The Ejecta Ray from the Ø 420 km Southern Ocean Crater in West-Australia

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

Summary :

The linear Fraser Range in Western Australia seems to be the result of an ejecta ray that was ejected from the Ø 420 km "Southern Ocean Crater". Different geophysical maps indicate this impact crater on the floor of the Southern Ocean, which I think is a secondary crater of the Permian Triassic Impact Event (→ weblink to my Permian Triassic Impact Hypothesis : → **Part 1** (**P1**), **Part 2** (**P2**), … of my hypothesis)

The best indication comes from a magnetic anomaly map of the ocean floor which shows a precise semi-circular anomaly (see map below). Further indicaten comes from a combination of a gravity anomaly map of Australia and a topographic map of Antarctica, where Australia and Antarctica were placed to each other, so as they were placed approx. 200-250 Ma ago. The visible bow-shaped structures indicate an impact crater of up to Ø 420 km.

To provide first evidence for this impact Crater I collected rock samples from the linear Fraser Range, which I believe was caused by a massive ejecta ray from this crater (see maps below). The age of the rock which forms the linear Fraser Range is given with ≈ 1.3 Ga. But this is the age of the crust-material that was ejected by the SOC ! I believe the impact event itself occured at the PT-boundary ≈252 Ma ago Note : The coastal area between Albany and Esperance should also contain shock-metamorphed rocks.

With a Raman microscope I analysed rock samples which I collected in the Fraser Range. The Raman spectra of quartz grains from the sample sites **50, 52** and **55** provide first indication for a shock event, the impact of an ejecta ray from the Southern Ocean Crater, which probably formed the Fraser Range.

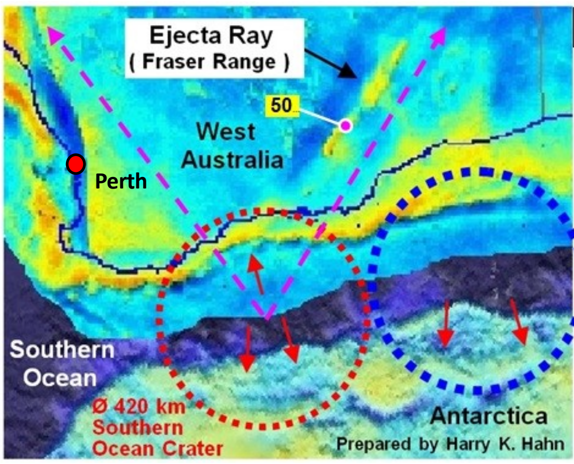
The shifts of two main Raman peaks of the analysed quartz grains from **sample site 55** (Stone 1) to the lower frequencies **263** and **205 cm^{-1}** and to **261/264** and **205 cm^{-1}**, and the shifts of two main Raman peaks in the quartz grains from **sample site 50** (Stone 2) to the lower frequencies **204** and **124 cm^{-1}** and to **260/265** and **204 (200,209) cm^{-1}** (double peaks), and similar shifts in samples from **site 52**, which are visible in the Raman Spectra provide a first indication that the quartz from these sample sites was exposed to a **shock pressure in the range of 20 - 22 GPa**. (→see diagram in Appendix at page **34**).

Even if these frequency shifts are small and didn't affected more than two of the main quartz peaks, at least this is a first indication for an impact shock event. The **microscopic images of some analysed quartz grains from site 50, 52 & 55** may provide further proof for a shock event (**see pages 7-9, 14 & 21**)

The rock material from sample sites 50 and 55 may provide further evidence for the ejecta ray theory. On **site 55** the rock consists of **glass-like material** that contains **pipe-shaped bubbles filled with air** (gas) All spectra were made with a **BRUKER Senterra-II Raman Microscope** (wavenumber precision <0.1cm^{-1})

→ Images of the analysed rock samples and photos of the sample sites are in the Appendix at **page 31**
→ More images of all sample sites are available on www.permiantriassic.de or www.permiantriassic.at
→ **General Summary** of my Analysis : see **Part 6** (**P6**) of my **PTI-hypothesis** (P1) / References : **page 35**

Note : A shock pressure of 20 GPa exceeds every pressure caused by normal terrestrial metamorphism. This indicates that the linear Fraser Range may be indeed the result of a strong **ejecta ray of the Southern Ocean Crater** as indicated on the gravity- and magnetic anomaly maps (→ see images below)



→ Gravity Anomaly Map

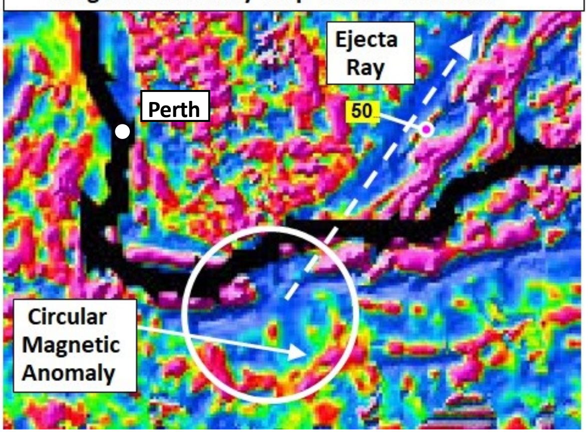
Explanation to this map :

A map combination of a gravity anomaly map of Australia and a topographic map of Antarctica, arranged to each other, so as they were ~ 200 Ma ago indicate a ≈ Ø 420 km Impact Crater.

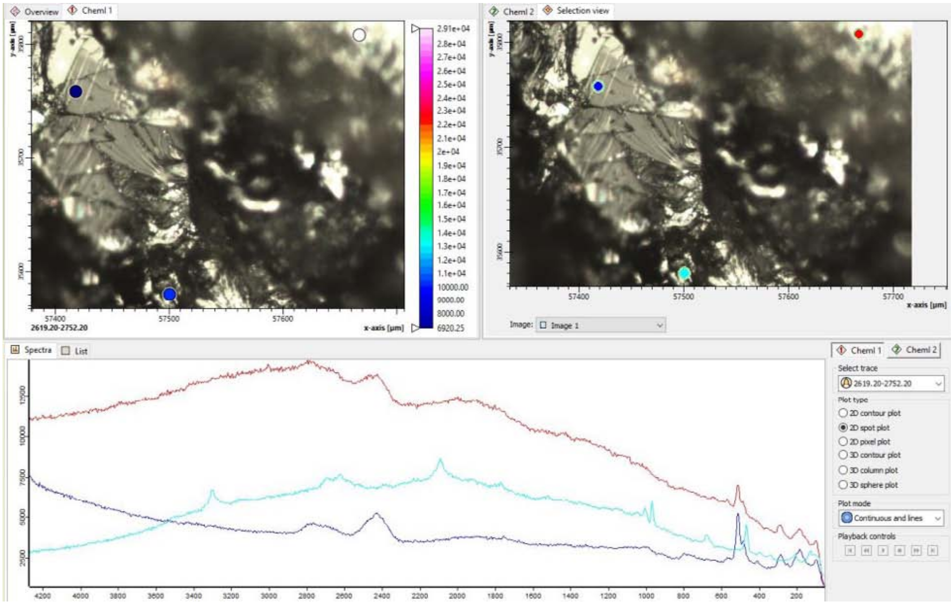
Note the ring structures, the strong ejecta ray and the triangular shaped gravity anomaly which has its apex in the center of the red marked impact crater.

And there may be another impact crater (blue marked).

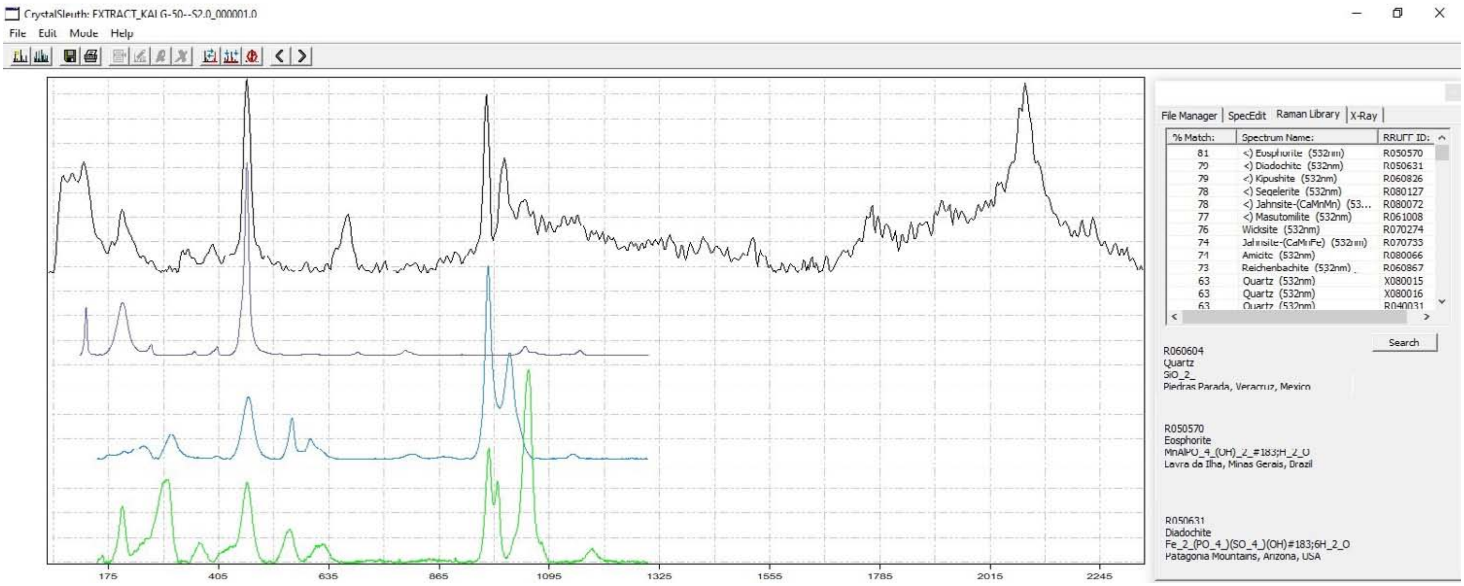
Magnetic Anomaly Map of SW - Australia



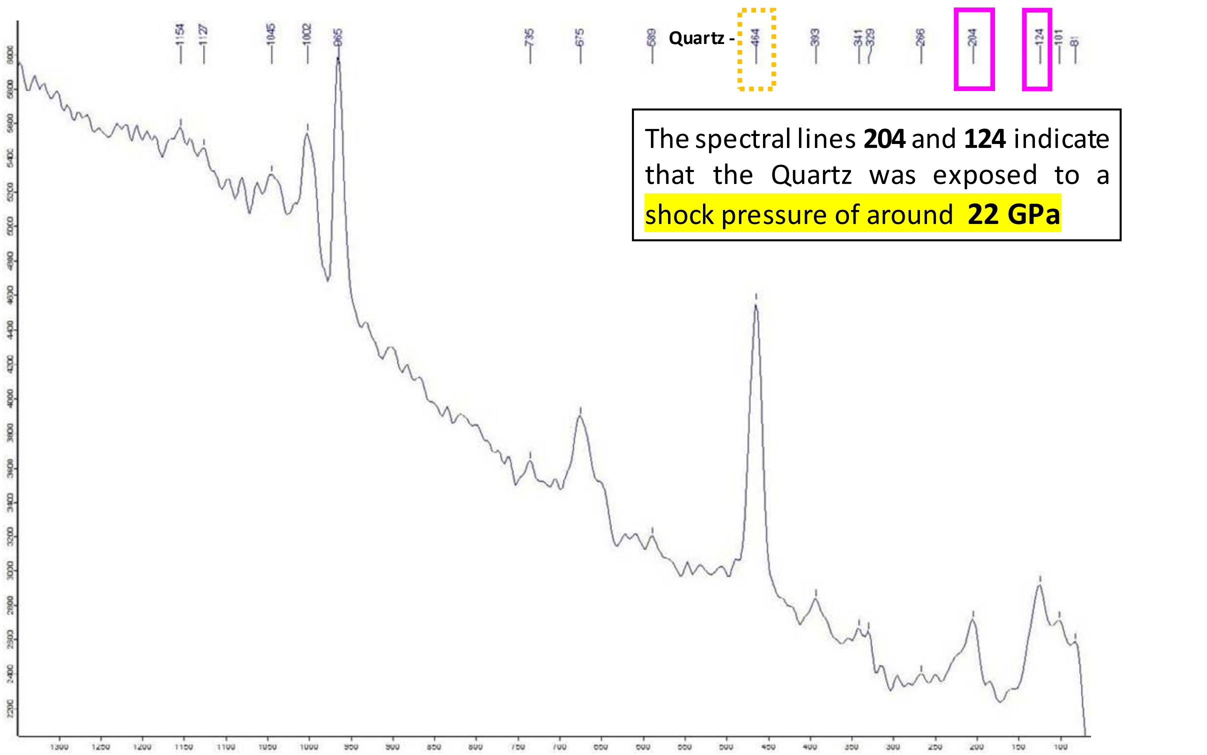
Sample Site 50 : Stone 2_spectra 1 indicates : Quartz & Eosphorite, Diadochite (→ see RRUFF_CS results)



Sample :

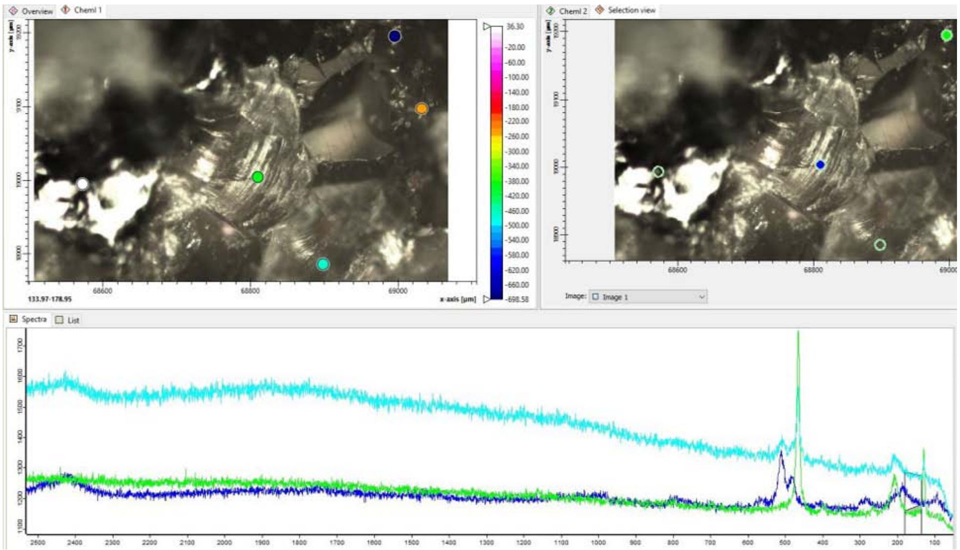


Indication for a shock event are the shifts of the marked Quartz spectral lines towards 204 and 124



The spectral lines **204** and **124** indicate that the Quartz was exposed to a shock pressure of around **22 GPa**

Sample Site 50 : Stone 2_spectra 2 indicates : Quartz (→ see RRUFF_CS results)



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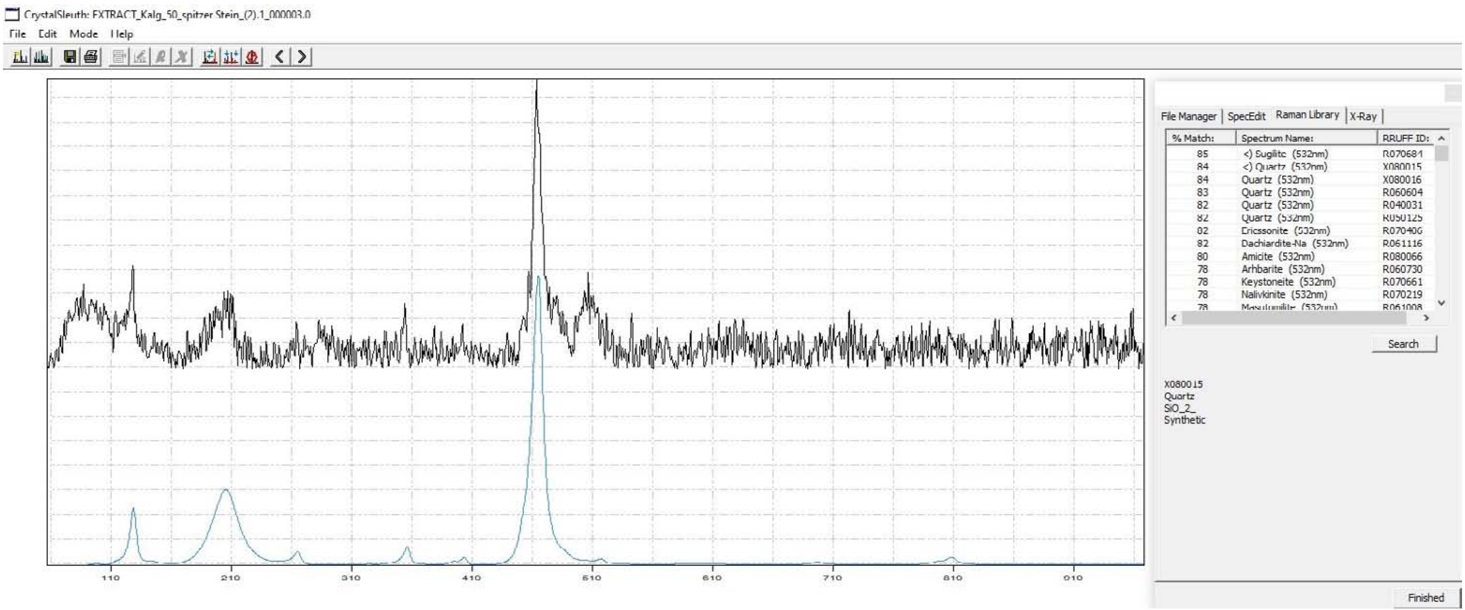
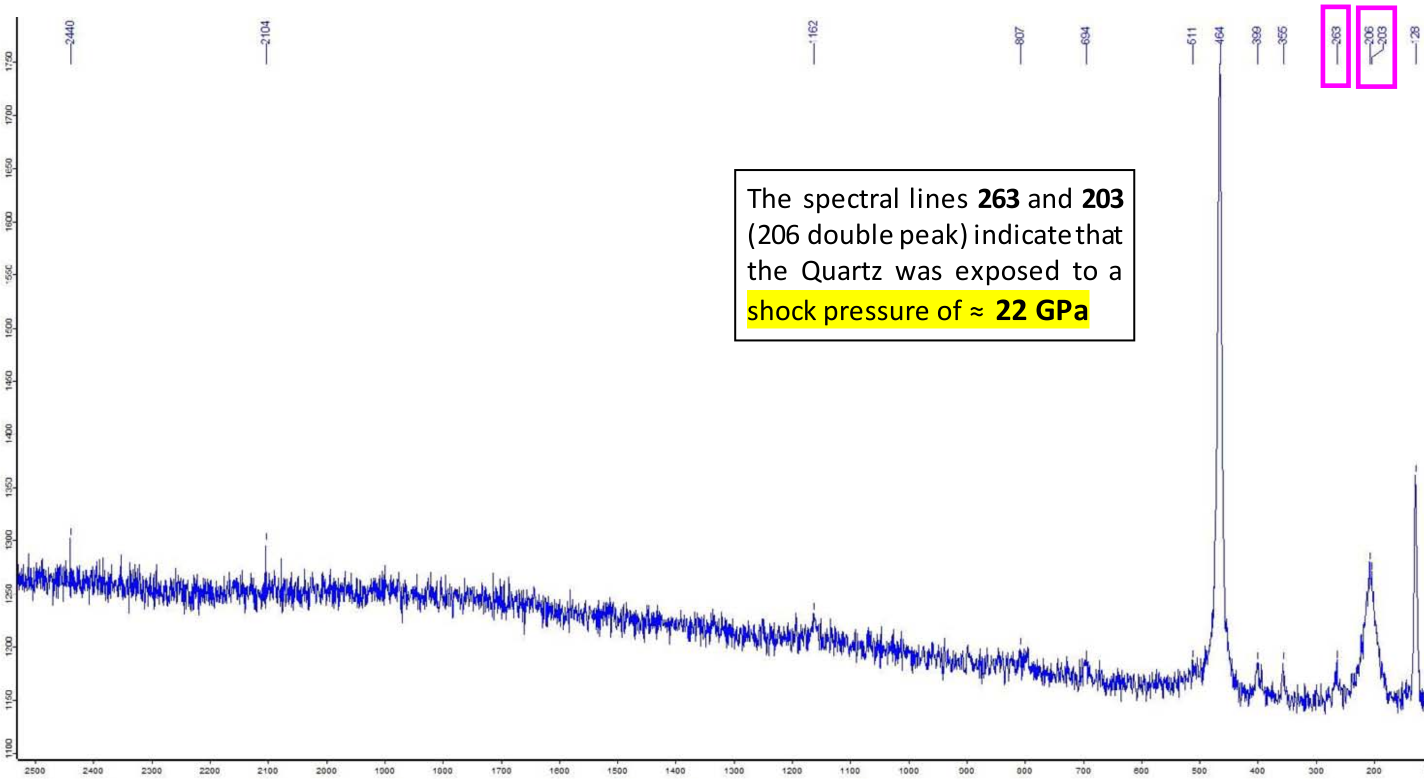
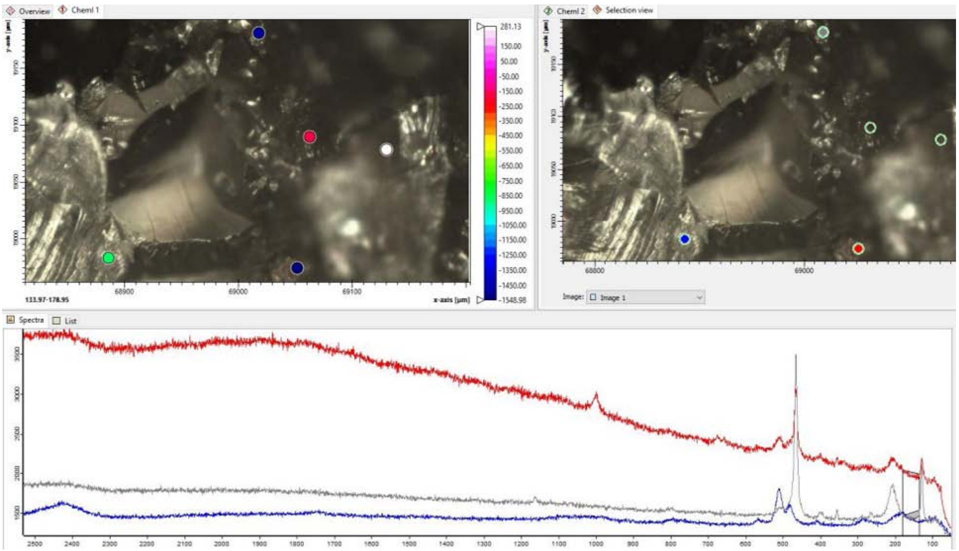


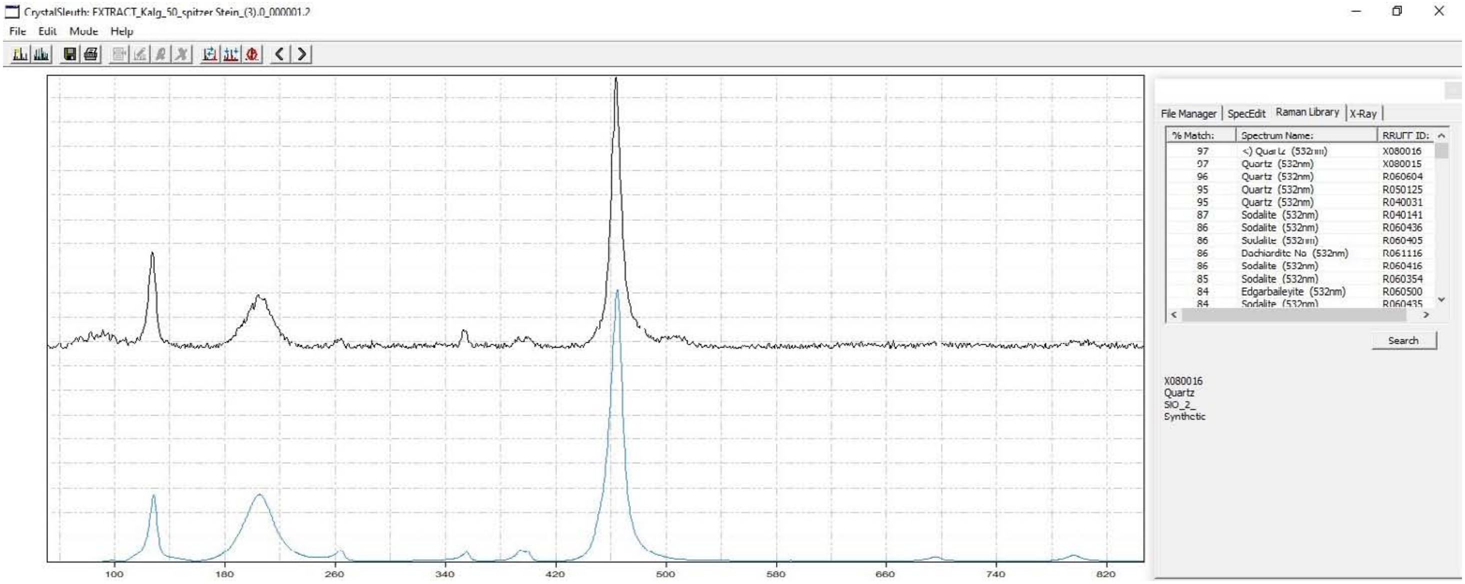
Indication for a shock event are the shifts of the marked Quartz spectral lines towards 263 and 203 (206)



