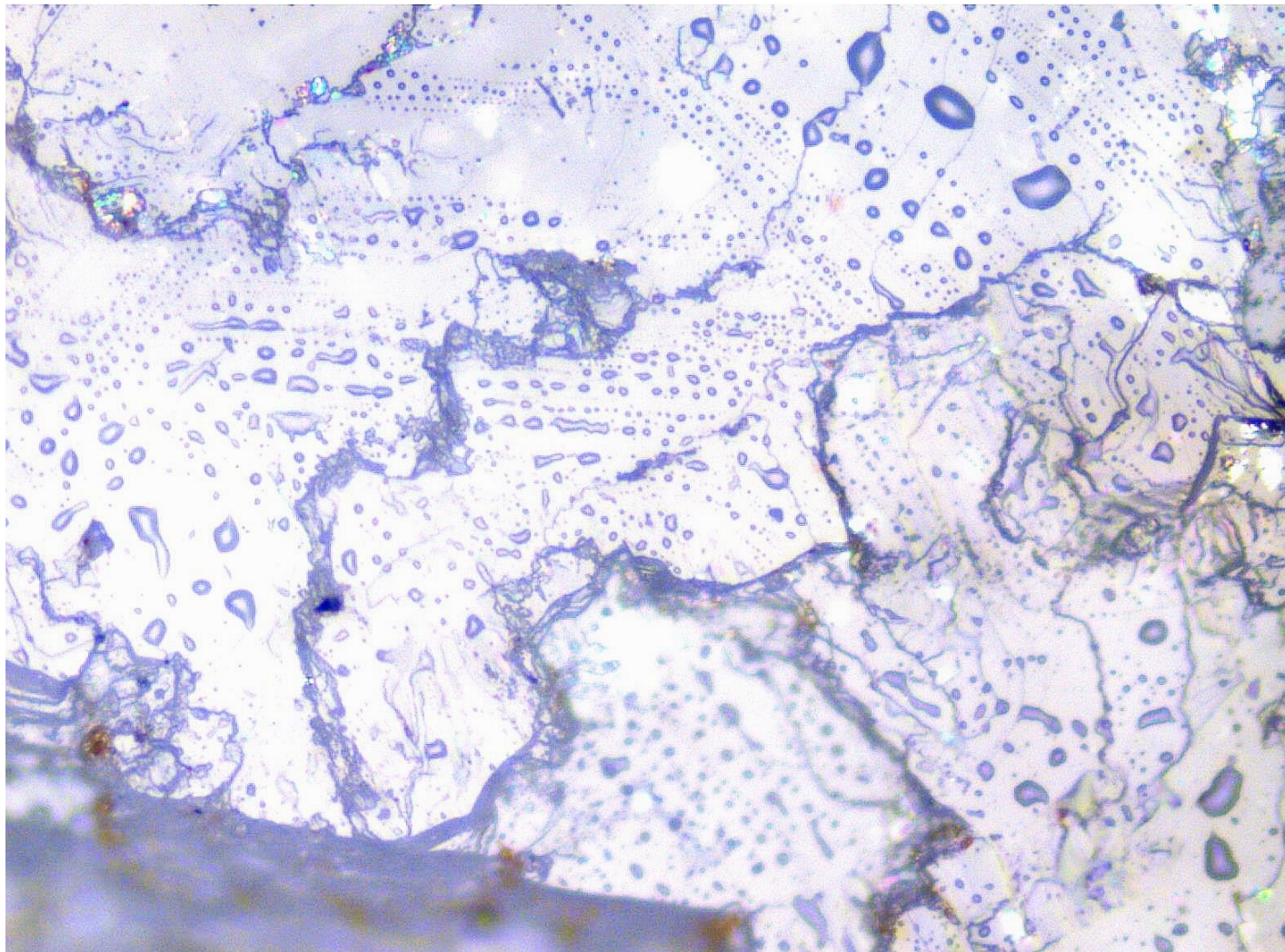
% Match:	Spectrum Name:	RRUFF ID:
92	Microcline (532nm)	R050054
89	Microcline (532nm)	R040154
88	Orthoclase (532nm)	R050185
87	Orthoclase (532nm)	R040055
86	Microcline (532nm)	R050193
85	Anorthoclase (532nm)	R060054
83	Orthoclase (532nm)	R070011
83	Microcline (532nm)	R050190
78	Hendersonite (532nm)	R070467
77	Labradorite (532nm)	R050104
77	Albite (532nm)	R050402
76	Albite (532nm)	R040068
74	Olinobasite (532nm)	R070268

R050054  
Microcline  
KAIS\_3\_D\_3\_  
Kembicha, Negele area, Sidamo Province, Ethiopia



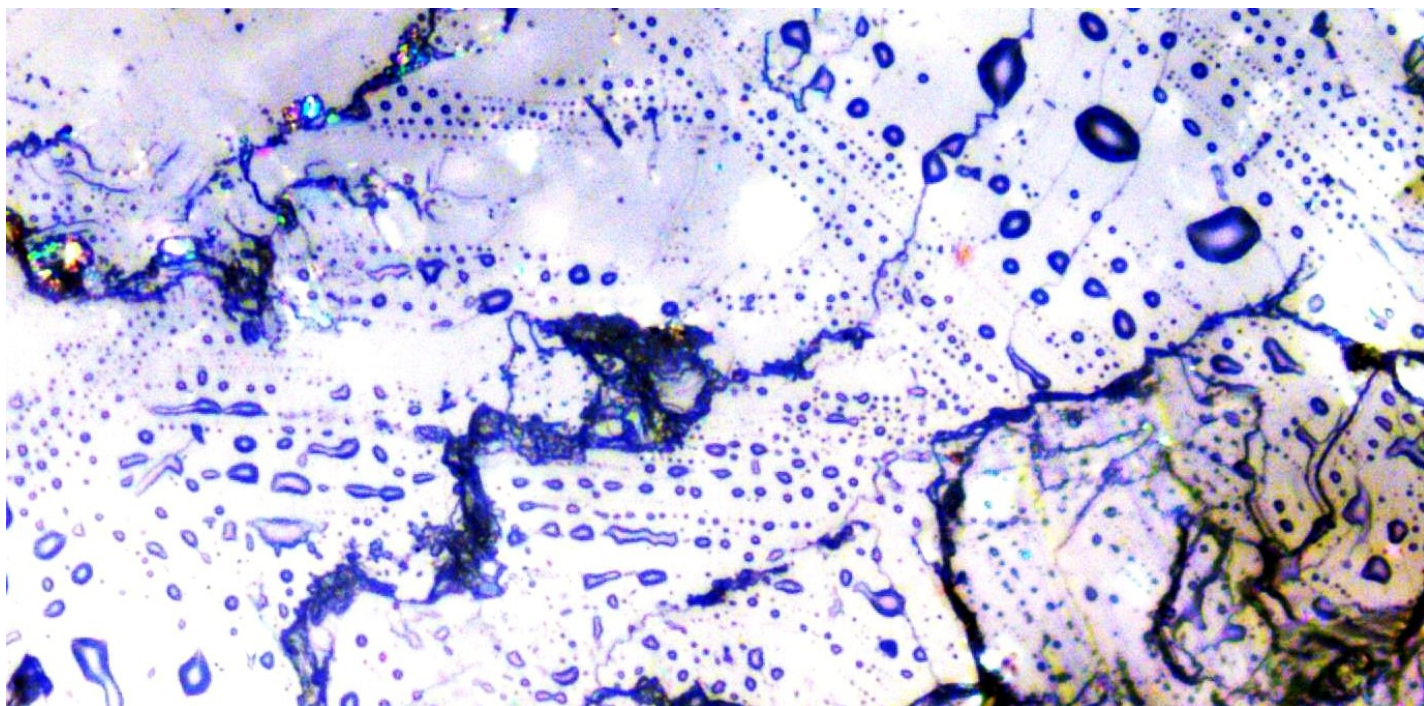
Microscopic Images : Sample from Site 25 → original state ( no preparation for analysis )

Sample Site 25 : Stone 3\_spectra 2 : Microcline → PDFs visible in sample - Image size : ~ 120 x 80 μm



Sample Site 25 : Stone 3\_spectra 2 : Microcline → PDFs Visible in sample - Image size : ~ 100 x 50 μm

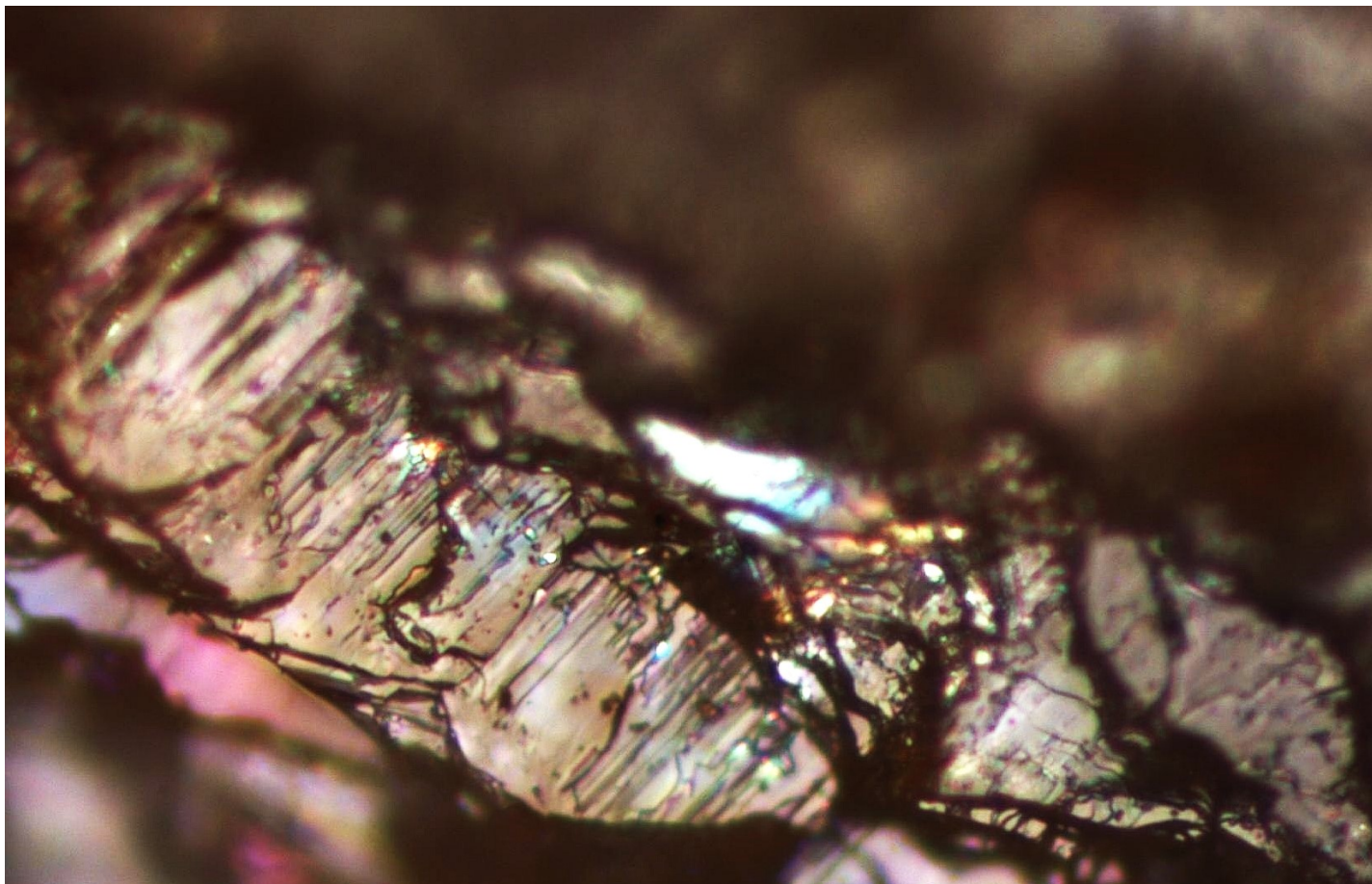
Detail : sets of parallel fractures which are orientated in defined angles to each other ! Indicating PDFs in the sample



