

# An Impact Structure Ø 30 km and Impact Crater Ø 1,6 x 1,2 km in Southern Spain

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

## Summary :

Raman spectra of samples taken from the sample sites **50**, **30** and **19** provide evidence that the large bow-shaped structure visible on the satellite image ( see image below ) was caused by an impact event. This bow-shaped structure  $\approx \text{Ø } 30 \text{ km}$  belongs to a large-scale impact event which according to my hypothesis was caused by (impacting) ejecta material from the Permian Triassic Crater in the Arctic Sea (  $\rightarrow$  weblink to my Permian Triassic Impact Hypothesis : see [Part 1 \(P1\)](#) and [Part 2 \(P2\)](#) of my study ).

The bow-shaped impact structure is located near Puerto de Mazarron in the state of Murcia in Andalucia. This impact structure belongs to large Secondary Crater Chain of the PT-Impact Event.

Further evidence for the large-scale impact event in Southern Spain ( Andalucia & Murcia ) comes from rock-samples collected in a small elliptical Crater with  $\text{Ø } 1,6 \times 1,2 \text{ km}$  near the town of Rodalquilar. This elliptical crater in the remote East of Andalucia, which belongs to the assumed large-scale impact event in Southern Spain, has the potential to provide precise evidence for my hypothesis, because it provides the precise trajectory and impact angle of the impactor (  $\rightarrow$  ejecta from the P/T-Crater ) !

The Raman spectra of quartz from sample site **50** on the outside of the crater-wall of the bow-shaped impact structure ( near the tunnel exit of the AP7 ) provides clear evidence for an impact event !

The shift of the main Raman bands ( peaks ) to the lower frequencies **463**, **261**, **205** and **127  $\text{cm}^{-1}$**  which is visible in the Raman Spectra of the quartz-sample, clearly indicates that the quartz was exposed to a **shock pressure of around 22 GPa**. ( see explanation in the Appendix at page **24** ). Similar shifts of the Raman bands are visible in the spectra of samples **19** & **30** from the center of the structure

The spectra of the quartz sample **40-B** from the center of the  $\text{Ø } 1,6 \times 1,2 \text{ km}$  elliptical Crater shows similar shifts of the Raman bands, e.g. the measured bands at **463**, **261/263**, **203** and **127  $\text{cm}^{-1}$** , which also indicate a shock pressure of  $\approx \text{22 GPa}$  that can only be the result of an impact event !

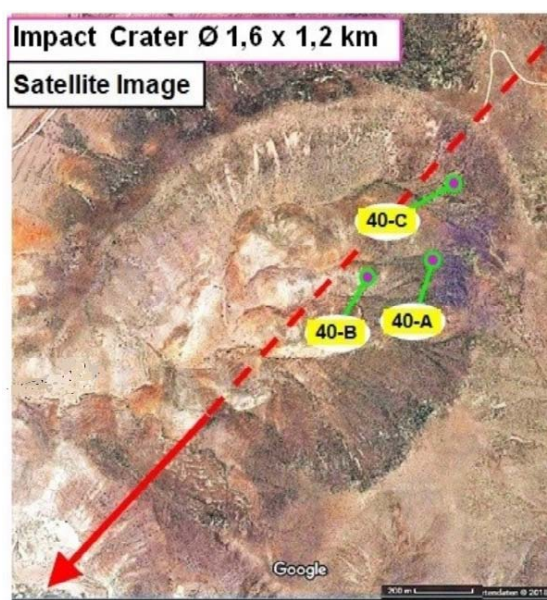
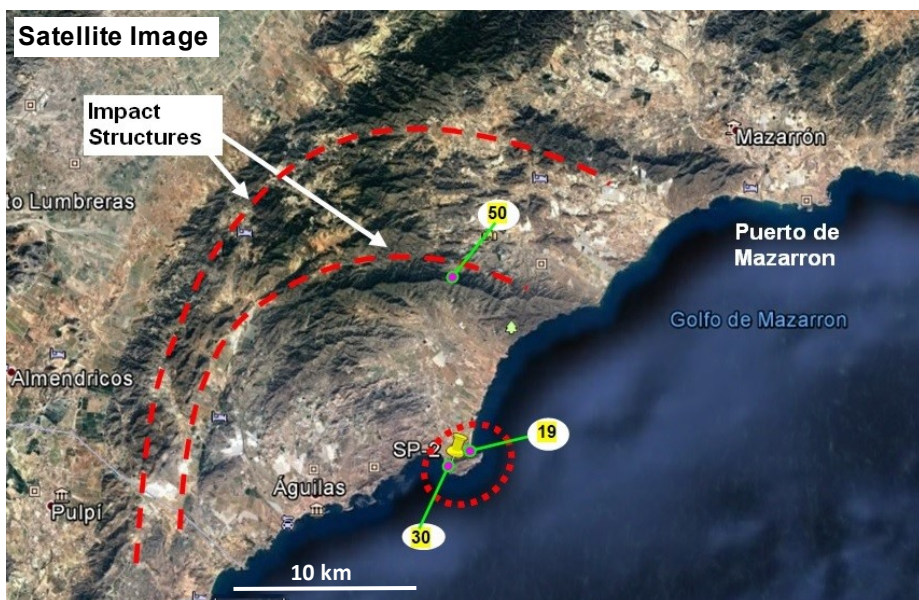
All spectra were made with a **BRUKER Senterra-II Raman Microscope** (wavenumber precision  $<0.1 \text{cm}^{-1}$ )

A shock pressure of 22 GPa far exceeds every pressure caused by normal terrestrial metamorphism. Therefore the quartz was clearly shocked by an impact event. The indicated shock pressure of 22 GPa is lower than the shock pressure that occurred in other large impact craters on Earth, which can reach 100 GPa. This indicates that the bow-shaped structure was caused by an oblique impact That means the impactor which formed the structure (  $\rightarrow$  ejecta of the PT-Crater ) impacted in a very shallow angle. The same is true for the yet unknown  $\text{Ø } 1,6 \times 1,2 \text{ km}$  elliptical Impact Crater near Rodalquilar.

$\rightarrow$  Images of the analysed rock samples and photos of the sample sites are in the Appendix at [page 19](#).

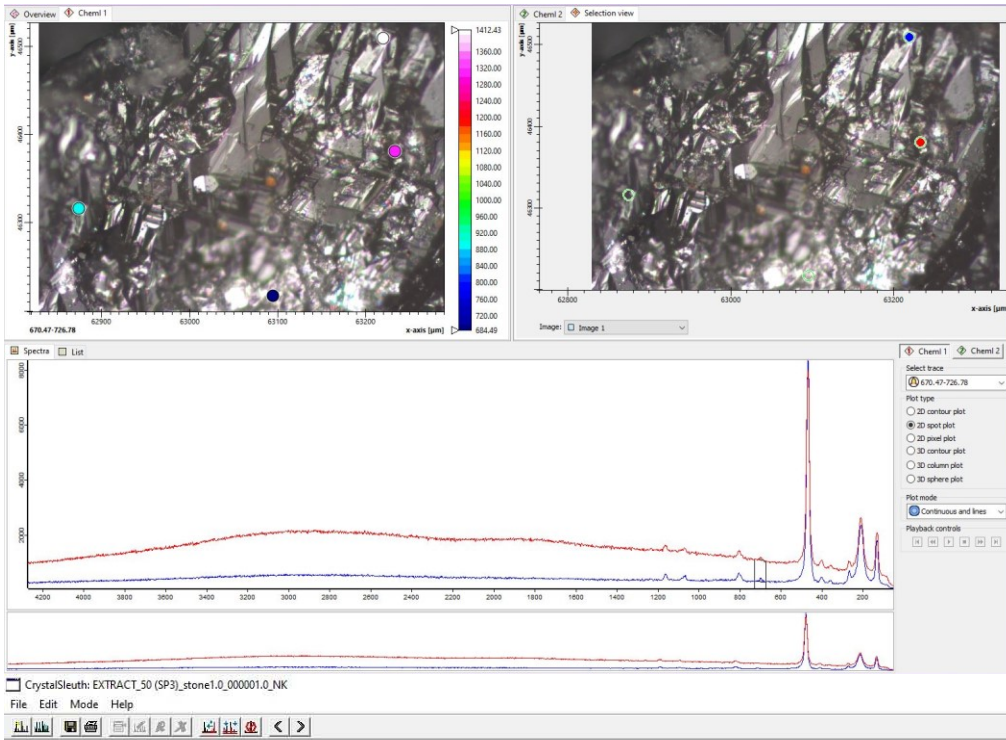
$\rightarrow$  A general summary to all analysed sample sites is provided by [Part 6 \(P6\)](#) of my [PTI-hypothesis \(P1\)](#)

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

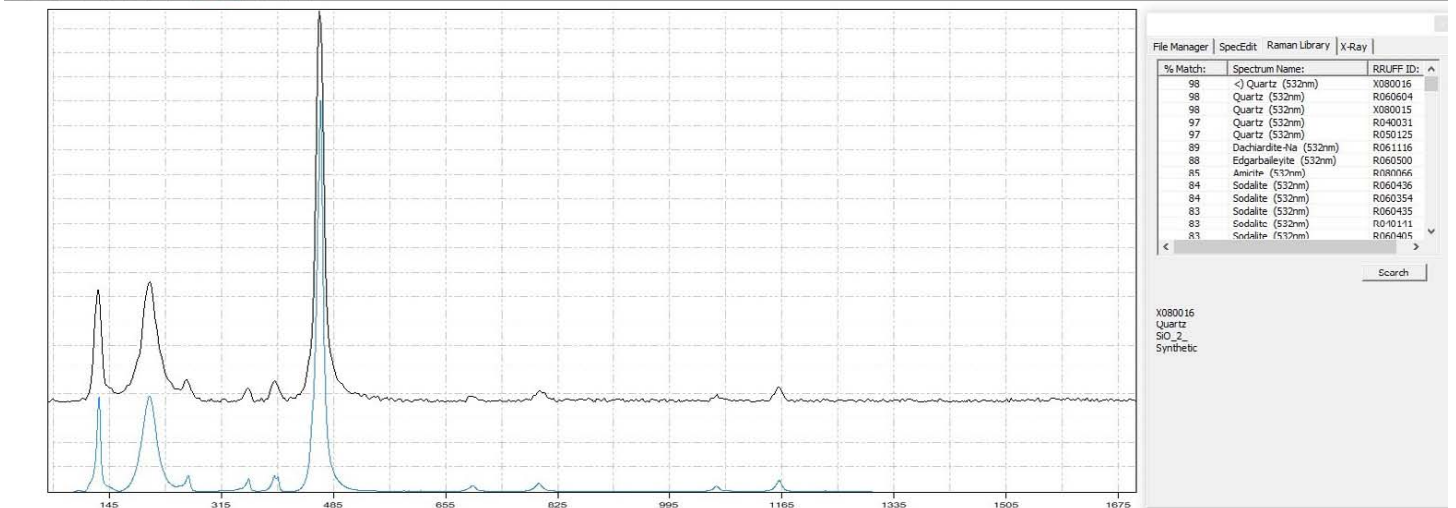
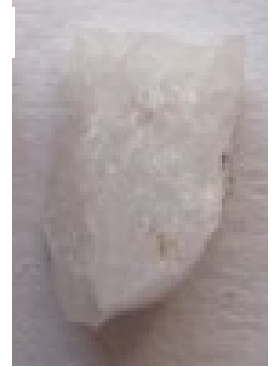


Sample Site 50: Stone 1\_spectra 1 indicates: **Quartz**

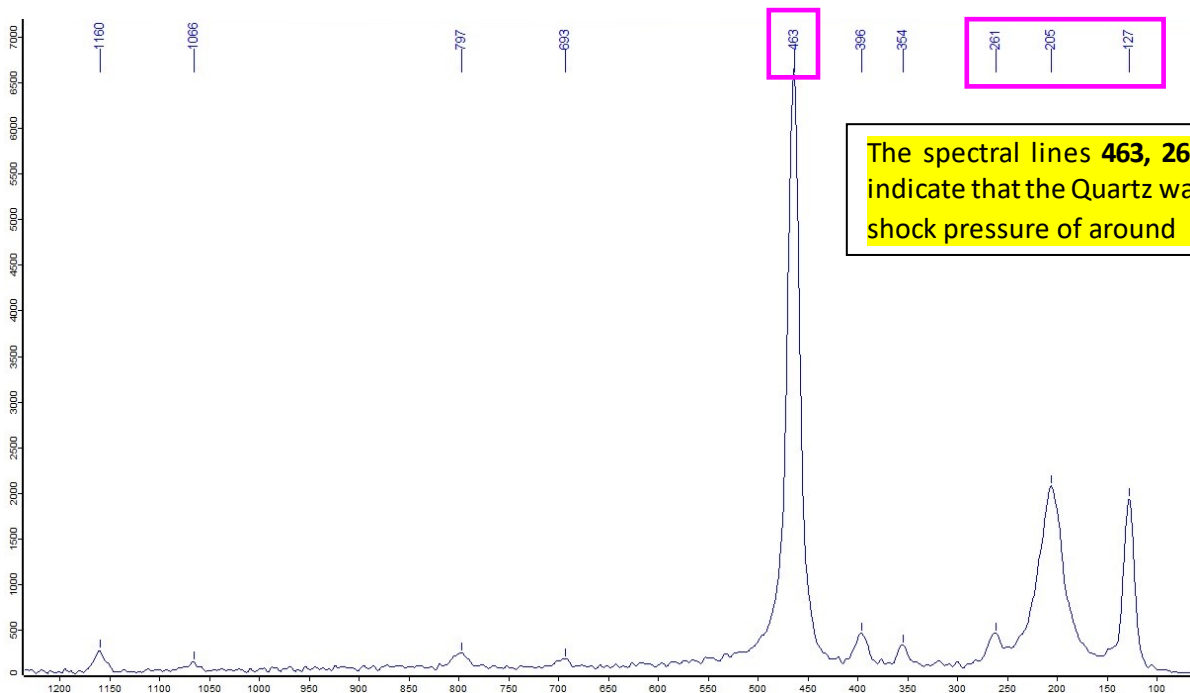
(→ see RRUFF\_search results)



Sample:



Indication for a shock event are the shifts of the marked Quartz spectral lines towards 463, 261, 205 and 127

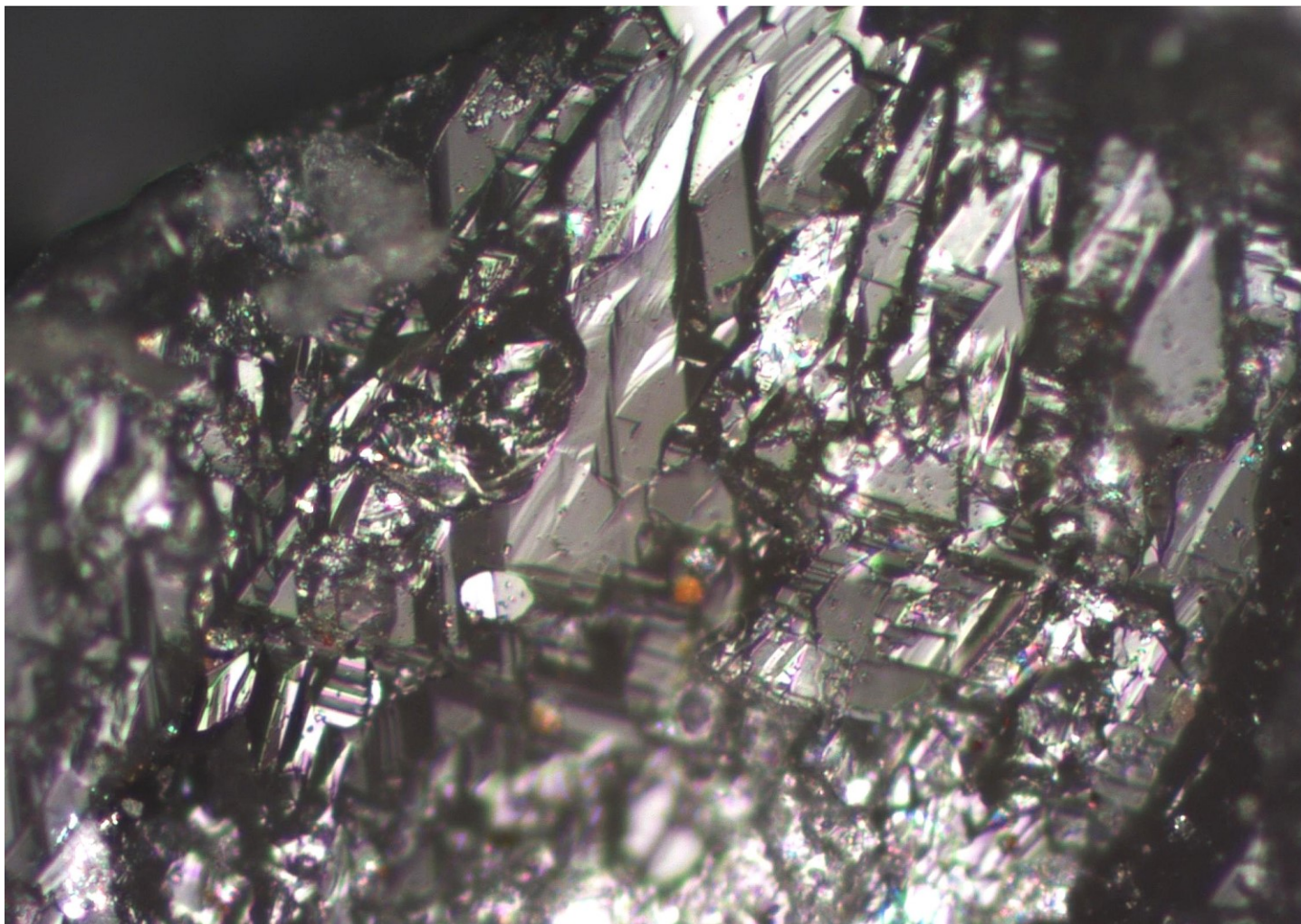


The spectral lines 463, 261, 205 and 127 indicate that the Quartz was exposed to a shock pressure of around 22 GPa