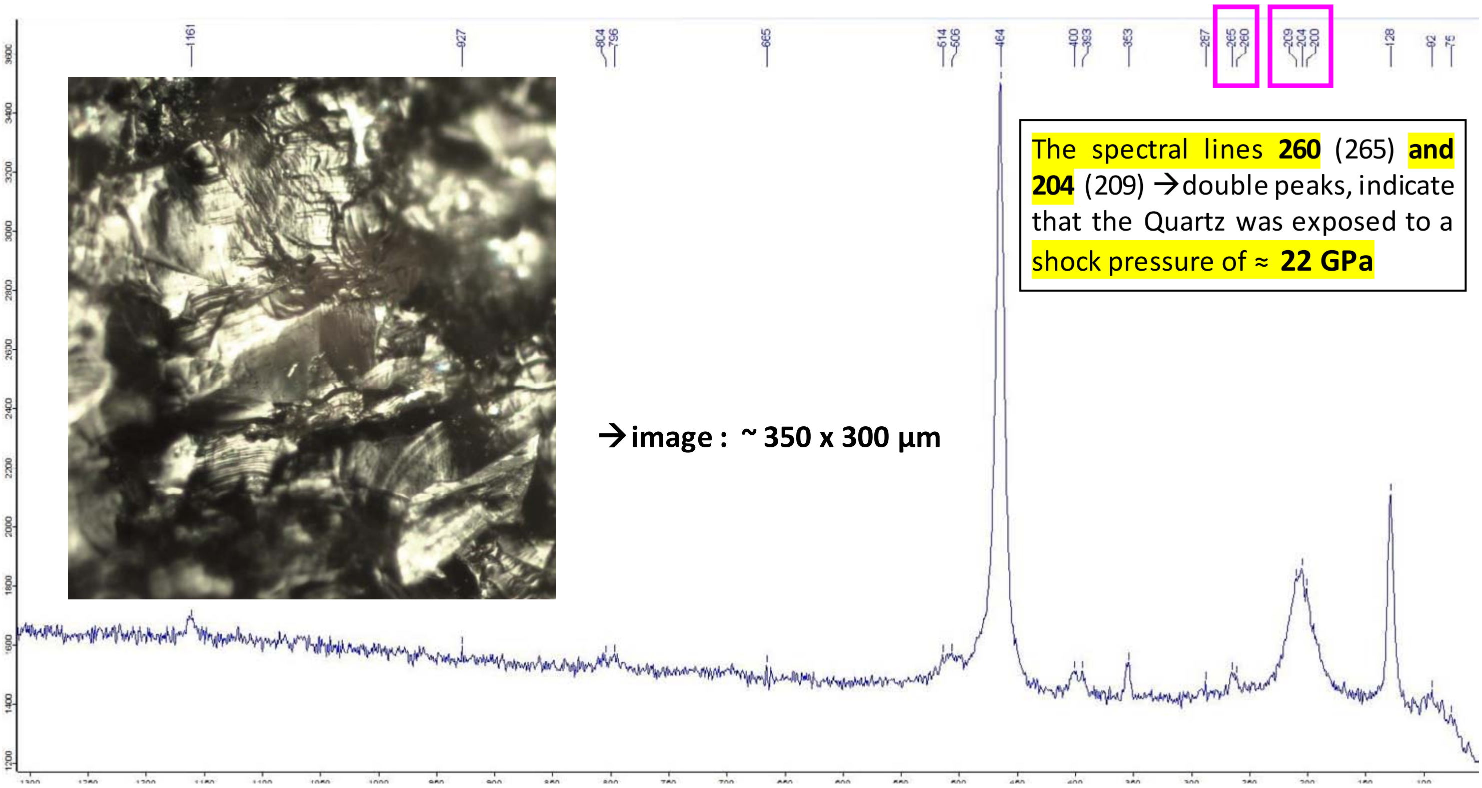
Sample Site 50 : Stone 2_spectra 3 indicates : Quartz (→ see RRUFF_CS results)



Sample :



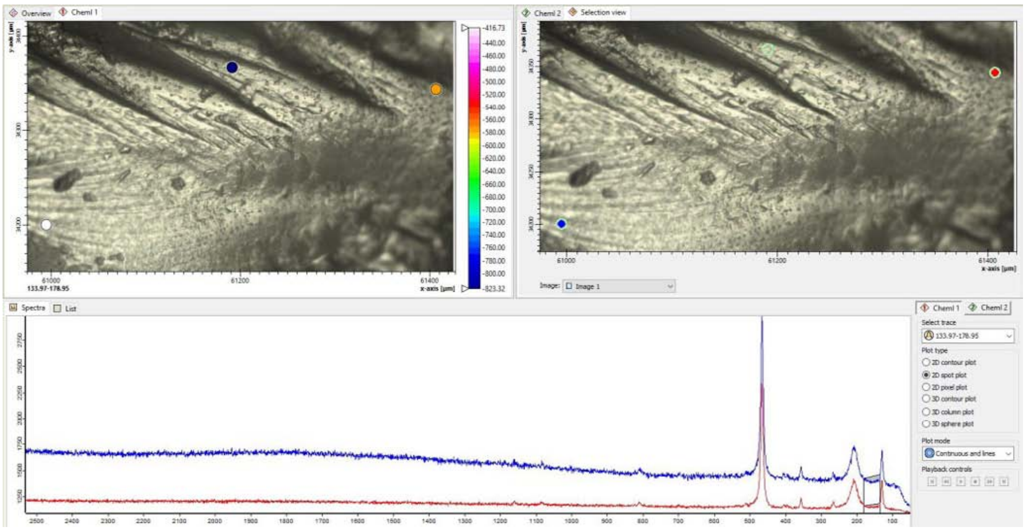
Indication for a shock event are the shifts of the marked Quartz spectral lines towards 260 (265) **and 204** (209)



The spectral lines **260** (265) **and 204** (209) → double peaks, indicate that the Quartz was exposed to a shock pressure of ≈ **22 GPa**

→ **image : ~ 350 x 300 µm**

Sample Site 55 : Stone 1_spectra 1 (white mineral) indicates : Quartz (→ see RRUFF_CS results)



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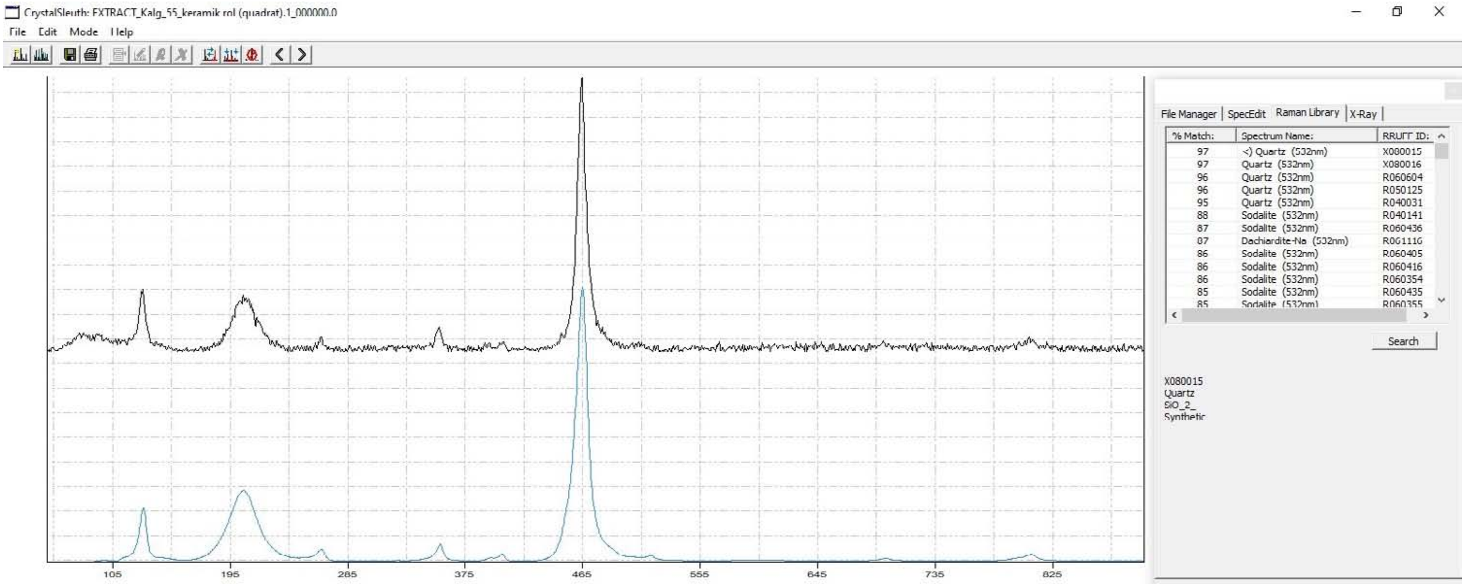
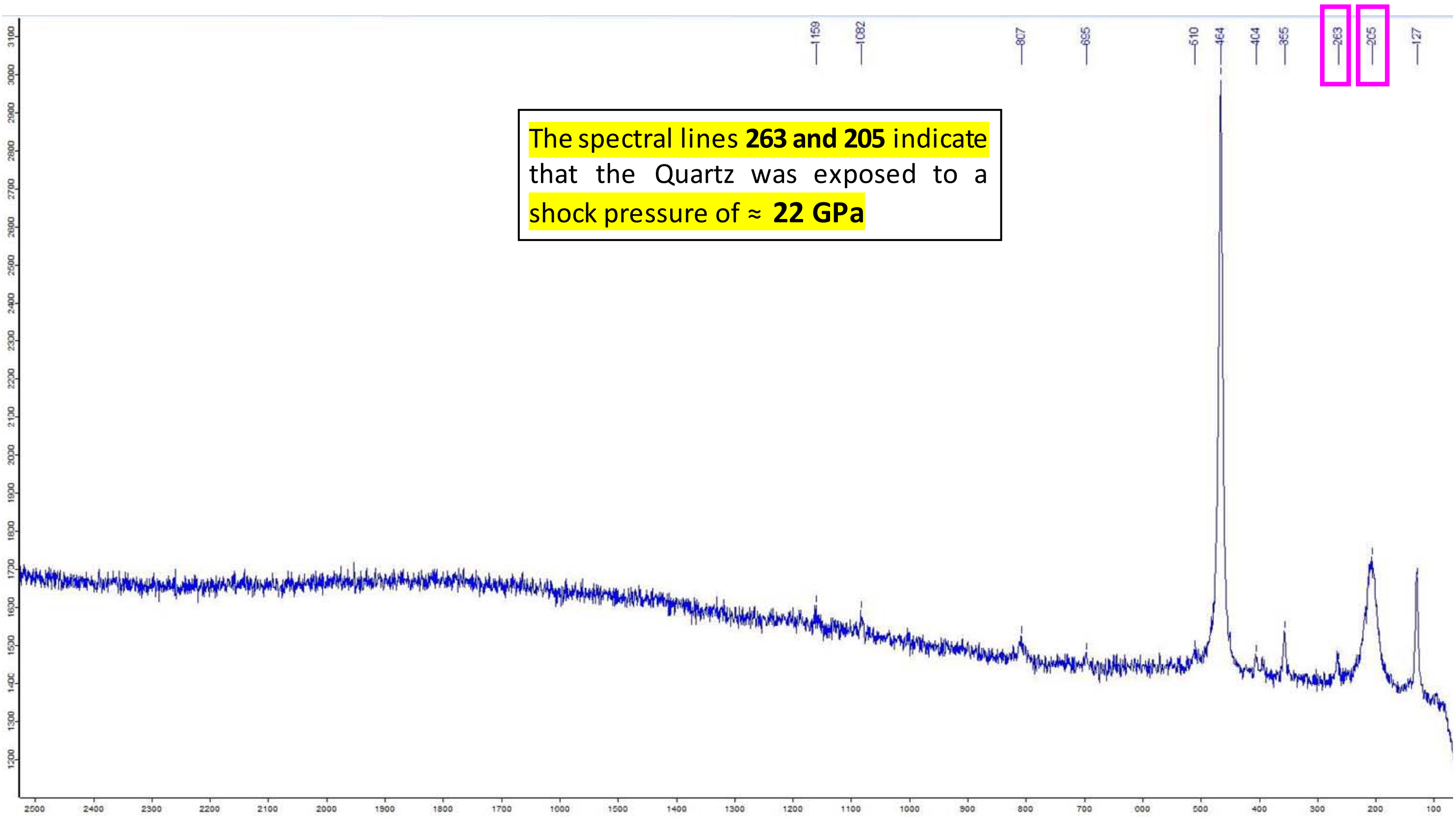
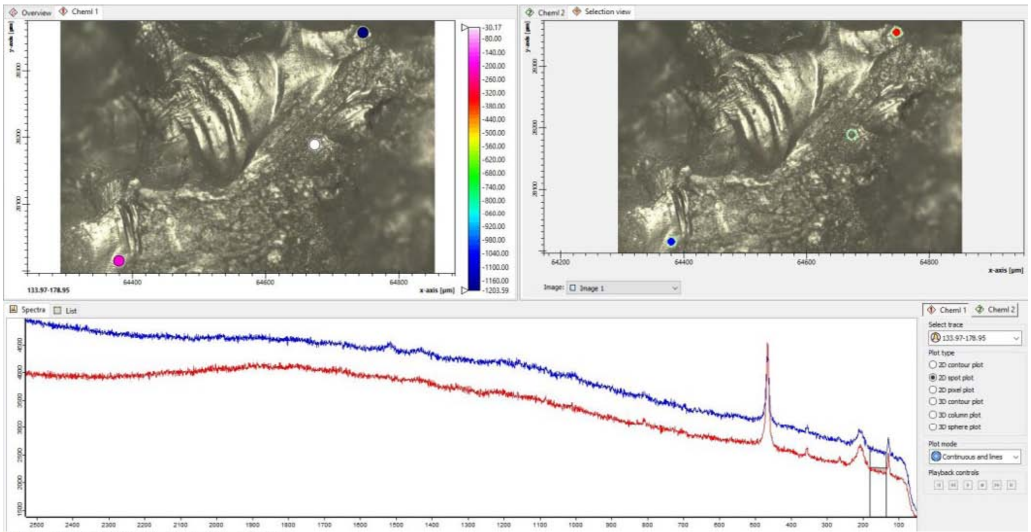


Indication for a shock event are the shifts of the marked Quartz spectral lines towards 263 and 205



Sample Site 55 : Stone 2_spectra 1 (white mineral) indicates : Quartz (→ see RRUFF_CS results)



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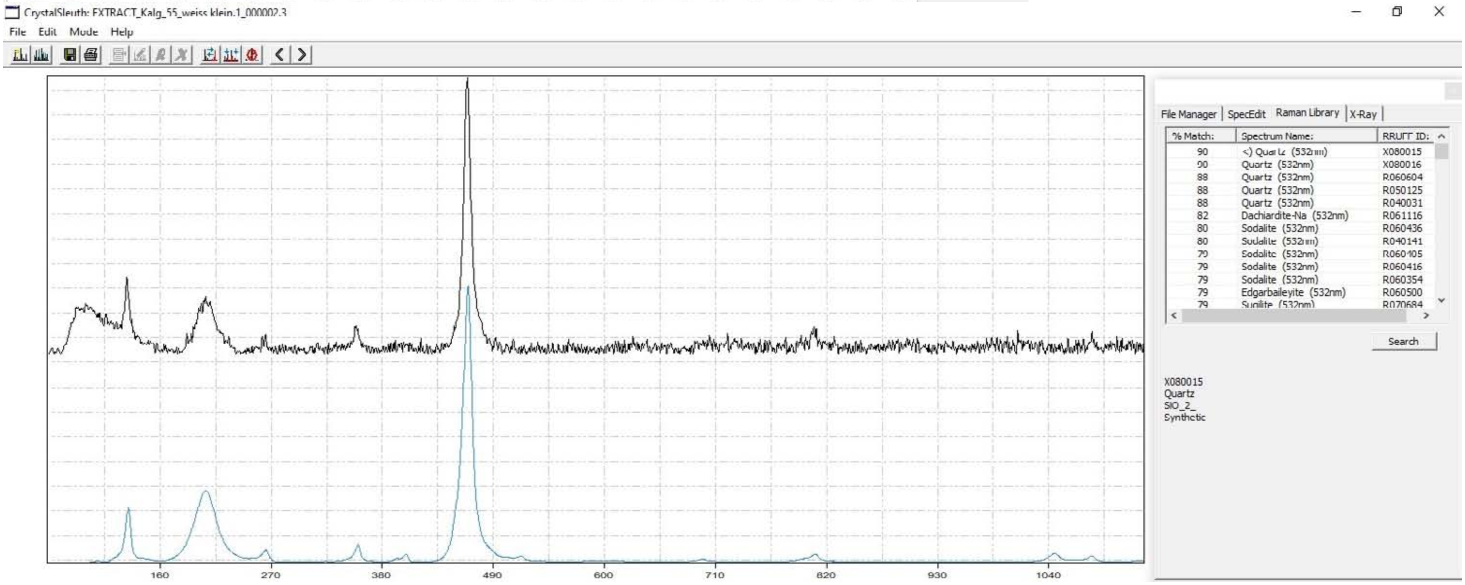
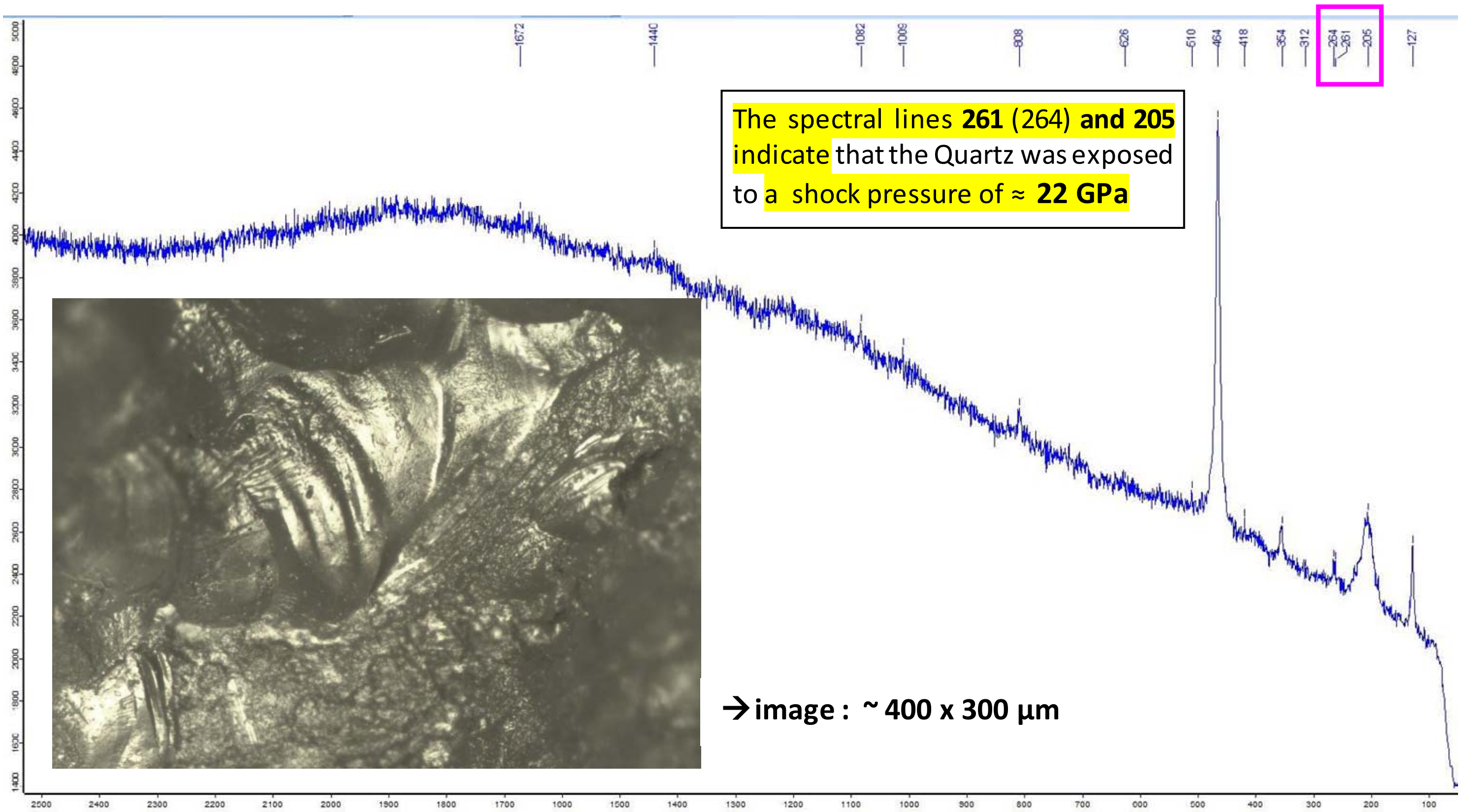
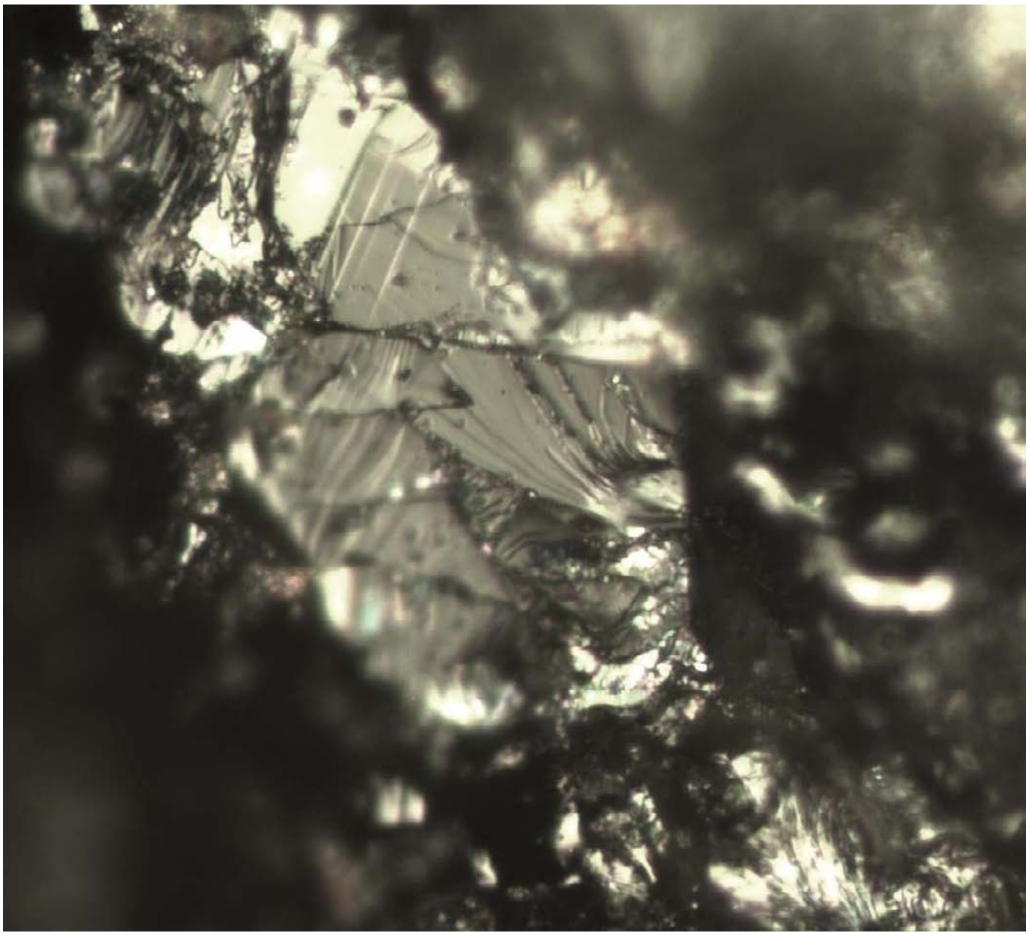


Indication for a shock event are the shifts of the marked Quartz spectral lines towards 261 (264) **and 205**

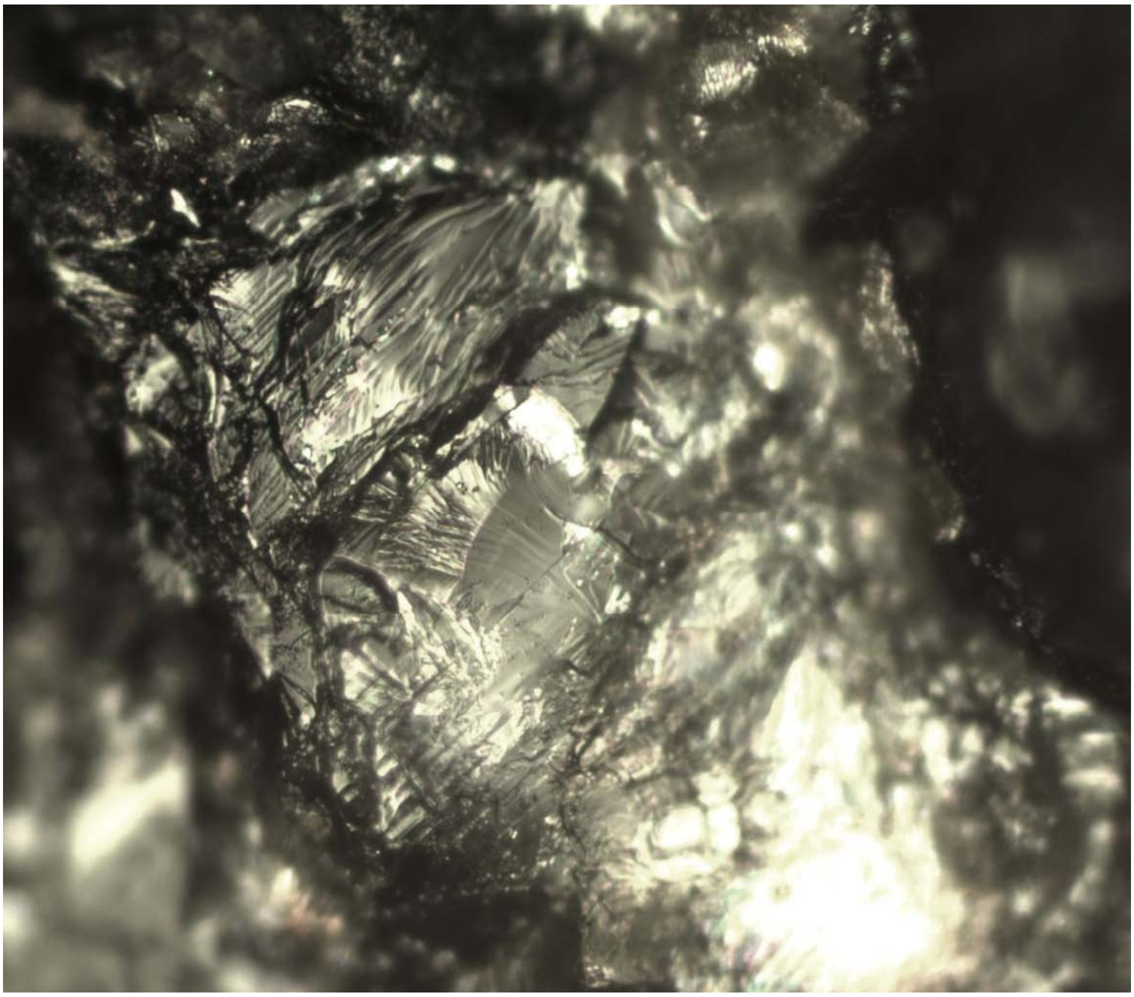


Microscopic Images : Samples from Site 50 → original state (no preparation)

Sample Site 50: Stone 2_spectra 1 : Quartz & Eosphorite, Diadochite - Image size : ~ 250 x 250 µm