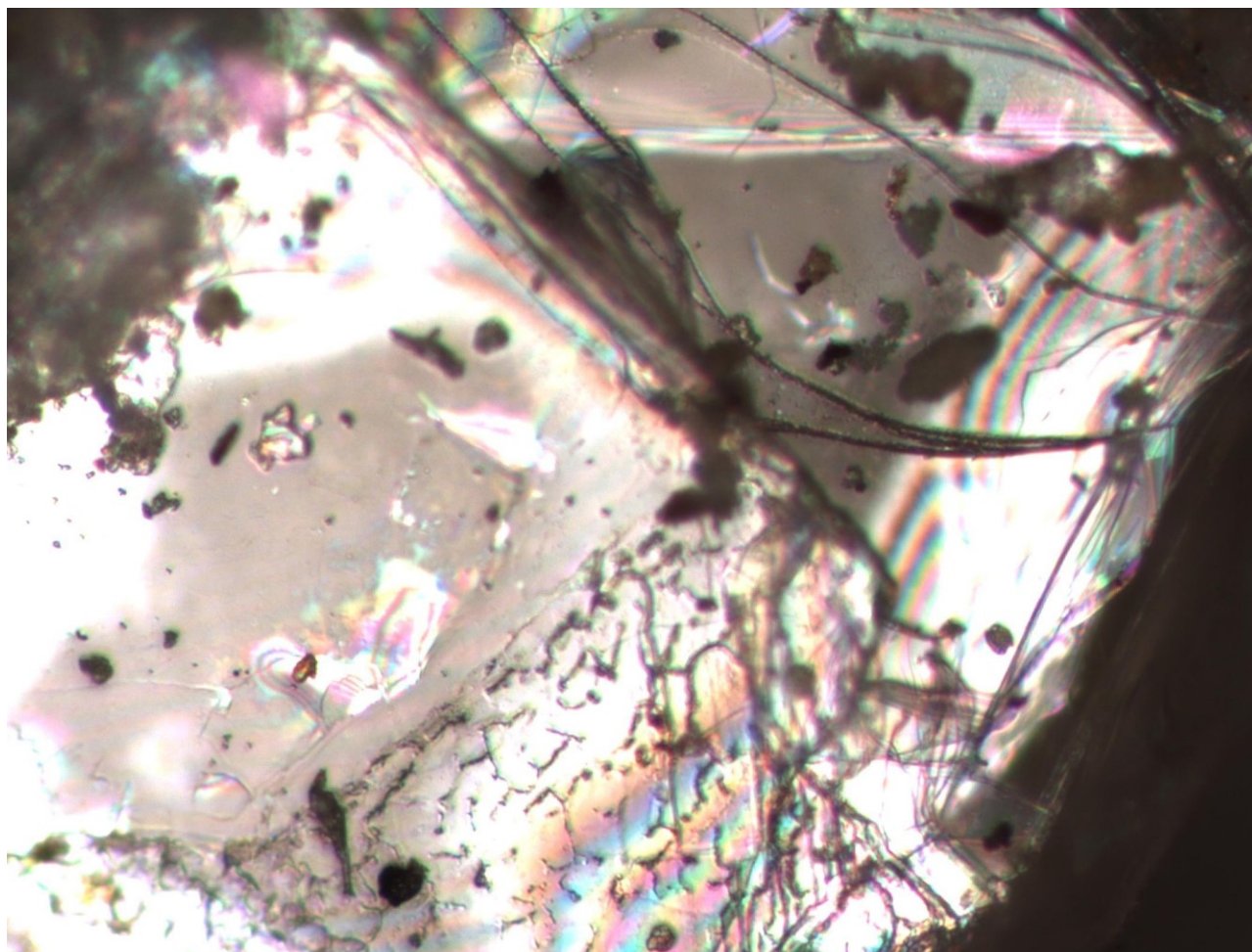
Microscopic Images : Sample from Site 25 → original state ( no preparation for analysis )

Sample Site 25 : Stone 3 : **Microcline, Orthoclase** - Image size : ~ 150 x 100 μm

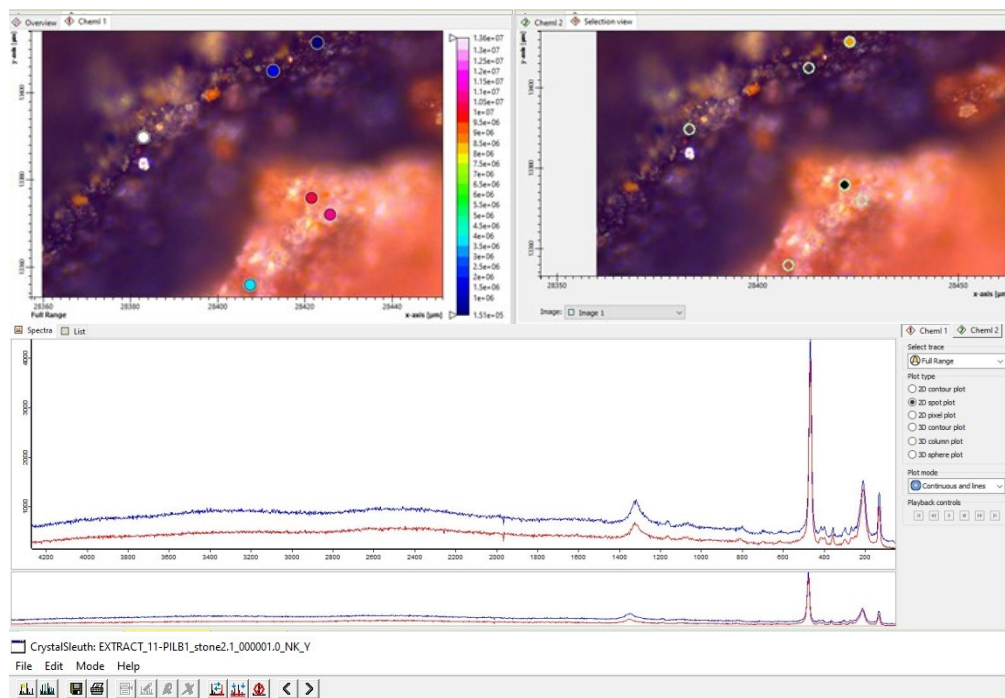
Detail : sets of parallel fractures which are orientated in defined angles to each other ! Indicating PDFs in the sample



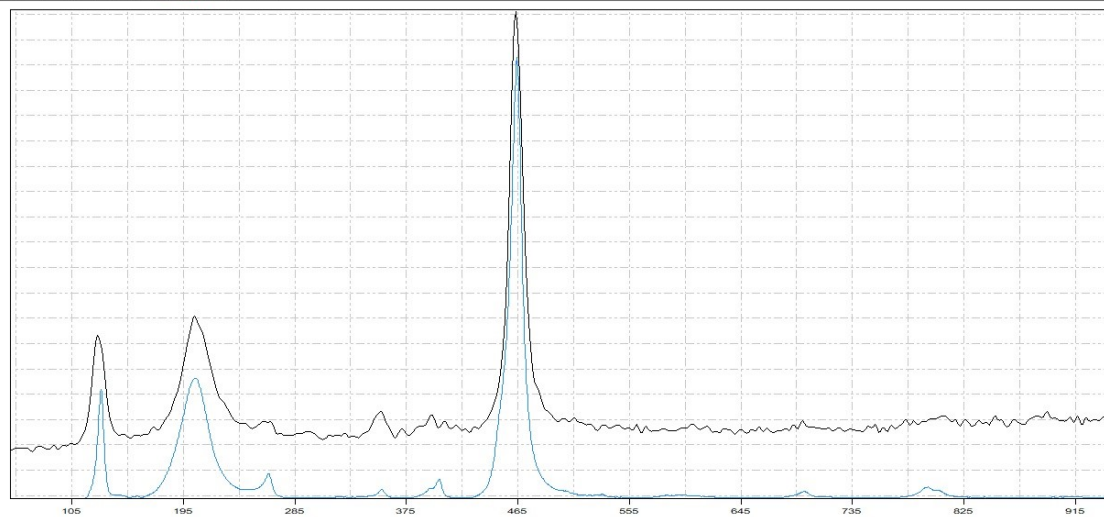
Sample Site 25 : Stone 2 : **Quartz** - Image size : ~ 200 x 150 μm



Sample Site **11** : Stone 2\_spectra 1 indicates : **Quartz** (→ see RRUFF\_CS results )



Sample :

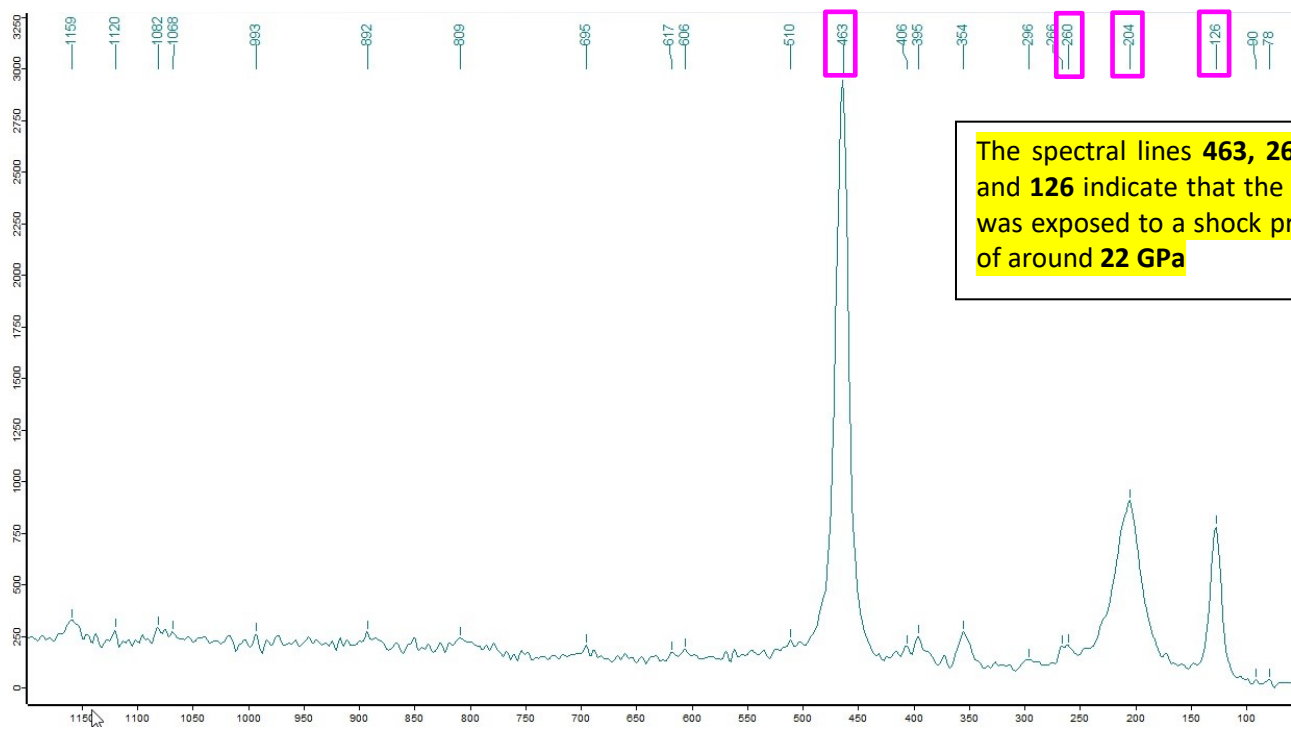


% Match:	Spectrum Name:	RRUFF ID:
92	<-> Quartz (532nm)	R060604
92	Quartz (532nm)	X080015
92	Dachardite-IVa (532nm)	R061116
92	Sugilite (532nm)	R070684
92	Quartz (532nm)	X080016
92	Quartz (532nm)	R040031
91	Quartz (532nm)	R050125
86	Edgarbaleyite (532nm)	R060500
85	Monazite-(Ce) (532nm)	R060925
85	Masutomilite (532nm)	R061008
84	Amicite (532nm)	R080066
84	Sodalite (532nm)	R060435
84	Chavesteite (532nm)	R070167