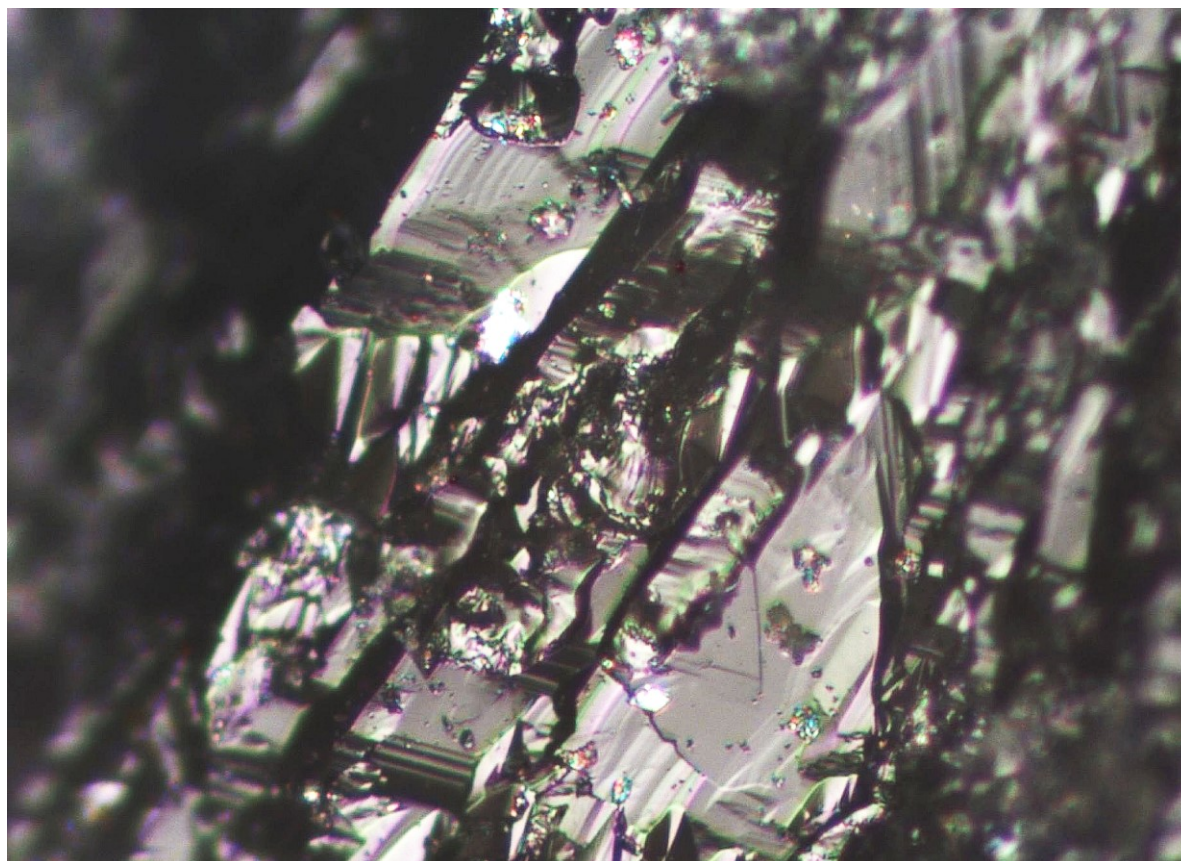
Microscopic Images : Sample from Site 50 → original state ( no preparation for analysis )

Sample Site 50 : Stone 1\_spectra 1 indicates : Quartz - Image size : ~ 400 x 300 μm

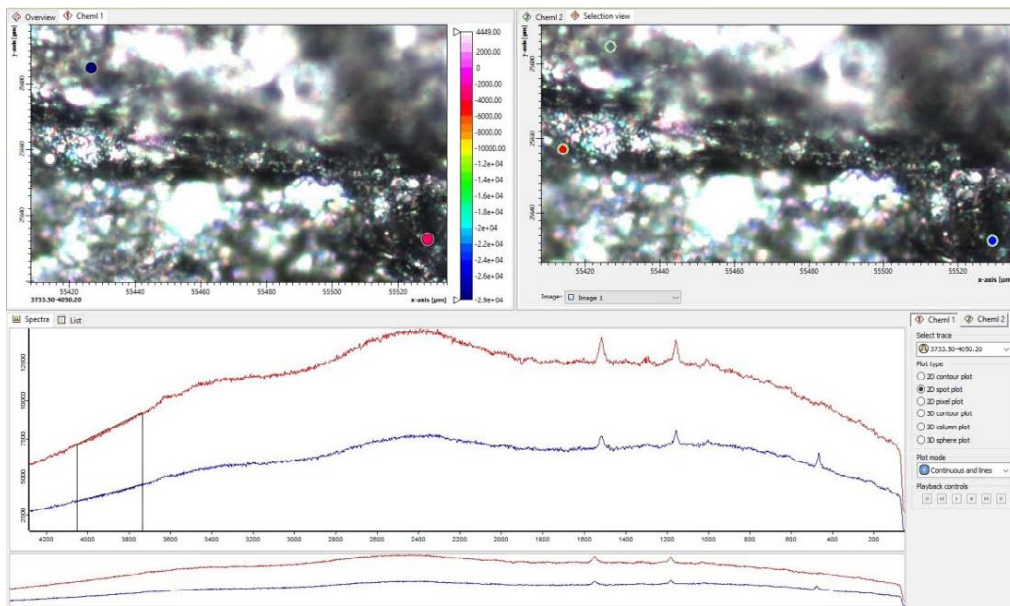
Note the exceptional fracture pattern visible in the quartz sample !



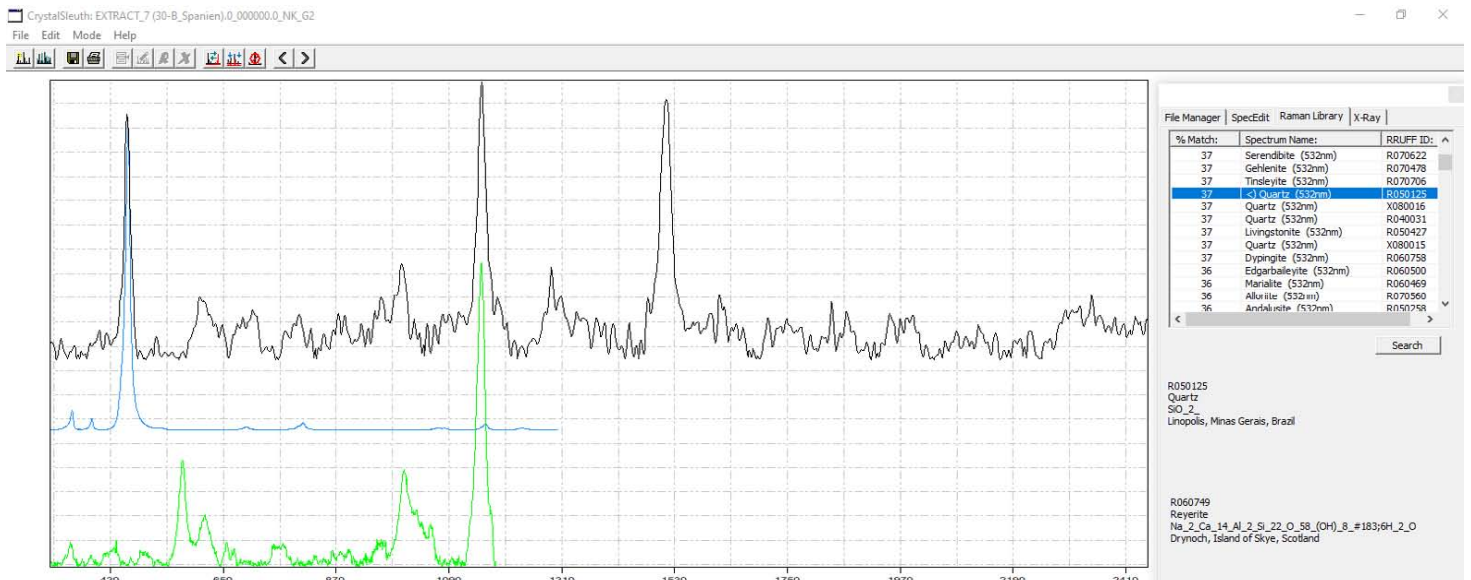
Sample Site 50 : Stone 1\_spectra 1 indicates : Quartz - Image size : ~ 300 x 200 μm



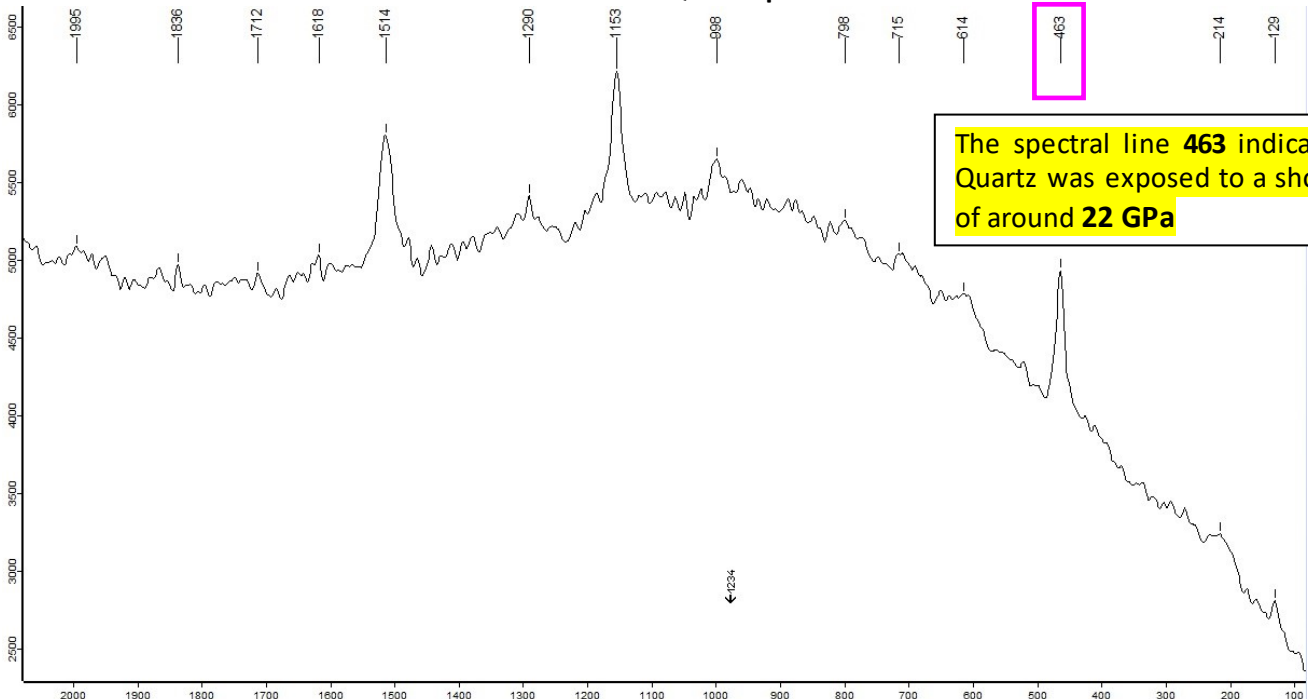
Sample Site **30-B** : Stone 1\_spectra 1 indicates : **Quarz, Reyerite** (→ see RRUFF\_search results)



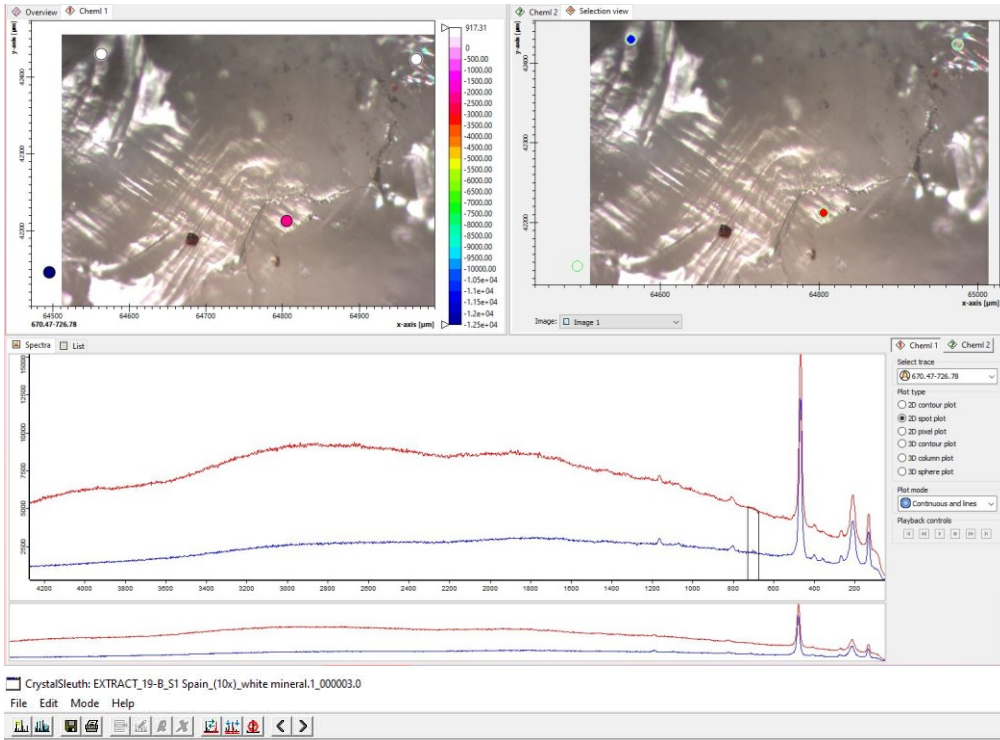
Sample :



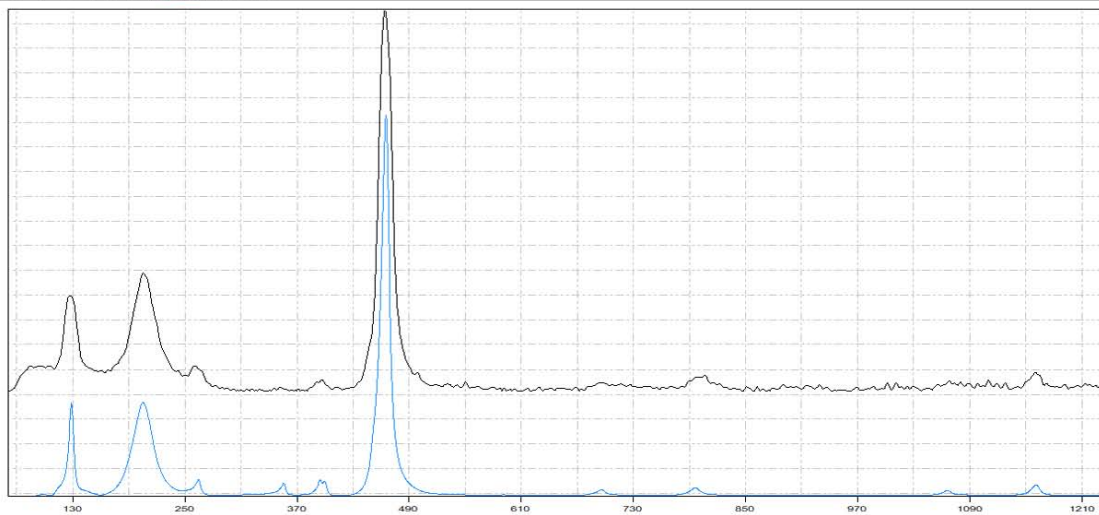
Indication for a shock event is the shift of the marked Quartz spectral line towards 463



Sample Site **19-B** : Stone 3\_spectra 1 indicates : **Quartz** (→ see RRUFF\_search results )



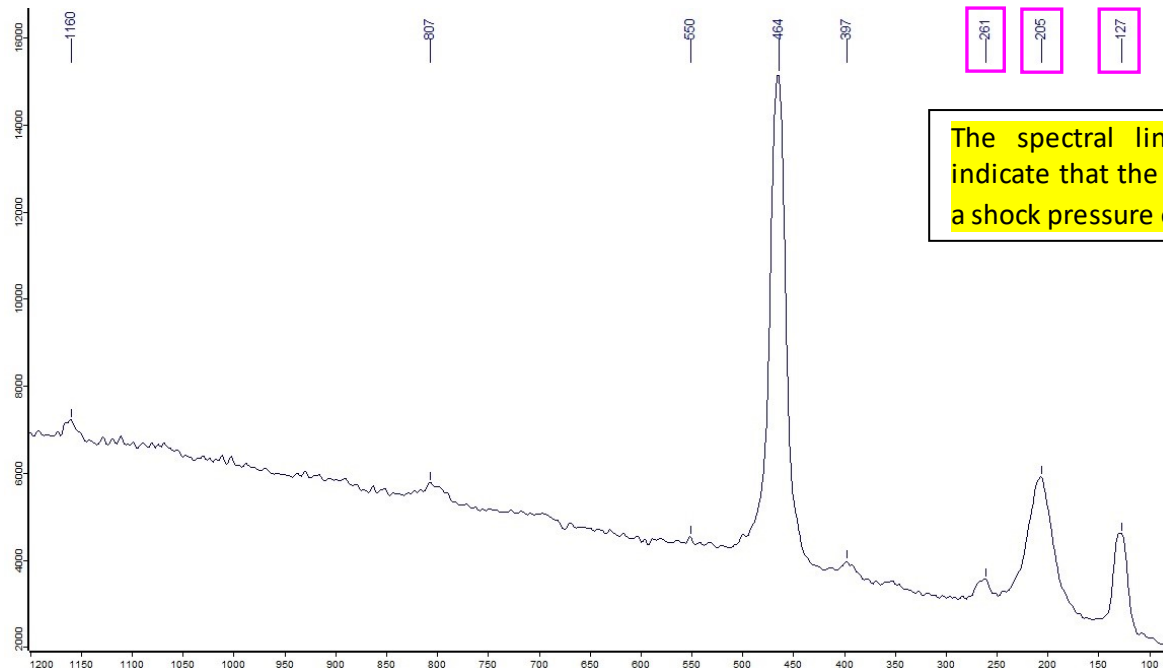
Sample :



| % Match: | Spectrum Name:        | RRUFF ID: |
|----------|-----------------------|-----------|
| 96       | <- Quartz (532nm)     | X080016   |
| 96       | Quartz (532nm)        | X080015   |
| 96       | Quartz (532nm)        | R060604   |
| 95       | Quartz (532nm)        | R050125   |
| 95       | Quartz (532nm)        | R040031   |
| 89       | Dechlorite-Na (532nm) | R061116   |
| 87       | Amicite (532nm)       | R080066   |
| 86       | Edgarbaeite (532nm)   | R060500   |
| 83       | Sodalite (532nm)      | R060354   |
| 83       | Sodalite (532nm)      | R060436   |
| 83       | Villamanite (532nm)   | R060514   |
| 83       | Sodalite (532nm)      | R060435   |
| 83       | Sodalite (532nm)      | R060415   |