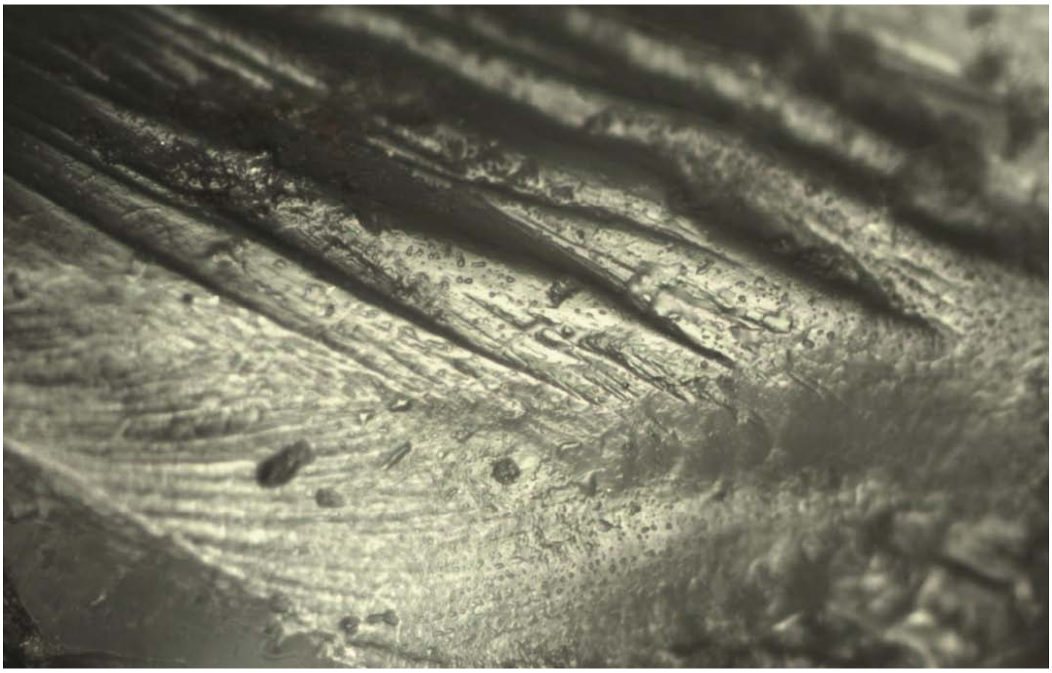


Sample Site 50 : Stone 2_spectra 2 indicates : Augite, Diopside, Johannsenite - image : ~ 400 x 300 µm

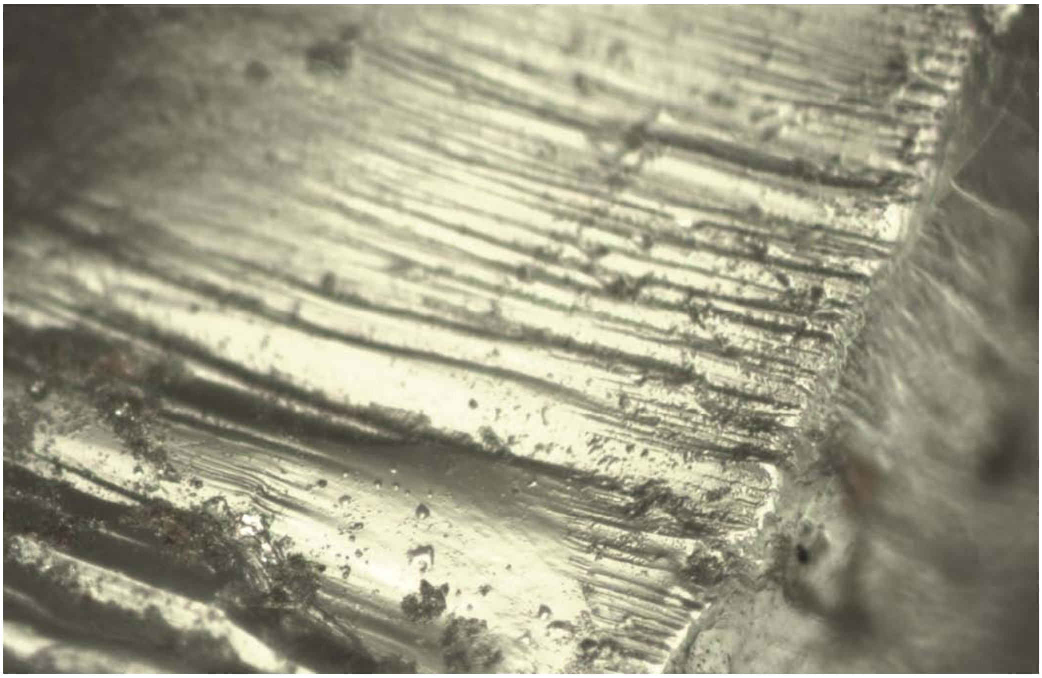


Microscopic Images : Samples from Site 55 → original state (no preparation)

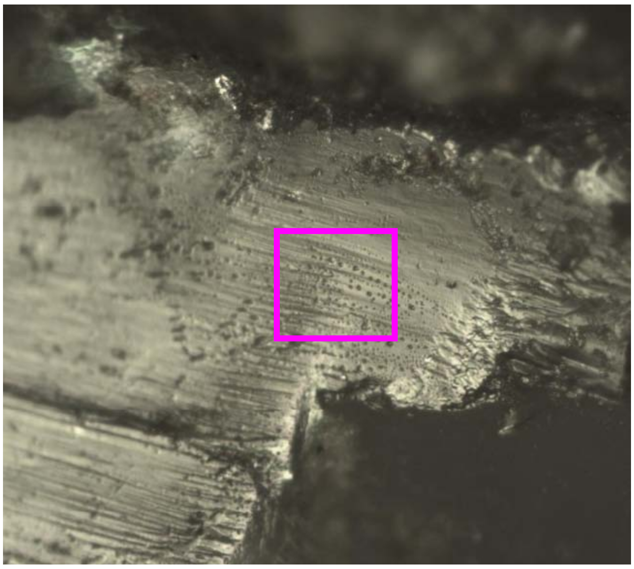
Sample Site 55 : Stone 1_spectra 1 indicates : Quartz - Image size : ~ 500 x 350 µm



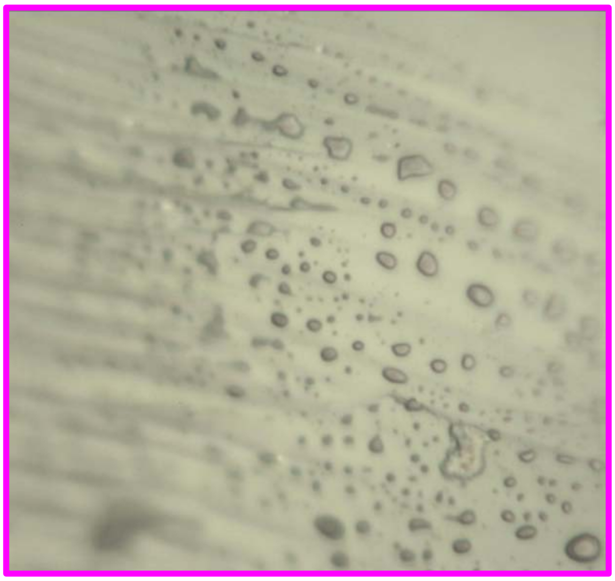
Sample Site 55 : Stone 1_spectra 1 indicates : Quartz : ~ 400 x 300 µm



Site 55 : Stone 1 : Quartz - Image: 400 x 350 µm

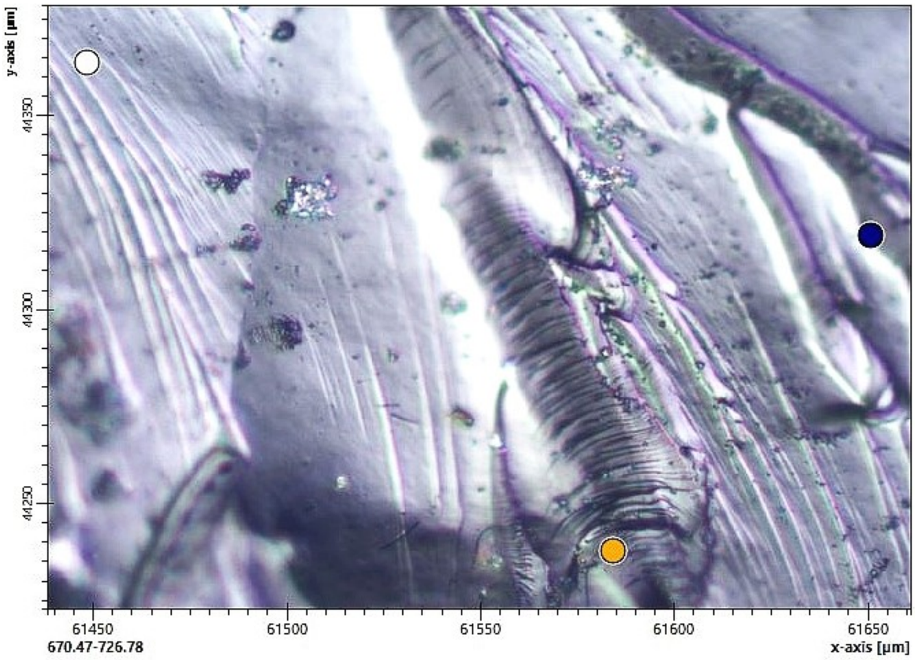


Site 55 : Stone 1 : Quartz - Image Detail : ≈ 90 x 70 µm

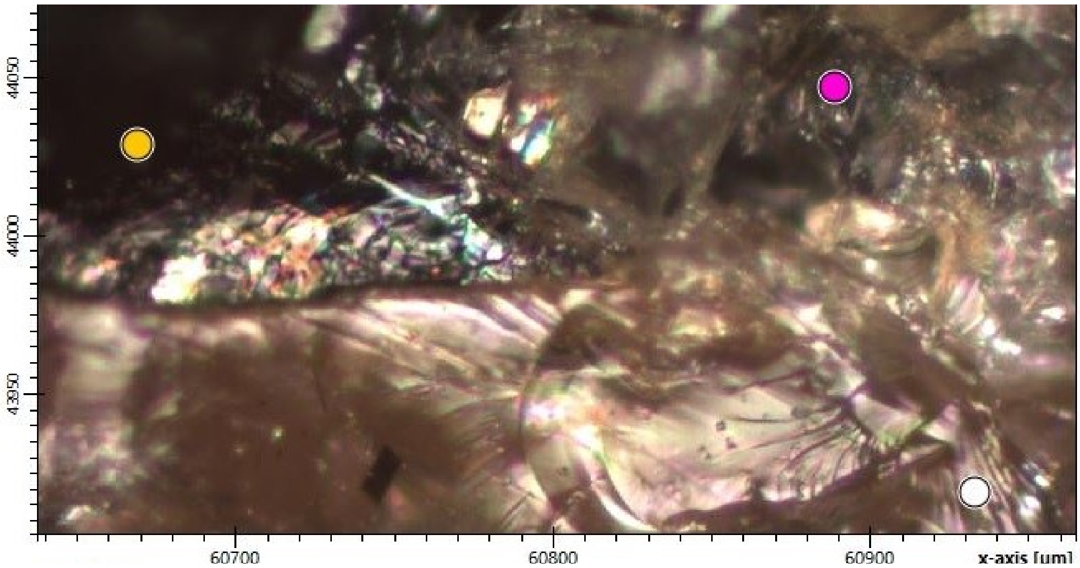


Microscopic Images : Samples from Site 52 → original state (no preparation)

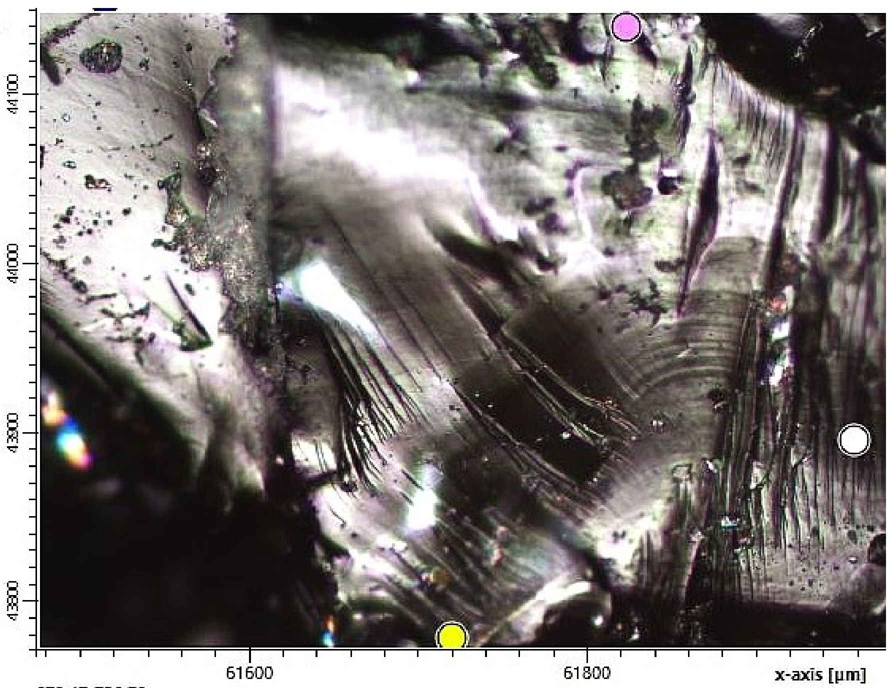
Sample Site 52 : Stone 2_spectra 2 indicates : Quartz - Image size : ~ 250 x 150 µm



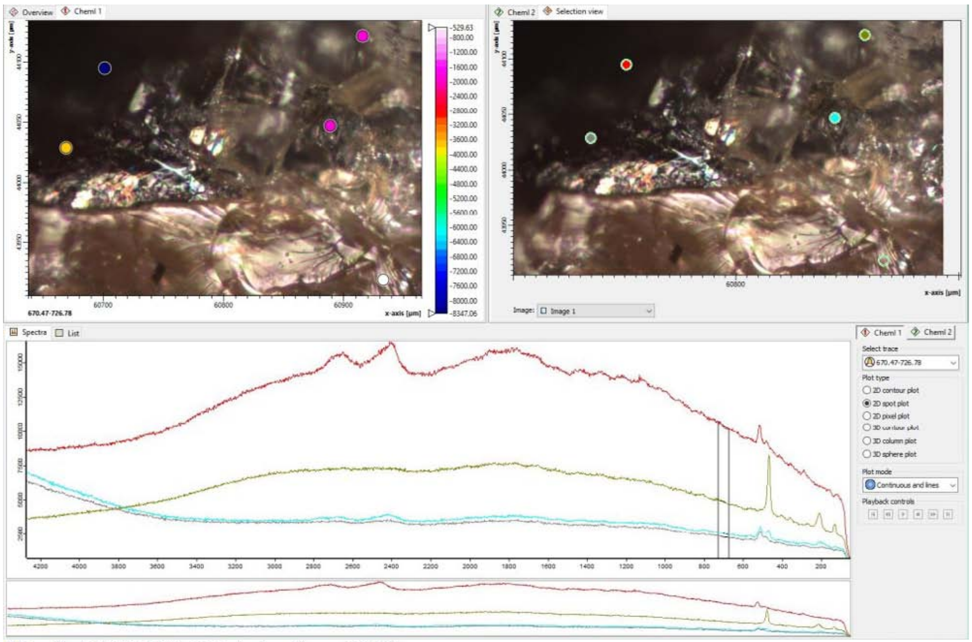
Sample Site 52 : Stone 3-B_spectra 3: Quartz (& Labradorite, Anorthoclase) - Image size : 250 x 150 µm



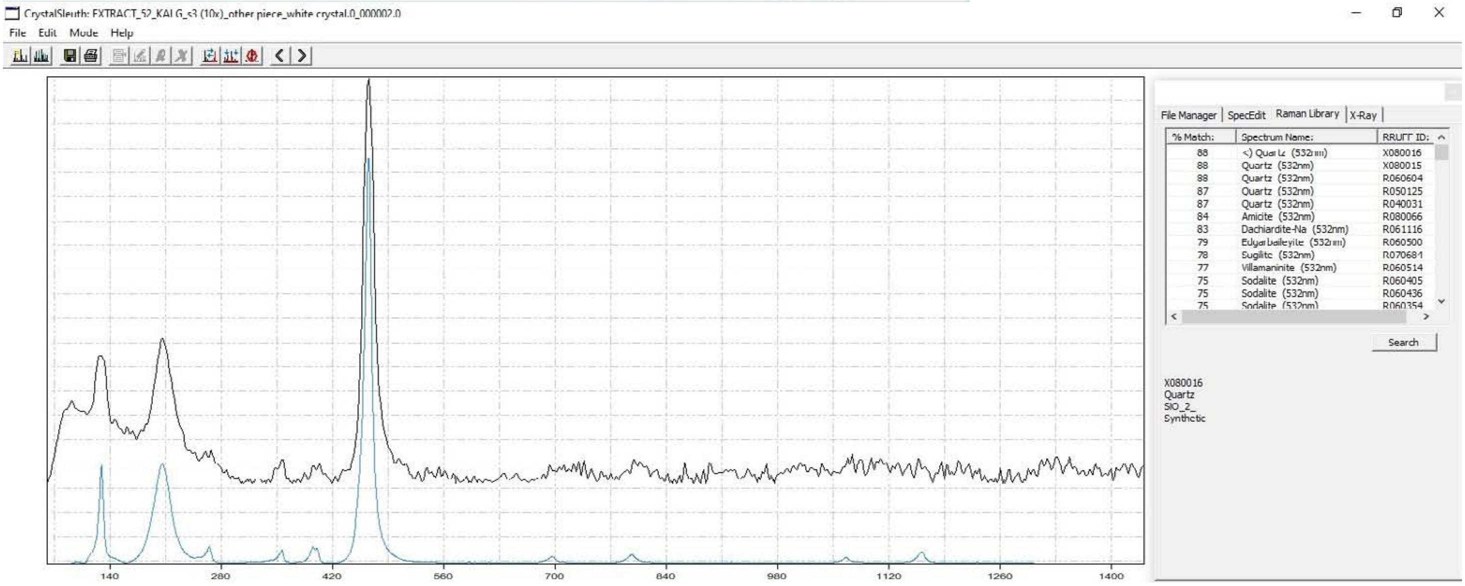
Sample Site 52 : Stone 2_spectra 3 indicates : Quartz : ~ 400 x 300 µm



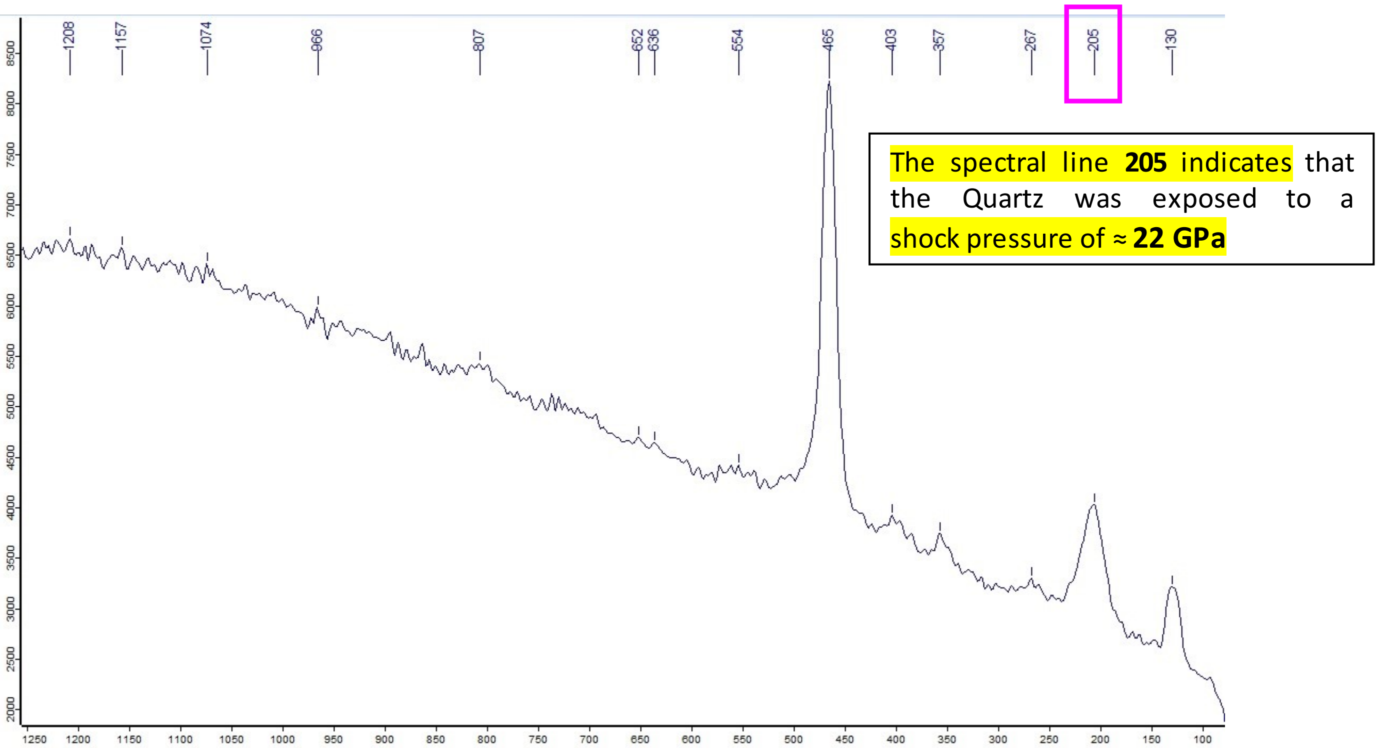
Sample Site 52 : Stone 3-B_spectra 3 (white mineral) indicates : Quartz (→ RRUFF_CS)



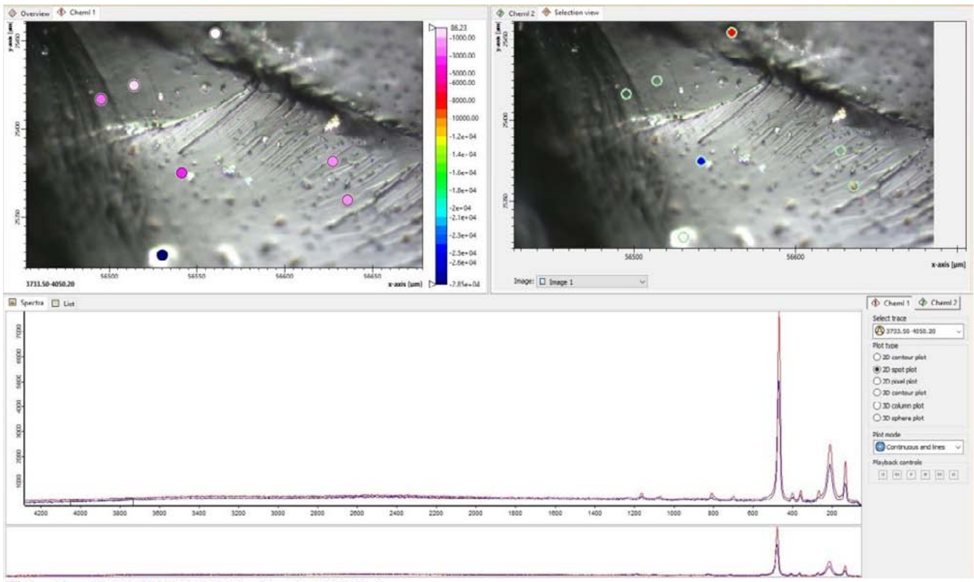
Sample :



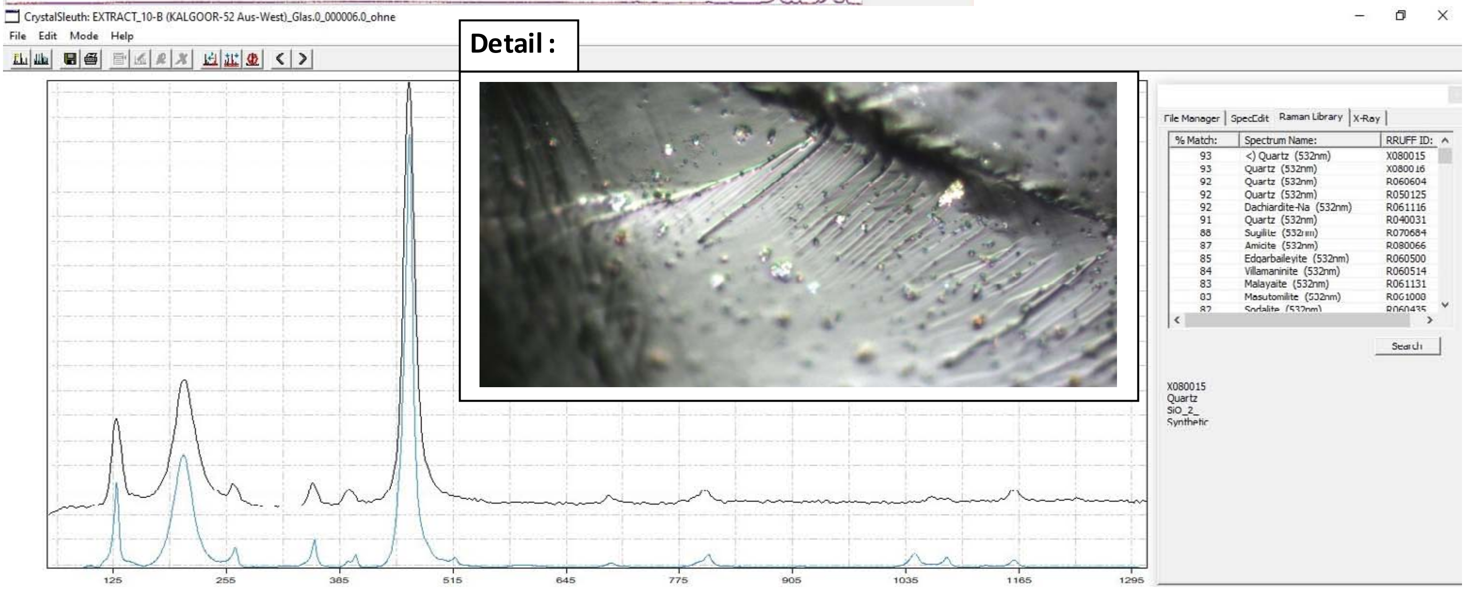
Indication for a shock event is the shift of the marked Quartz spectral line towards 205