Search:

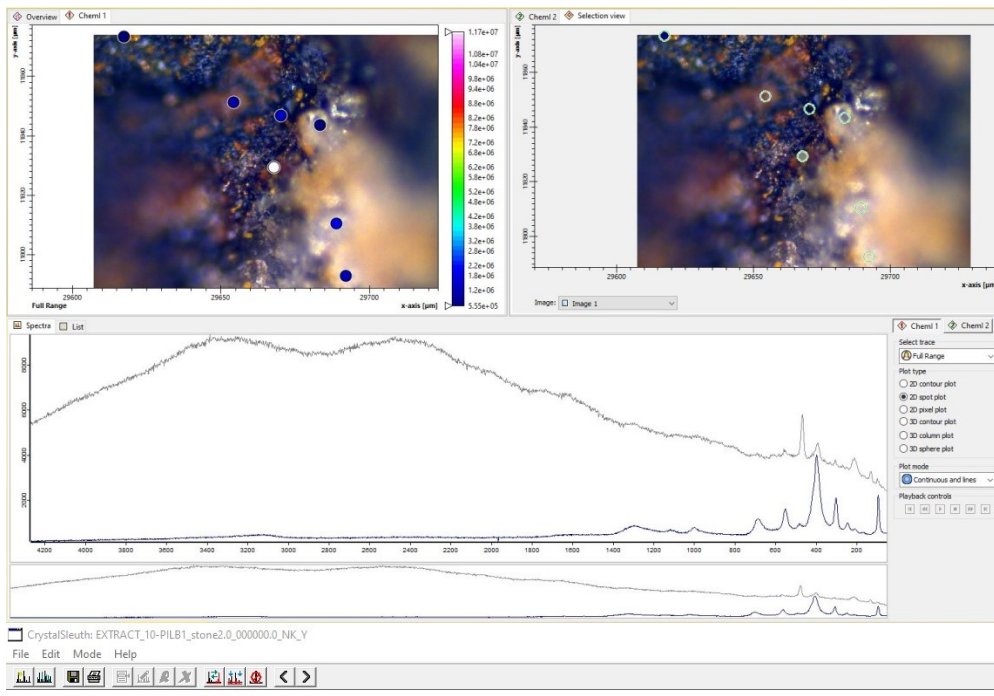
R060604  
Quartz  
SiO<sub>2</sub>  
Piedras Parada, Veracruz, Mexico

Indication for a shock event are the shifts of the marked Quartz spectral lines towards 463, 260, 204

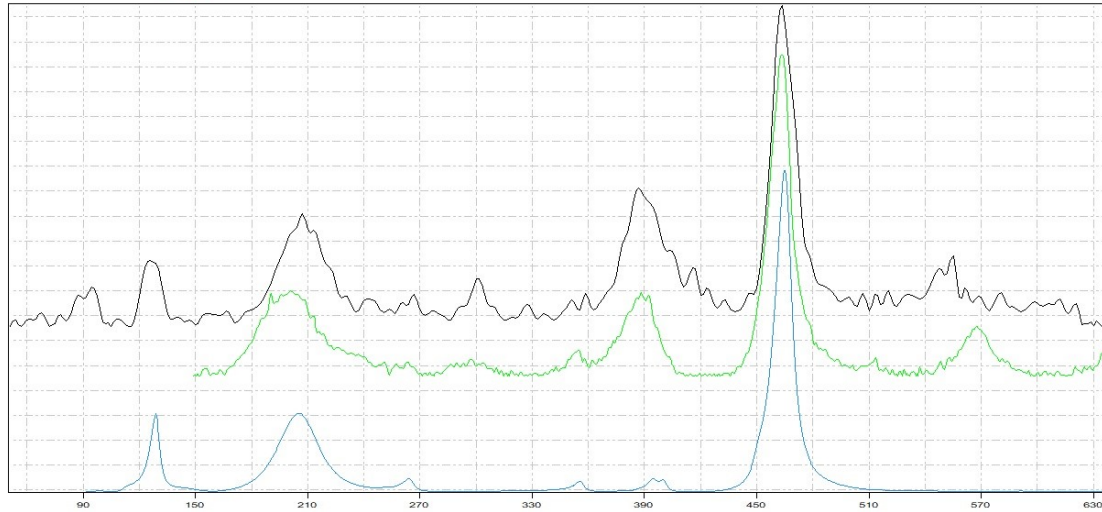


The spectral lines 463, 260, 204 and 126 indicate that the Quartz was exposed to a shock pressure of around 22 GPa

Sample Site **10** : Stone 2\_spectra 1 indicates : **Quartz , Ericssonite.** (→ see RRUFF\_CS results )



Sample :

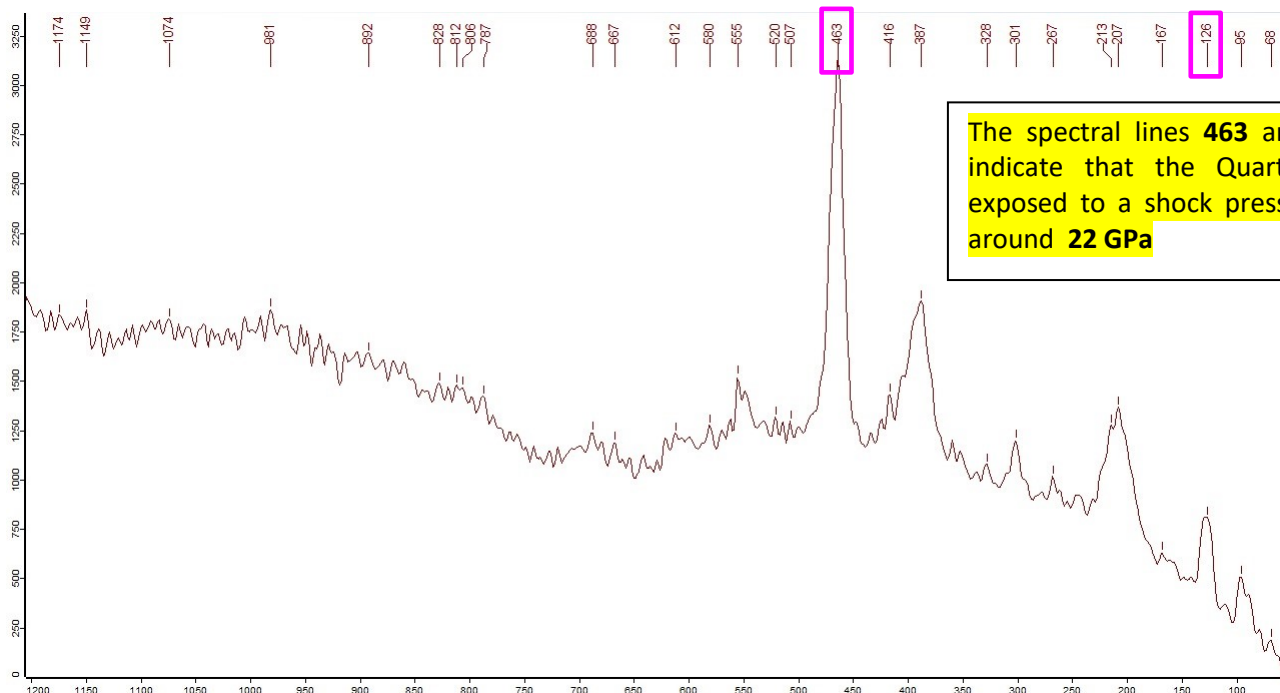


% Match	Spectrum Name	RRUFF ID
91	Ericssonite (532nm)	R070406
91	<-) Dechlorite-Na (532nm)	R061116
85	<-) Suggite (532nm)	R070584
85	Heulandite-Sr (532nm)	R070272
84	<-) Quartz (532nm)	X080016
84	Quartz (532nm)	R060604
84	Quartz (532nm)	X080015
84	Monazite-(Ce) (532nm)	R060925
84	Quartz (532nm)	R050125
83	Mordenite (532nm)	R061118
83	Quartz (532nm)	R040031
82	Amicite (532nm)	R080066
82	Nah-Kinshp (532nm)	R070719

R070406  
Ericssonite  
BaFeIn<sub>2</sub>O(Si<sub>2</sub>O<sub>7</sub>)OH  
Big Creek, Fresno County, California, USA

X080016  
Quartz  
SiO<sub>2</sub>  
Synthetic

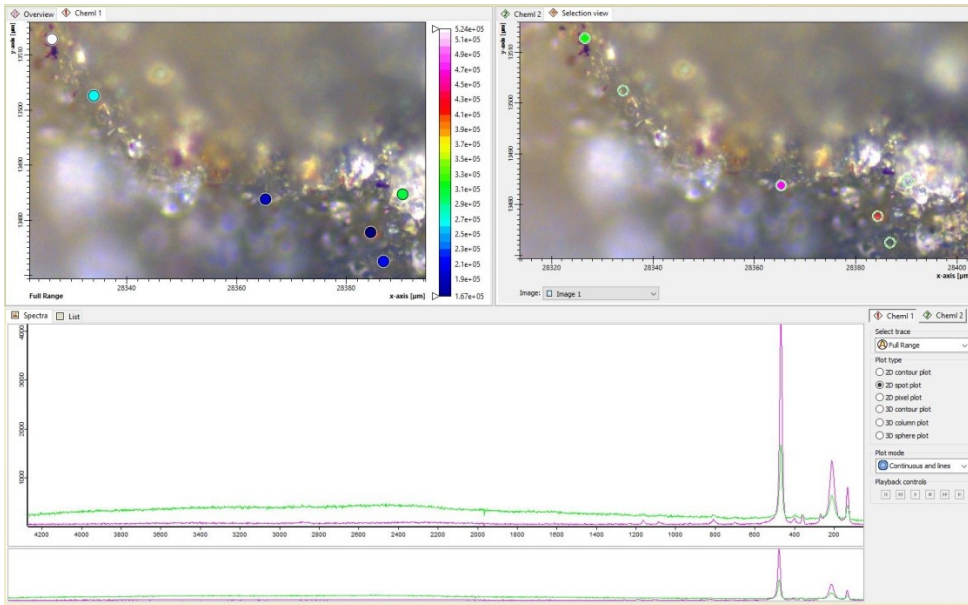
Indication for a shock event are the shifts of the marked Quartz spectral lines towards 463 and 126