X080015  
Quartz  
SiO<sub>2</sub>  
Synthetic

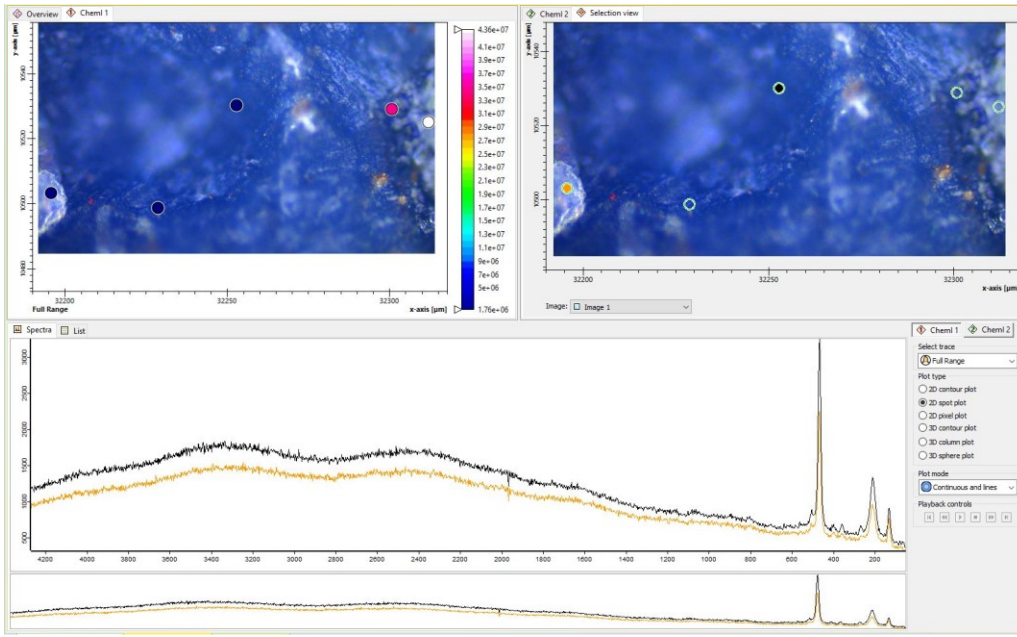
Indication for a shock event are the shifts of the marked Quartz spectral lines towards 261, 205 and 127



The spectral lines 261, 205 and 127 indicate that the Quartz was exposed to a shock pressure of around 20 – 22 GPa

Sample Site **40-B** : Stone 1\_spectra 1 indicates : **Quartz**

(→ see RRUFF\_search results )

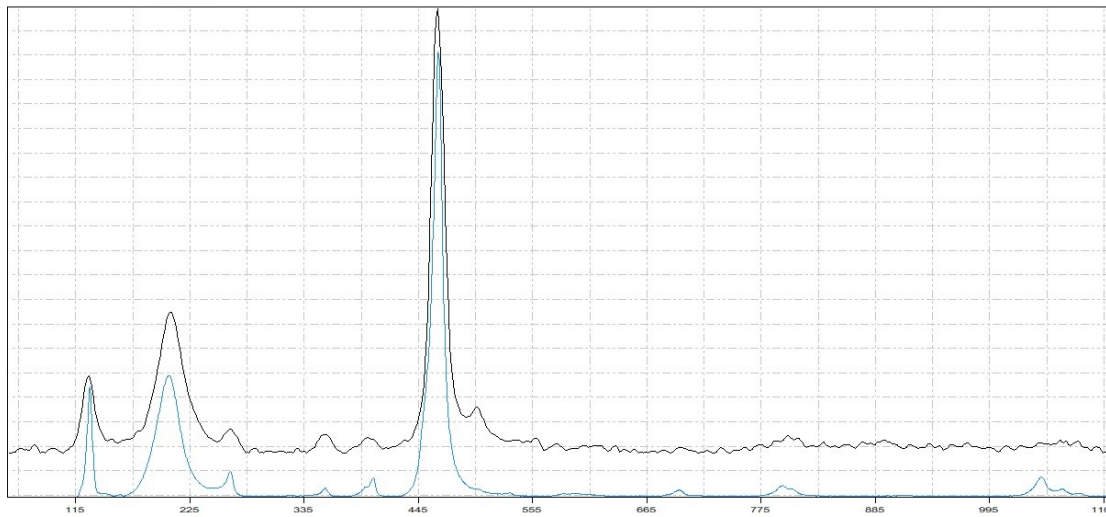


Sample :



CrystalSleuth: EXTRACT\_40-B (SP3)\_messung1.0\_000000.0\_G1\_NK

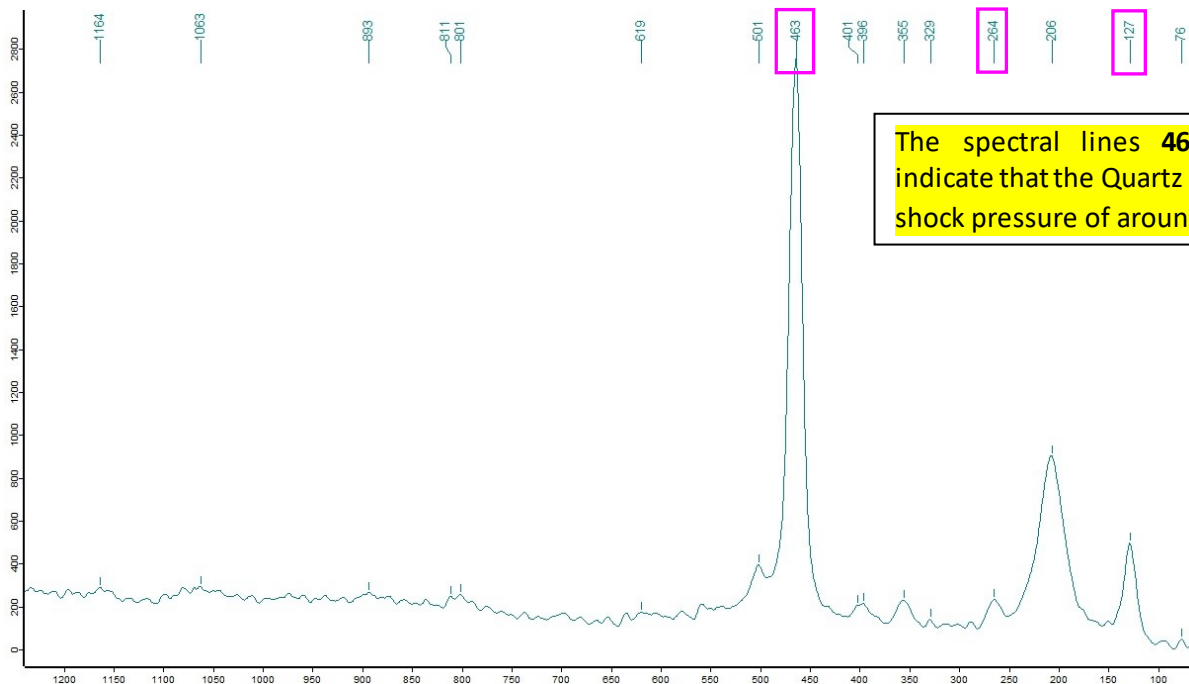
File Edit Mode Help



| % Match: | Spectrum Name:         | RRUFF ID: |
|----------|------------------------|-----------|
| 97       | <- Quartz (532nm)      | R060604   |
| 97       | <- Quartz (532nm)      | X080015   |
| 97       | <- Quartz (532nm)      | R040031   |
| 97       | <- Quartz (532nm)      | X080016   |
| 97       | Quartz (532nm)         | R050125   |
| 92       | Dachiardite-Na (532nm) | R061116   |
| 88       | Edgarbaeyleite (532nm) | R060500   |
| 87       | Amisite (532nm)        | R080056   |
| 85       | Sodalite (532nm)       | R060435   |
| 85       | Sodalite (532nm)       | R060354   |
| 85       | Sodalite (532nm)       | R060436   |
| 85       | Sugilite (532nm)       | R070684   |
| 85       | Sodalite (532nm)       | R040141   |

X080015  
Quartz  
SiO<sub>2</sub>  
Synthetic

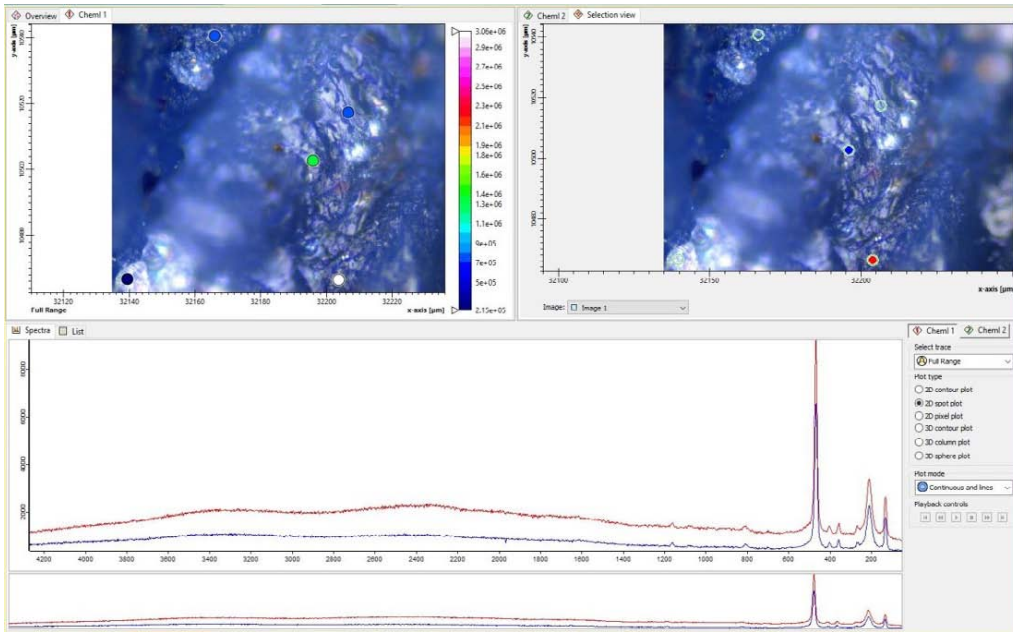
Indication for a shock event are the shifts of the marked Quartz spectral lines towards 463, 264 and 127



The spectral lines 463, 264 and 127 indicate that the Quartz was exposed to a shock pressure of around 22 GPa

Sample Site **40-B** : Stone 1\_spectra 2 indicates : **Quartz**

(→ see RRUFF\_search results )

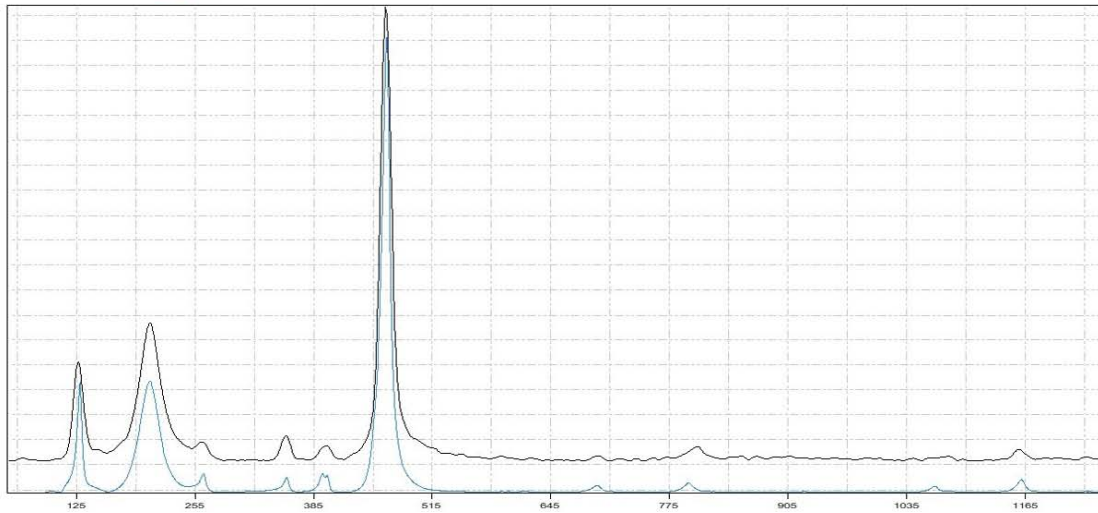


Sample :



CrystalSleuth: EXTRACT\_40-B (SP3)\_messung2.0\_000000.0\_NK\_G2

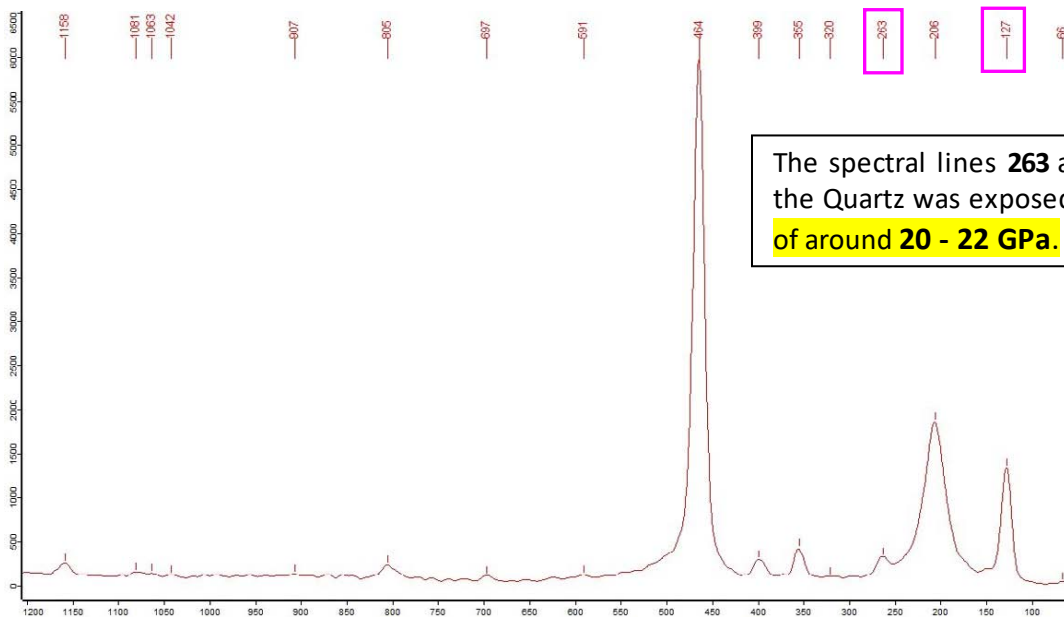
File Edit Mode Help



| % Match: | Spectrum Name:        | RRUFF ID: |
|----------|-----------------------|-----------|
| 99       | <- Quartz (532nm)     | X080016   |
| 99       | Quartz (532nm)        | X080015   |
| 98       | Quartz (532nm)        | R060604   |
| 98       | Quartz (532nm)        | R060175   |
| 98       | Quartz (532nm)        | R040031   |
| 90       | Dachardite-Ha (532nm) | R061116   |
| 88       | Edgarbaleyite (532nm) | R060500   |
| 86       | Amicite (532nm)       | R080066   |
| 85       | Sodalite (532nm)      | R060436   |
| 84       | Sodalite (532nm)      | R060354   |
| 84       | Sodalite (532nm)      | R040141   |
| 84       | Sodalite (532nm)      | R060435   |
| 84       | Sodalite (532nm)      | R060405   |

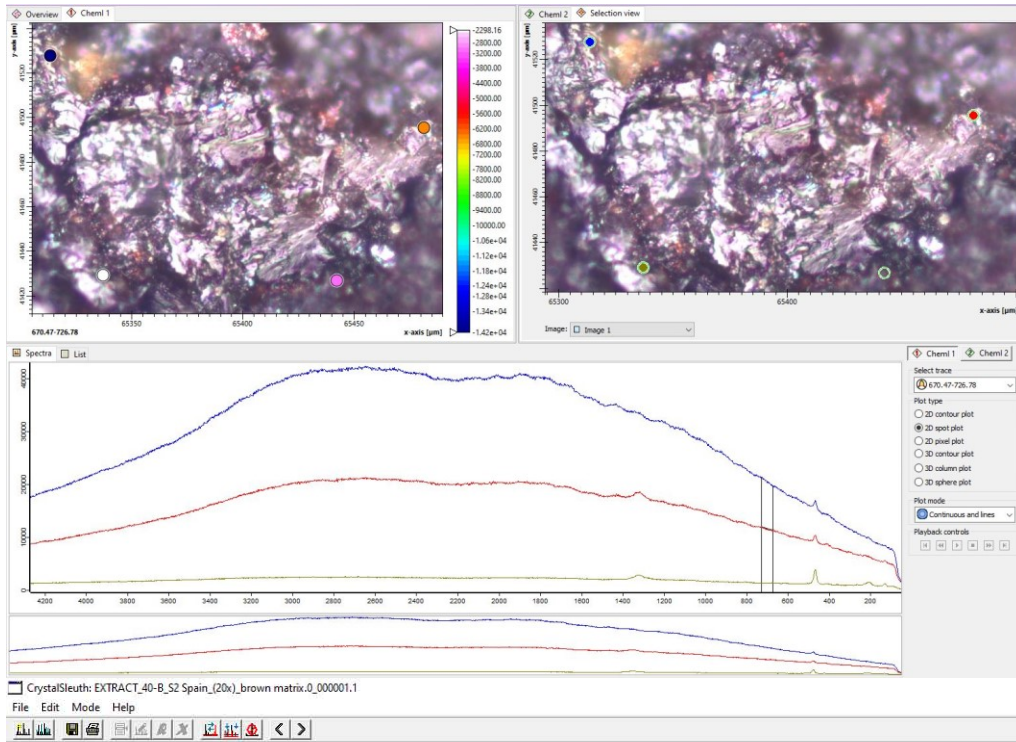
X080016  
Quartz  
SiO<sub>2</sub>  
Synthetic

Indication for a shock event are the shifts of the marked Quartz spectral lines towards 263 and 127

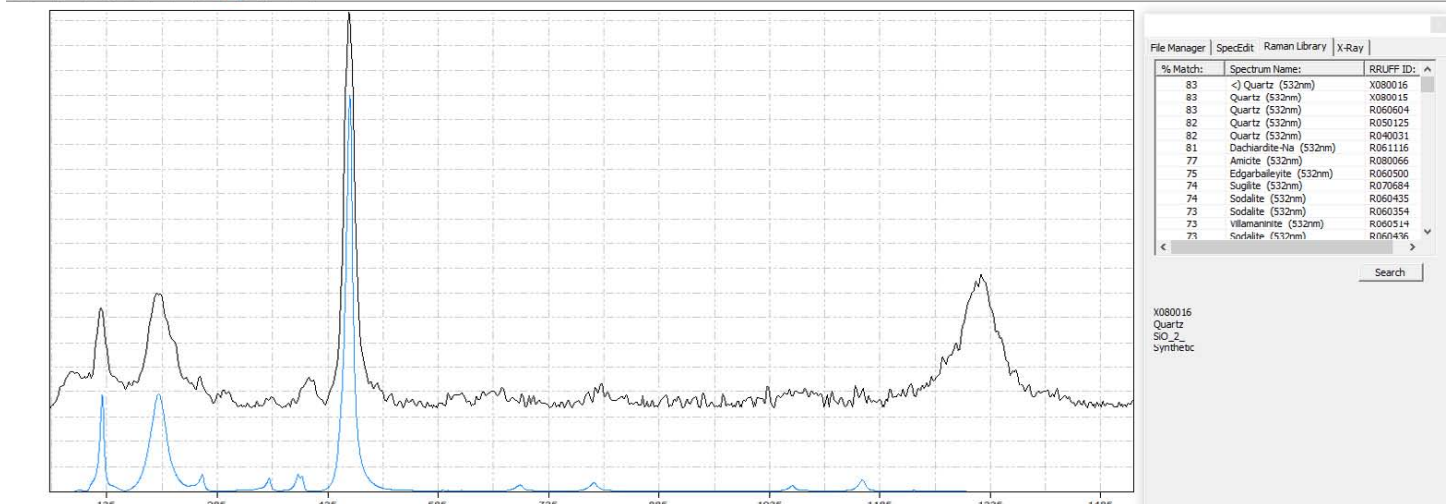
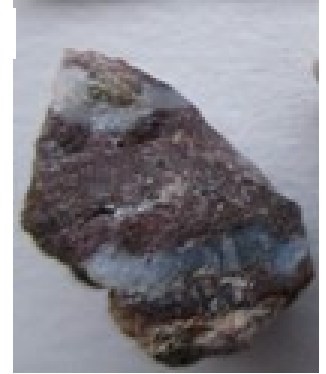