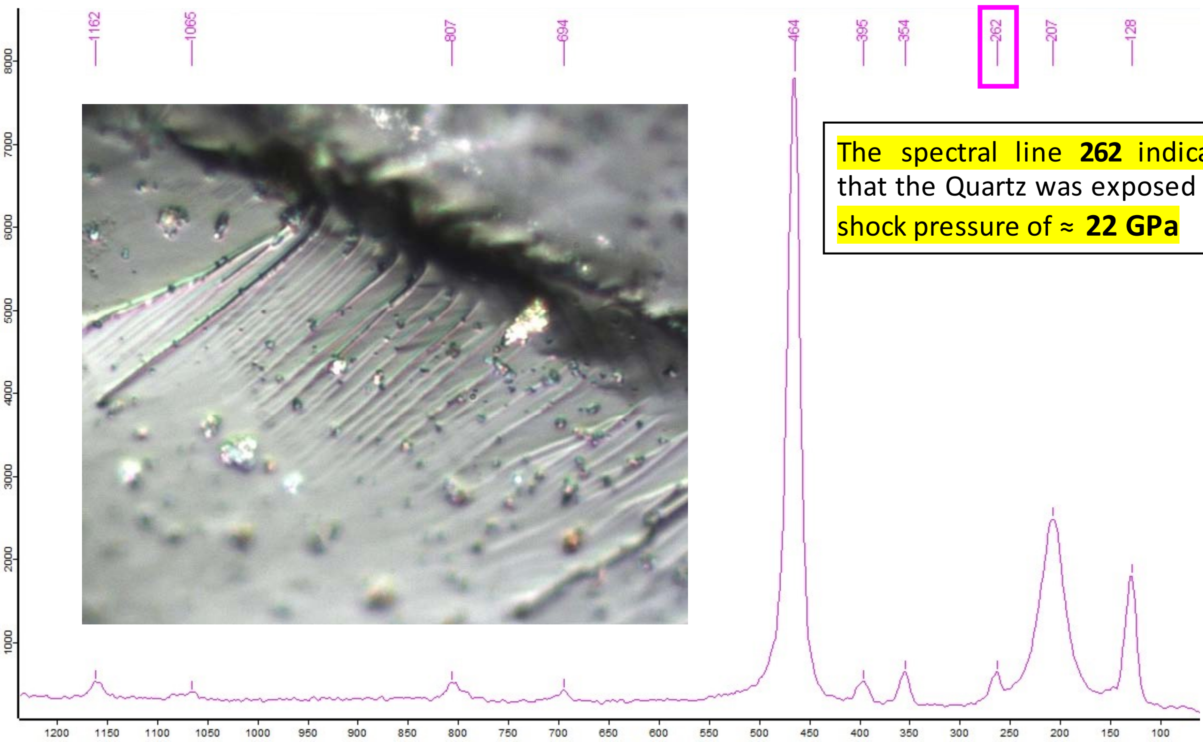
Sample Site 52 : Stone 2_spectra 1 indicates : Quartz (→ see RRUFF_CS results)



Sample :

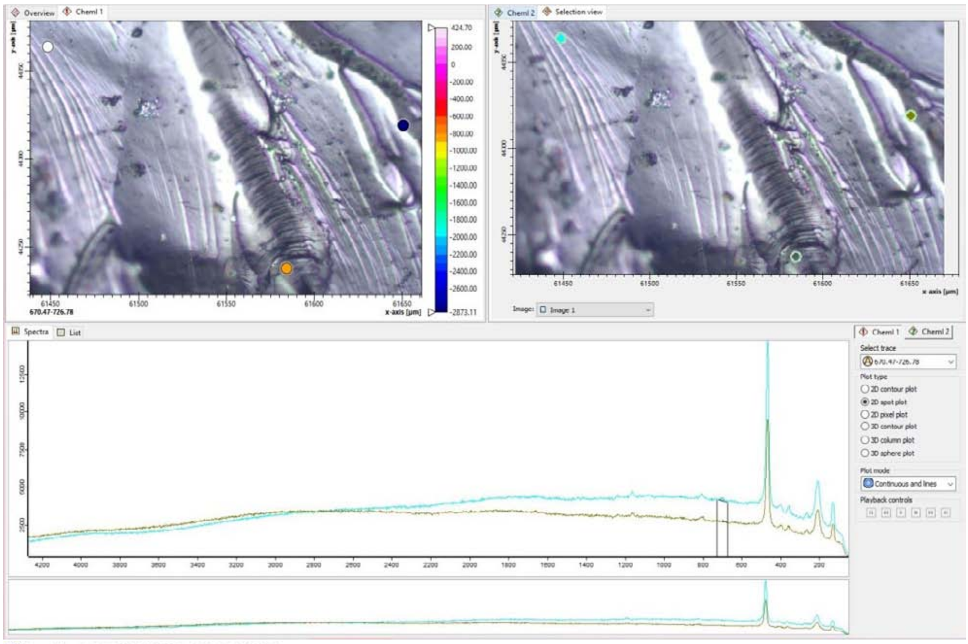


Indication for a shock event is the shifts is the marked Quartz spectral line towards 262

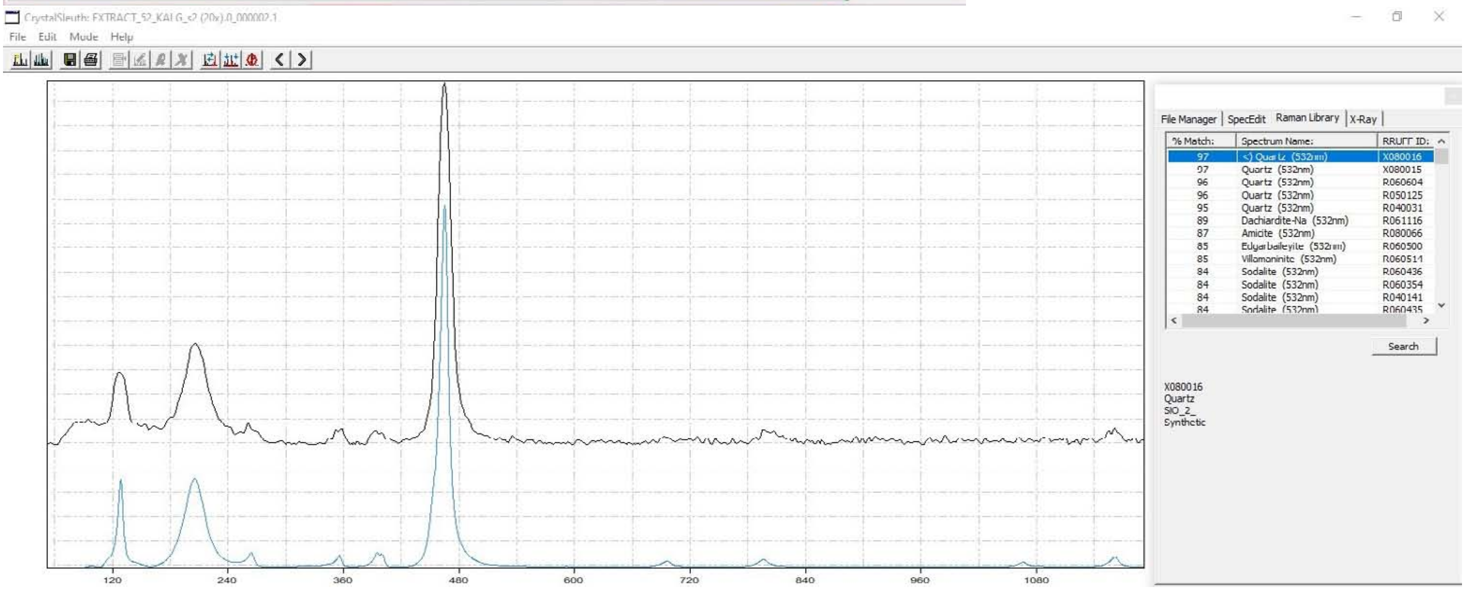


The spectral line **262** indicates that the Quartz was exposed to a shock pressure of ≈ **22 GPa**

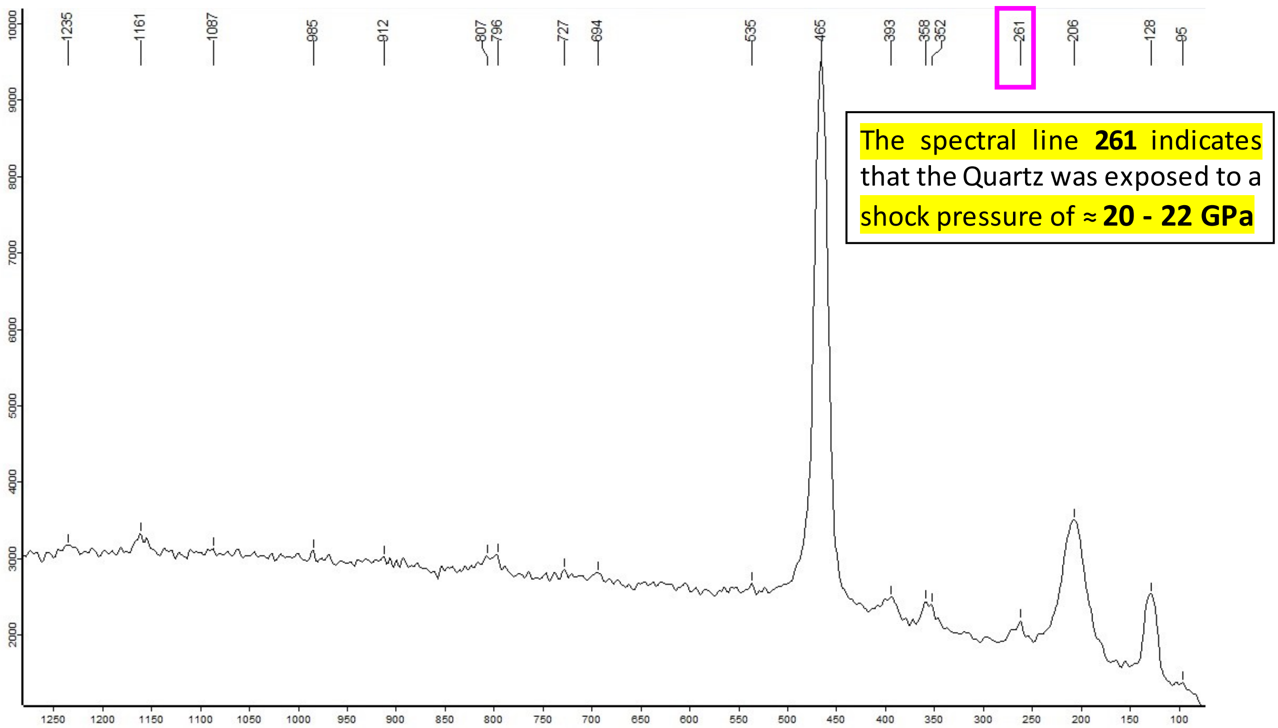
Sample-Site 52 : Stone 2_spectra 2 indicates : Quartz (→ see RRUFF_CS results)



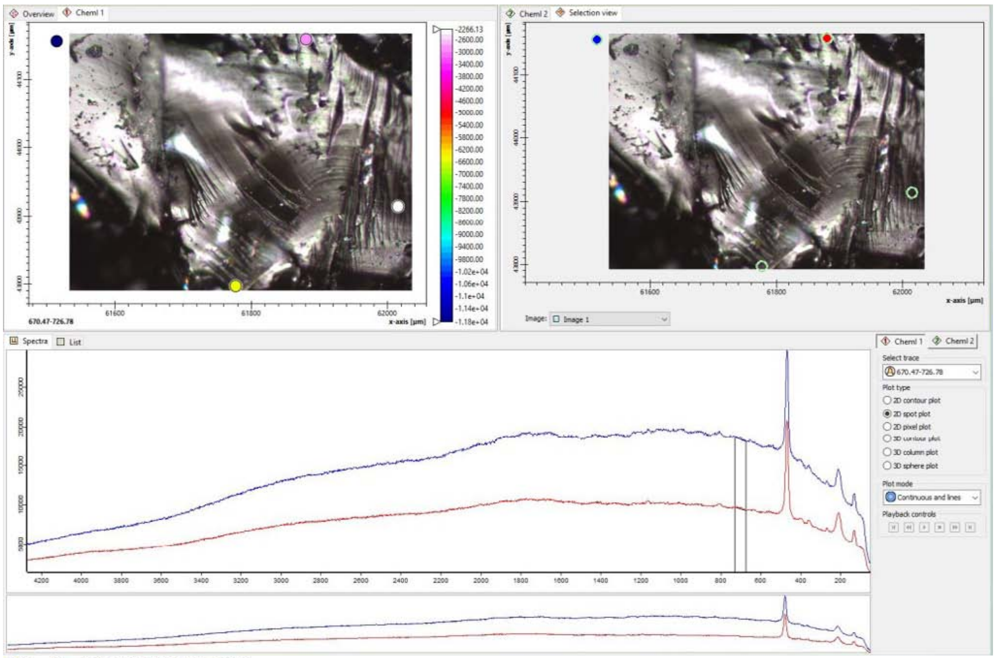
Sample :



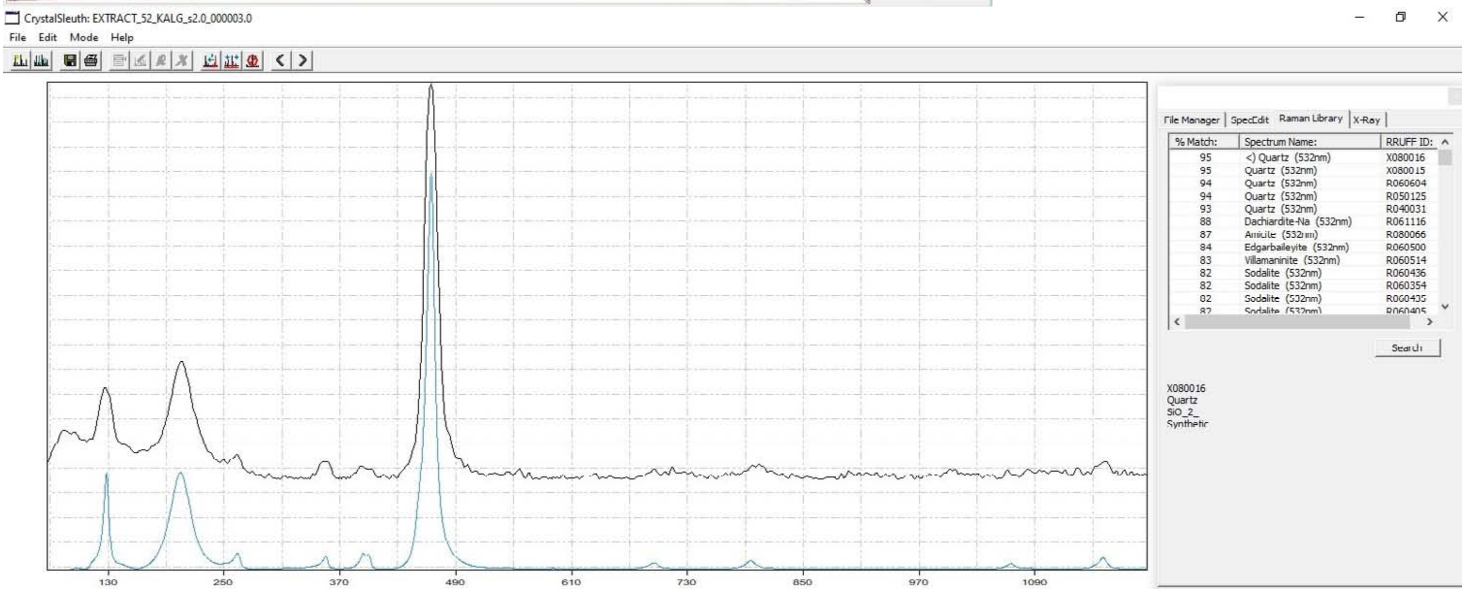
Indication for a shock event is the shift of the marked Quartz spectral line towards 261

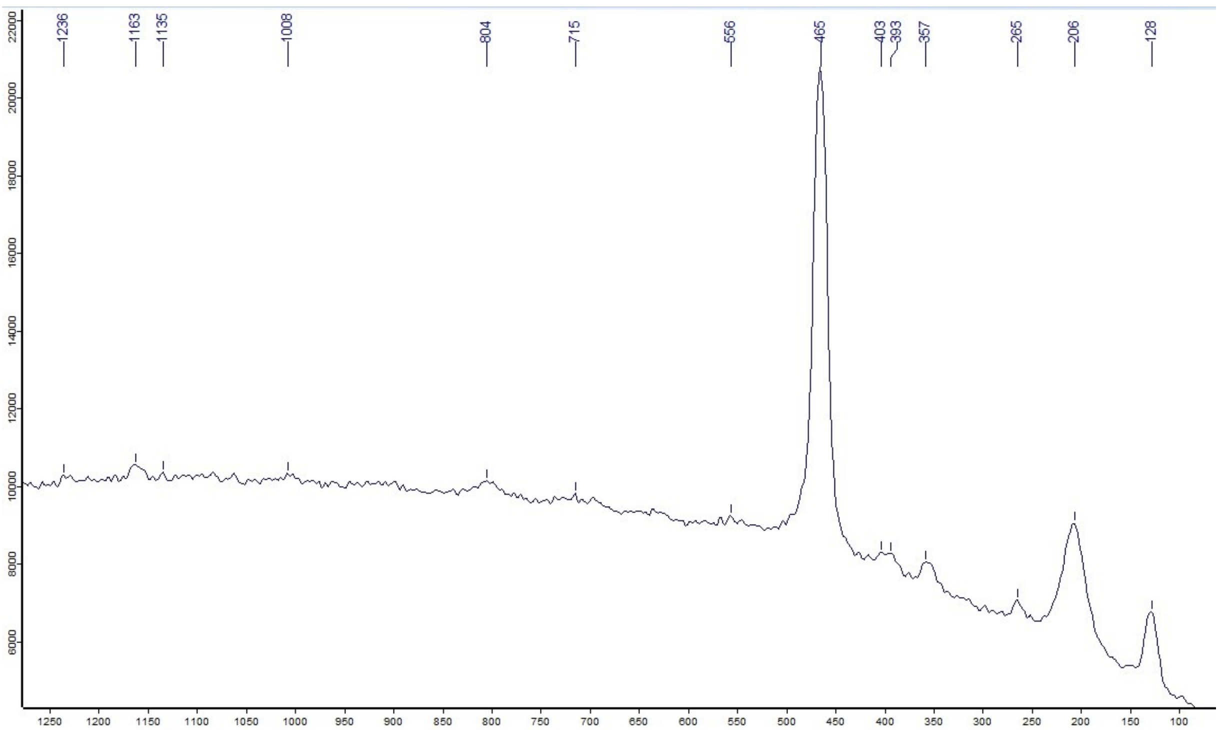


Sample-Site 52 : Stone 2_spectra 3 indicates : Quartz (→ see RRUFF_CS results)

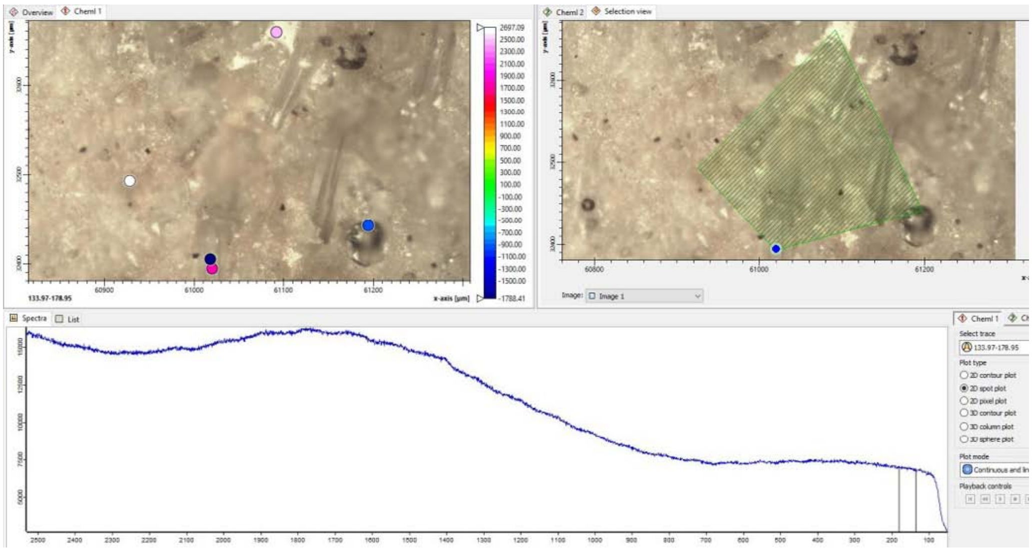


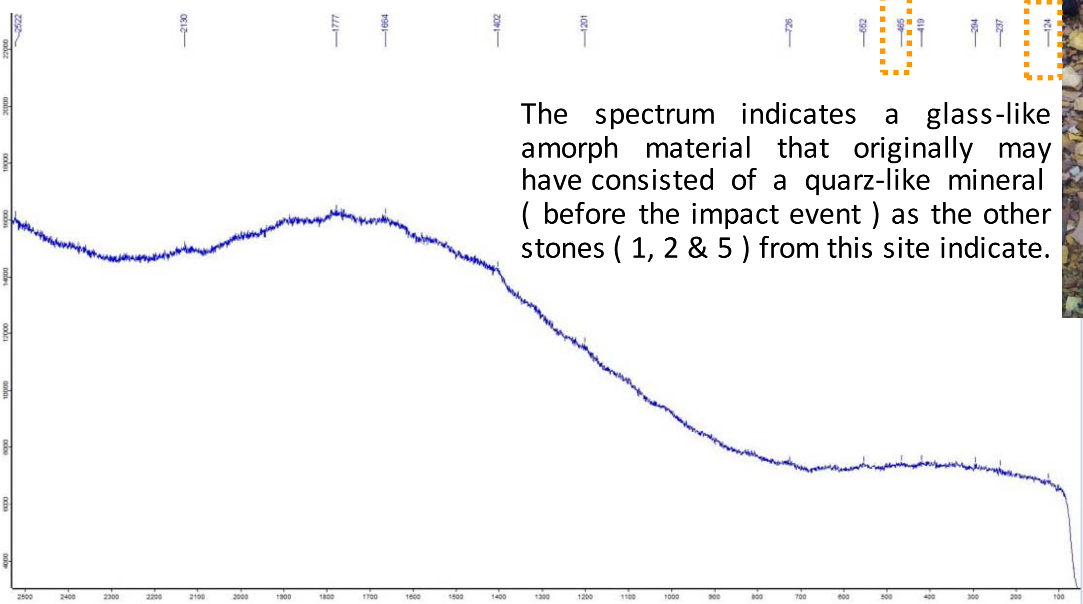
Sample :





Sample Site 55 : Stone 3_spectra 1 indicates : no result ! (→ see RRUFF_CS results)



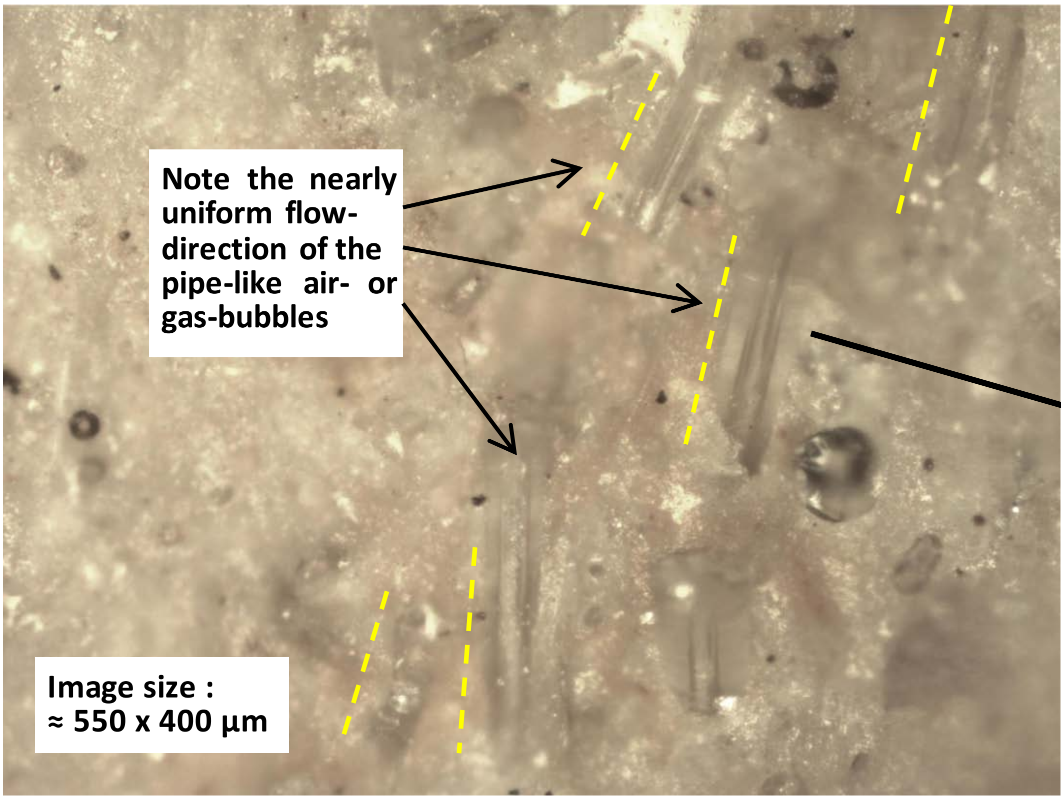


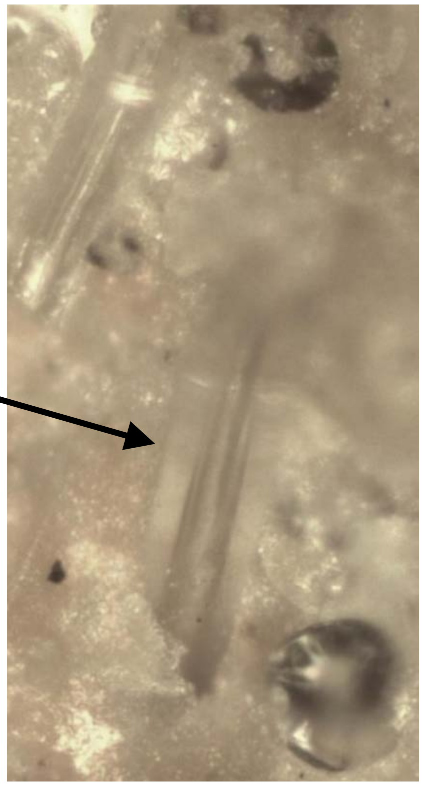
The spectrum indicates a glass-like amorph material that originally may have consisted of a quarz-like mineral (before the impact event) as the other stones (1, 2 & 5) from this site indicate.

Sample :

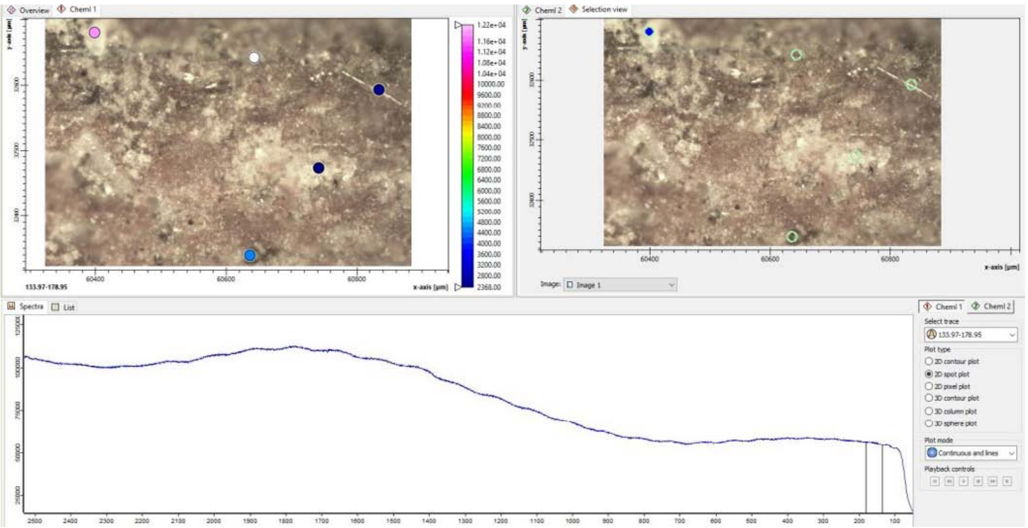
The ground on sample site 55 seems to consist of one coherent mass of ceramic- (glass-) like material with linear flow-texture and a low density like wood ! The flow direction of the material was along the axis of the Fraser Range !