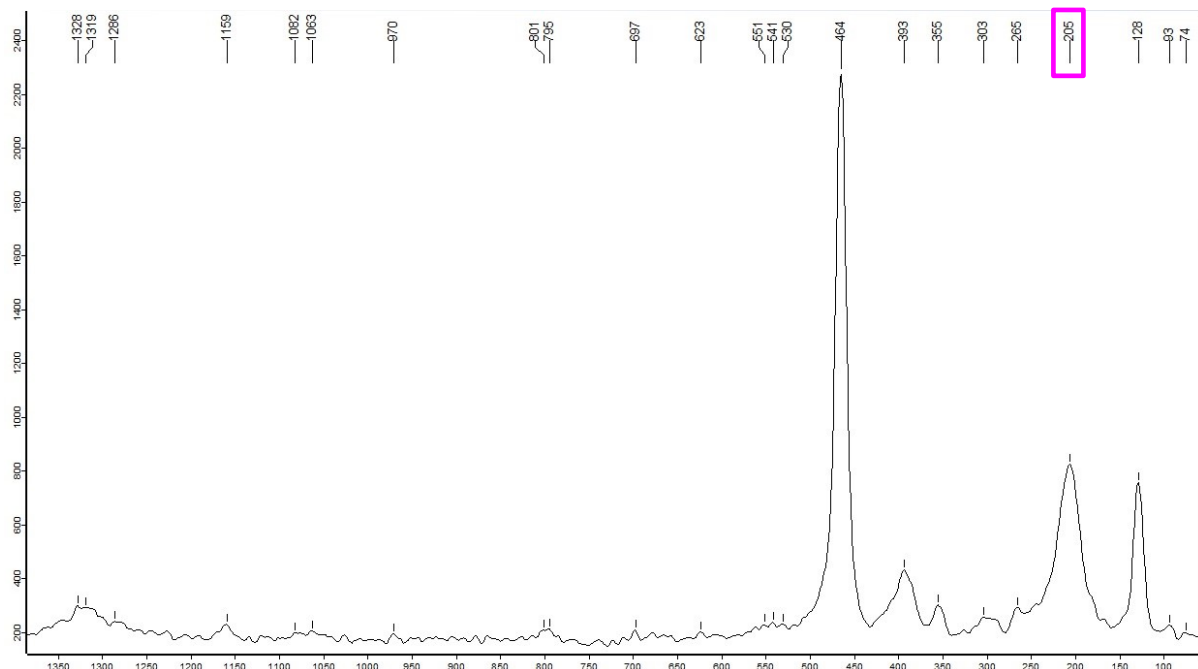
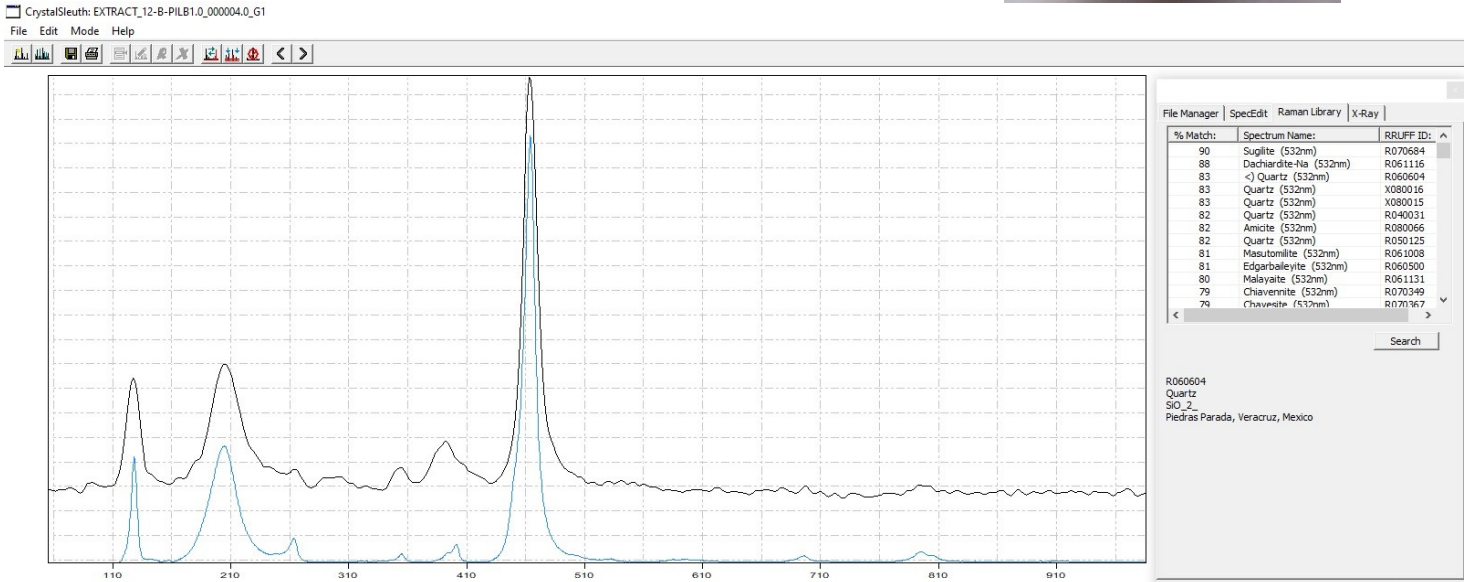
The spectral lines 463 and 126 indicate that the Quartz was exposed to a shock pressure of around 22 GPa



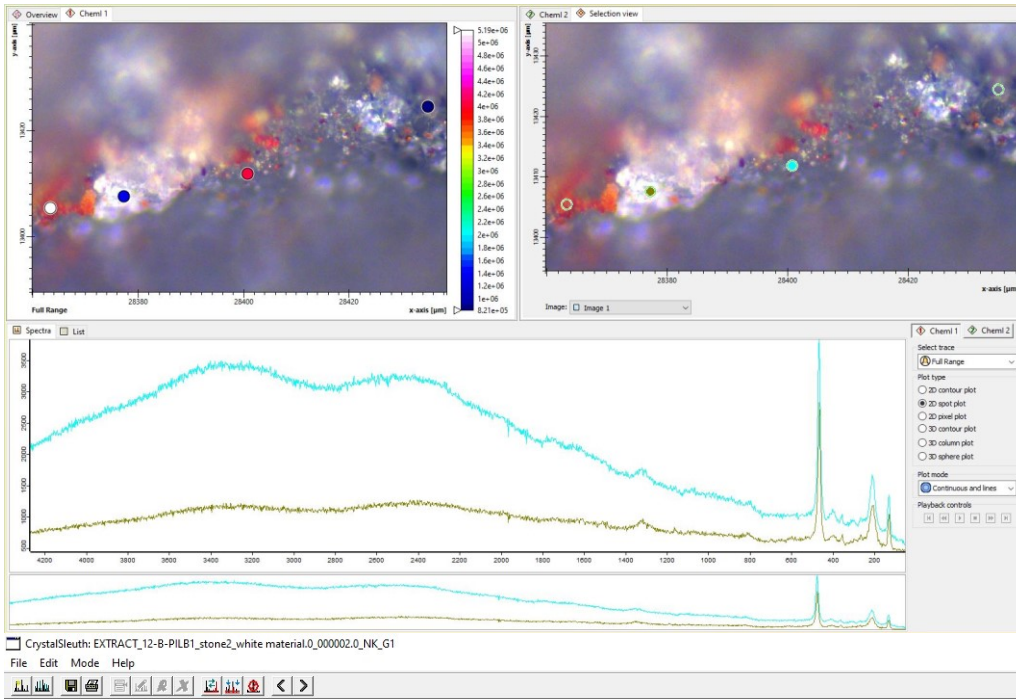
Sample Site **12-B** : Stone 1\_spectra 1 indicates : **Quartz** (→ see RRUFF\_CS results )



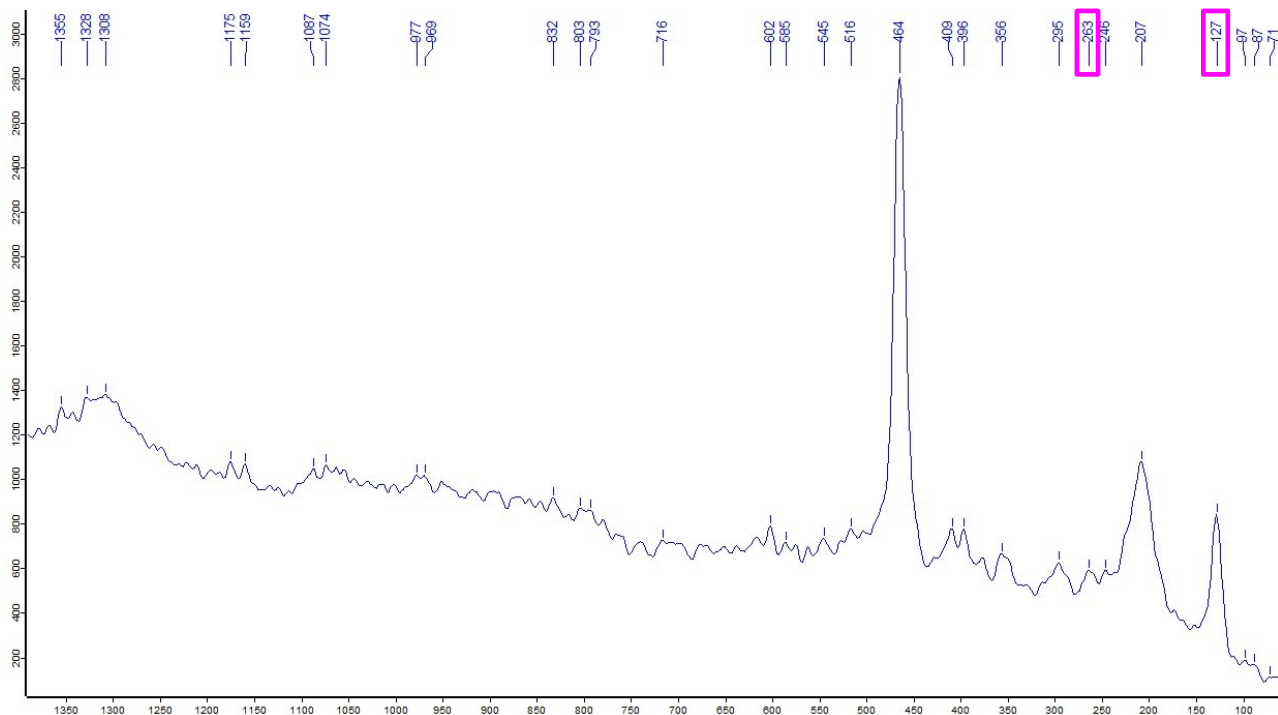
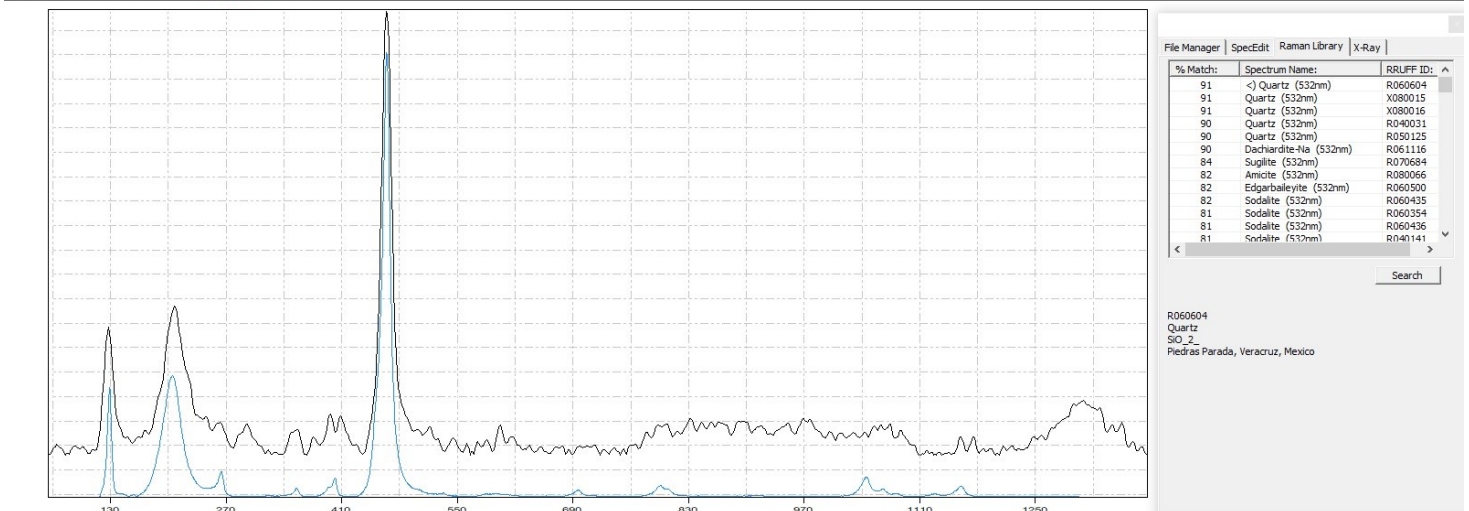
Sample :



Sample Site **12-B** : Stone 2\_spectra 1 ( white mineral ) indicates : **Quartz** (→ see RRUFF\_CS results )