The spectral lines **263** and **127** indicate that the Quartz was exposed to a **shock pressure of around 20 - 22 GPa.**

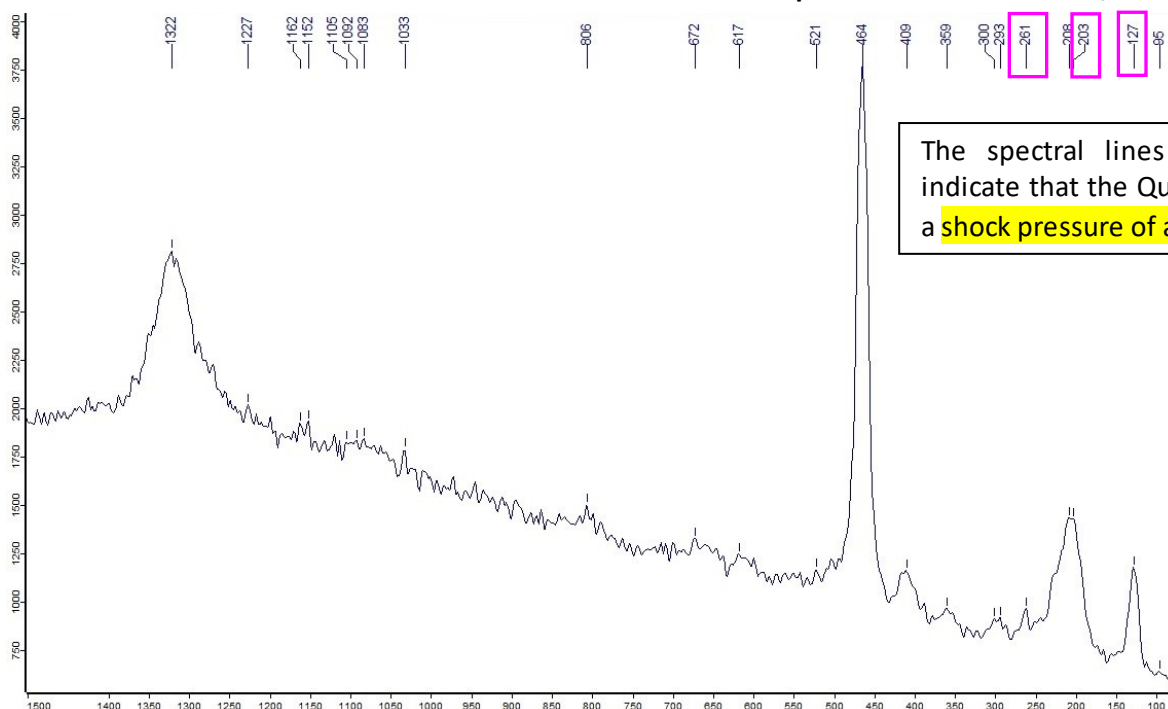
Sample Site **40-B** : Stone 2\_spectra 1 ( brown mineral ) indicates : **Quartz** (→ see RRUFF\_search results )



Sample :



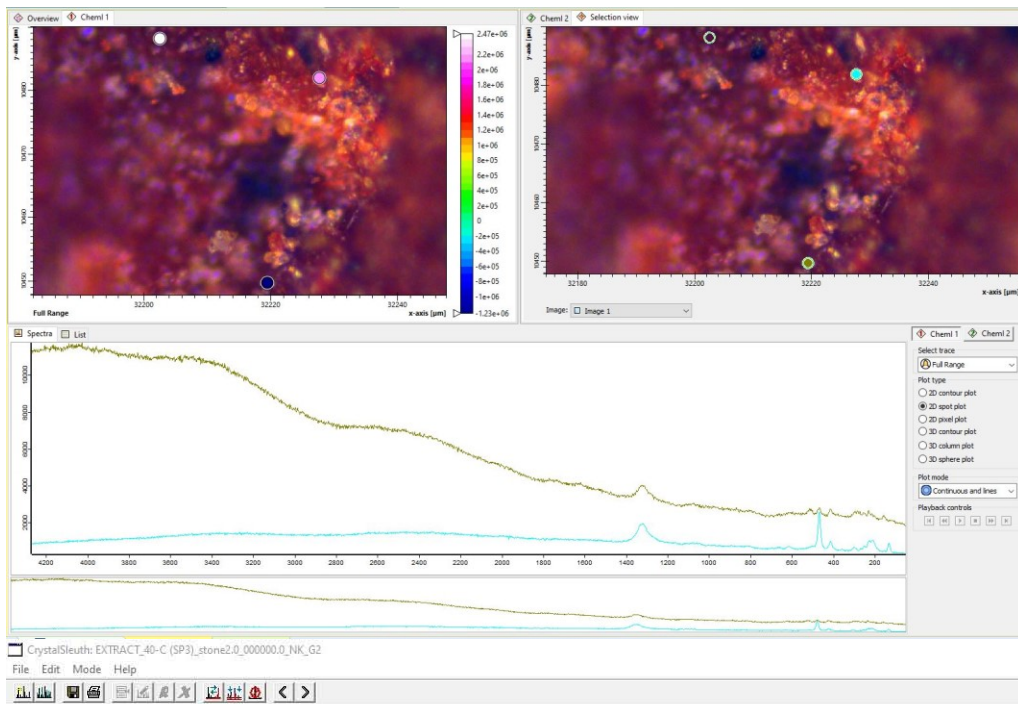
Indication for a shock event are the shifts of the marked Quartz spectral lines towards 261, 203 and 127



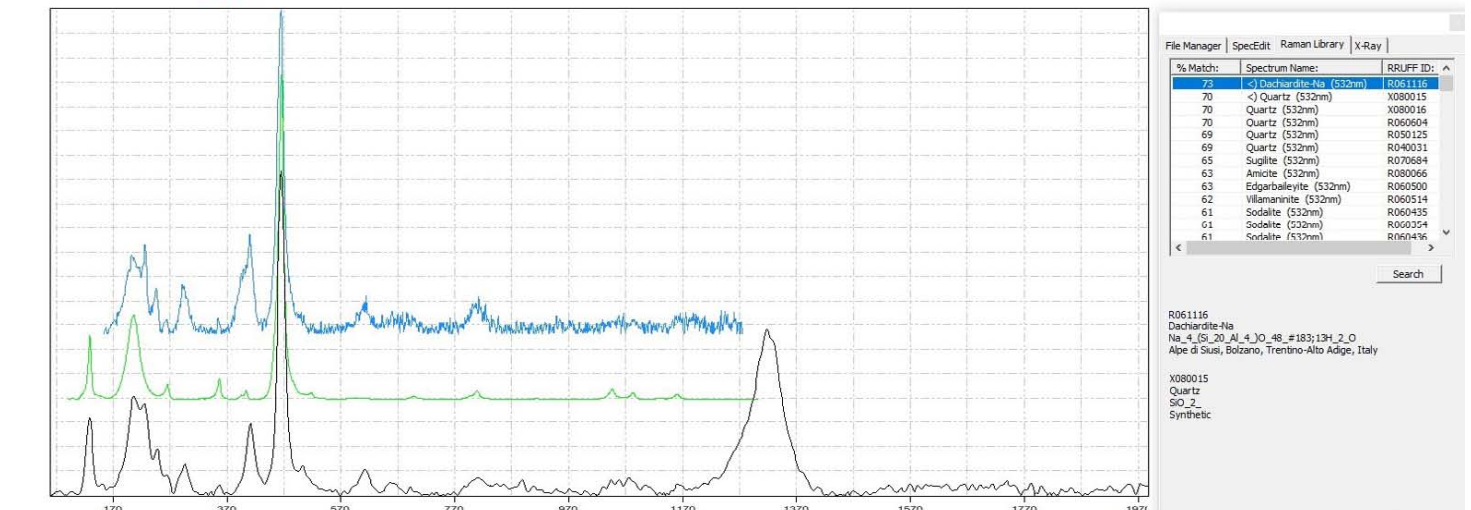
The spectral lines 261, 203 and 127 indicate that the Quartz was exposed to a shock pressure of around 20 – 22 GPa



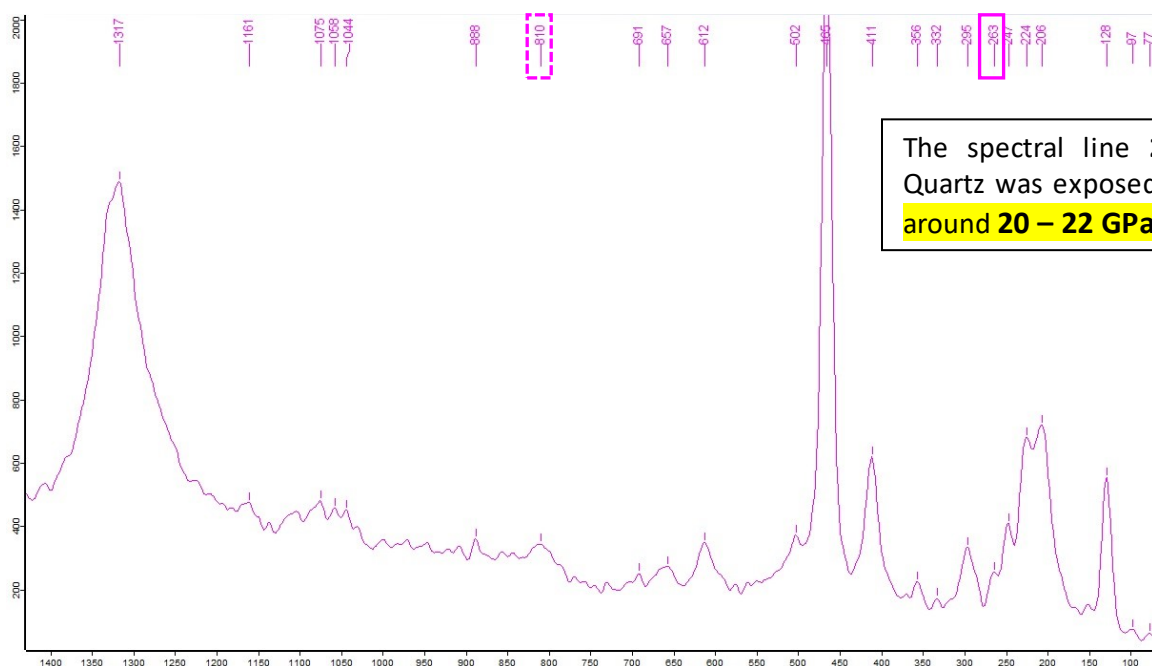
Sample Site **40-C** : Stone 2\_spectra 1( brown mineral ) indicates : **Quartz, Dachardite-Na** (→RRUFF)



Sample :



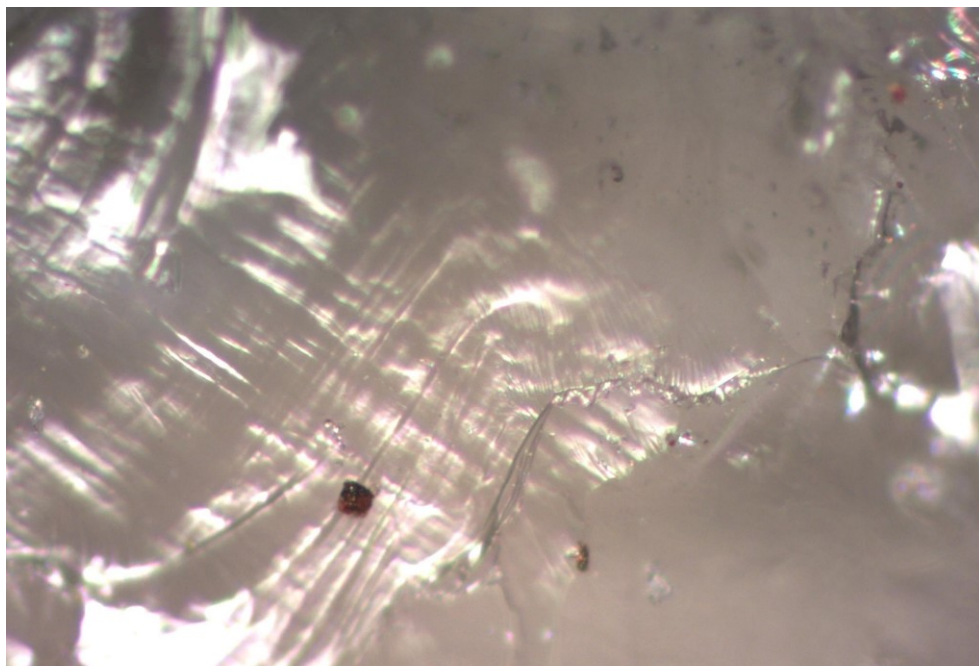
Indication for a shock event are the shifts of the marked Quartz spectral line towards 263



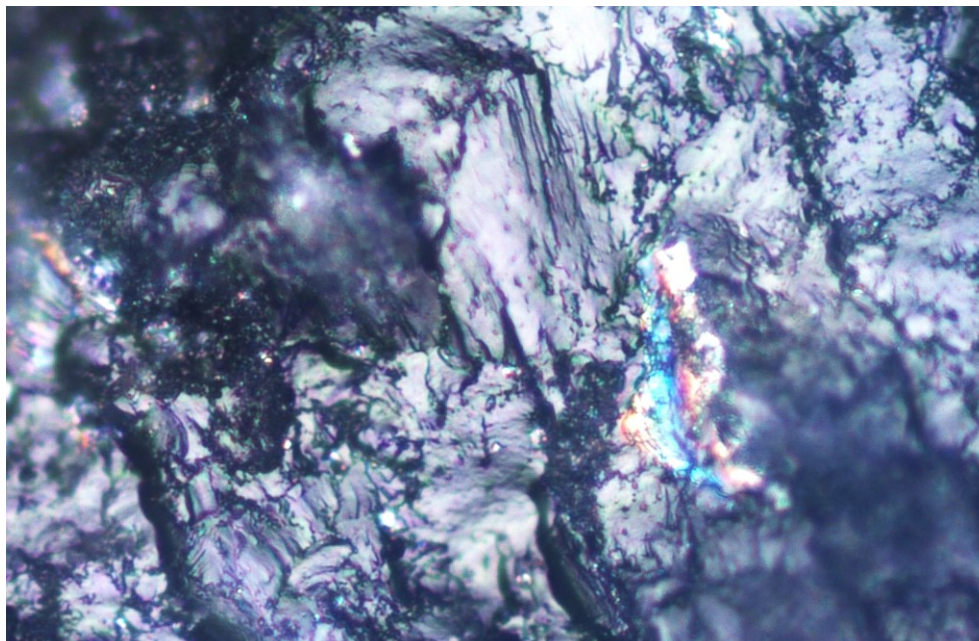
The spectral line **263** indicates that the Quartz was exposed to a **shock pressure of around 20 – 22 GPa**

Microscopic Images : Sample from Sites 19-B, 40-B and 40-C → original state ( no preparation )

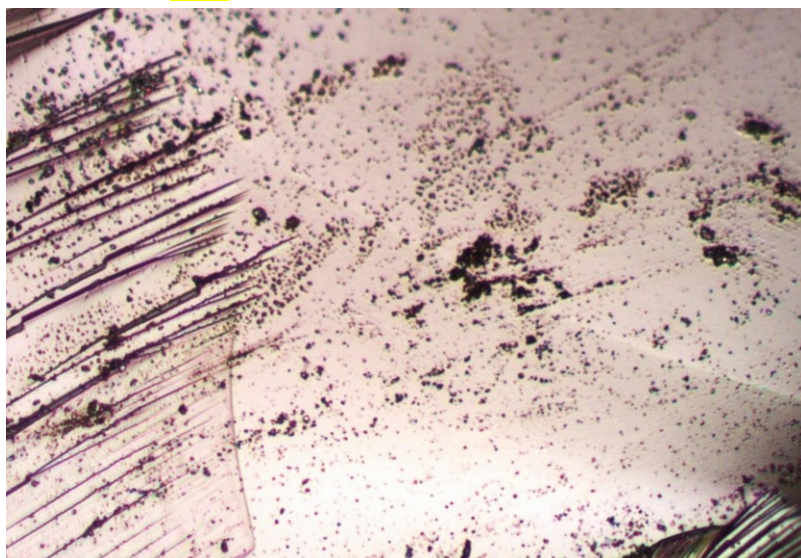
Sample Site 19-B : Stone 3\_spectra 1 : Quartz - Image size : ~ 400 x 300 μm