The light-weight glass-like (ceramic-like) material contains pipe-shaped bubbles which are filled with air or gas ! Probably a result of the ejecta process (atmospheric trajectory)

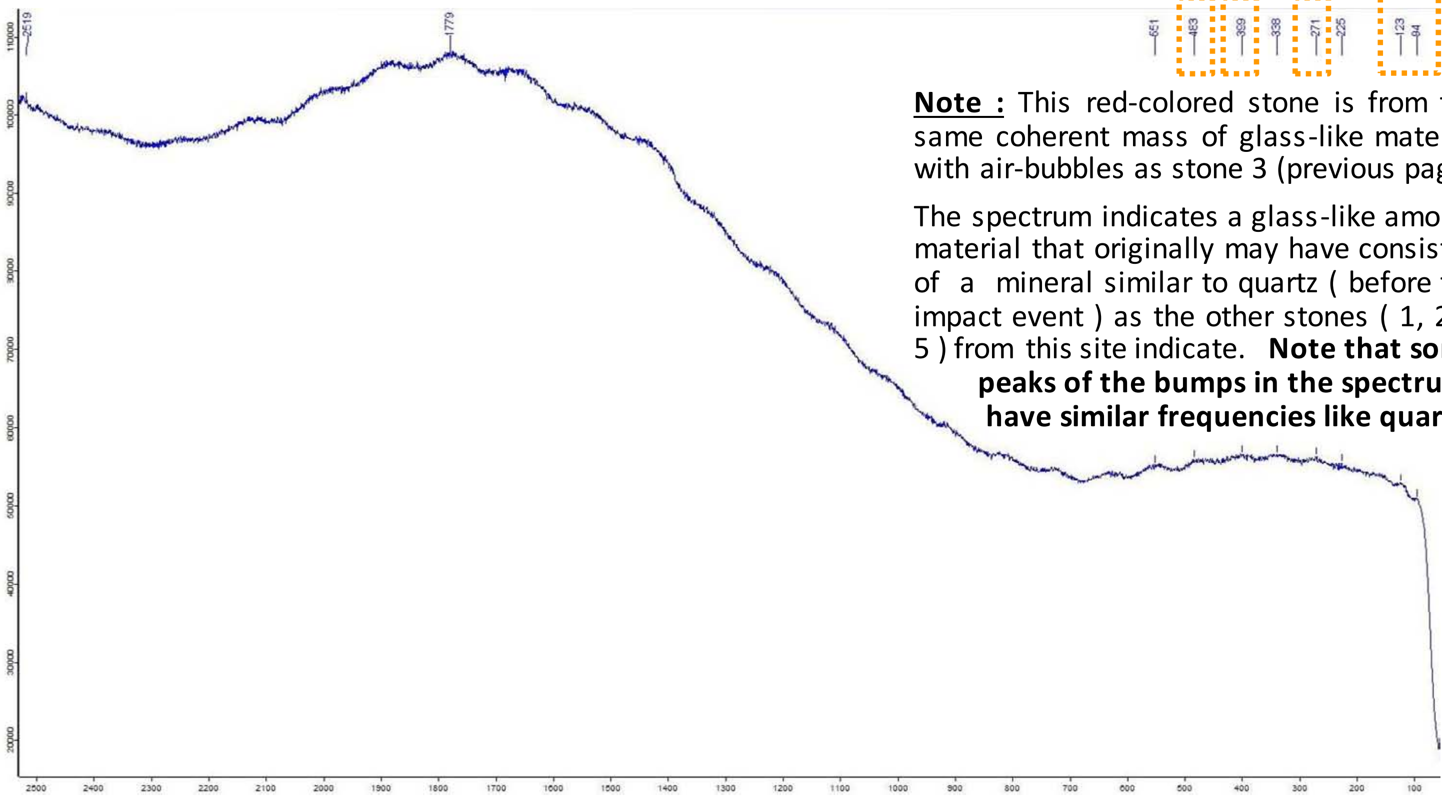




Sample Site 55 : Stone 4_spectra 1 indicates : no result ! (→ see RRUFF_CS results)

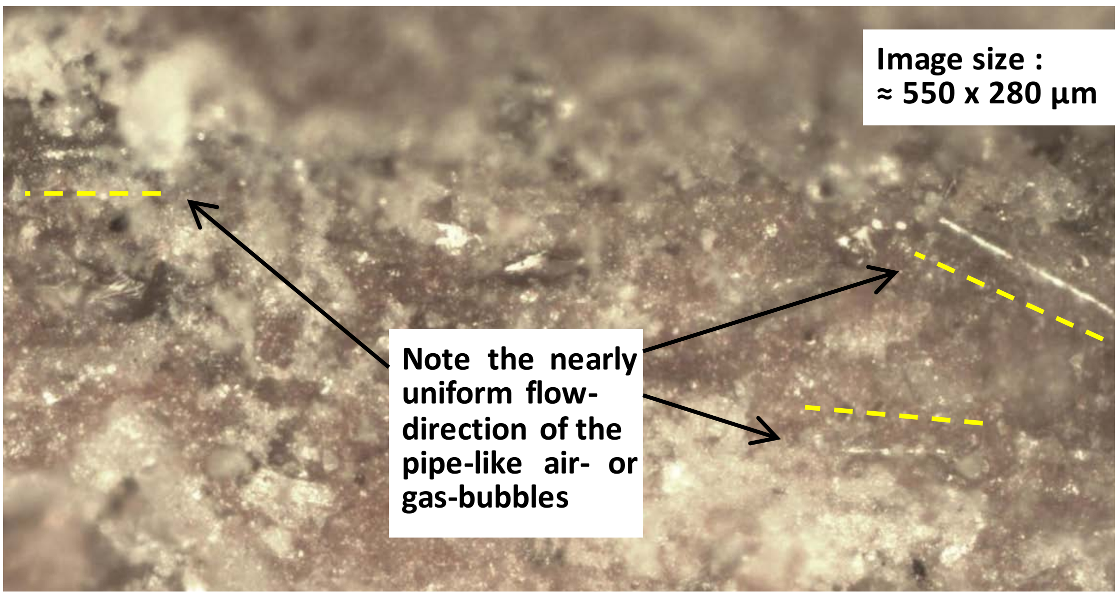


Sample :

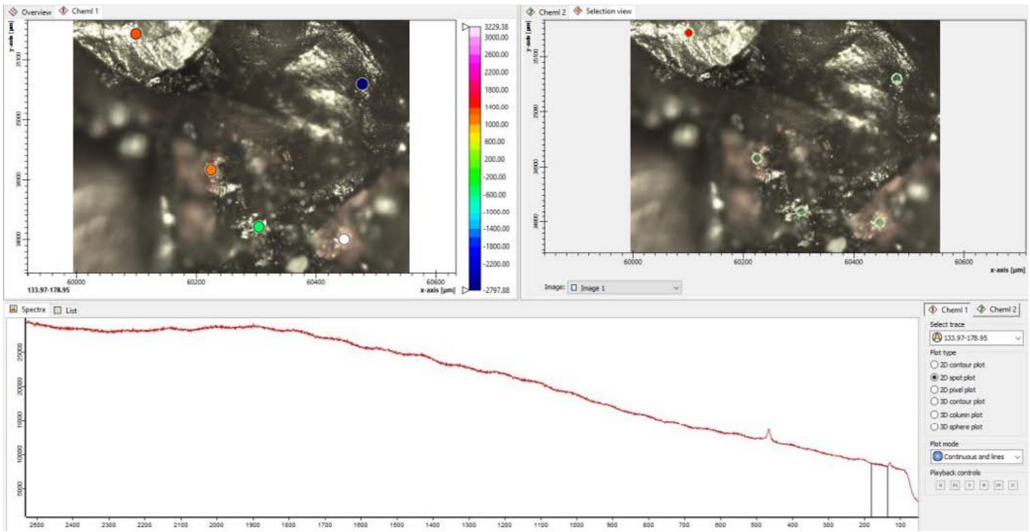


Note : This red-colored stone is from the same coherent mass of glass-like material with air-bubbles as stone 3 (previous page)

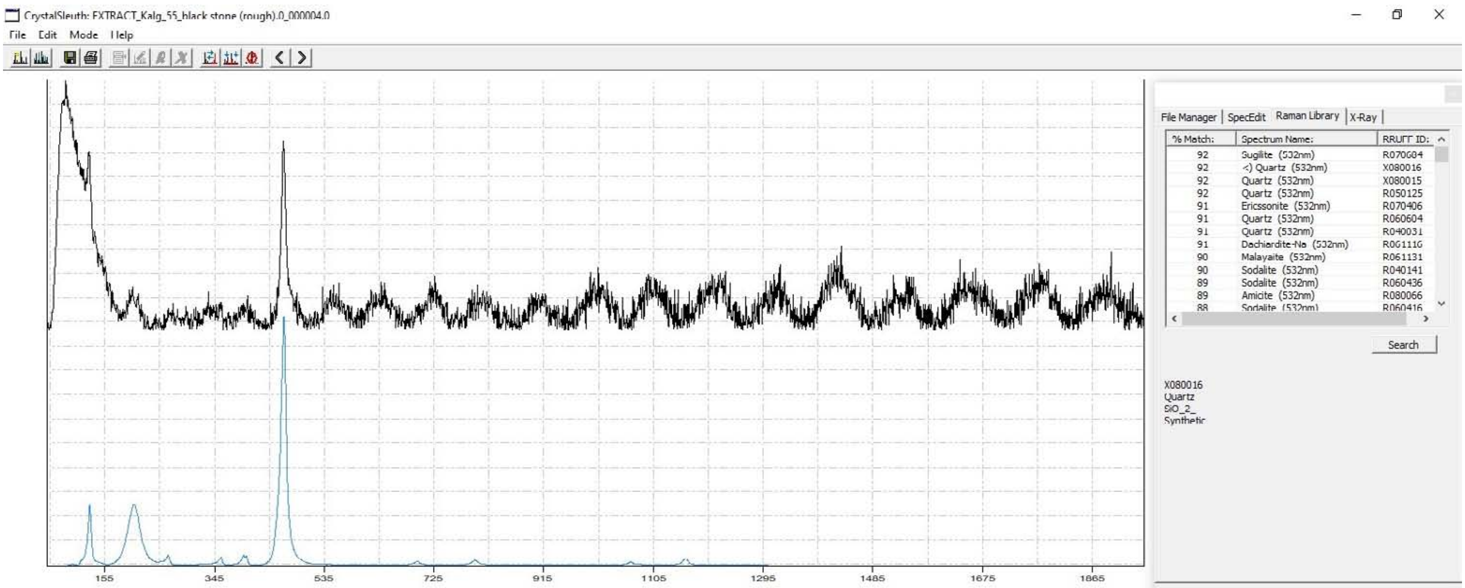
The spectrum indicates a glass-like amorph material that originally may have consisted of a mineral similar to quartz (before the impact event) as the other stones (1, 2 & 5) from this site indicate. **Note that some peaks of the bumps in the spectrum have similar frequencies like quartz.**



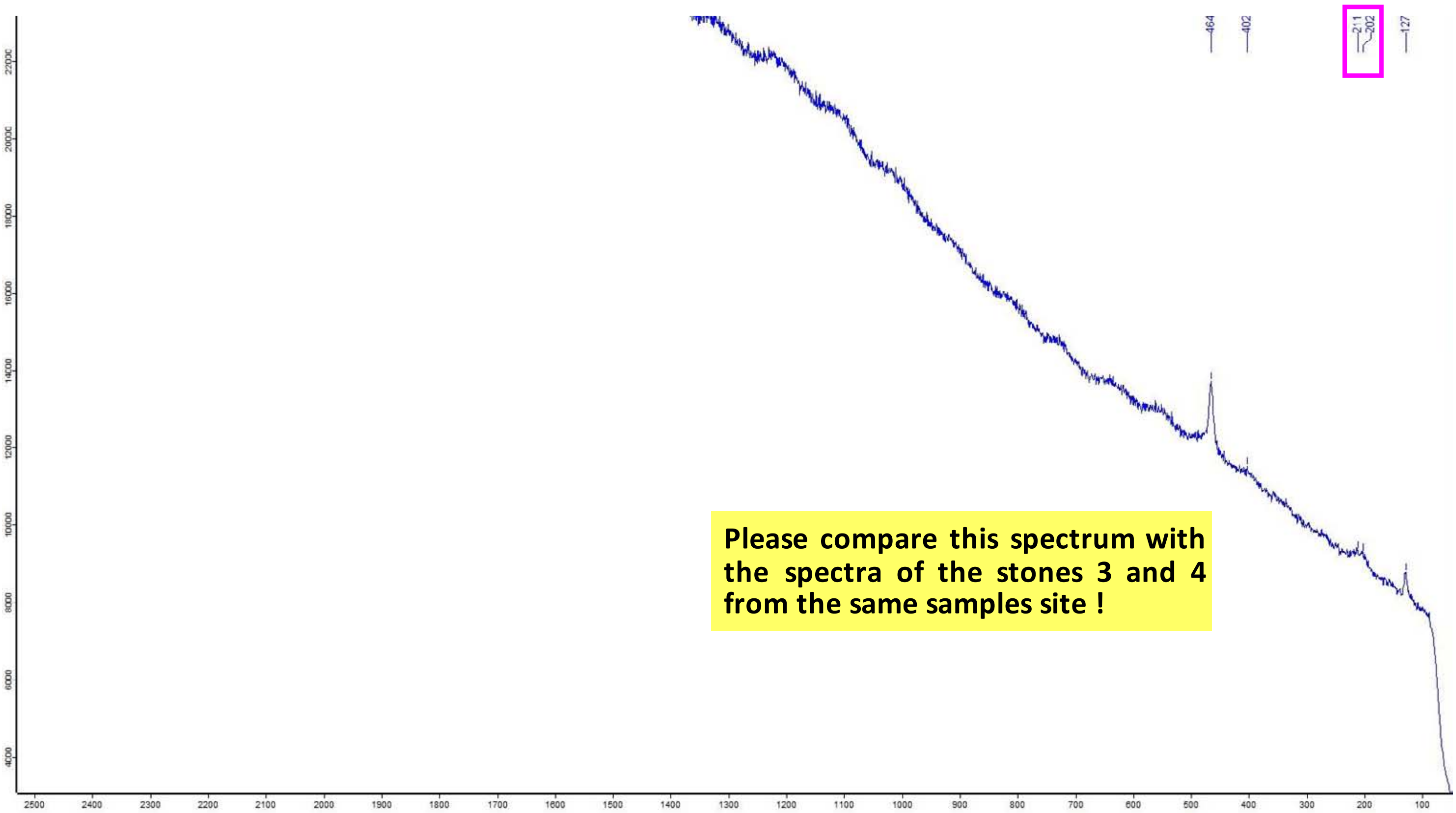
Sample Site 55 : Stone 5_spectra 1 indicates : Quartz (→ see RRUFF_CS results)



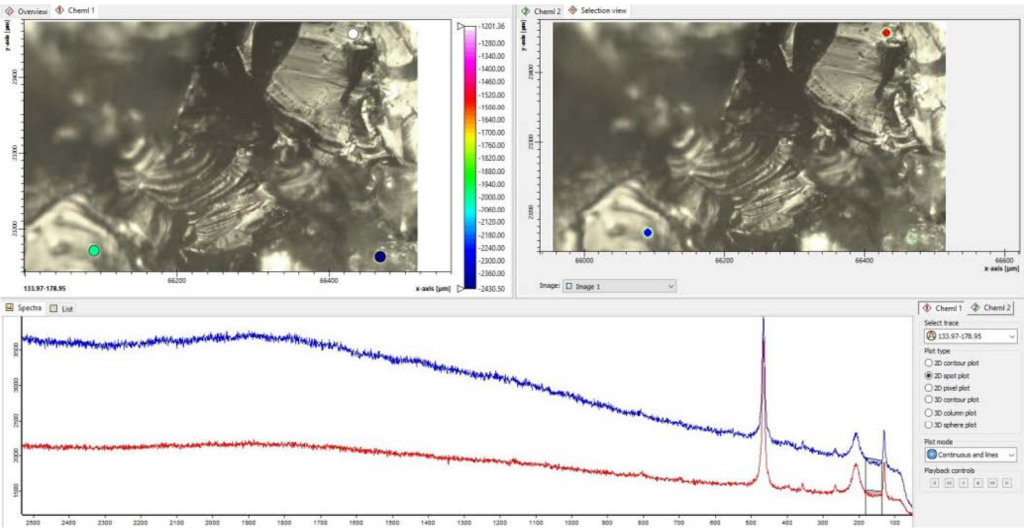
Sample :



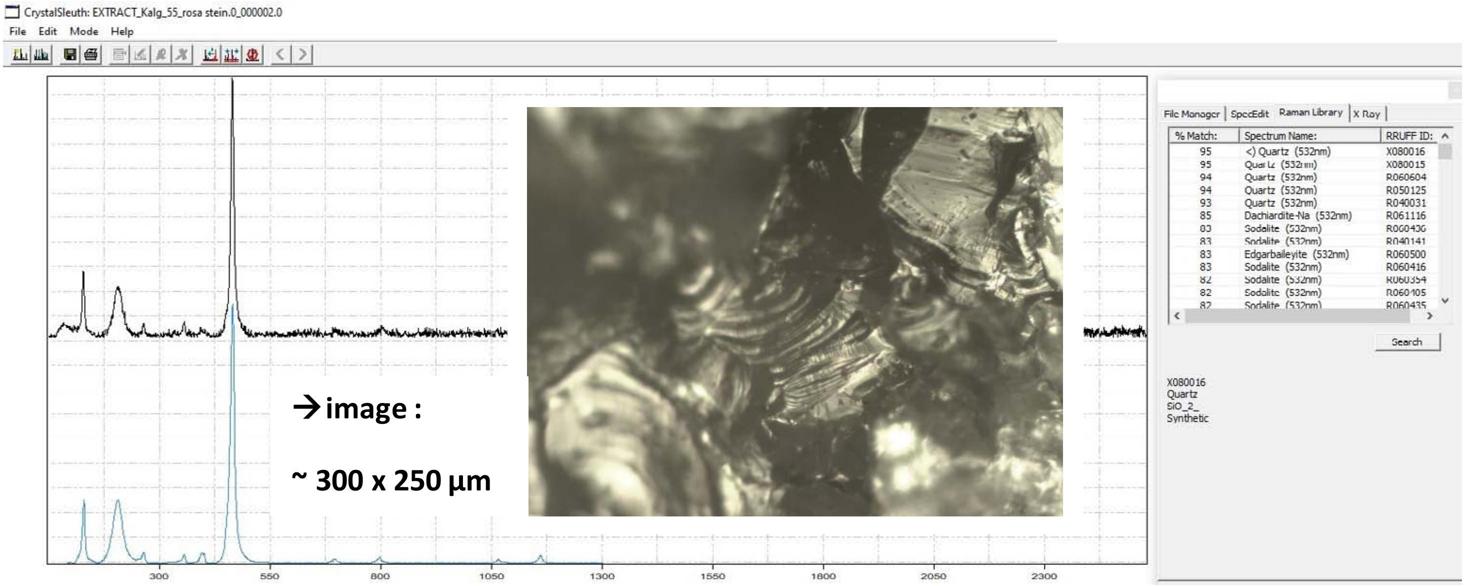
Note the nealy disappeared spectrum (→ destroyed crystal lattice ?) of the quartz → metamorphed by impact event ?



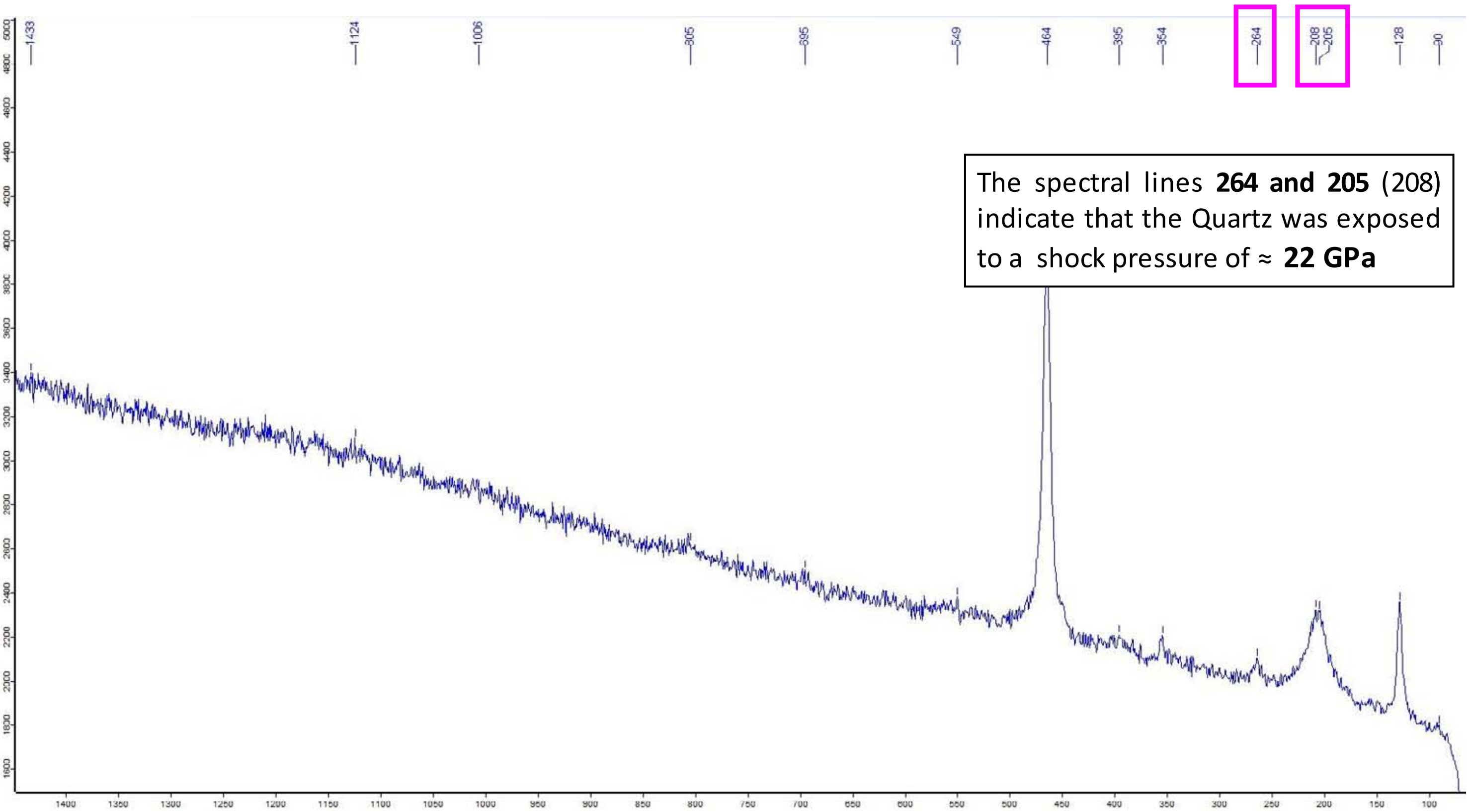
Sample Site 55 : Stone 6_spectra 1 (light pink mineral) indicates : Quartz (→ see RRUFF_CS results)



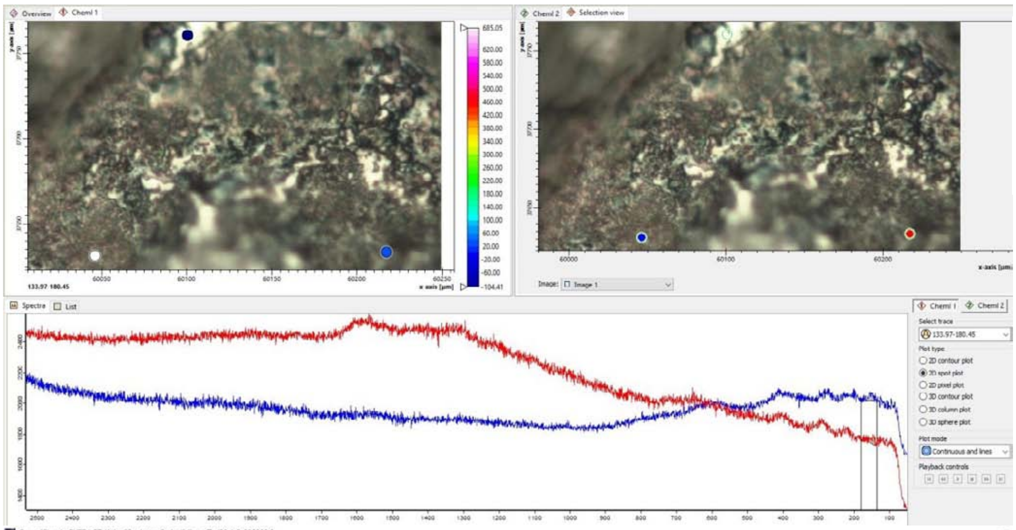
Sample :



Indication for a shock event are the shifts of the marked Quartz spectral lines towards 264 and 205 (208)

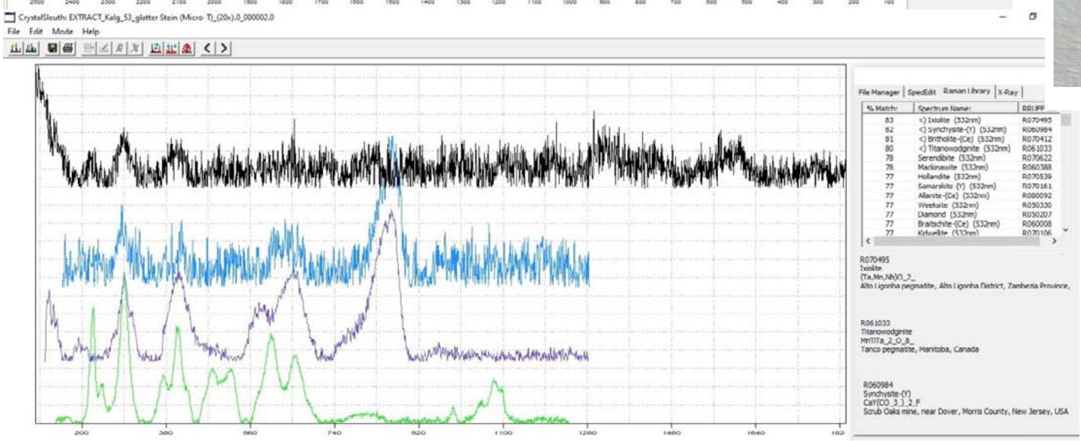


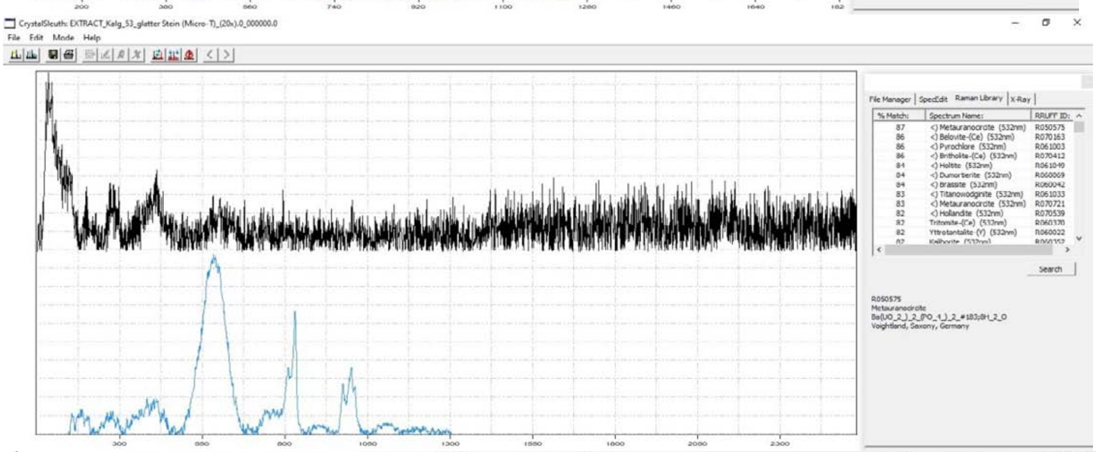
Sample Site 53 : Stone 1_spectra 1 indicates : Ixiolite, Titanowodginite, Synchysite-(y) & Metauranocirite

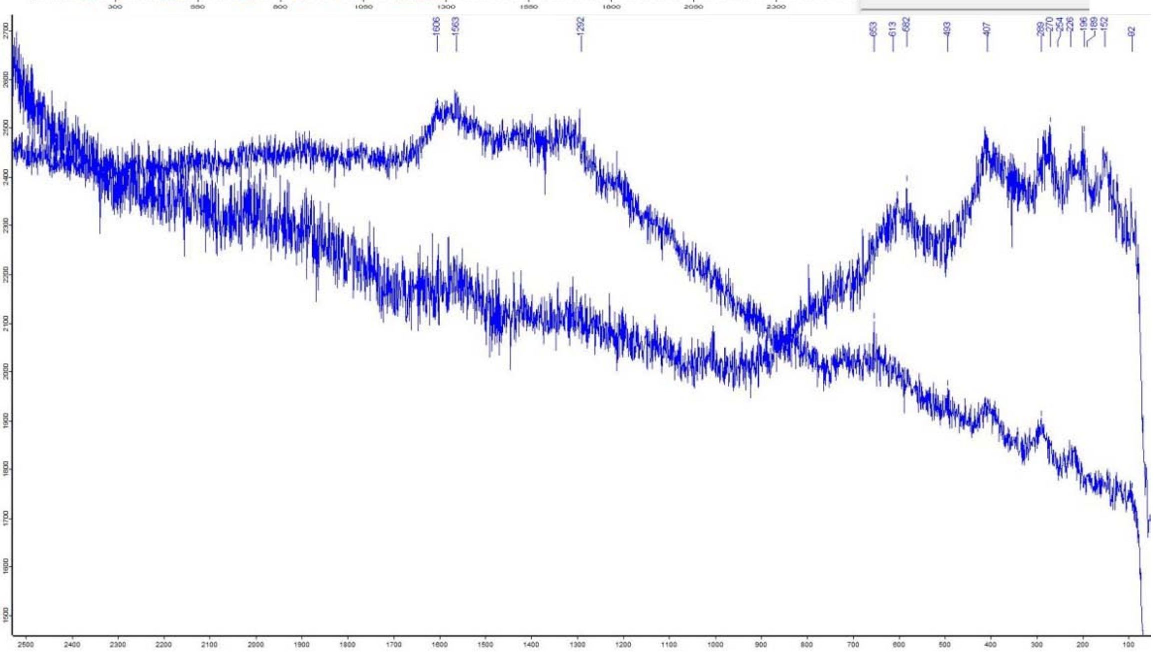


Note : This black glass.like material is covering the surface of sample site 53.