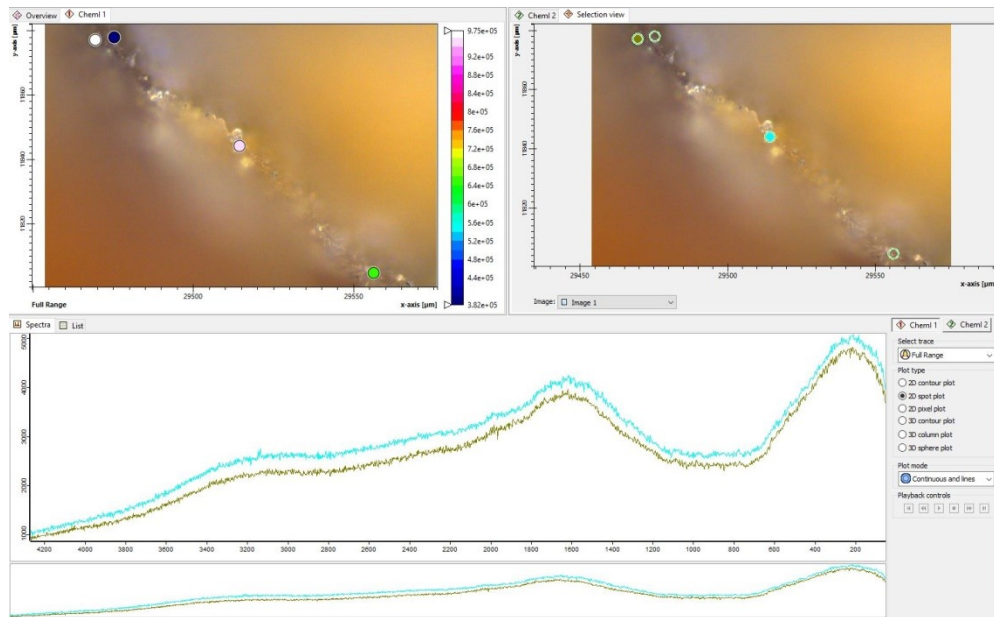


Sample :

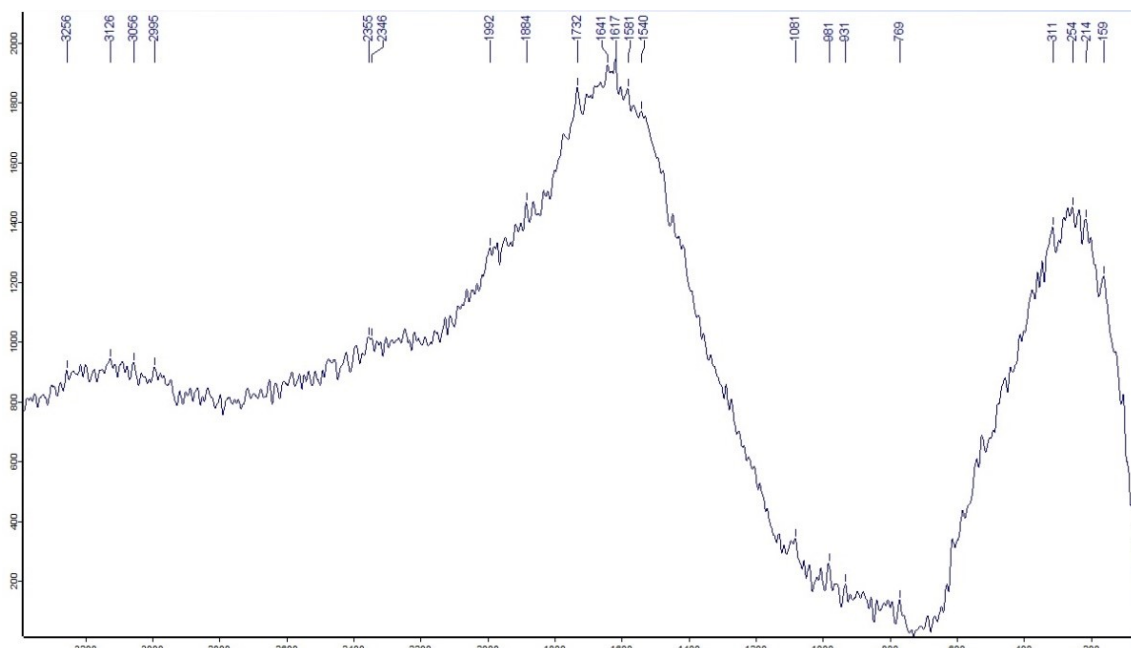
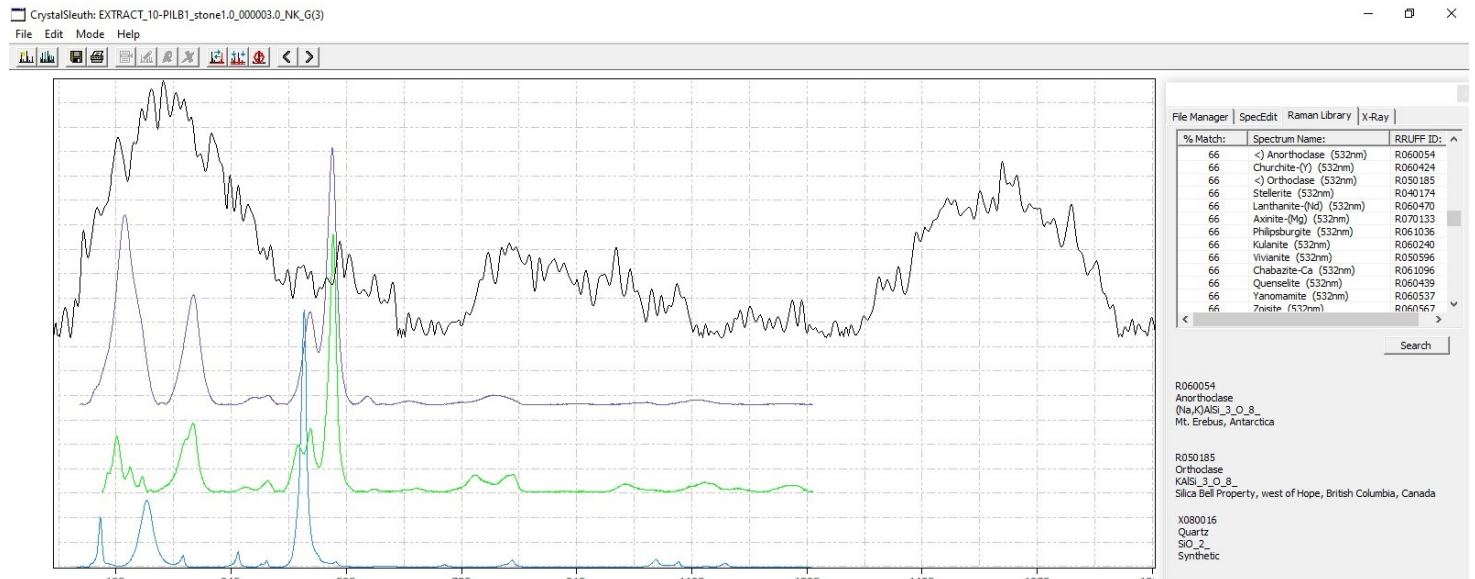




**Sample Site 10** : Stone 1\_spectra 1 indicates : (Anorthoclase, Orthoclase (Quartz) ?? (→ see RRUFF\_CS results)  
 Spectra contains to less information ! No proper analysis possible.

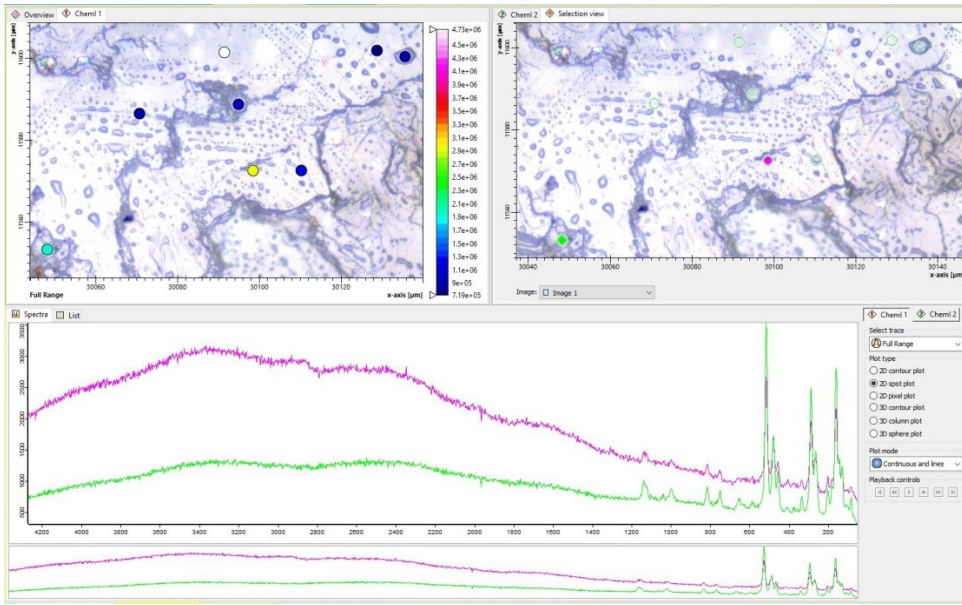


**Sample :**



Sample Site 25 : Stone 3\_spectra 1 indicates : **Microcline , Orthoclase**

(→ see RRUFF\_CS results )

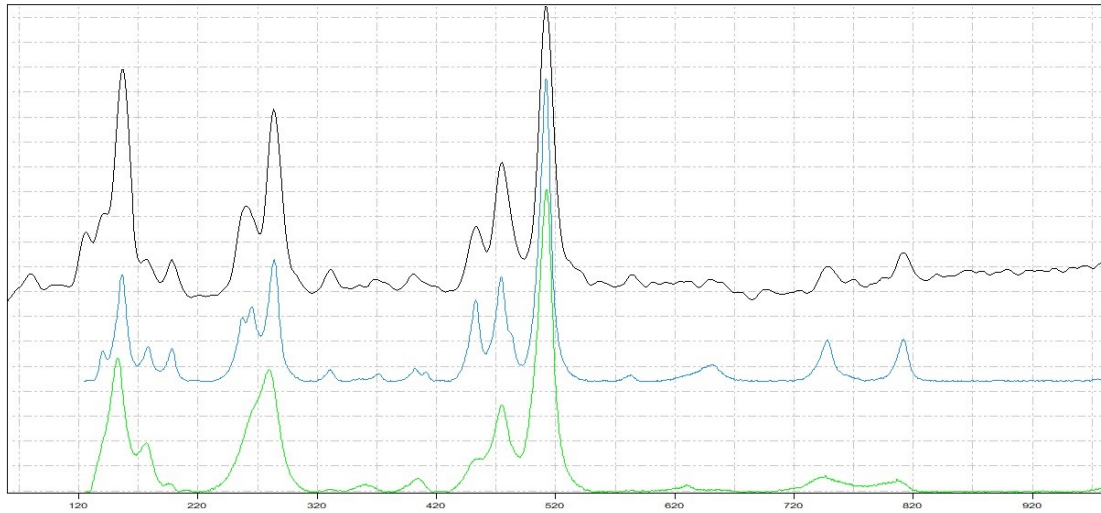


Sample :