Sample Site 40-B : Stone 1\_spectra 2 : Quartz - Image size : ~ 400 x 300 μm

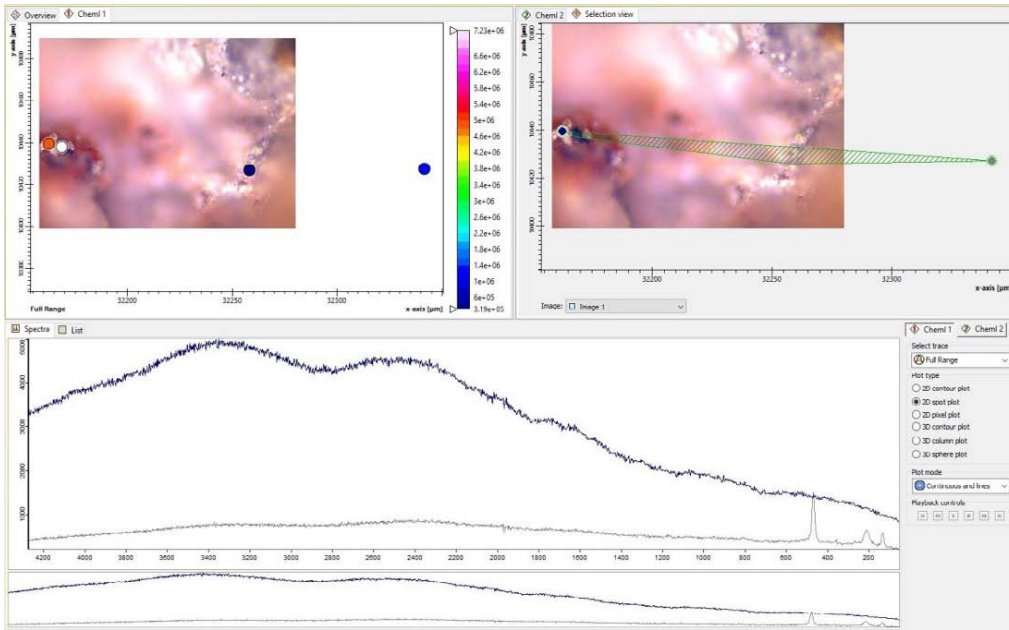


Sample Site 40-C : Stone 2 : Quartz, : ~ 300 x 200 μm

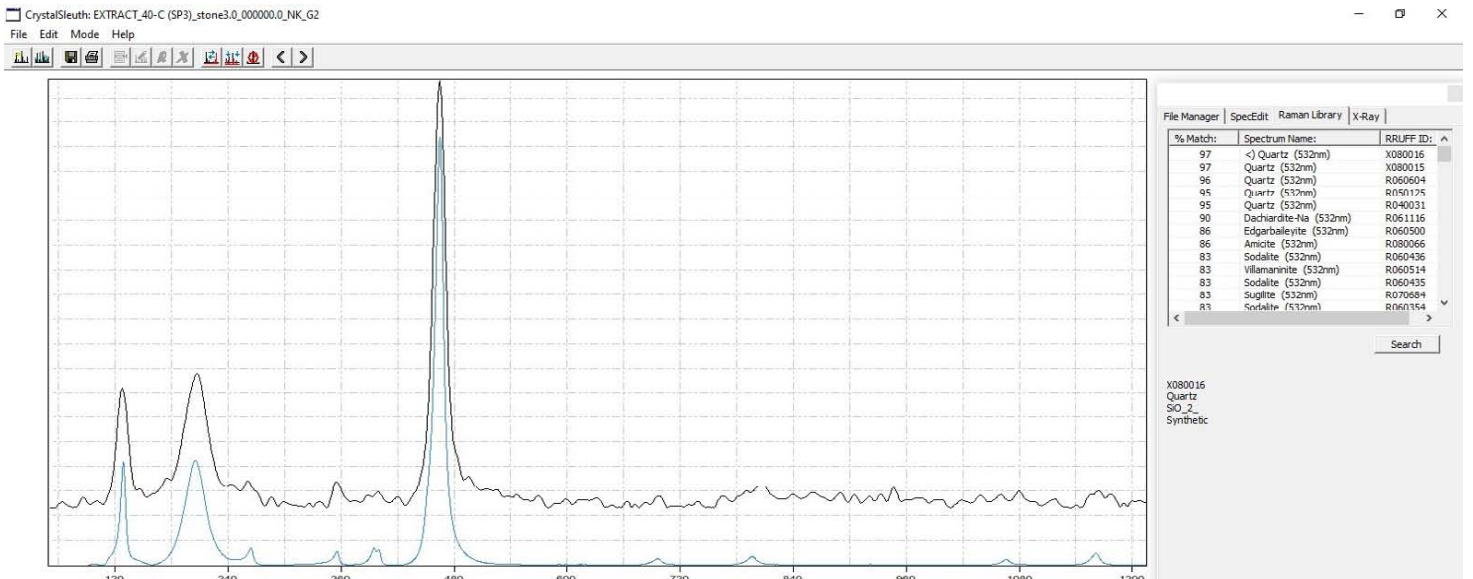


Sample Site **40-C** : Stone 3\_spectra 1 indicates : **Quartz**

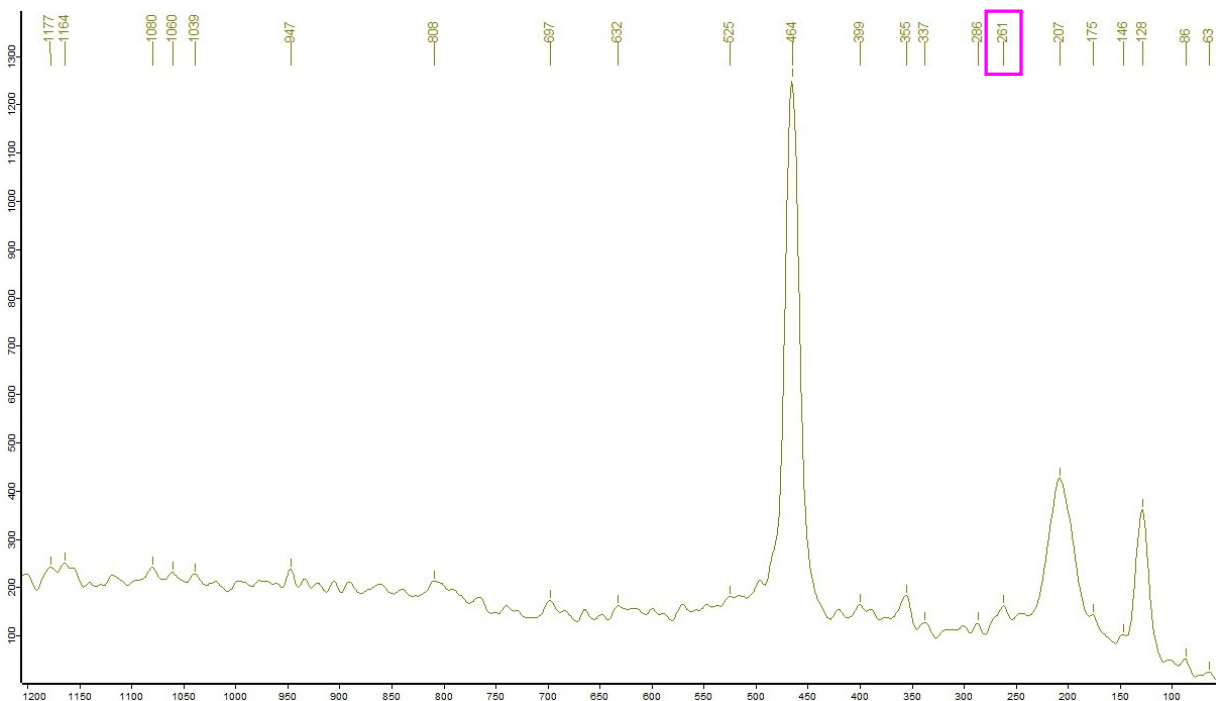
(→ see RRUFF\_search results )



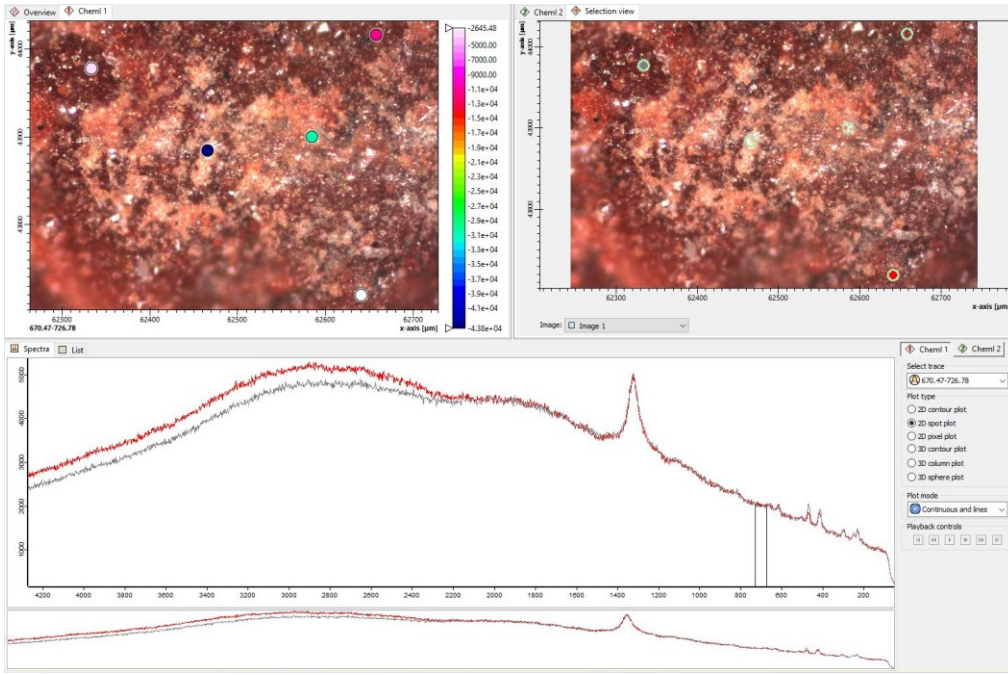
Sample :



Indication for a shock event are the shifts of the marked Quartz spectral lines towards 261



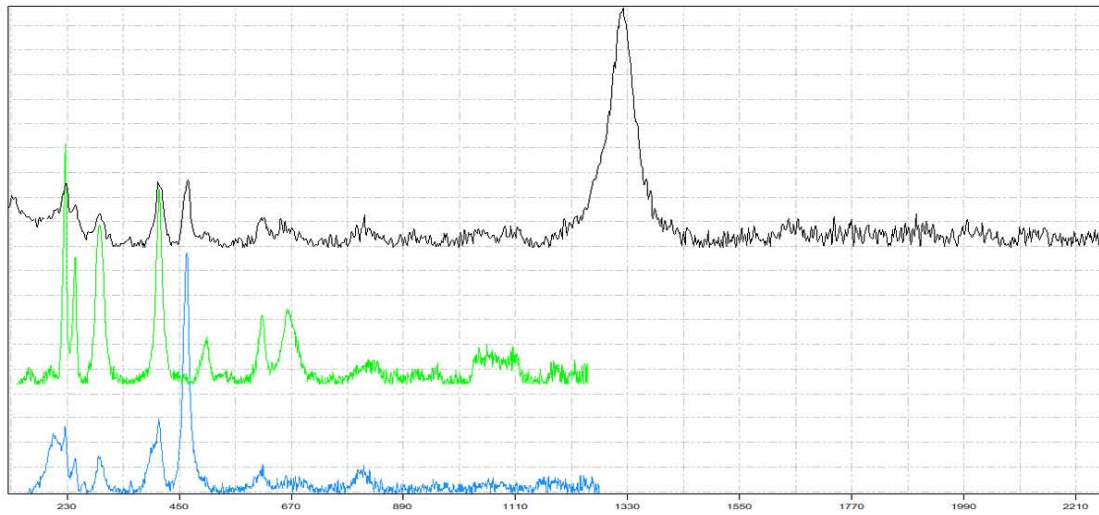
Sample Site **40-C** : Stone 3\_spectra 2 indicates : **Dachiardite-Na, Versiliaite** (→ see RRUFF\_search results )



Sample :



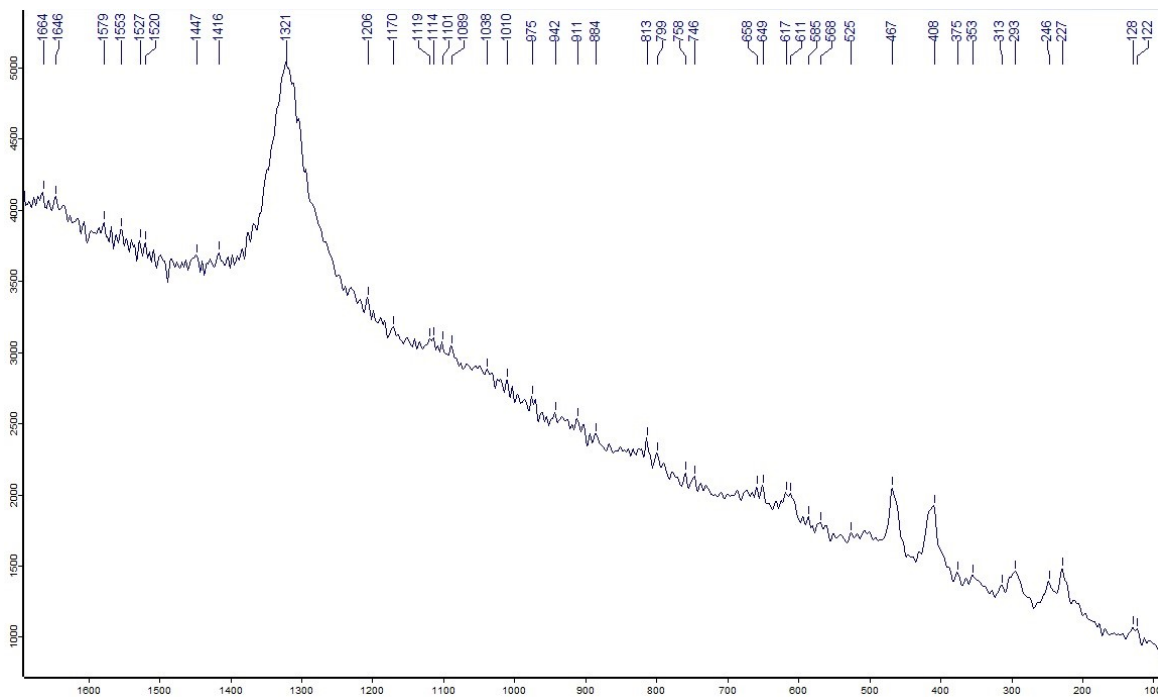
CrystalSleuth: EXTRACT\_40-C s3 Spain\_(10x)\_0\_000003.0  
File Edit Mode Help



| % Match | Spectrum Name             | RRUFF ID: |
|---------|---------------------------|-----------|
| 78      | <) Versiliaite (532nm)    | R060531   |
| 77      | <) Dachiardite-Na (532nm) | R061116   |
| 75      | Mordenite (532nm)         | R061118   |
| 75      | Hierulandite-K (532nm)    | R061117   |
| 74      | Hematite (532nm)          | R040024   |
| 74      | Synchysite-(Y) (532nm)    | R060984   |
| 74      | Mordenite (532nm)         | R070524   |
| 73      | Chernovite-(Y) (532nm)    | R070368   |
| 73      | Armalcolite (532nm)       | R070260   |
| 72      | Allanite-(Ce) (532nm)     | R080044   |
| 71      | Villaumite (532nm)        | R060916   |
| 71      | Cuprite (532nm)           | R050264   |
| 70      | Hierulandite (532nm)      | R070714   |

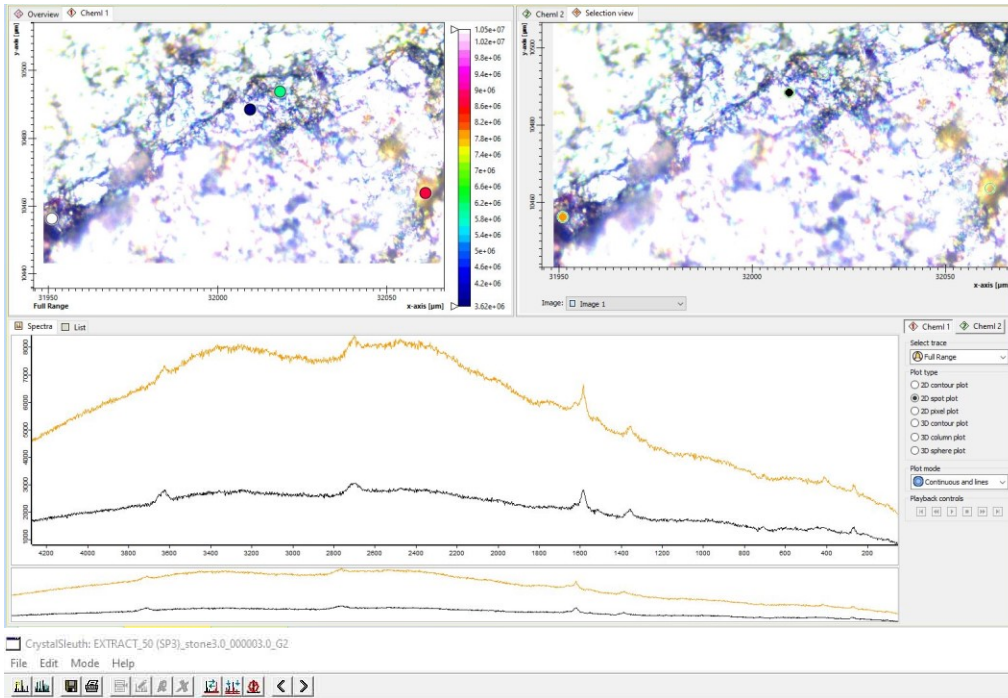
R060531  
Versiliaite  
(Fe,Fe,Zn)<sub>8</sub>(Sb,Fe,As)<sub>16</sub>O<sub>32</sub>S<sub>1-3</sub>  
Buca Della Vena mine, Tuscany, Italy

R061116  
Dachiardite-Na  
Na<sub>4</sub>(Si<sub>20</sub>Al<sub>4</sub>O<sub>48</sub> #183;13H<sub>2</sub>O  
Alpe di Siusi, Bolzano, Trentino-Alto Adige, Italy

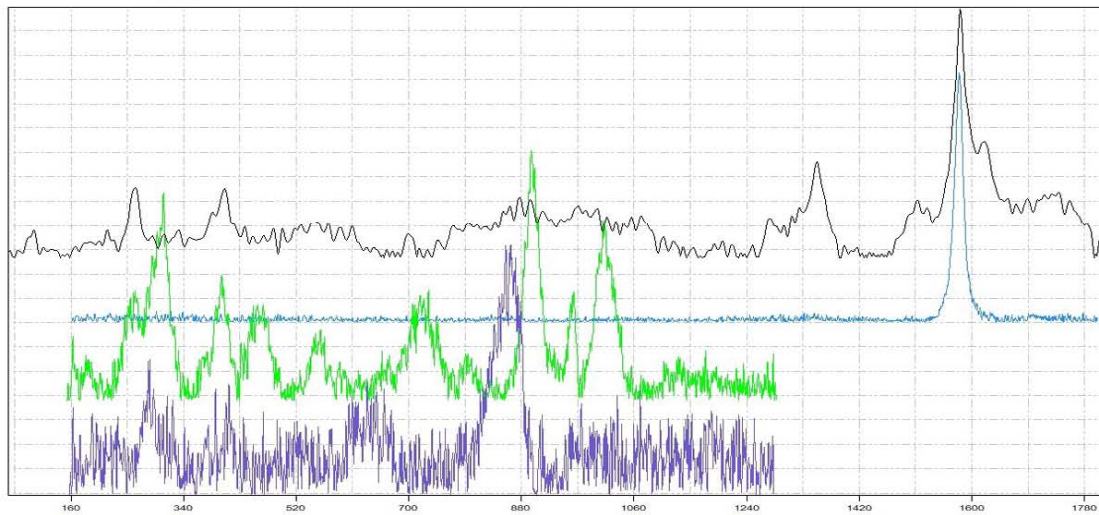


Sample Site 50: Stone 3\_spectra 1 indicates : **Graphite** ( less probable : Stillwellite , Ixiolite ) ( →RRUFF )

The Spectral Lines 264 and 129 indicate that also Quartz is present in the sample



Sample :