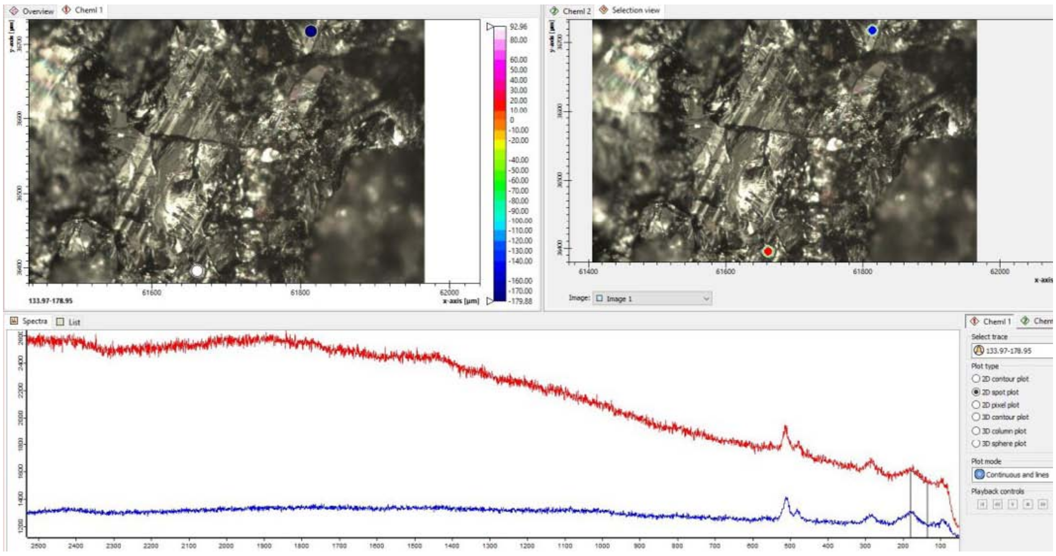
Sample :



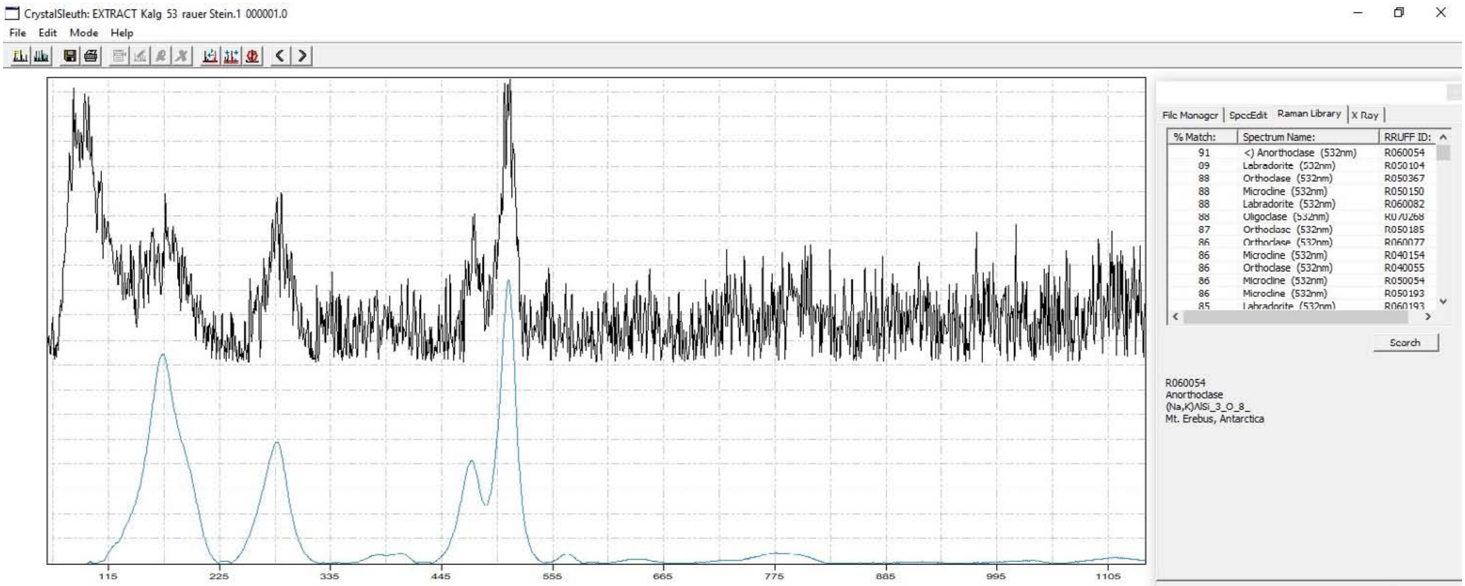


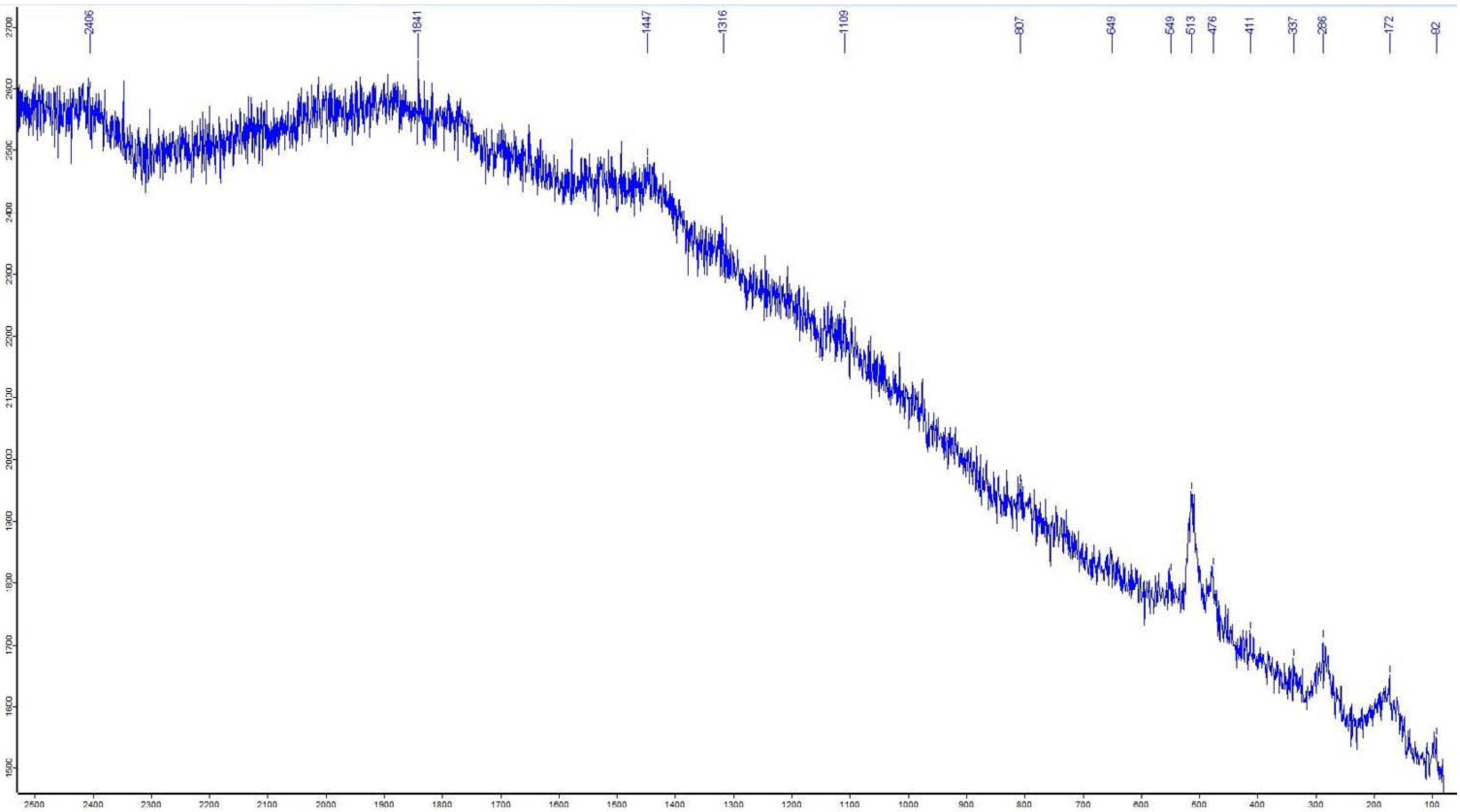


Sample-Site 53 : Stone 2_spectra 1 indicates : Anorthoclase (→ see RRUFF_CS results)

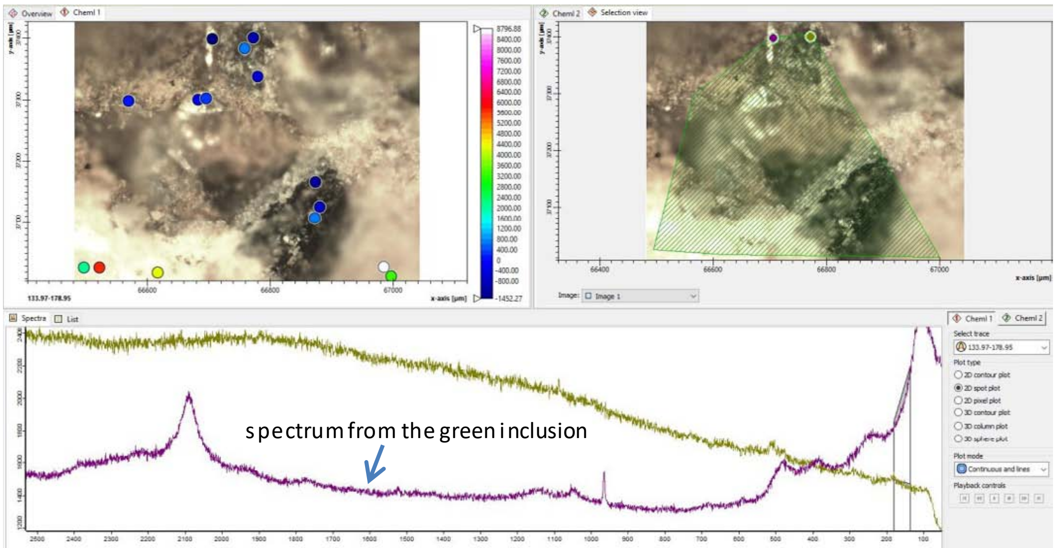


Sample :



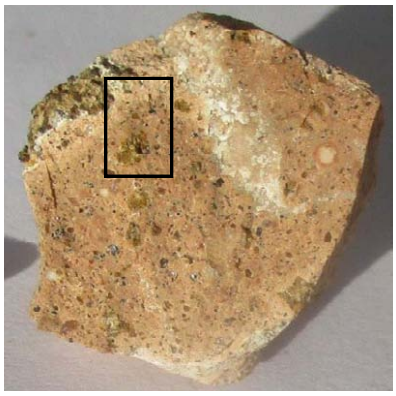


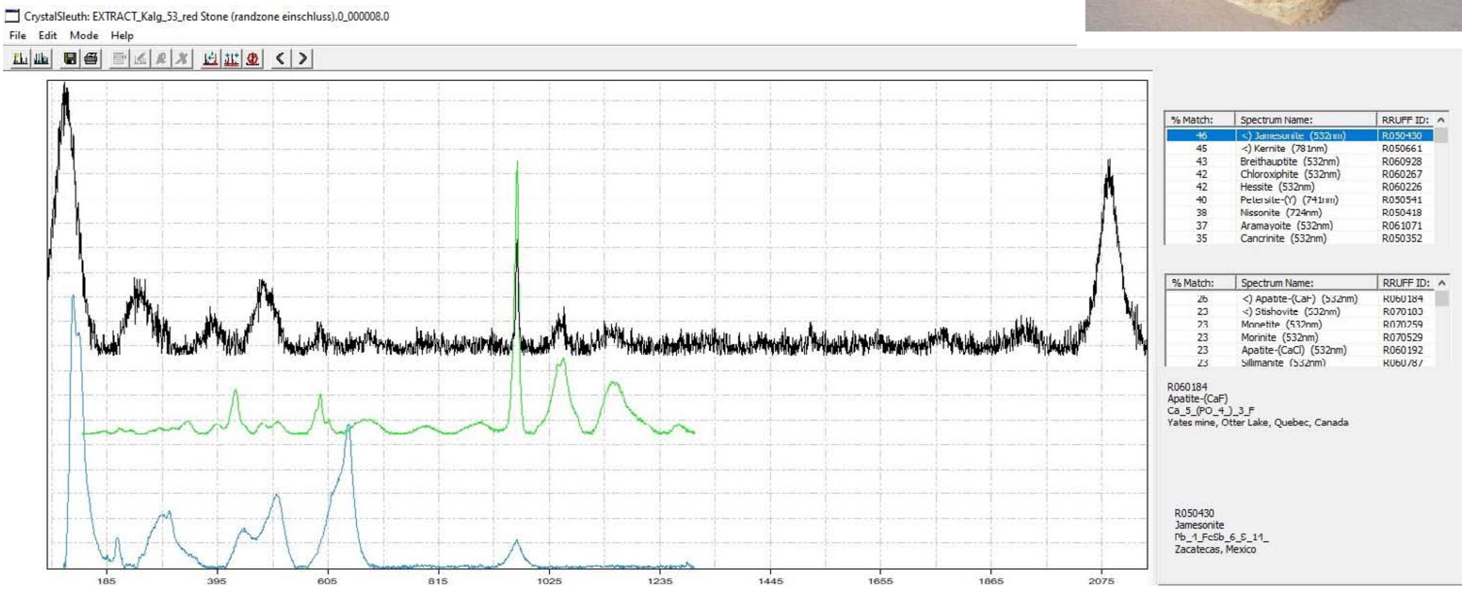
Sample-Site 53 : Stone 3_spectra 1 indicates : Jamesonite, Apatite-(CaF) (→ see RRUFF_CS results)

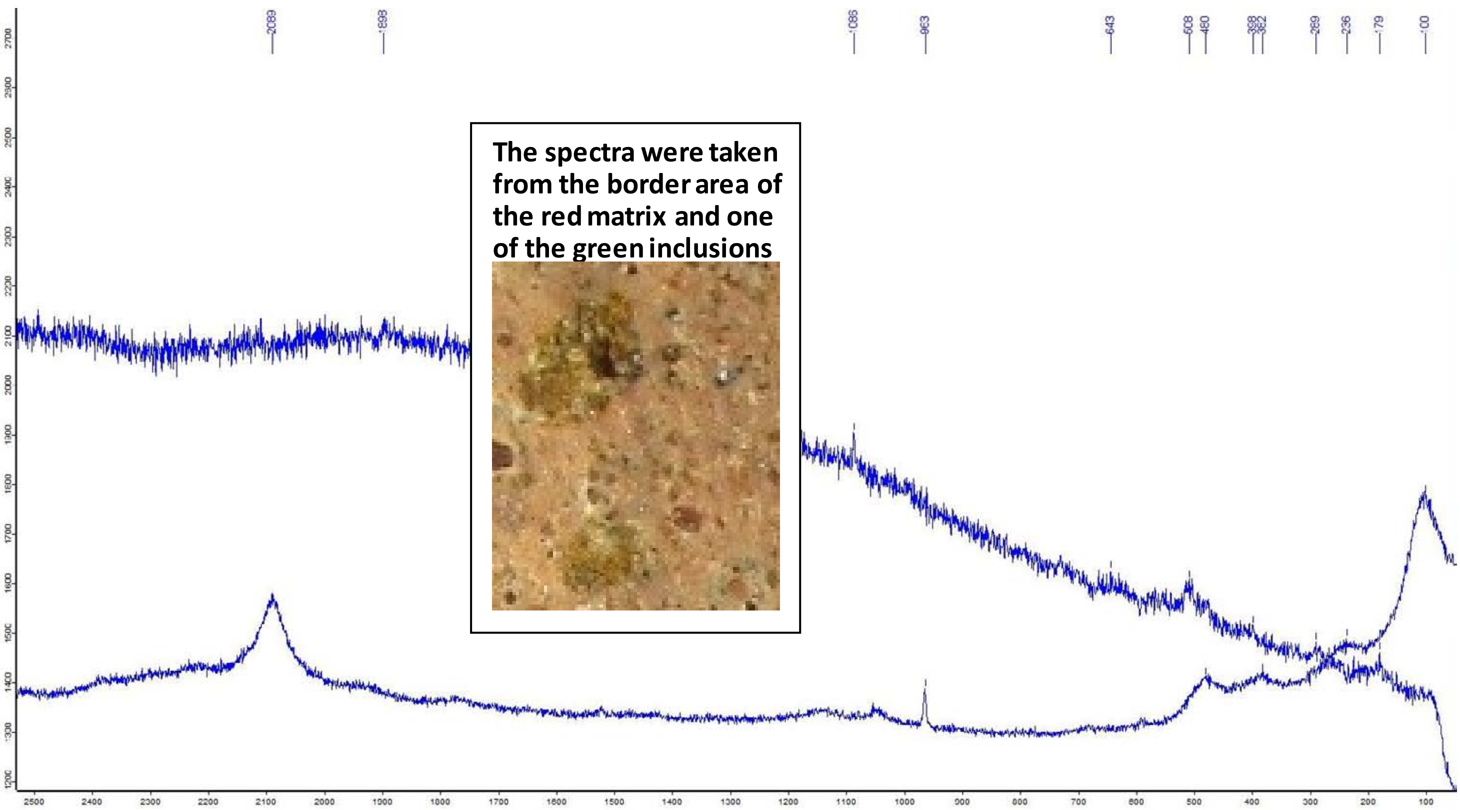


Note : the red matrix of the stone didn't provide a usable spectrum. Only the green inclusion provided a usable spectrum

Sample :

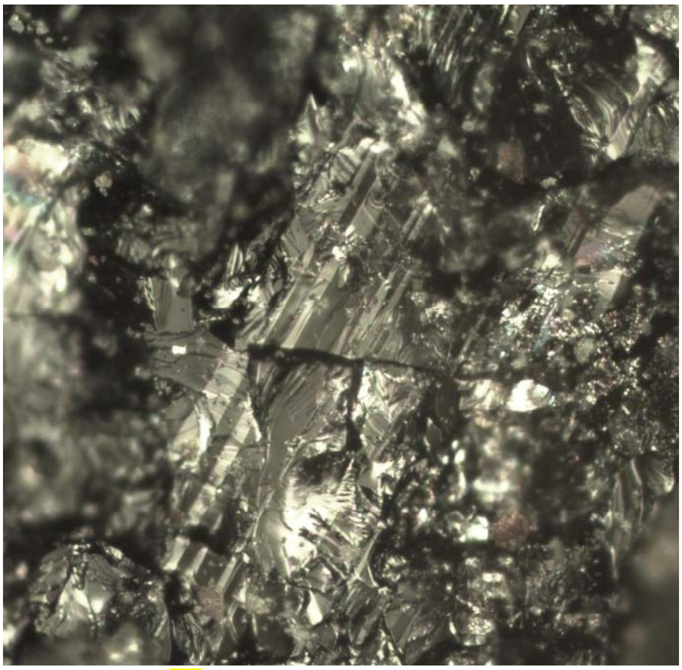




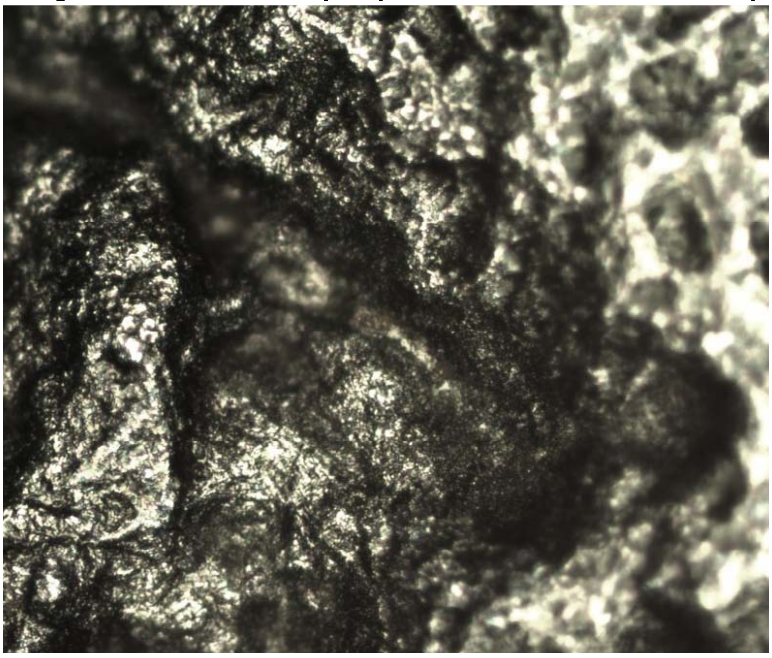


Microscopic Images : Samples from Site 53 an 55 → original state (no preparation)

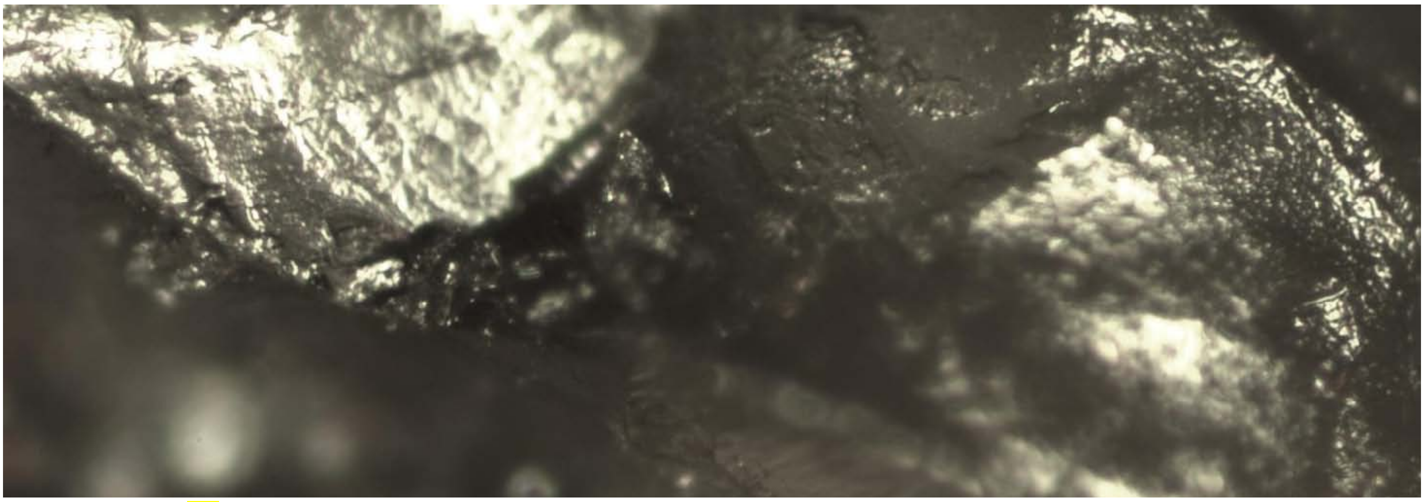
Sample Site 53 : Stone 2_spectra 1 indicates : Anorthoclase - Image size : ~ 300 x 300 µm



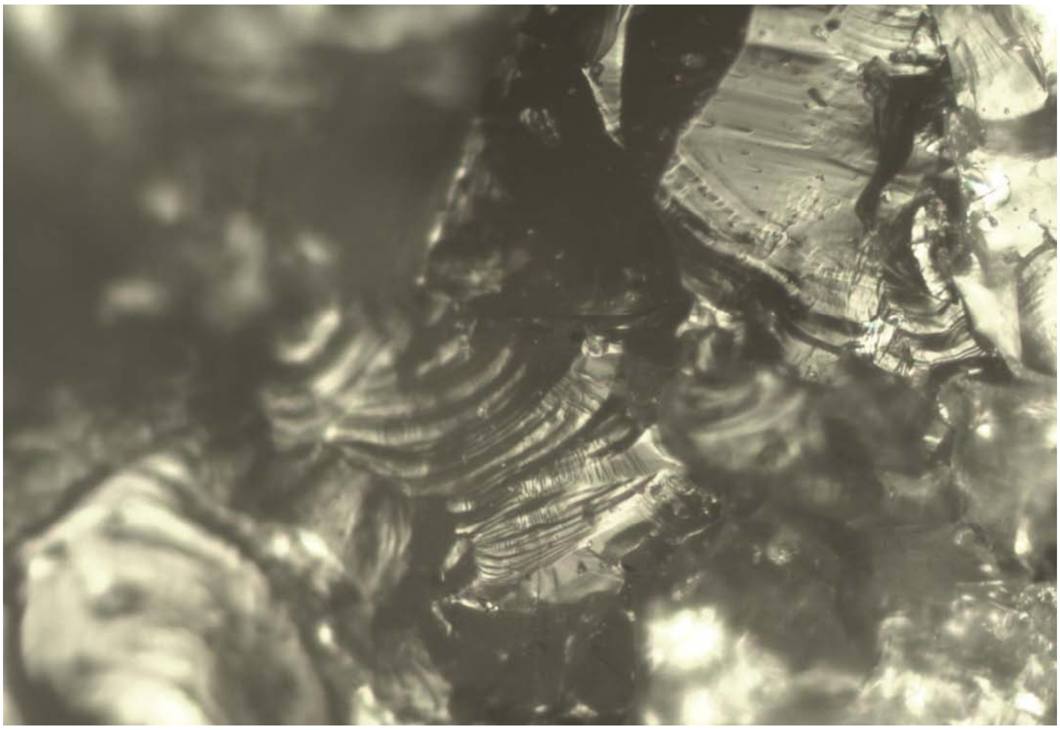
Sample Site 53 : Stone 1_spectra 1 indicates : Ixiolite, Titanowodginite, Synchysite-(y) & Metauranocirite
Image size : ~ 350 x 300 µm (melted surface structure ?)