CrystalSleuth: EXTRACT\_25-PILB1\_stone3.0\_000000.0\_NK\_G1

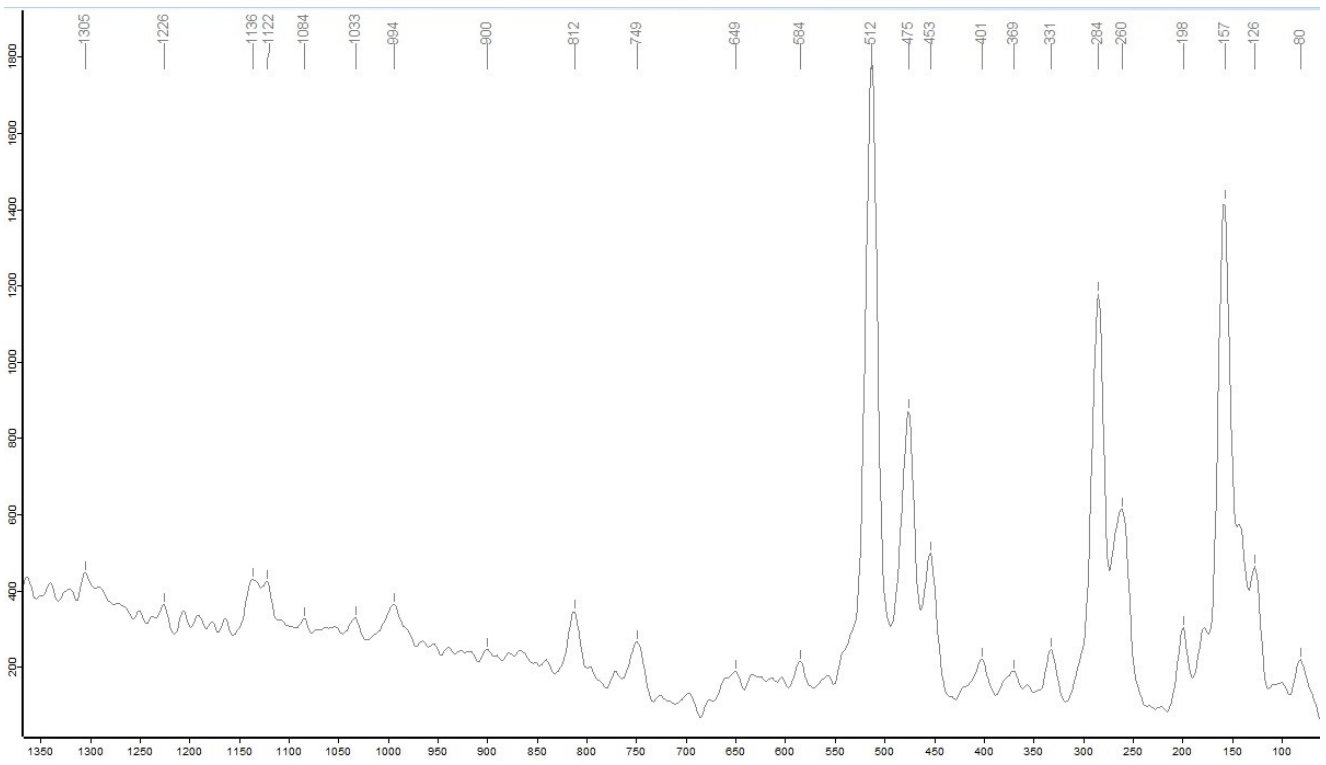
File Edit Mode Help



% Match:	Spectrum Name:	RRUFF ID:
83	< Microcline (532nm)	R050054
82	< Orthoclase (532nm)	R050367
80	Microcline (532nm)	R040154
79	Orthoclase (532nm)	R050185
78	Orthoclase (532nm)	R040055
77	Microcline (532nm)	R050150
77	Microcline (532nm)	R050193
76	Amorphoclase (532nm)	R050054
74	Orthoclase (532nm)	R070001
74	Hendersonite (532nm)	R070467
72	Albite (532nm)	R040068
72	Emeleusite (532nm)	R061034
77	Albite (532nm)	R070467

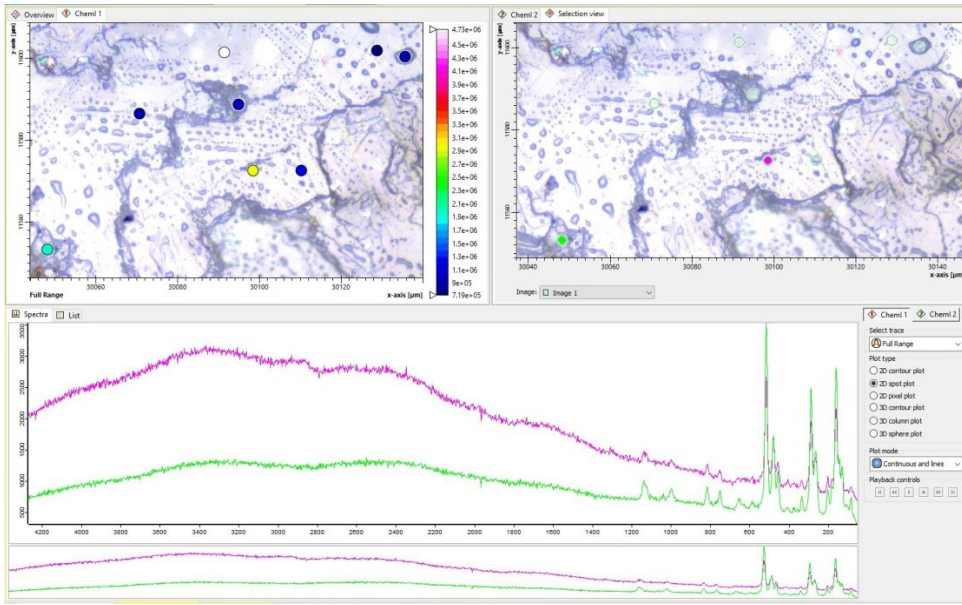
R050054  
Microcline  
KAISI\_3\_O\_8  
Kenticha, Negele area, Sidamo Province, Ethiopia

R050367  
Orthoclase  
KAISI\_3\_O\_8  
Pazunsek, Mandalay Division, Burma



Sample Site **25** : Stone 3\_spectra 3 indicates : **Microcline**

(→ see RRUFF\_CS results)

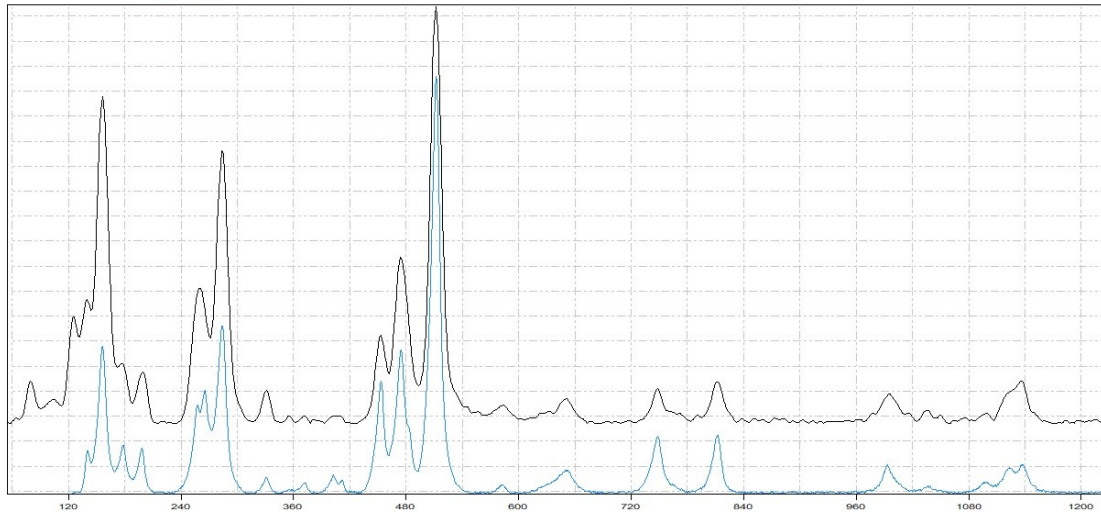


Sample :



CrystalSleuth: EXTRACT\_25-PILB1\_stone3\_0\_000007.1\_NK\_G1

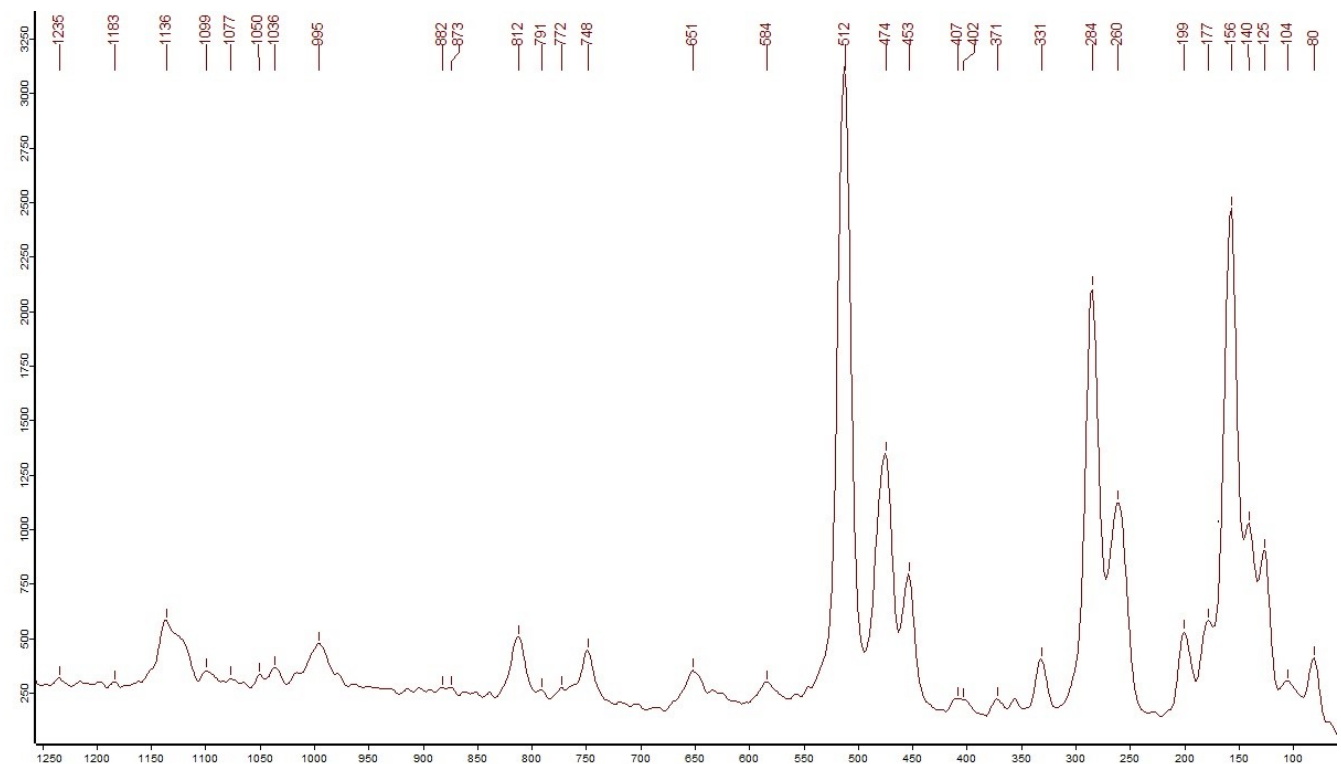
File Edit Mode Help



File Manager | SpecEdit | Raman Library | X-Ray

% Match:	Spectrum Name:	RRUFF ID:
92	Microcline (532nm)	R050054
88	Microcline (532nm)	R040194
87	Orthoclase (532nm)	R050185
87	Orthoclase (532nm)	R040055
85	Anorthoclase (532nm)	R060054
85	Microcline (532nm)	R050193
82	Orthoclase (532nm)	R070001
81	Microcline (532nm)	R050150
77	Albite (532nm)	R050402
77	Hendersonite (532nm)	R070467
76	Labradorite (532nm)	R050104
76	Albite (532nm)	R040068
73	Conchrite (532nm)	R060765

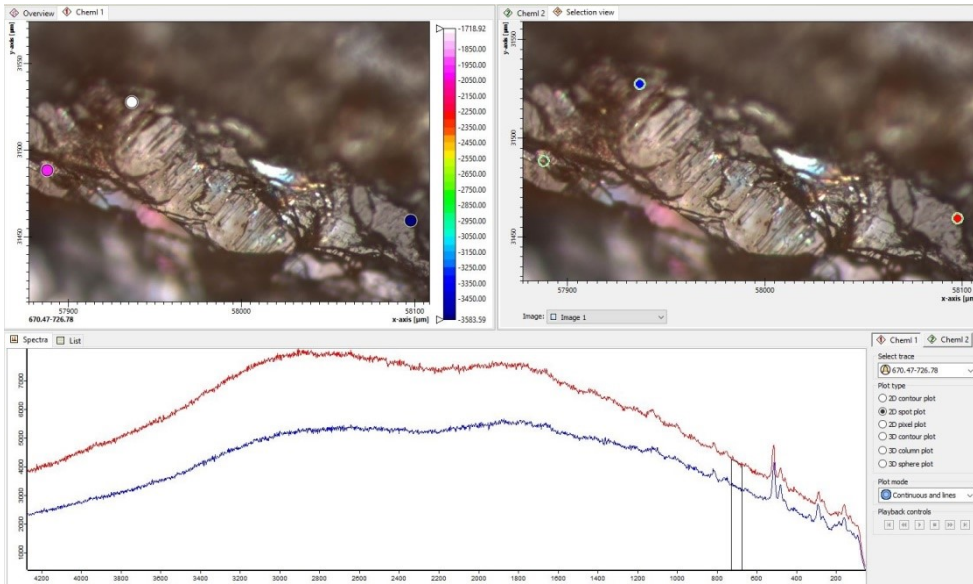
R050054  
Microcline  
KAlSi<sub>3</sub>O<sub>8</sub>  
Kenticha, Negele area, Sidamo Province, Ethiopia



Sample Site **25** : Stone 3\_spectra 4 indicates : **Microcline, Orthoclase**

(→ see RRUFF\_CS results )

Possible PDFs (Planar Deformation Features) in the sample !