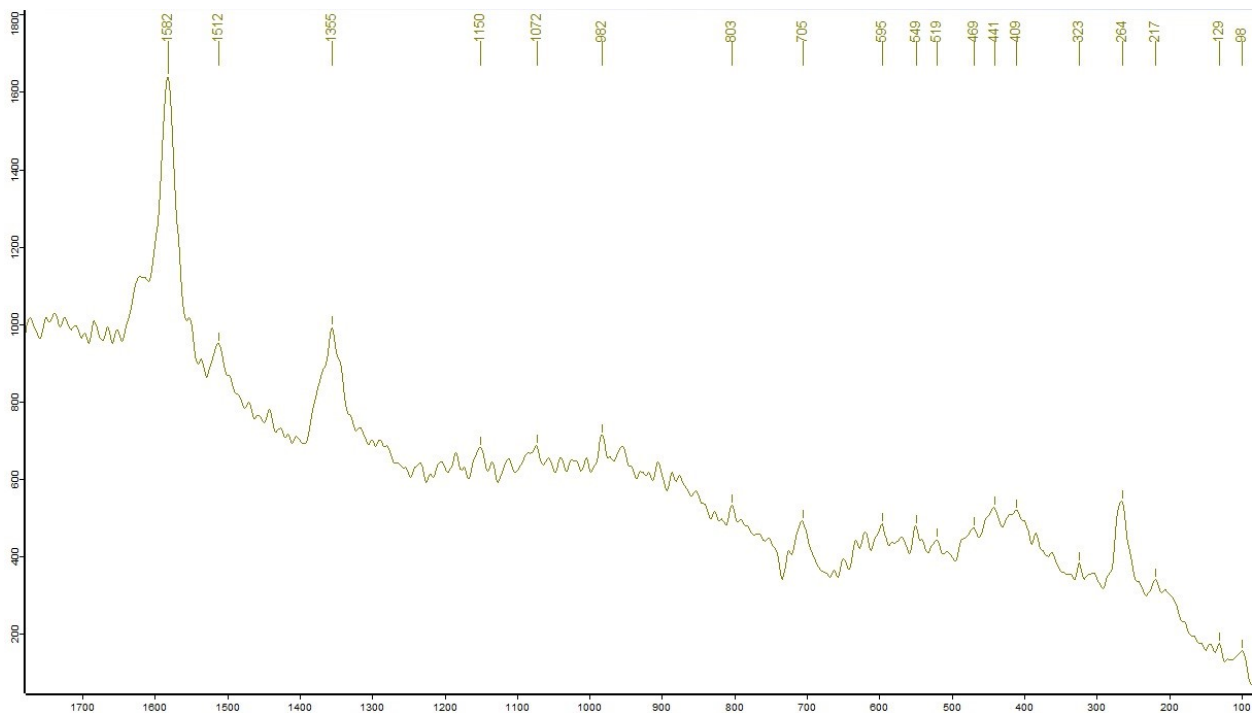


| % Match: | Spectrum Name:               | RRUFF ID: |
|----------|------------------------------|-----------|
| 63       | Graphite (532nm)             | R050503   |
| 63       | Graphite (532nm)             | R090047   |
| 42       | <  Clnohedrite (532nm)       | R050416   |
| 39       | <  Mordenite (532nm)         | R070524   |
| 38       | <  Digenite (532nm)          | R060840   |
| 38       | <  Issemannite (532nm)       | R070513   |
| 38       | <  Stillwellite-(Ce) (532nm) | R060911   |
| 38       | <  Wickenburgite (532nm)     | R060048   |
| 38       | <  Ishikawite (532nm)        | R070496   |
| 38       | <  Ixiolite (532nm)          | R070495   |
| 38       | Trotterite (532nm)           | R060623   |
| 38       | Radokrishnrite (532nm)       | R070711   |
| 37       | Zuurzalte (532nm)            | R070483   |

R050503  
Graphite  
C  
Sterling mine, Ogdensburg, New Jersey, USA

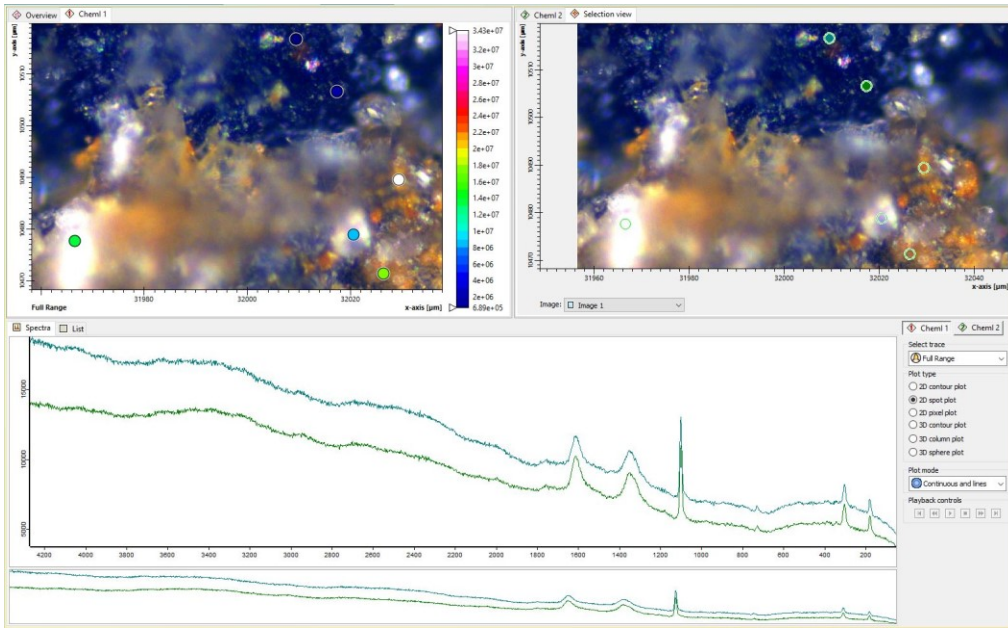
R060911  
Stillwellite-(Ce)  
CeBSiO<sub>5</sub>  
Dimbulah, Queensland, Australia

R070495  
Ixiolite  
(Ta,Mn,Nb)O<sub>2</sub>  
Alto Ligonha pegmatite, Alto Ligonha District, Zambezia Province,



Sample Site 50 : Stone 2\_spectra 1 indicates : **Dolomite**

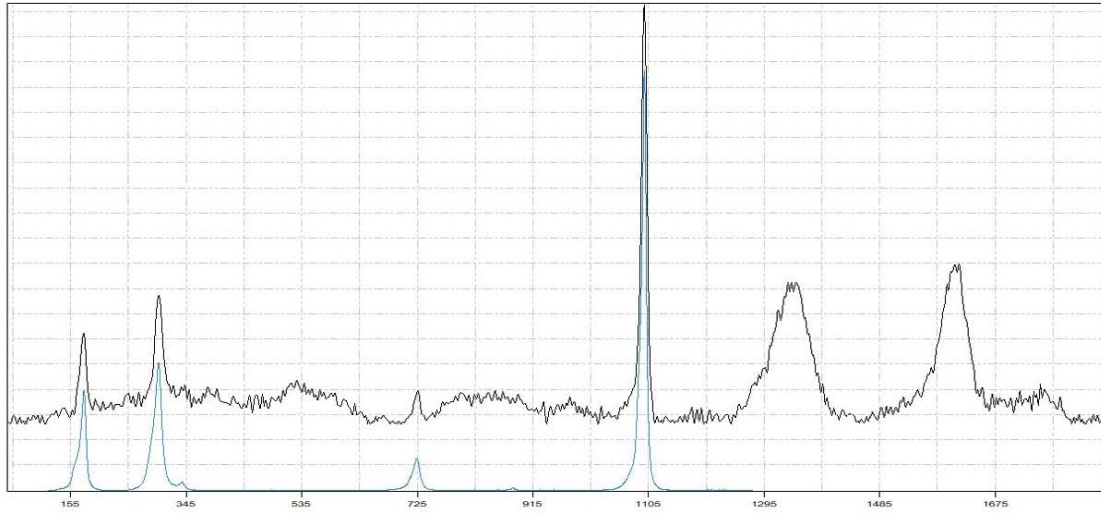
(→ see RRUFF\_search results )



Sample :

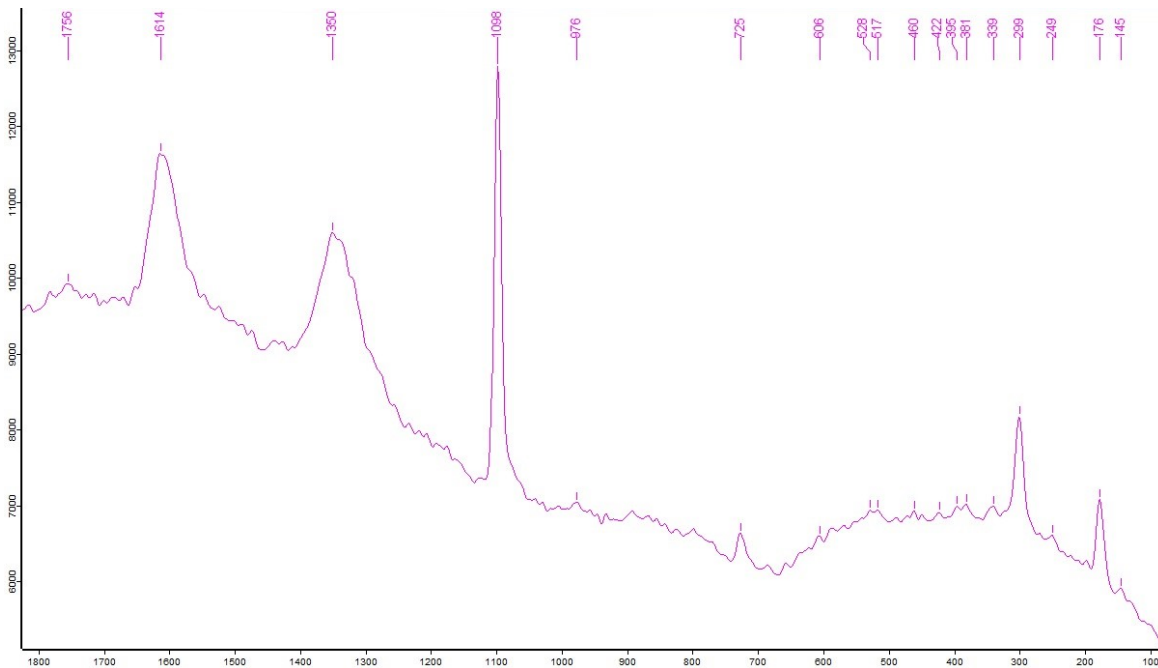


CrystalSleuth: EXTRACT\_50 (SP3)\_stone2\_0\_000005\_0\_NK

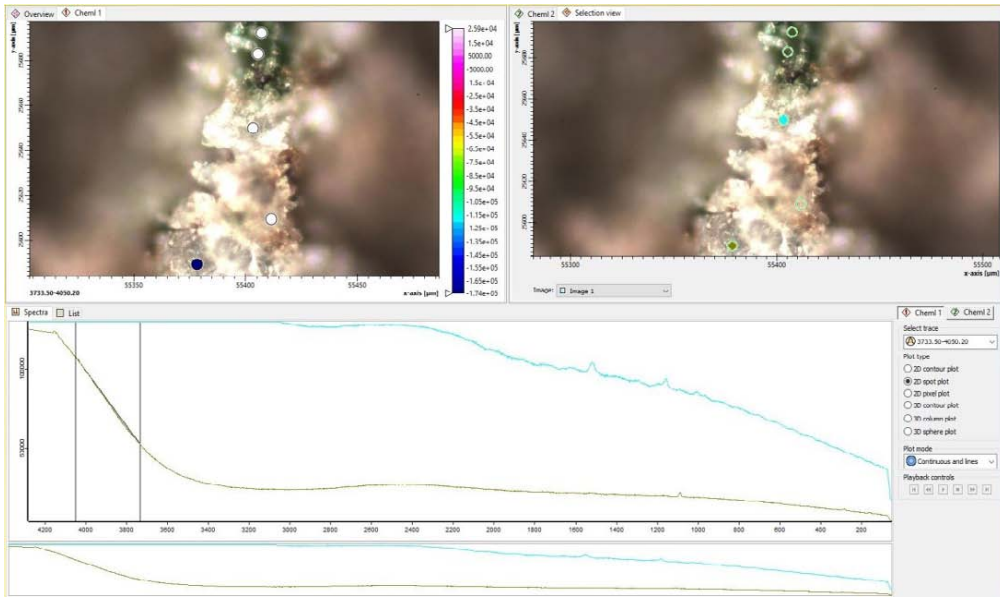


| % Match | Spectrum Name             | RRUFF ID |
|---------|---------------------------|----------|
| 64      | <) Dolomite (532nm)       | R050357  |
| 64      | Sahamalite-(Ce) (532nm)   | R080043  |
| 63      | Dolomite (532nm)          | R050241  |
| 62      | Dolomite (532nm)          | R040030  |
| 61      | Dolomite (532nm)          | R050370  |
| 59      | Nesquehonite (532nm)      | R050629  |
| 56      | Dolomite (532nm)          | R050272  |
| 55      | Kimuraite-(Y) (736nm)     | R050586  |
| 54      | Lokkaiite-(Y) (532nm)     | R061092  |
| 54      | Alumohydrocalcite (532nm) | R070516  |
| 52      | Tengertite-(Y) (532nm)    | R060480  |
| 52      | Dolomite (532nm)          | R050129  |
| 52      | Bastnaesite-(Ce) (532nm)  | R060737  |

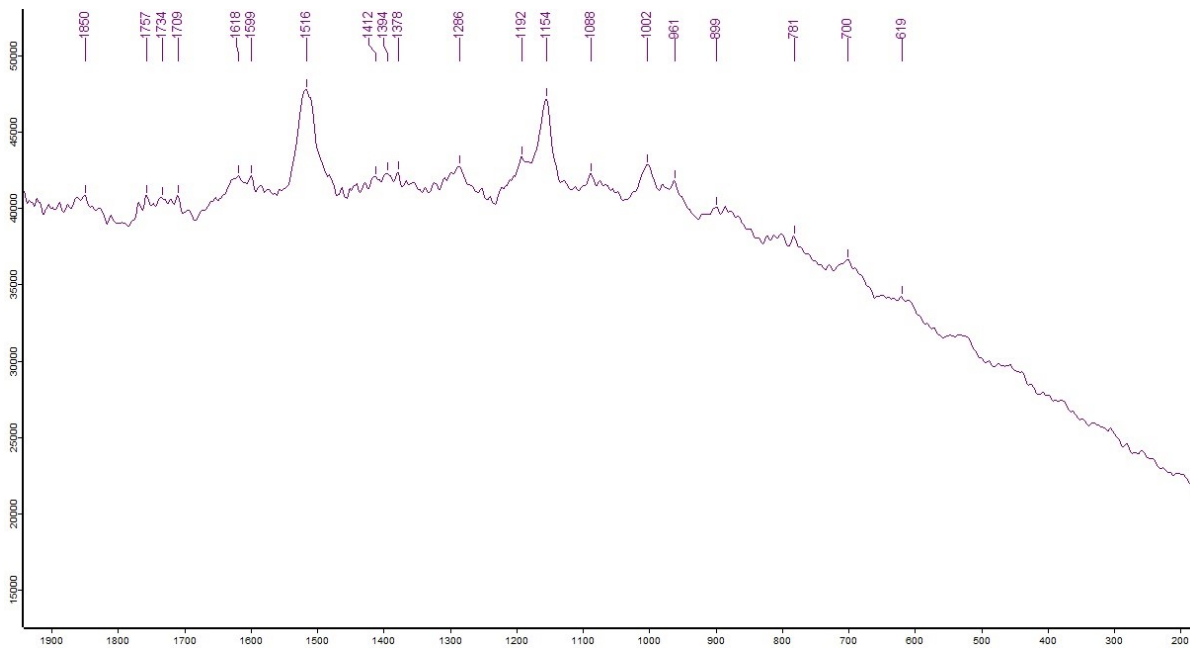
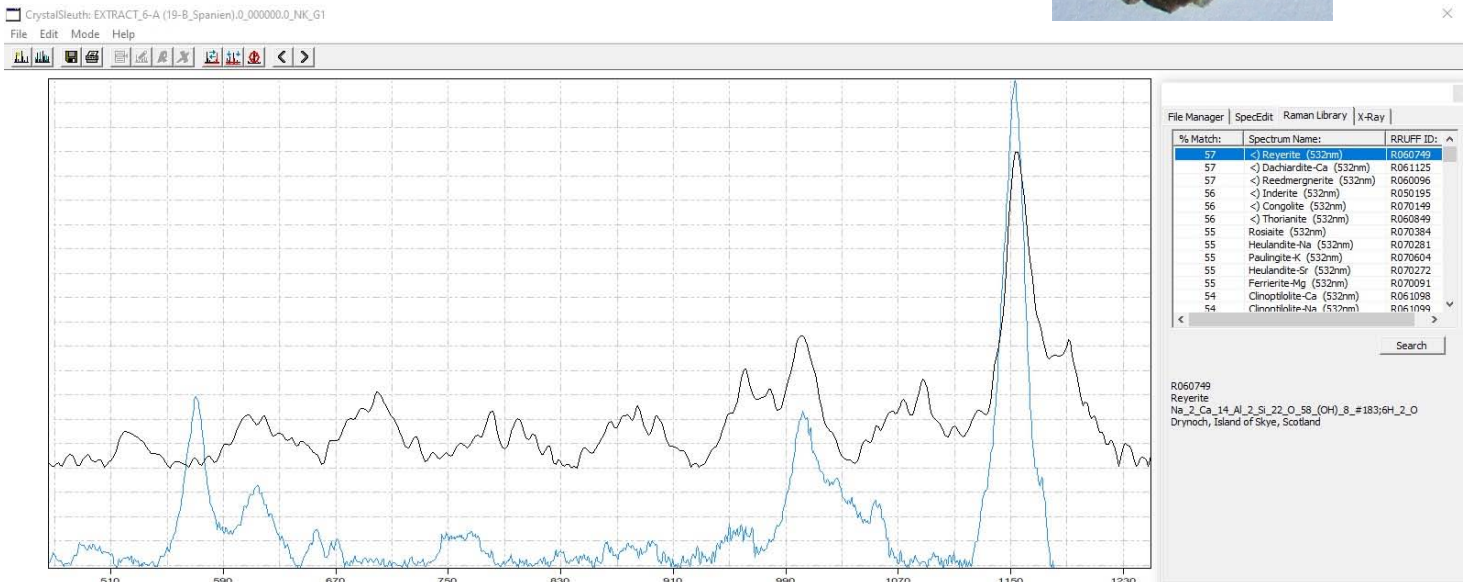
R050357  
Dolomite  
CaMg(CO<sub>3</sub>)<sub>2</sub>  
Black Rock, Lawrence County, Arkansas, USA



Sample Site **19-B** : Stone 1\_spectra 1 indicates : **Reyerite** (→ see RRUFF\_search results )