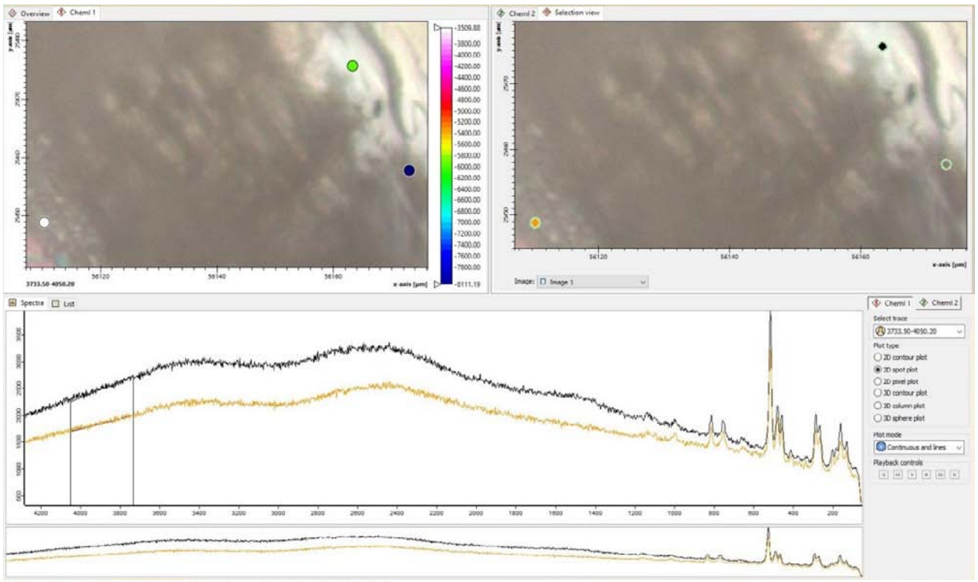
Sample Site 55 : Stone 5_spectra 1: Quartz - Image size : 500 x 170 µm



Sample Site 55 : Stone 6_spectra 1 indicates : Quartz : ~ 400 x 300 µm

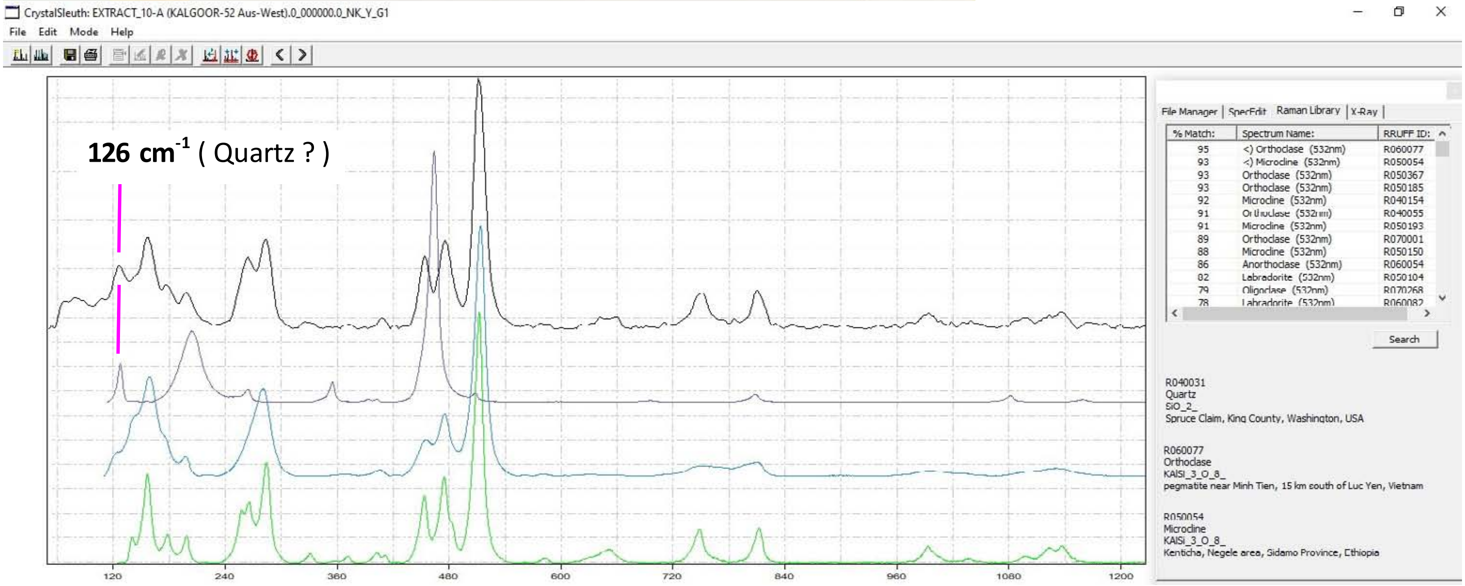


Sample Site 52 : Stone 1_spectra 1 indicates : Orthoclase / Microcline + Quartz (→ see RRUFF_CS results)

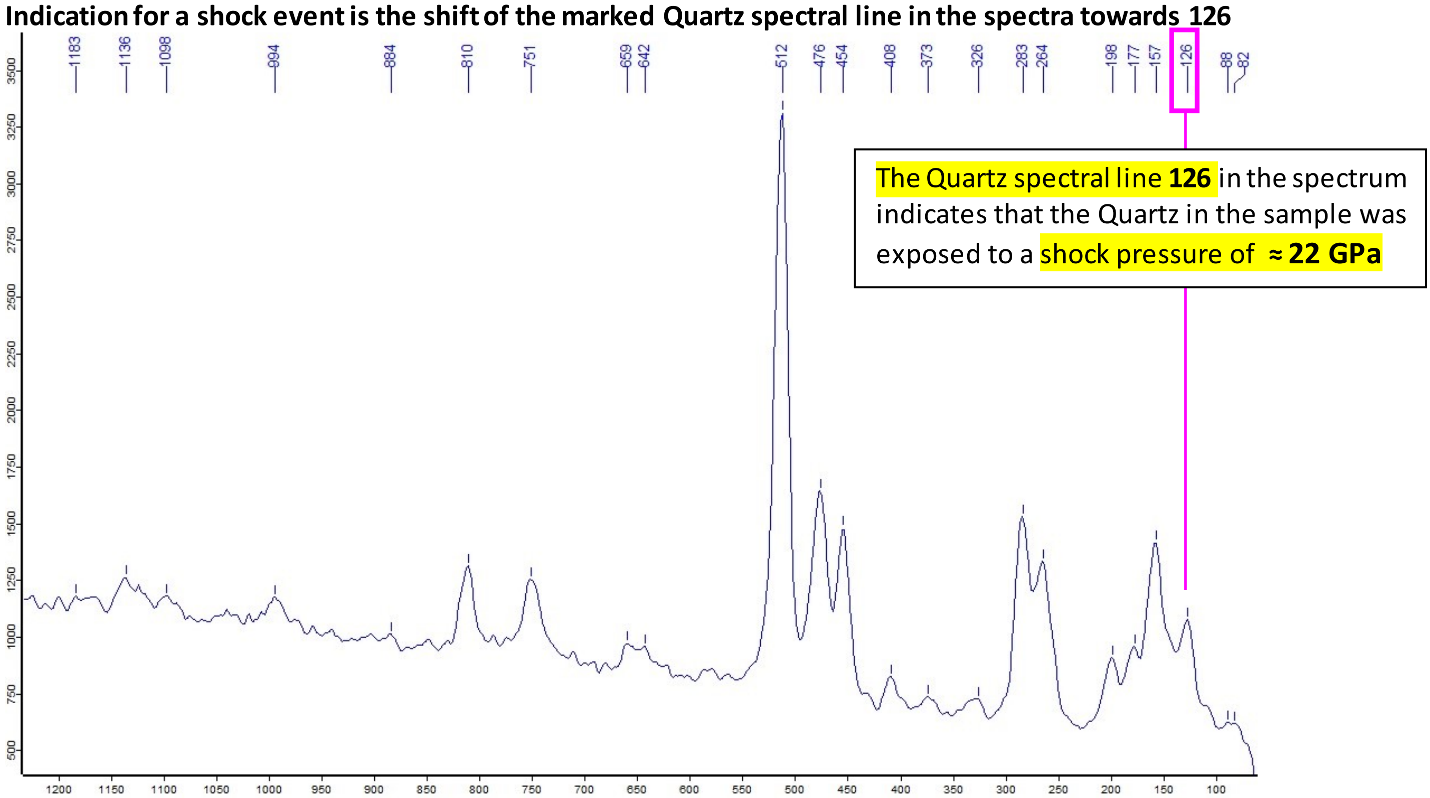


The spectral line at **126 cm^{-1}** indicates that Quartz is present in the sample. (30 % match) The stone probably contains a small amount of Quartz

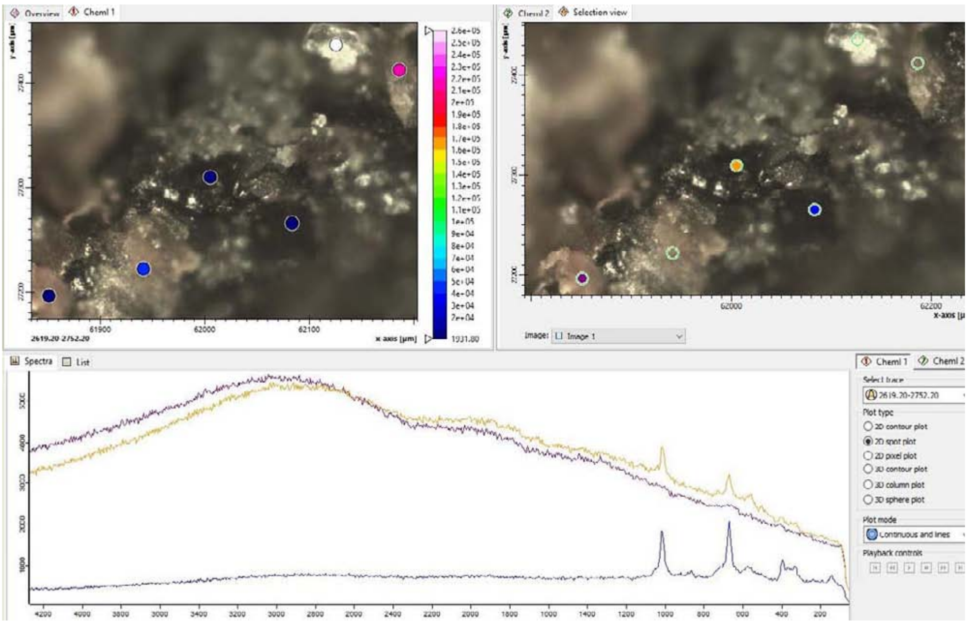
Sample :



Indication for a shock event is the shift of the marked Quartz spectral line in the spectra towards 126

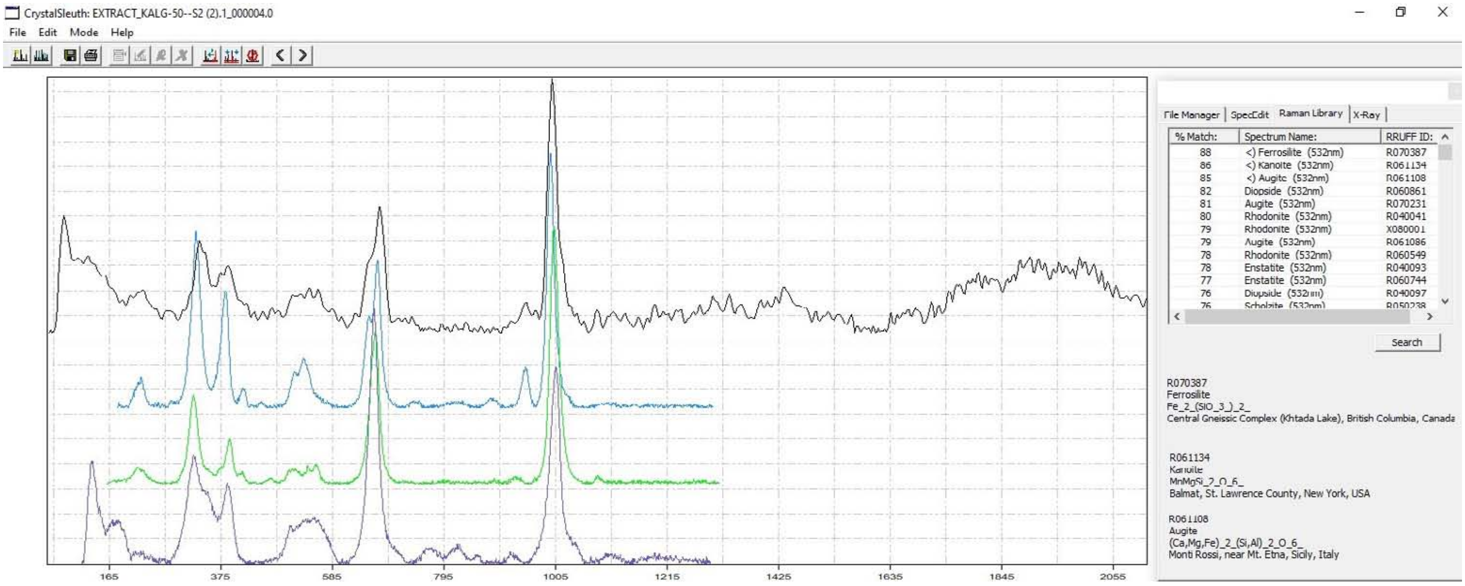


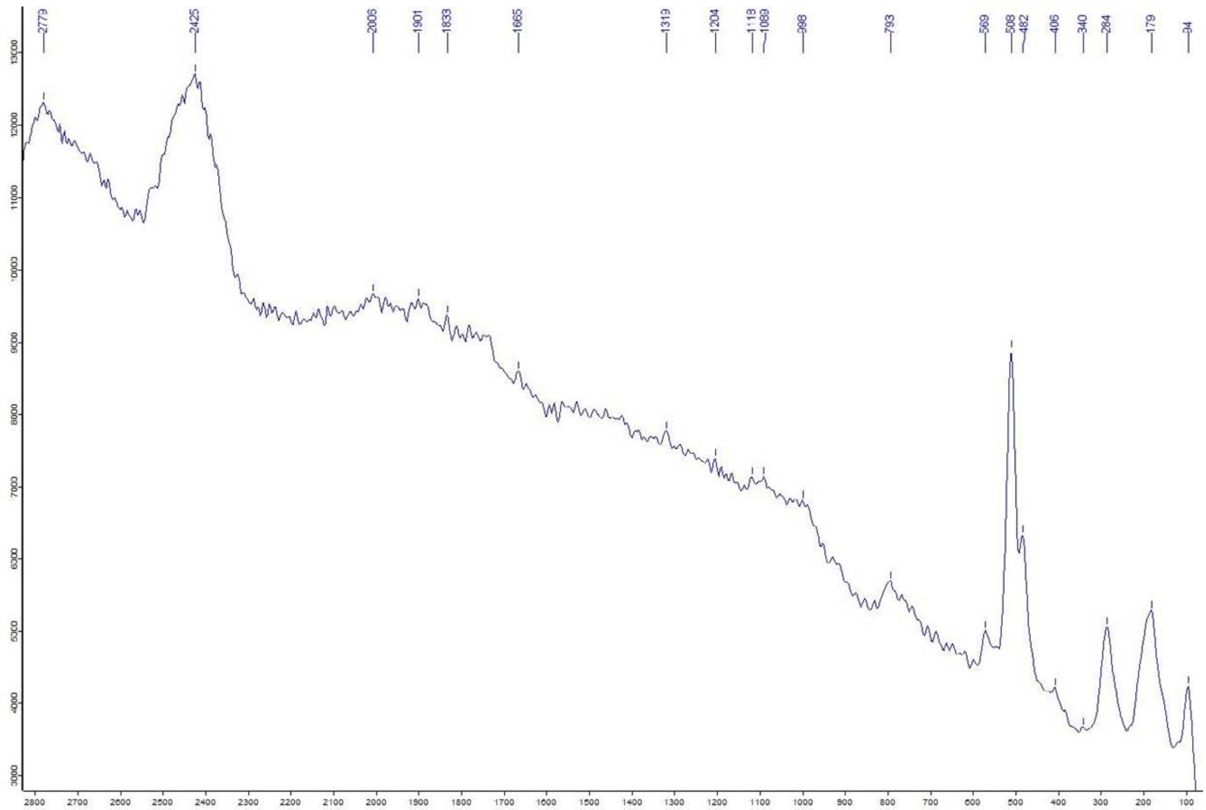
Sample-Site 50 : Stone 2_spectra 2 indicates : Ferrosilite, Kanoite, Augite (→ see RRUFF_CS results)



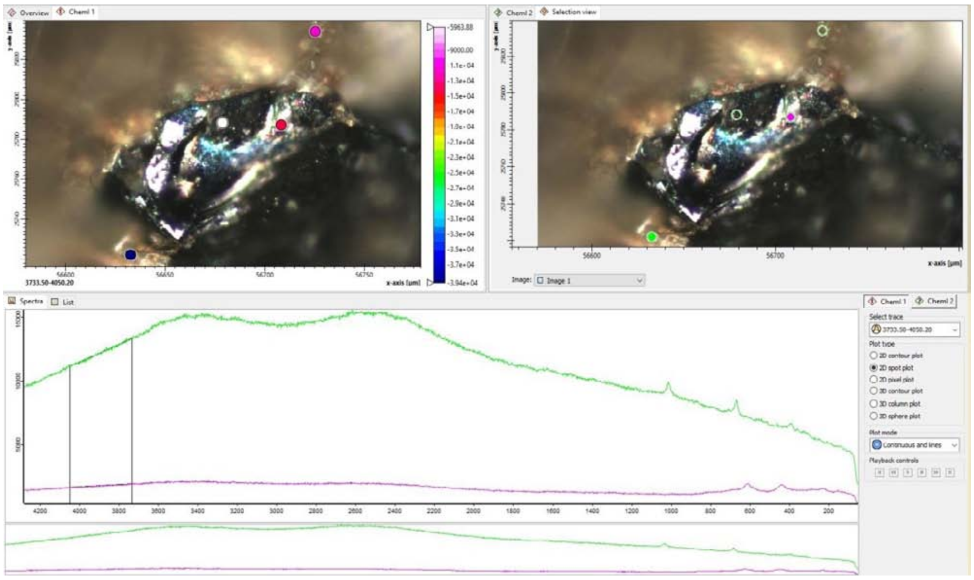
Note : Ferrosilite forms under conditions as they are in Earth's crust in ≈ 30 km depth. It contains iron and it occurs in igneous rock.
→ An indication for an origin in ejecta of a big secondary impact crater.

Sample :





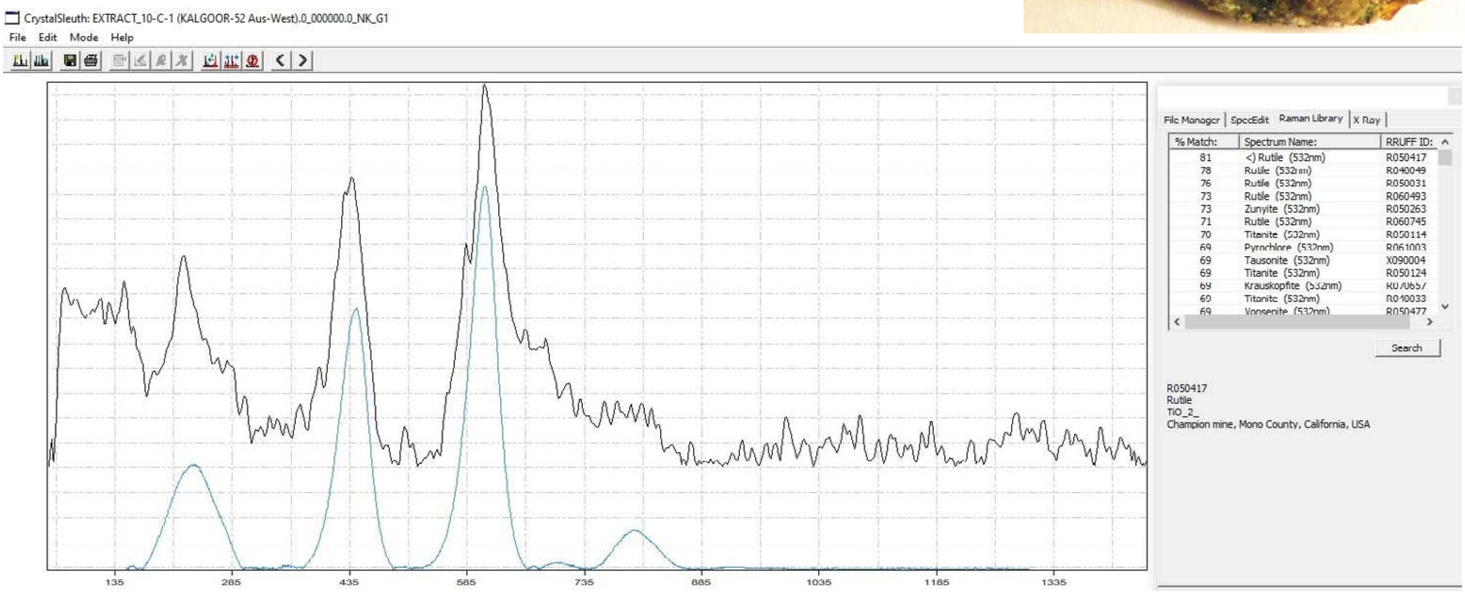
Sample Site 52 : Stone 3-A_spectra 1 indicates : Rutile (Titandioxid) (→ see RRUFF_CS results)

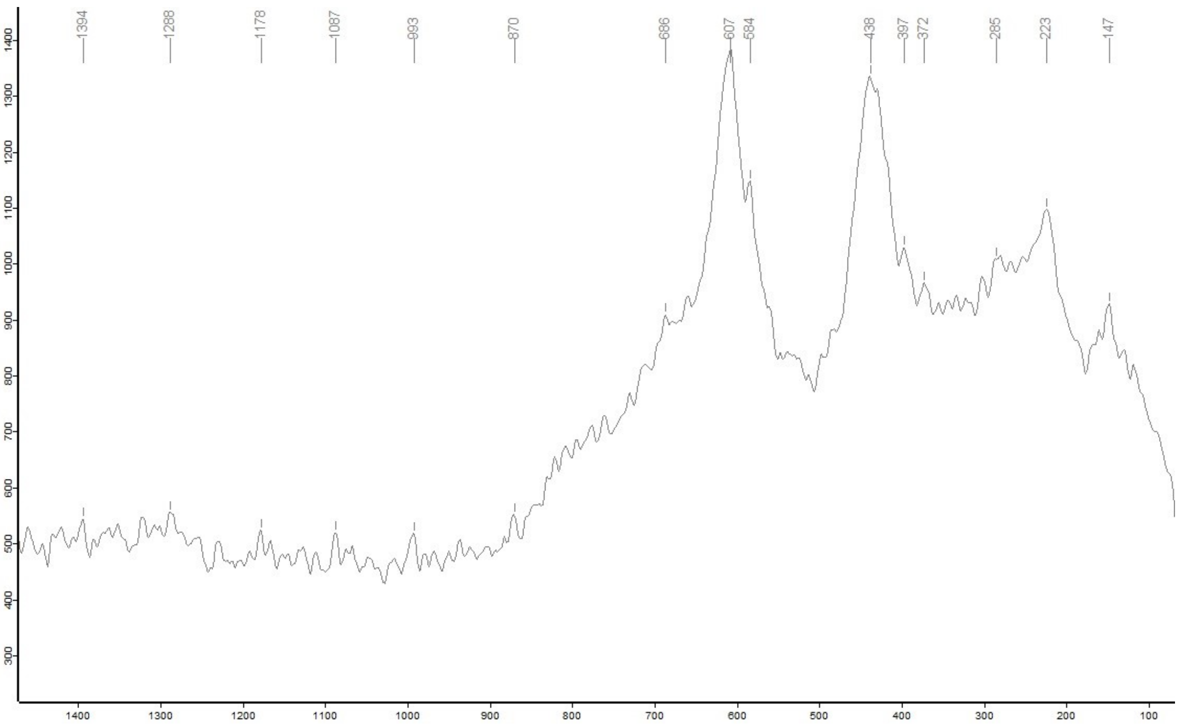


Note : Rutile forms under high-pressure or high-temperature conditions !