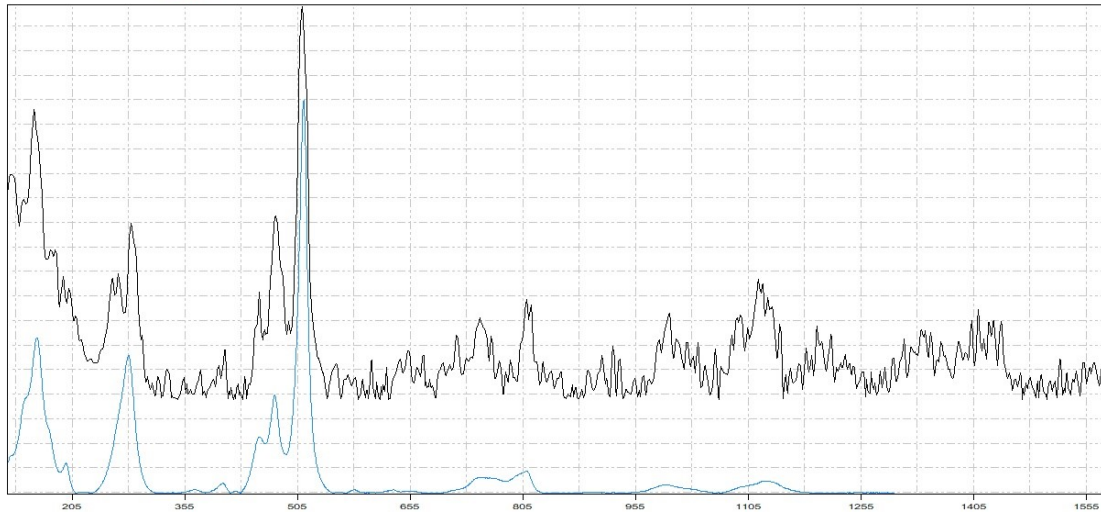


Sample :



CrystalSleuth: EXTRACT\_25\_PILB 1 (10x)\_S3.0\_000002.0

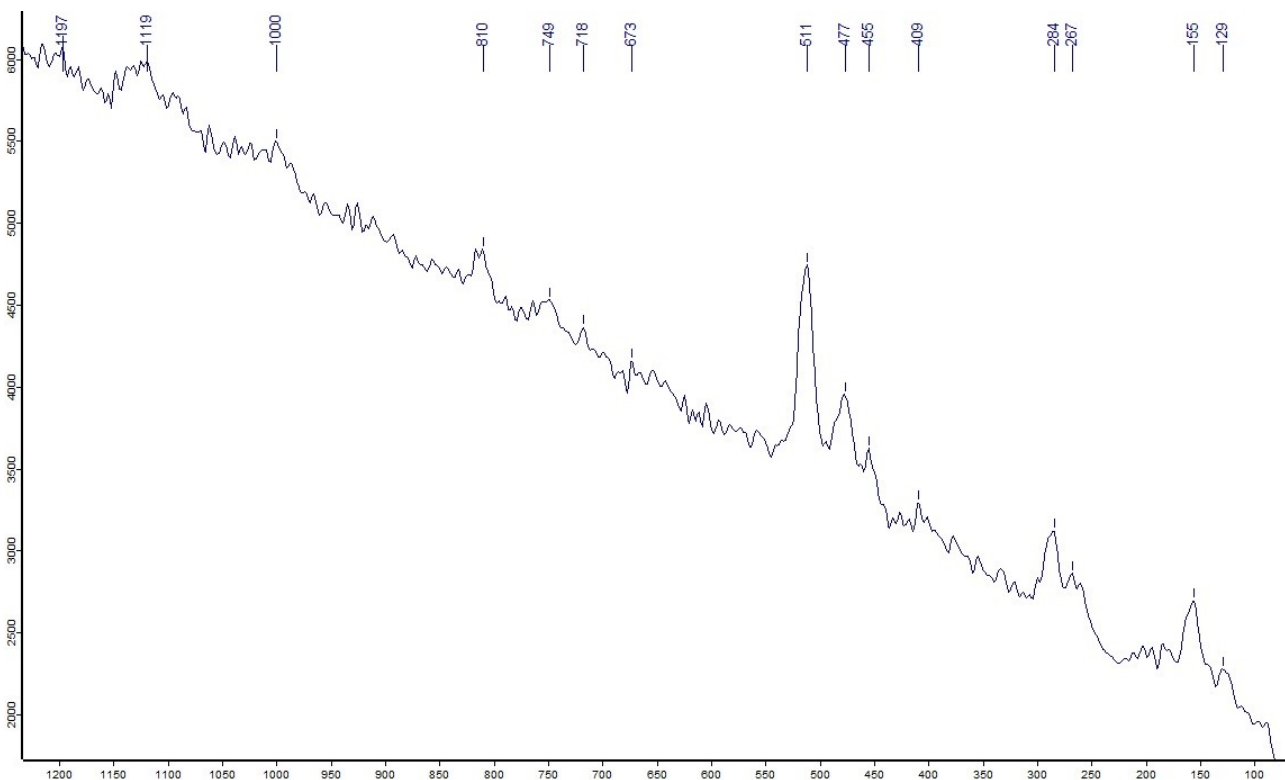
File Edit Mode Help



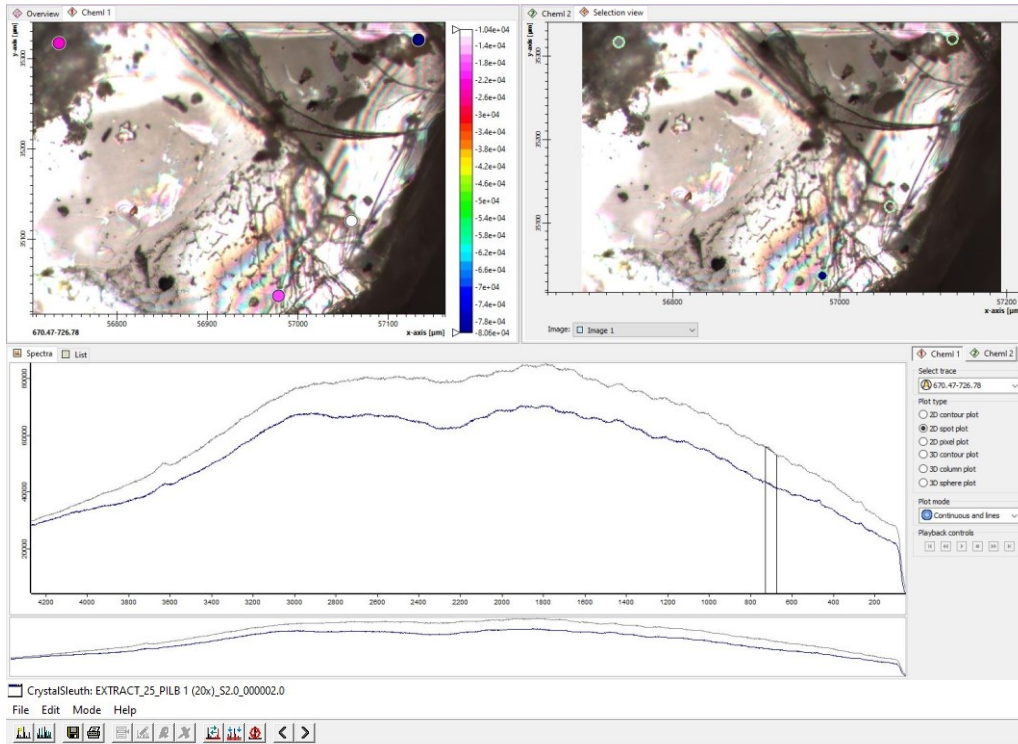
File Manager | SpecEdit | Raman Library | X-Ray |

% Match	Spectrum Name	RRUFF ID
83	Orthoclase (532nm)	R050077
81	Amorphouse (532nm)	R060054
79	Orthoclase (532nm)	R050367
78	Microcline (532nm)	R050054
75	Orthoclase (532nm)	R040055
75	Orthoclase (532nm)	R050185
75	Microcline (532nm)	R040154
73	Corvusite (532nm)	R060265
72	Albite (532nm)	R050402
71	Albite (532nm)	R040068
71	Microcline (532nm)	R050193
71	Microcline (532nm)	R050150
71	Labradorite (532nm)	R060087

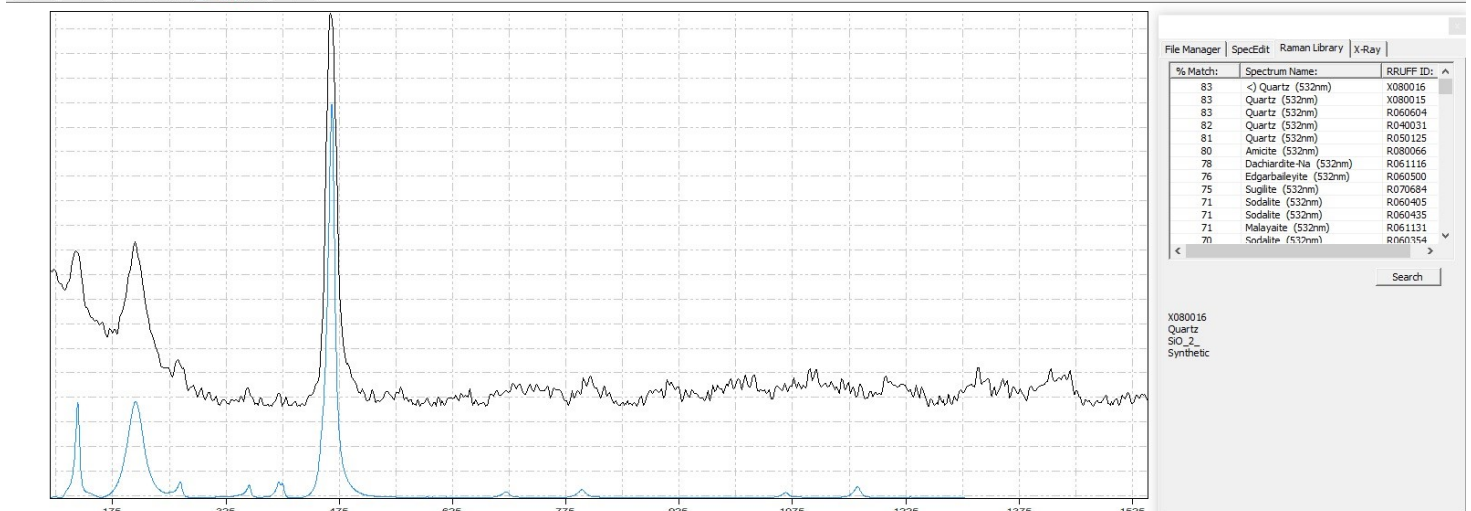
R060077  
Orthoclase  
KAlSi<sub>3</sub>O<sub>8</sub>  
pegmatite near Minh Tien, 15 km south of Luc Yen, Vietnam