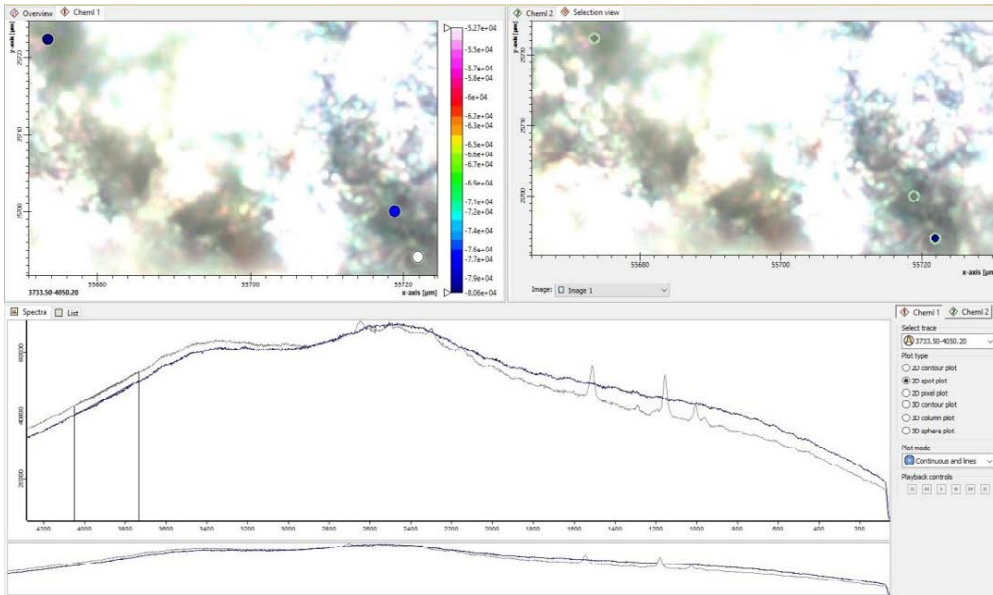


Sample :

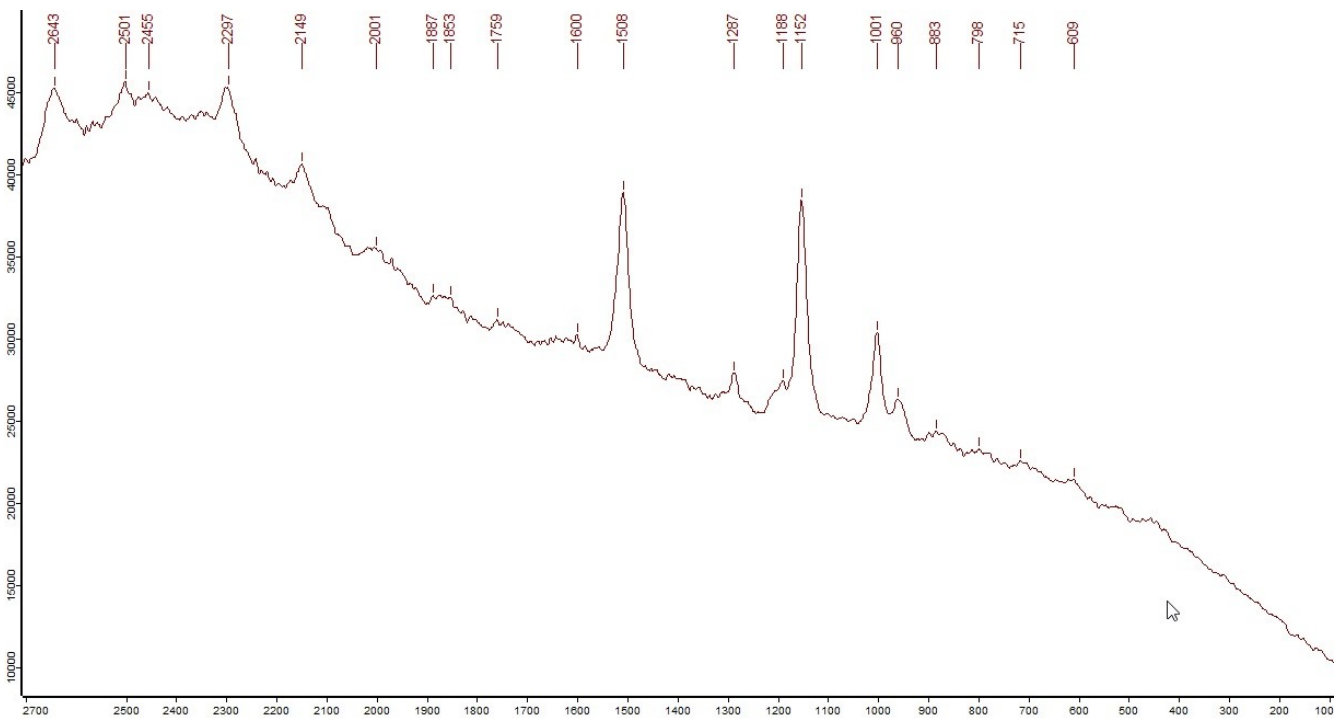
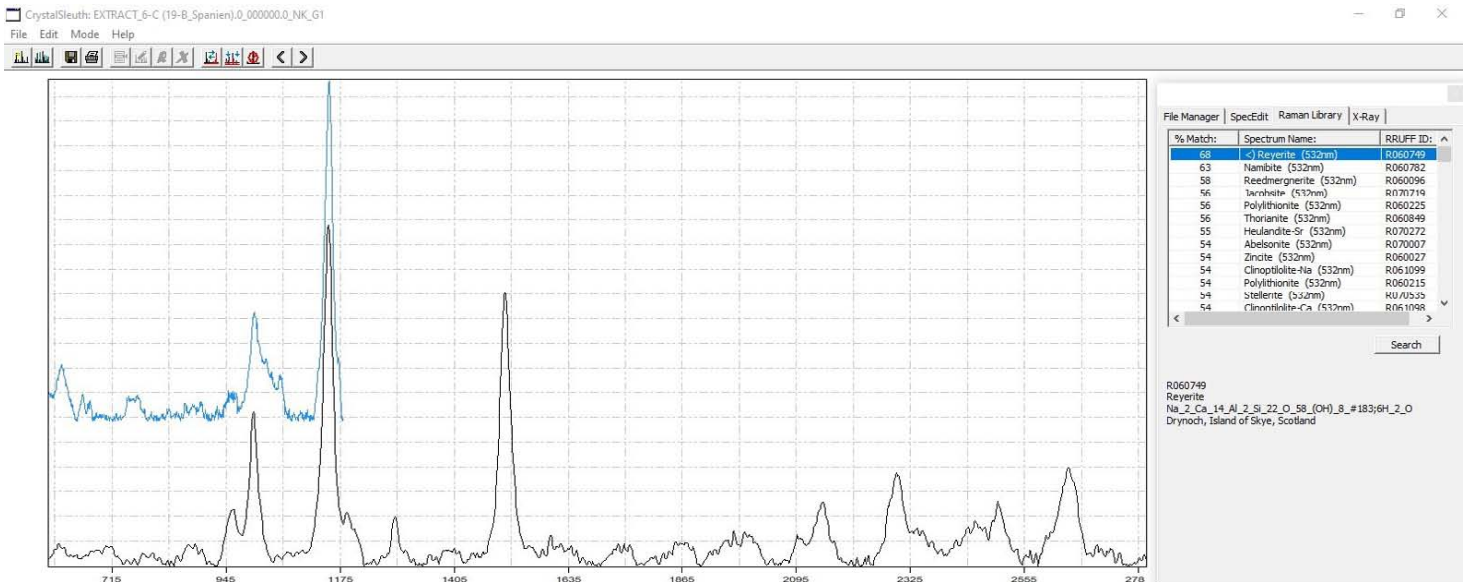


Sample Site **19-B** : Stone 2\_spectra 1 indicates : **Reyerite**

(→ see RRUFF\_search results )



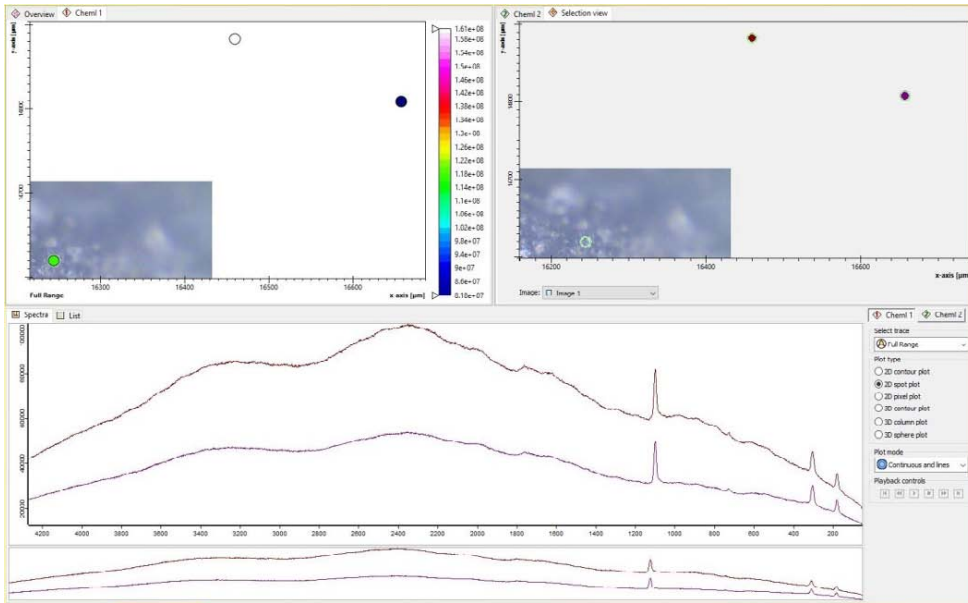
Sample :





Sample Site **19-B** : Stone 3\_spectra 2 indicates : **Sahamalite, Dolomite**

(→ see RRUFF\_search results )

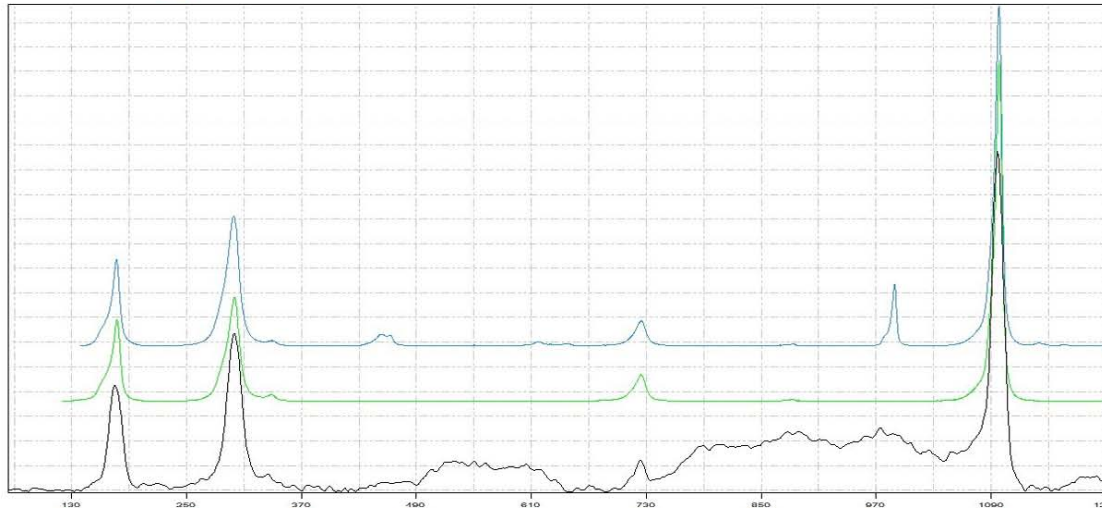


Sample :



CrystalSleuth: EXTRACT\_19-B(SP1)\_1.0\_000000.0\_NK\_G1

File Edit Mode Help



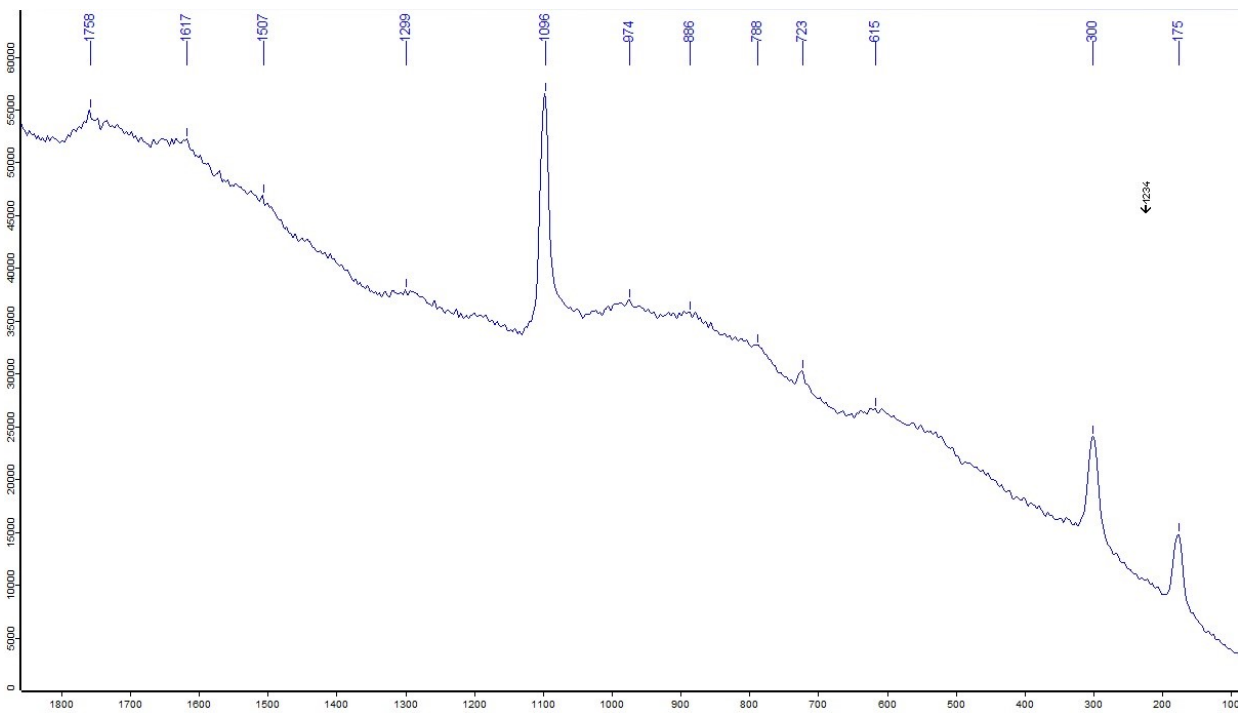
File Manager | SpecEdit | Raman Library | X-Ray

| % Match | Spectrum Name               | RRUFF ID |
|---------|-----------------------------|----------|
| 82      | <-> Sahamalite-(Ce) (532nm) | R080043  |
| 81      | <-> Dolomite (532nm)        | R050357  |
| 80      | Dolomite (532nm)            | R040030  |
| 79      | Dolomite (532nm)            | R050370  |
| 77      | Dolomite (532nm)            | R050241  |
| 75      | Dolomite (532nm)            | R050272  |
| 72      | Kimuraite-(Y) (736nm)       | R050586  |
| 72      | Dundasite (532nm)           | R060760  |
| 72      | Rosasite (532nm)            | R050294  |
| 71      | Nesquehonite (532nm)        | R050639  |
| 71      | Smithsonite (532nm)         | R040035  |
| 71      | Tengerite-(Y) (532nm)       | R060480  |
| 71      | Senthorite (532nm)          | R040111  |

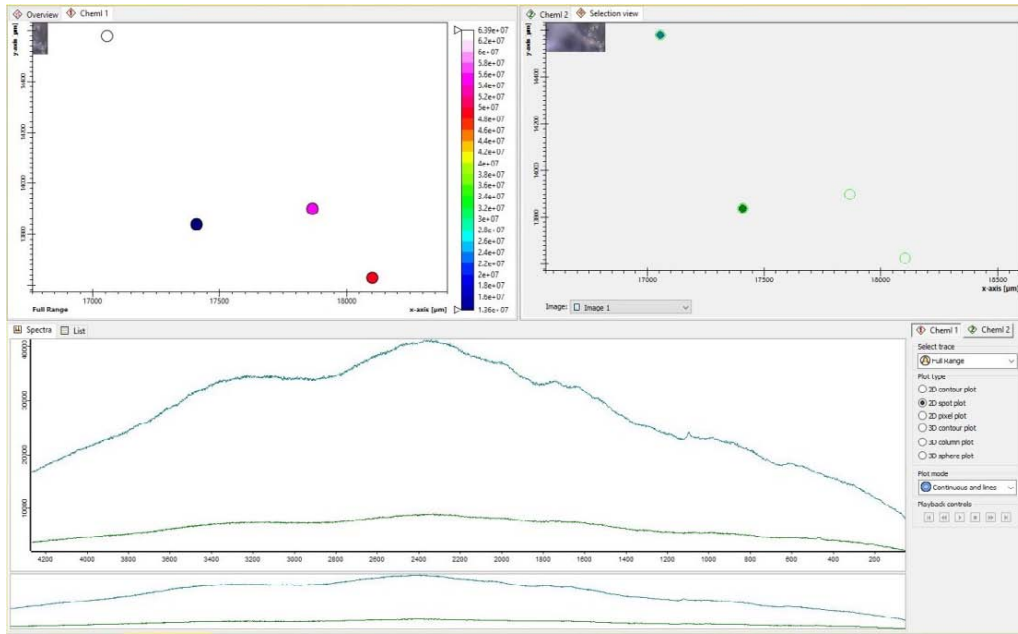
Search

R080043  
Sahamalite-(Ce)  
Ce<sub>2</sub>Mg(CO<sub>3</sub>)<sub>2</sub>  
Mountain Pass Mine (Sulfide Queen mine; Bastnaesite deposit; Mo

R050357  
Dolomite  
CaMg(CO<sub>3</sub>)<sub>2</sub>  
Black Rod, Lawrence County, Arkansas, USA



Sample Site **19-B** : Stone 4 : no usable search result



Sample :