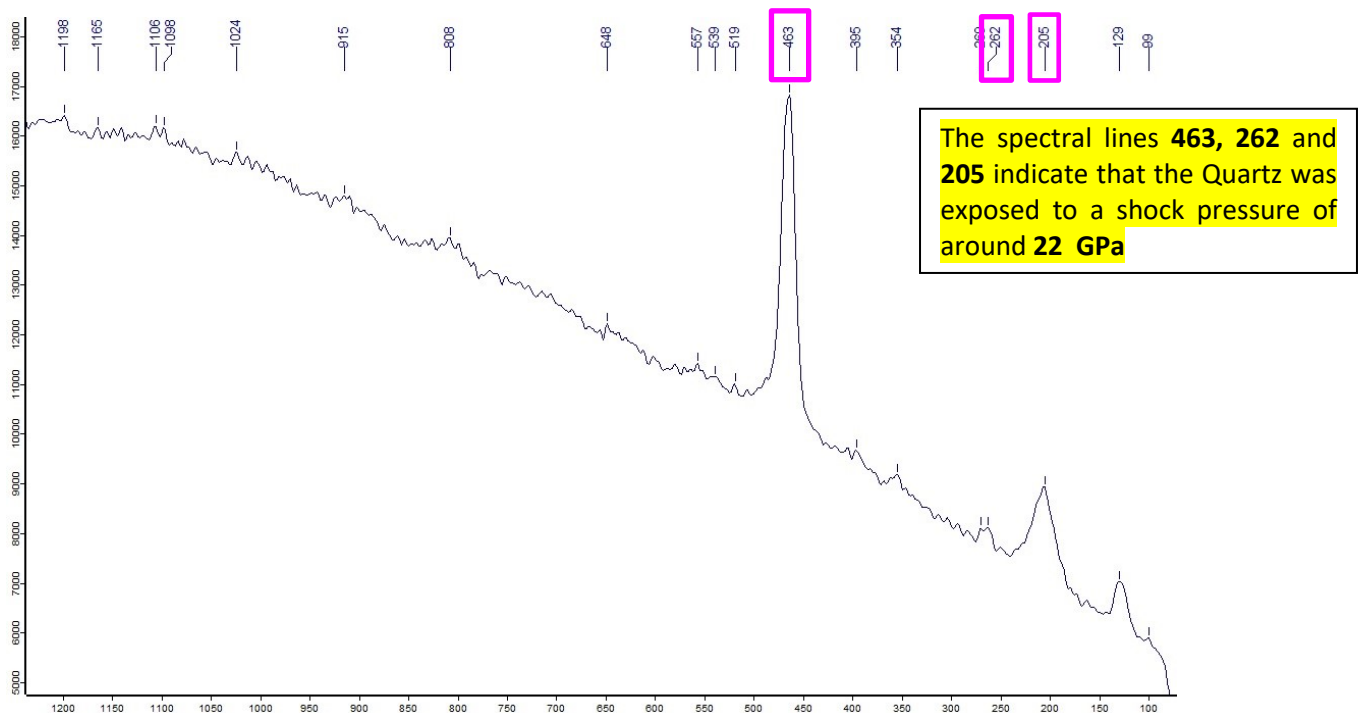
Sample-Site **25** : Stone 2\_spectra 3 indicates : **Quartz** (→ see RRUFF\_CS results )



Sample :



Indication for a shock event are the shifts of the marked Quartz spectral lines towards 463, 262 and 205





**Appendix 1 : Photos of the rock samples from sample sites : 25, 10, 11 and 12-B**

**Please note :** Photos of the Samples Sites **25, 10, 11** and 12-B and other sample sites are available on my website. → weblink : **Sample Sites Pilbara Crater 1**

**25**



**Note :** Site 25 is accessible over an unsealed road. But it is located on a mine-site. Permission may be required !

**Photos of the Samples Sites** (alternative links) **25, 10, 11** and other sites on : **Sample Sites Pilbara Crater 1**

**10**





**Note** : The Sites 10, 11, 12 and 25 are accessible over unsealed roads But they are located on mine-sites ! Permission may be required to do an expedition !



Area of the samples sites 10,11 & 12-B : Image of the secondary impact site as it was in the 1960's Mt Goldsworthy had the world's richest deposits of ferrous ore. They were graded as high as 68 % !

**Note** : The base-rock of the area is 2.9 Ga old. But these **impact structures seem to be much younger !**

Ferrous (iron)-ore outcrops on the surface



Photos of the Samples Sites [25](#), [10](#), [11](#) and other sites on : [Sample Sites Pilbara Crater 1](#)

## Appendix 2 : A short overview : The Raman bands (peaks) of Quartz shocked with 22-26 GPa

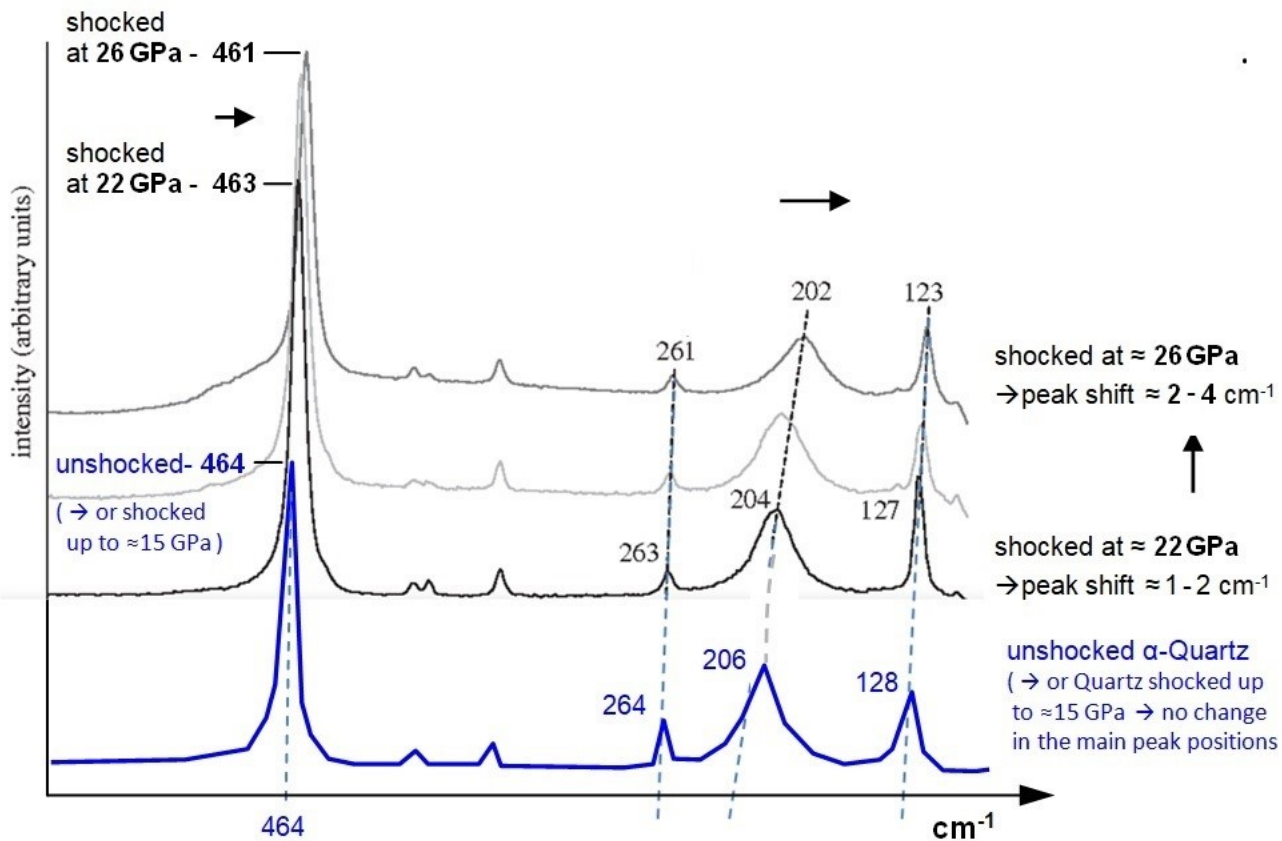
In order to verify a sample site as an impact site or impact structure, [shock-metamorphic effects](#) must be discovered in the rocks of the sample site. This can be done by different methods.

For example with the help of PDFs ( planar deformation features ) which are visible in the quartz with the help of a microscope. However this requires careful preparation of the samples and expertise.

Another, easier method, is the use of a RAMAN microscope. Micro-RAMAN Spectroscopy on quartz grains in the samples can provide the first evidence for a shock event, that was caused by an impact.

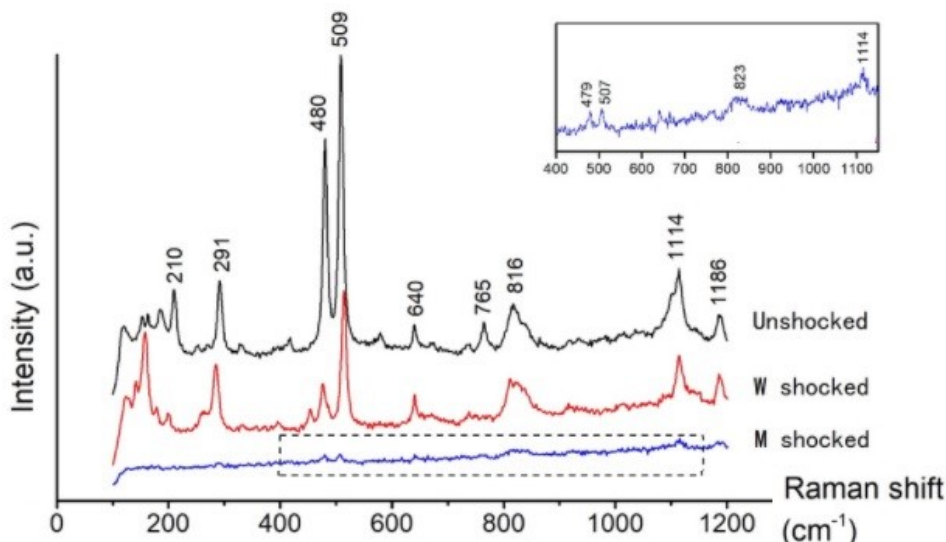
Mc Millan et al. (1992) and others have shown that the main RAMAN-peaks of Quartz shift towards lower frequencies if the Quartz was exposed to a shock-pressure > 15 GPa. → see diagram below

The shift of the main quartz RAMAN-peaks can be used to identify quartz that was shocked by an impact



Quartz shocked with 22 GPa and 26 GPa shows shifts of the main RAMAN-peaks of 1 - 4 cm<sup>-1</sup> to lower frequencies

## Appendix 3 : Raman spectra of (W) weakly-shocked & (M) moderately-shocked Alkali-Feldspar



Weakly shocked alkali feldspar mainly developed irregular fractures and undulatory extinction. Note that the Raman-lines 210 and 765 are missing in the w-shocked feldspar, and an additional line at ≈ 150 appears.

The shock pressure for the w-shocked feldspar was estimated to be between 5 and 14 GPa

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**Part 1 :** [The 1270 X 950 km Permian-Triassic Impact Crater caused Earth's Plate Tectonics of the Last 250 Ma](#)

**Part 2 :** [The Permian-Triassic Impact Event caused Secondary-Craters and Impact Structures in Europe, Africa & Australia](#)

**Part 3 :** [The PT-Impact Event caused Secondary-Craters and Impact Structures in India, South-America & Australia](#)

**Part 4 :** [The PT-Impact Event and its Importance for the World Economy and for the Exploration- and Mining-Industry](#)

**Part 5 :** [Global Impact Events are the cause for Plate Tectonics and the formation of Continents and Oceans \(Part 5\)](#)

**Part 6 :** [Mineralogical- and Geological Evidence for the Permian-Triassic Impact Event](#)

Alternative weblinks for my Study **Parts 1 - 6 with slightly higher resolution** : [Part 1](#), [Part 2](#), [Part 3](#), [Part 4](#), [Part 5](#), [Part 6](#)

Parts 1 – 6 of my PTI-hypothesis are also available on my website : [www.permiantriassic.de](http://www.permiantriassic.de) or [www.permiantriassic.at](http://www.permiantriassic.at)

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