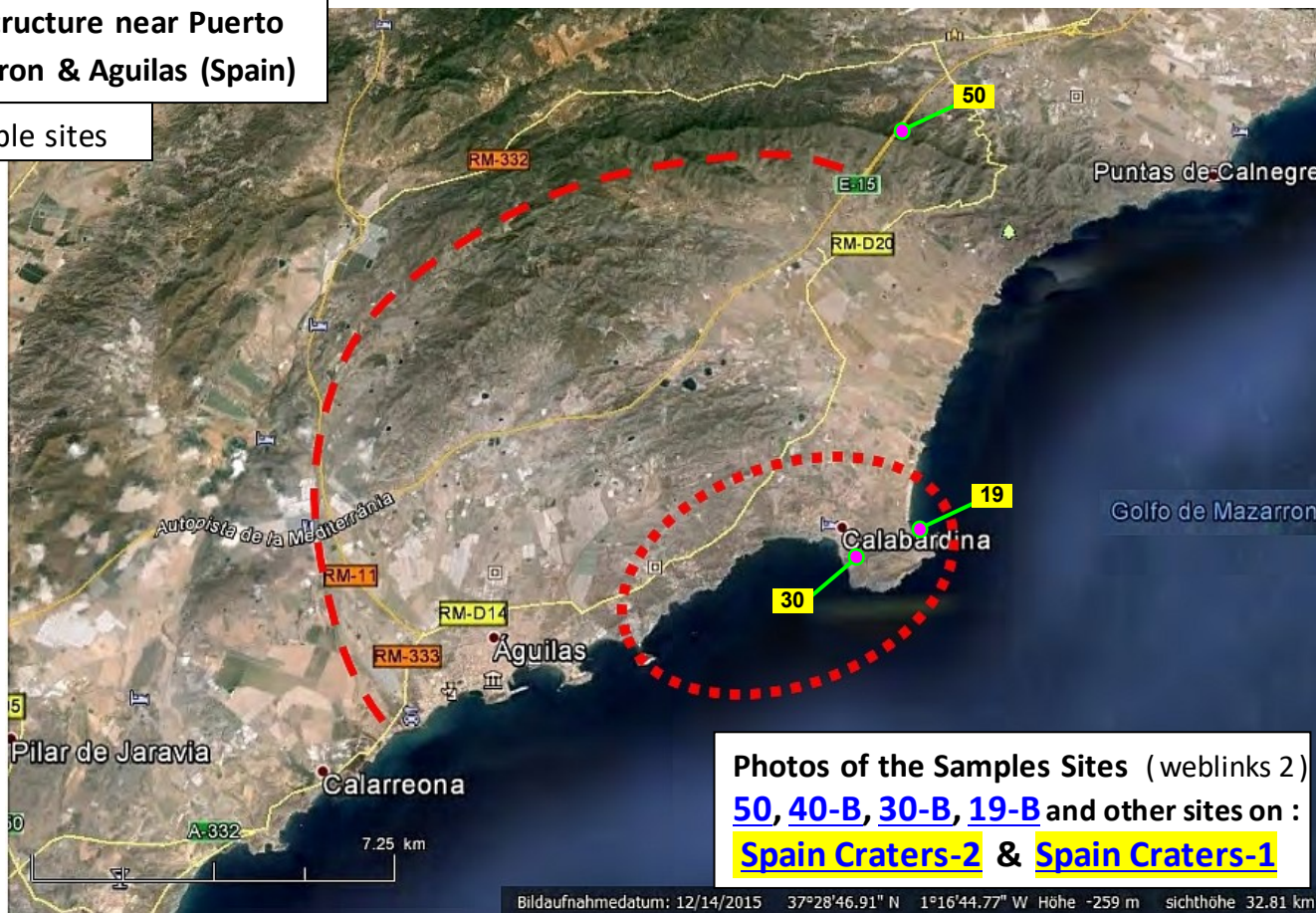


**Appendix 1 : Photos of the rock samples from sample sites : 50, 30-B, 19-B, 40-B/C**

**Please note :** Photos of the Sample- Sites [50](#), [30-B](#), [19-B](#), [40-B/C](#) and other sample sites are available here → weblink : Sample Sites : [Spain Craters-2](#) & [Spain Craters-1](#)



**Impact Structure near Puerto de Mazarron & Aguilas (Spain)**  
with sample sites



Photos of the Samples Sites ( weblinks 2 )  
[50](#), [40-B](#), [30-B](#), [19-B](#) and other sites on :  
[Spain Craters-2](#) & [Spain Craters-1](#)

30

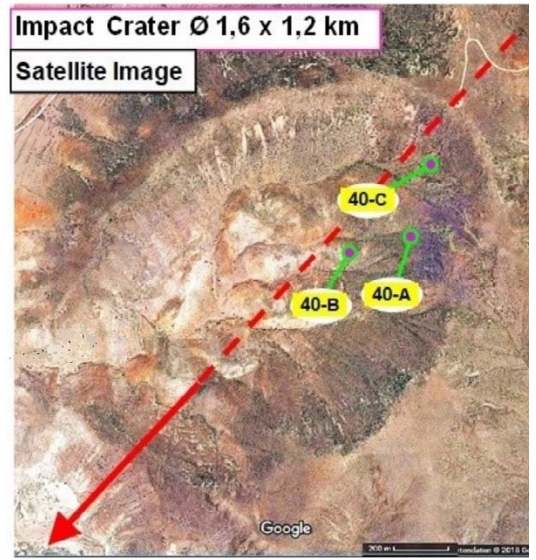


19



**Please note :** The rock samples **40-B** were collected close to the center of an elliptical Crater  $\varnothing$  1.6 x 1.2 km that is completely unknown to impact research yet !

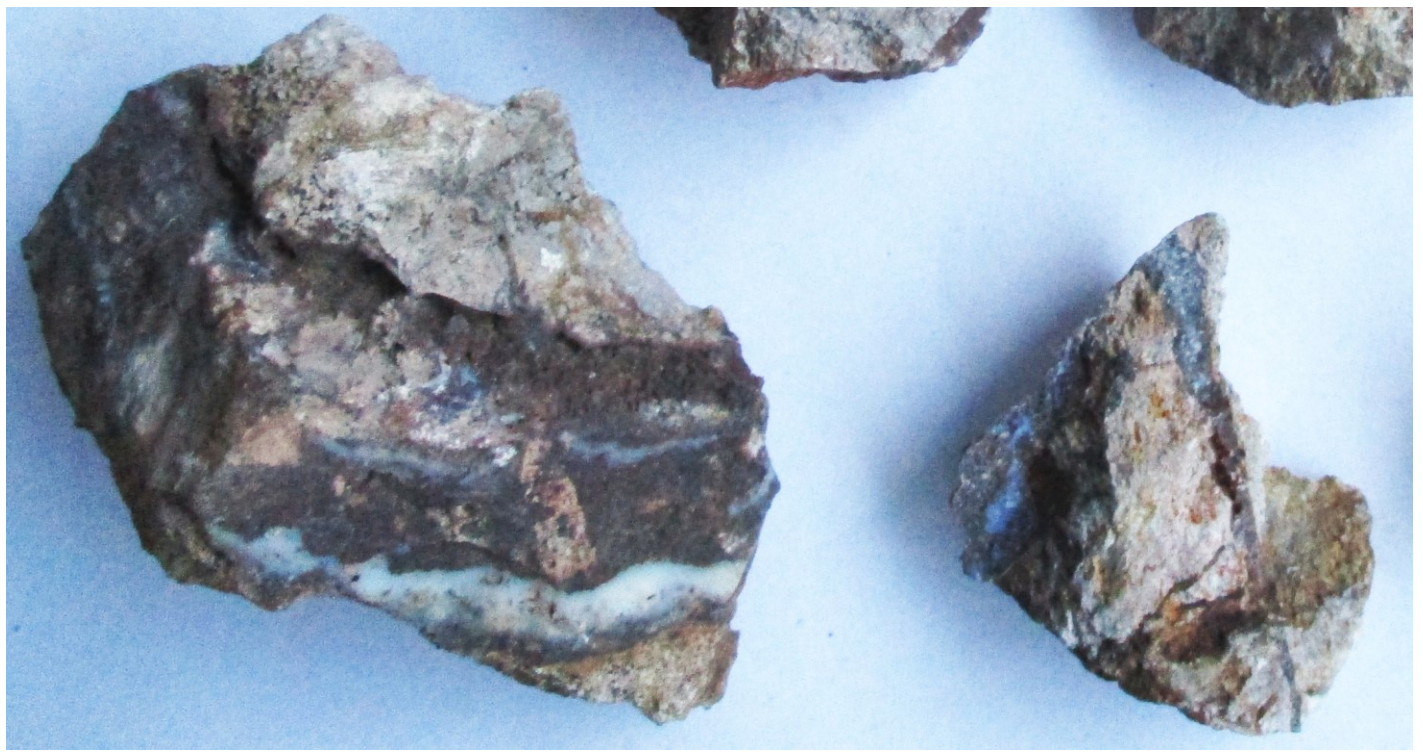
All photos of the samples site here **40-B** ( or alternatively available here : **40-B** ) ( $\rightarrow$  **Spain Craters-2** or **Spain Craters-2**



40-B



40-B 36° 49,823 N 2° 5,035 W 8 m Spain 3 - (Southern Area)



### Site 50 :

( the crater-wall ) is accessible over the Highway AP7 ( but a long stop on the side-strip of the highway isn't really recommended ! )  
The site is located near the exit of the highway tunnel just outside of the crater-wall



### Site 19-B :

The site is very easy accessible by road.  
From a little parking area on the coast it's a 300 m walk to the Impact-affected rocks  
The image shows the rocks in the foreground.  
Looking towards the parking area, in the background of the image the Crater-wall ( the Site 50 ) of this Secondary Impact-Structure of the Permian Triassic (PT) Impact Event is visible



### Site 40-B :

The image shows the center of the small  $\varnothing$  1,6 x 1,2 km elliptical Impact Crater near the village Rodalquilar.  
In the background of the image a section of the inner crater-wall is visible. In the foreground an outcrop of impact breccia is visible  
The crater is accessible over an unsealed road.  
But there is a radar station on the crater rim.  
Permission may be required for an expedition

The  $\varnothing$  1,6 x 1,2 km elliptical Impact Crater



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

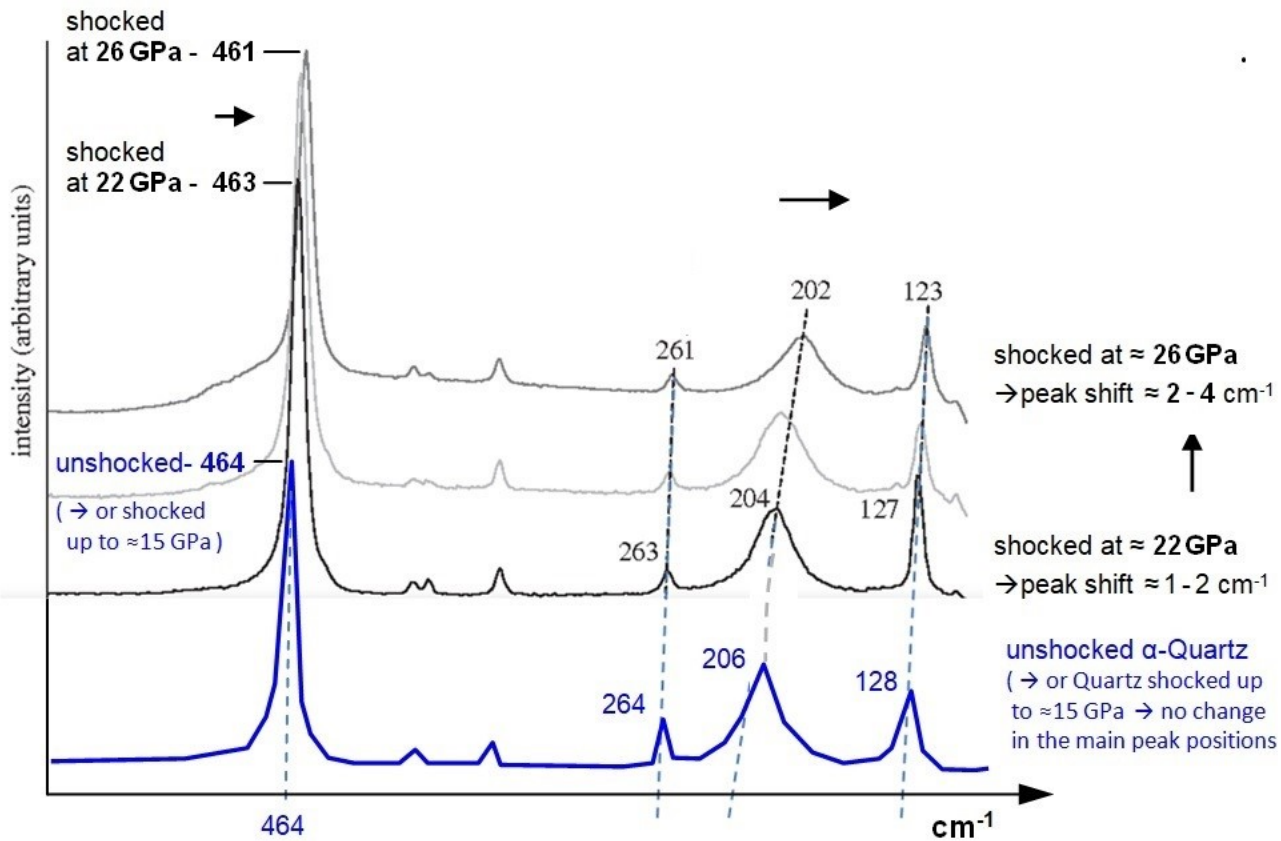
In order to verify a sample site as an impact site or impact structure, [shock-metamorphic effects](#) must be discovered in the rocks of the sample site. This can be done by different methods.

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.

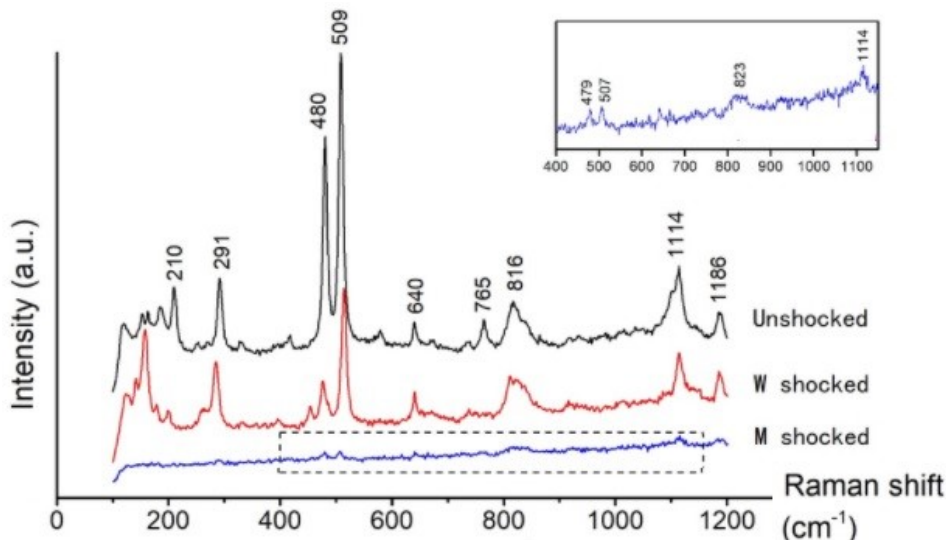
Mc Millan et al. (1992) and others have shown that the main RAMAN-peaks of Quartz shift towards lower frequencies if the Quartz was exposed the a shock-pressure > 15 GPa. → see diagram below

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



## References :

Photos of all Sample Sites & Rock Samples are available on : [Spain Craters-2](#) & [Spain Craters-1](#) ( or : [Spain-2](#) & [Spain-1](#) )

**The Permian-Triassic (PT) Impact hypothesis** - by Harry K. Hahn - 8. July 2017 :

**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)

**Shock-metamorphic effects in rocks and minerals** - <https://www.lpi.usra.edu/publications/books/CB-954/chapter4.pdf>

**Shock metamorphism of planetary silicate rocks and sediments: Proposal for an updated classification system**

Stöffler - 2018 - Meteoritics & Planetary Science – Wiley: <https://onlinelibrary.wiley.com/doi/epdf/10.1111/maps.12912>

**A Raman spectroscopic study of shocked single crystalline quartz** - by P. McMillan, G. Wolf, Phillipe Lambert, 1992

<https://asu.pure.elsevier.com/en/publications/a-raman-spectroscopic-study-of-shocked-single-crystalline-quartz>

alternative : <https://www.semanticscholar.org/paper/A-Raman-spectroscopic-study-of-shocked-single-McMillan-Wolf/cfaaf6eb3e46fbd2912fb91c7acf40e88e721132>

**Raman spectroscopy of natural silica in Chicxulub impactite, Mexico** - by M. Ostroumov, E. Faulques, E. Lounejeva

[https://www.academia.edu/8003100/Raman\\_spectroscopy\\_of\\_natural\\_silica\\_in\\_Chicxulub\\_impactite\\_Mexico](https://www.academia.edu/8003100/Raman_spectroscopy_of_natural_silica_in_Chicxulub_impactite_Mexico)

alternative : <https://www.sciencedirect.com/science/article/pii/S1631071302017005>

**Shock-induced irreversible transition from  $\alpha$ -quartz to CaCl<sub>2</sub>-like silica** - Journal of Applied Physics: Vol 96, No 8

<https://aip.scitation.org/doi/10.1063/1.1783609>

**Shock experiments on quartz targets pre-cooled to 77 K** - J. Fritz, K. Wünnemann, W. U. Reimold, C. Meyer

[https://www.researchgate.net/publication/234026075\\_Shock\\_experiments\\_on\\_quartz\\_targets\\_pre-cooled\\_to\\_77\\_K](https://www.researchgate.net/publication/234026075_Shock_experiments_on_quartz_targets_pre-cooled_to_77_K)

**A Raman spectroscopic study of a fulgurite** – by E. A. Carter, M.D. Hargreaves, ...

[https://www.researchgate.net/publication/44655699\\_Raman\\_Spectroscopic\\_Study\\_of\\_a\\_Fulgurite](https://www.researchgate.net/publication/44655699_Raman_Spectroscopic_Study_of_a_Fulgurite)

alternative : <https://royalsocietypublishing.org/doi/abs/10.1098/rsta.2010.0022>

**Shock-Related Deformation of Feldspars from the Tenoumer Impact Crater, Mauritania** - by Steven J. Jaret

<https://trace.tennessee.edu/cgi/viewcontent.cgi?article=1002&context=pursuit>

**A Study of Shock-Metamorphic Features of Feldspars from the Xiuyan Impact Crater** - by Feng Yin, Dequi Dai

[https://www.researchgate.net/publication/339672303\\_A\\_Study\\_of\\_Shock-Metamorphic\\_Features\\_of\\_Feldspars\\_from\\_the\\_Xiuyan\\_Impact\\_Crater](https://www.researchgate.net/publication/339672303_A_Study_of_Shock-Metamorphic_Features_of_Feldspars_from_the_Xiuyan_Impact_Crater)

**Shock effects in plagioclase feldspar from the Mistastin Lake impact structure, Canada** – A. E. Pickersgill – 2015

<https://onlinelibrary.wiley.com/doi/pdf/10.1111/maps.12495>

**Shock Effects in feldspar: an overview** - by A. E. Pickersgill

<https://www.hou.usra.edu/meetings/lmi2019/pdf/5086.pdf>

**ExoMars Raman Laser Spectrometer RLS, a tool for the potential recognition of wet target craters on Mars**

[https://www.researchgate.net/publication/348675414\\_ExoMars\\_Raman\\_Laser\\_Spectrometer\\_RLS\\_a\\_tool\\_for\\_the\\_potential\\_recognition\\_of\\_wet\\_target\\_craters\\_on\\_Mars](https://www.researchgate.net/publication/348675414_ExoMars_Raman_Laser_Spectrometer_RLS_a_tool_for_the_potential_recognition_of_wet_target_craters_on_Mars)