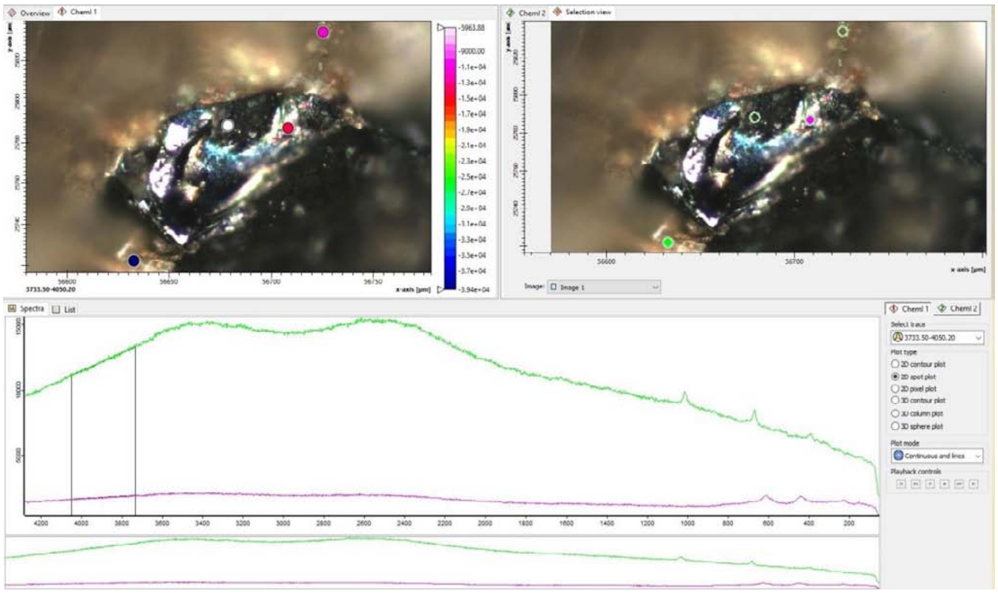
(below 500°C > 10 GPa is needed for its formation out of Anatase , above 600°C it forms under atmospheric Pressure)

Sample :

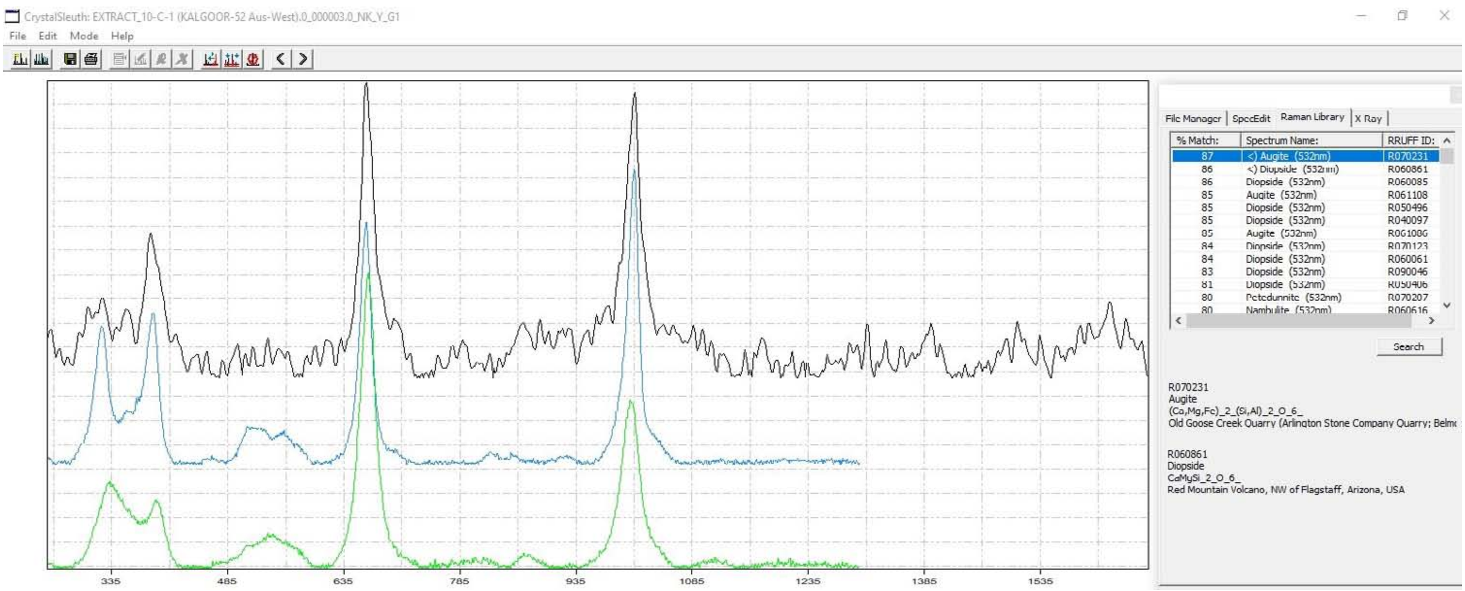


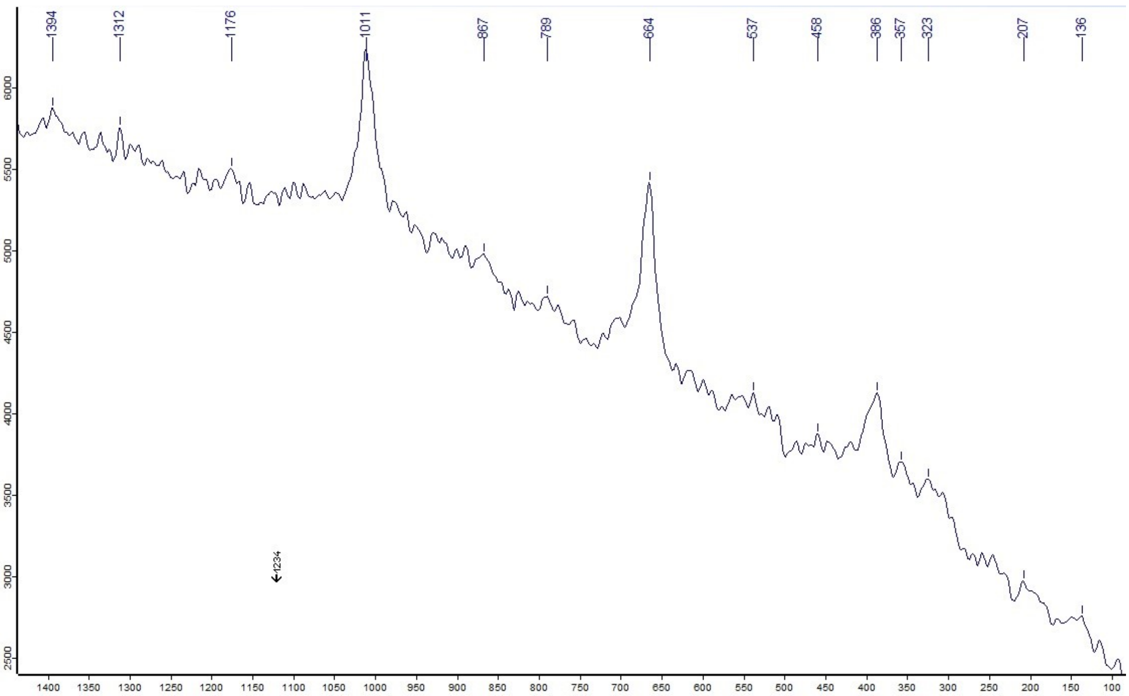


Sample Site 52 : Stone 3-A_spectra 2 indicates : Augite , Diopsite (→ see RRUFF_CS results)

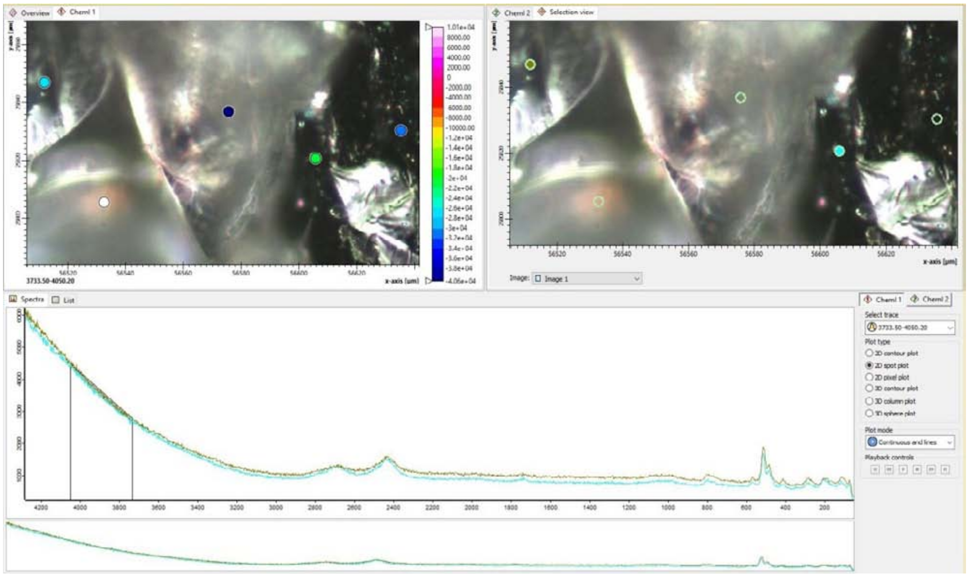


Sample :





Sample Site 52 : Stone 3-B_spectra 1 indicates : Labradorite (→ see RRUFF_CS results)



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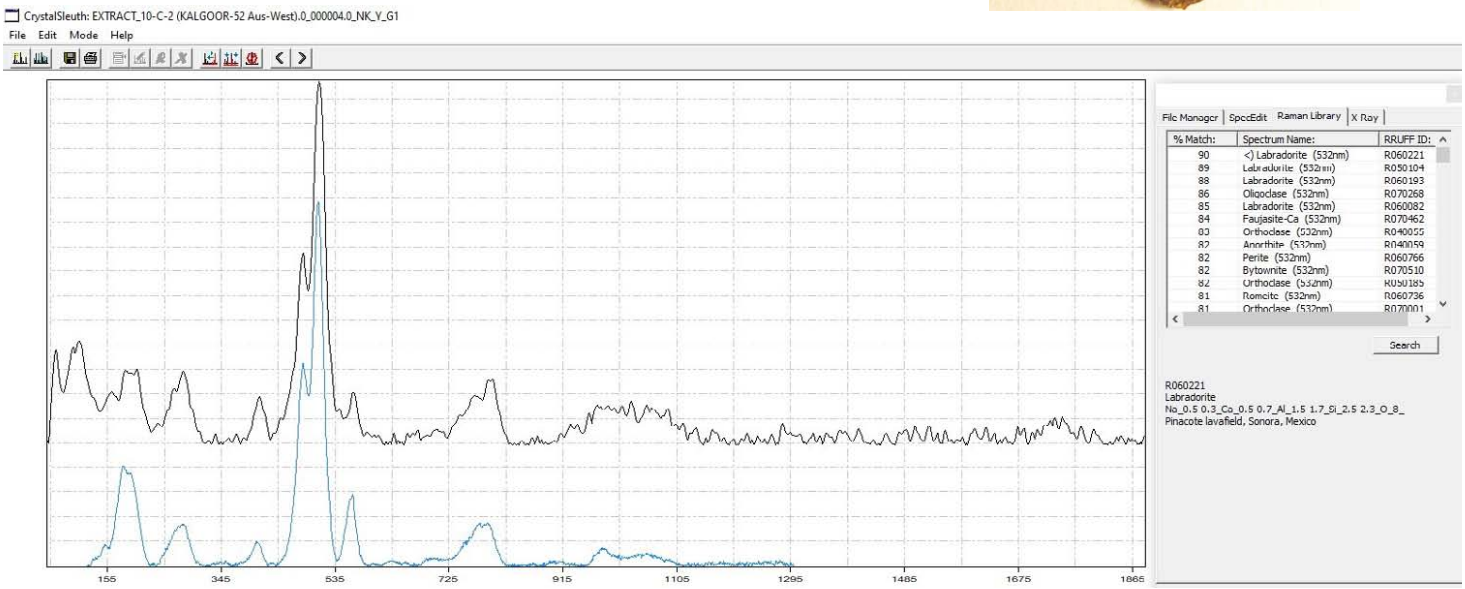
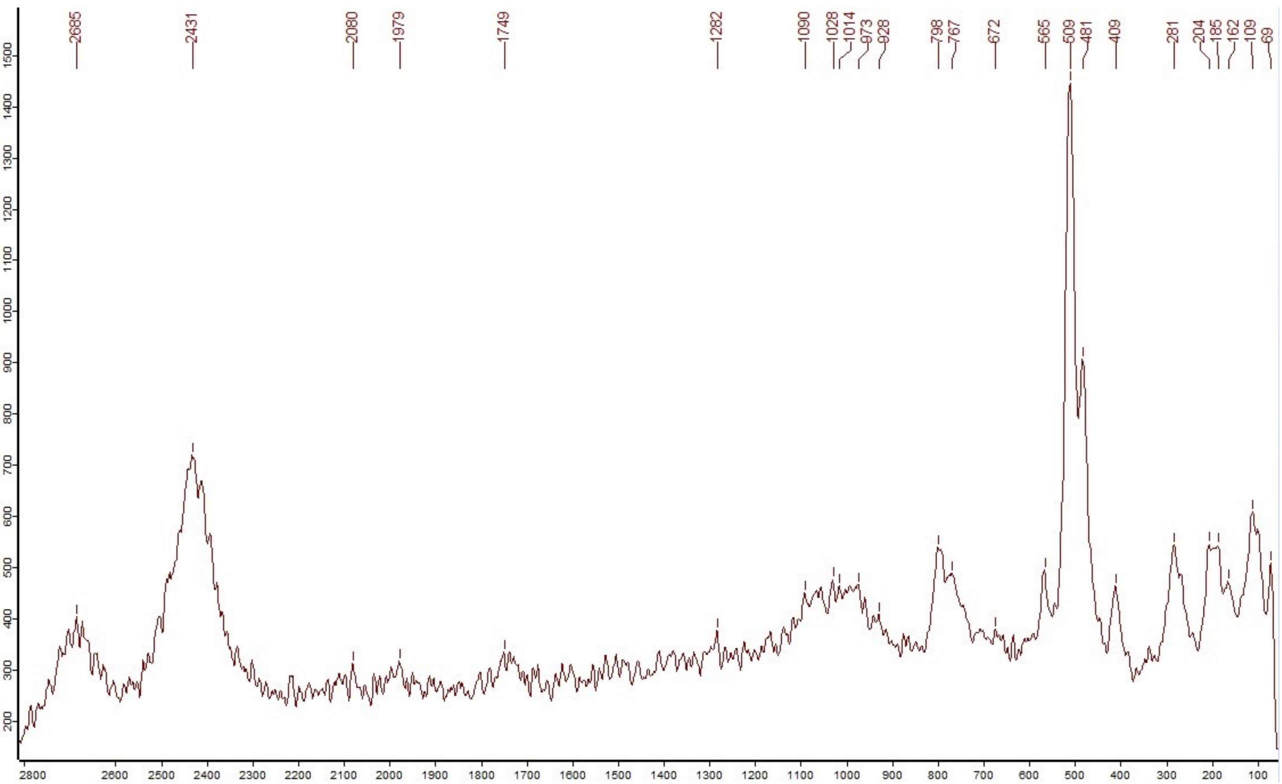
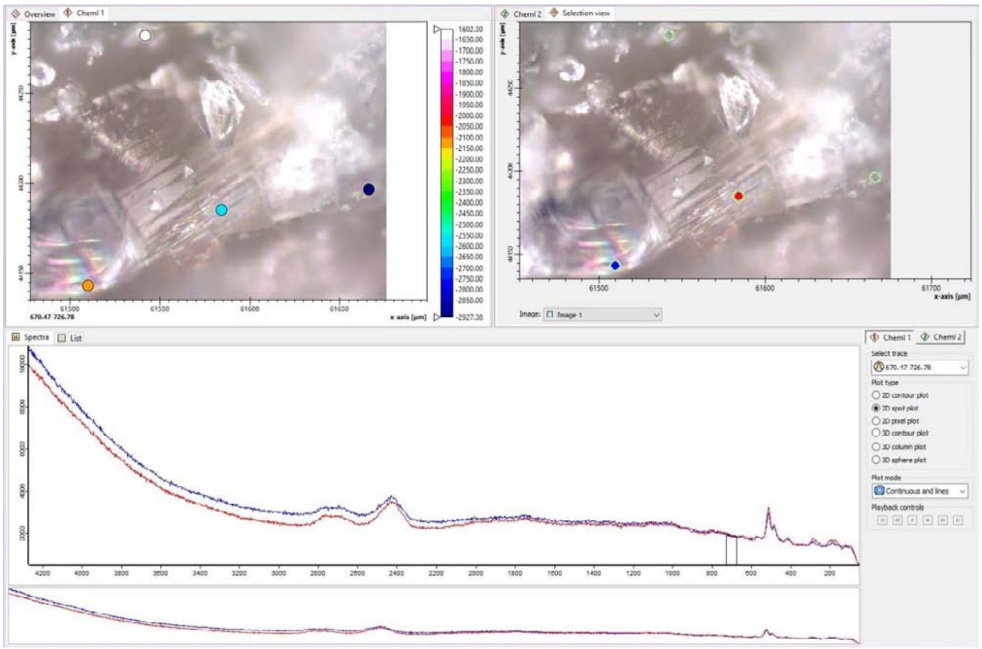
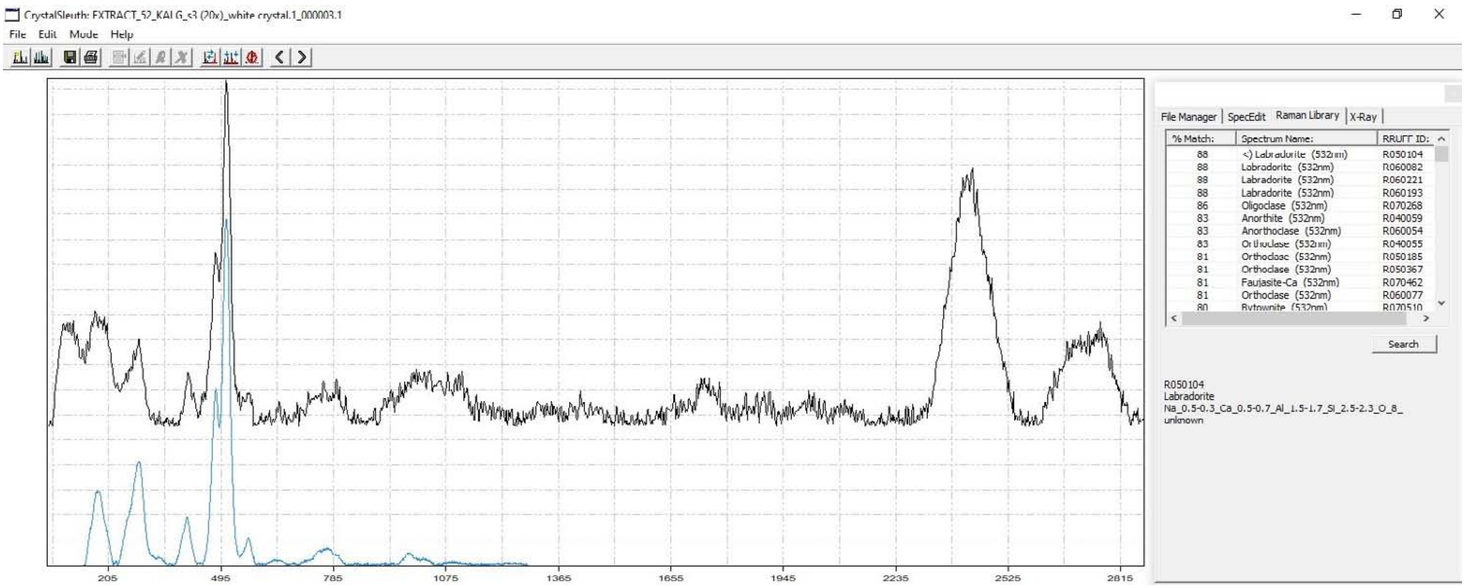


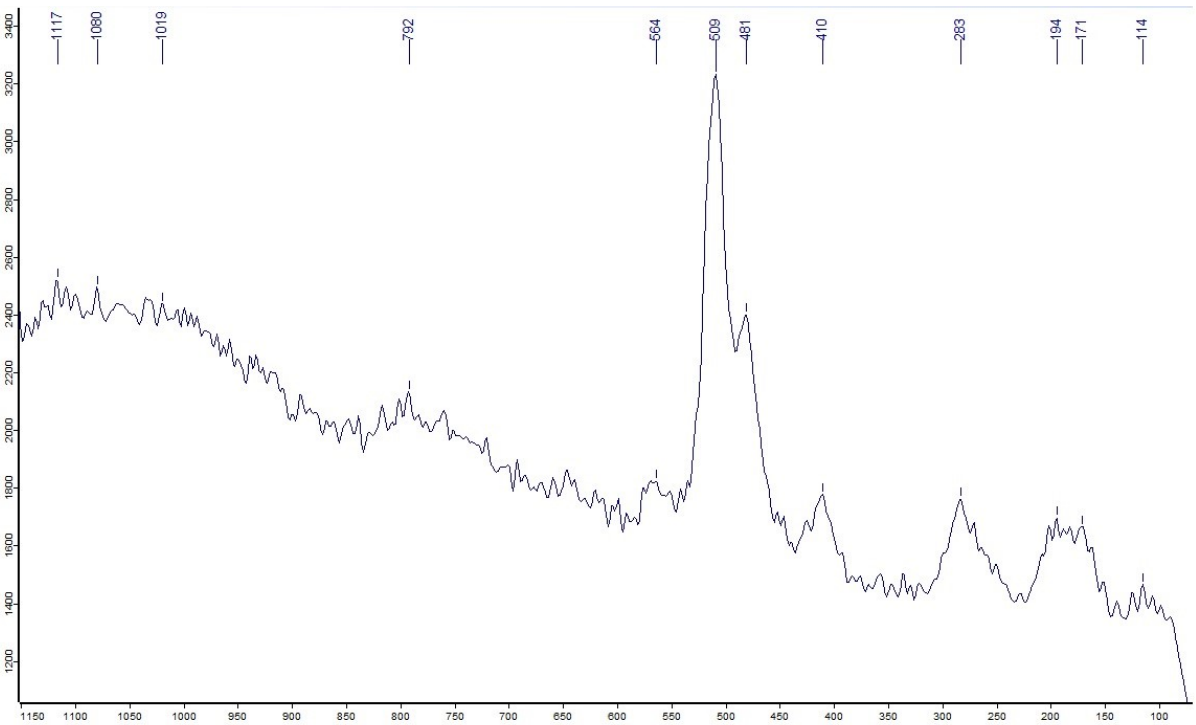


Sample Site 52 : Stone 3-B_spectra 2 indicates : Labradorite (→ see RRUFF_CS results)

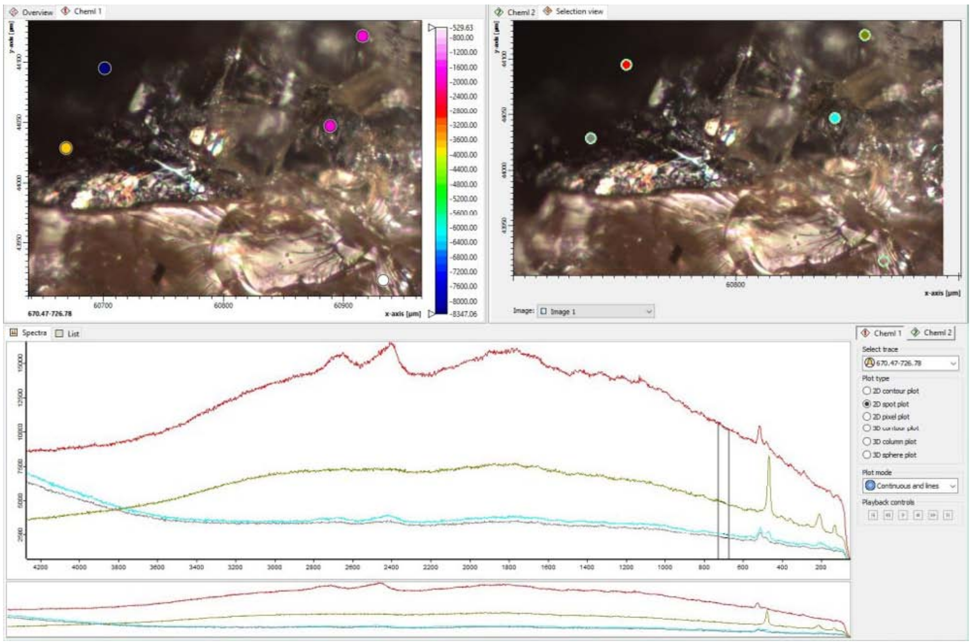


Sample :

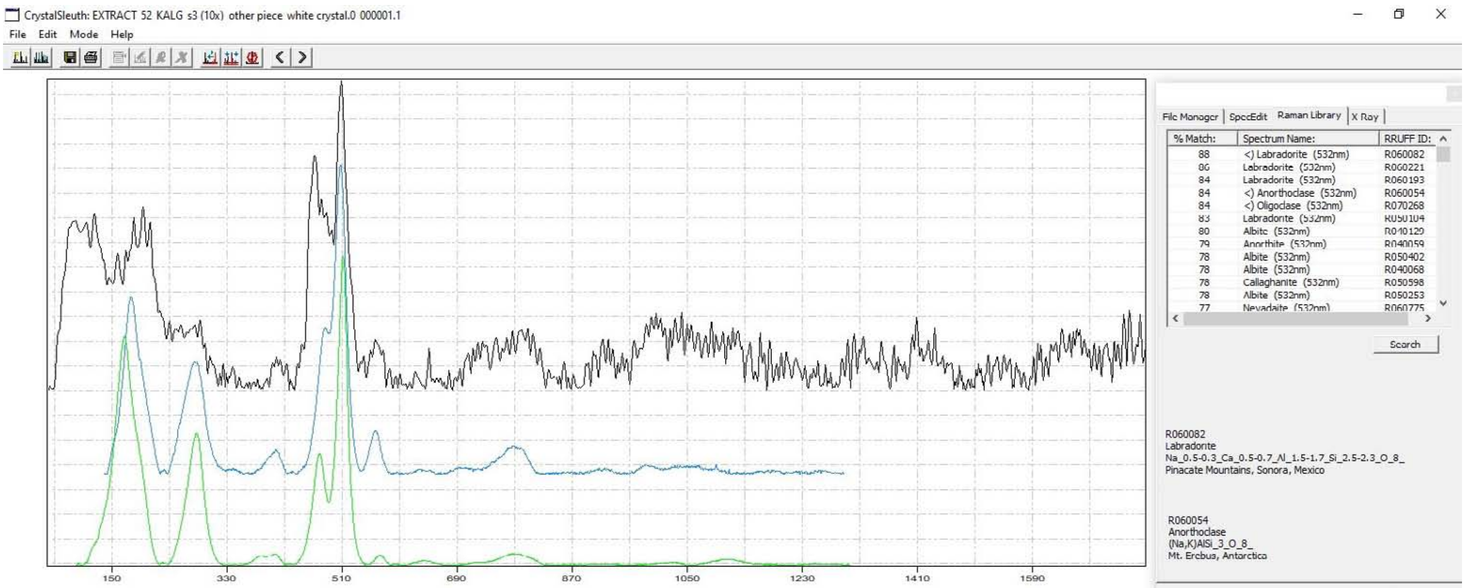


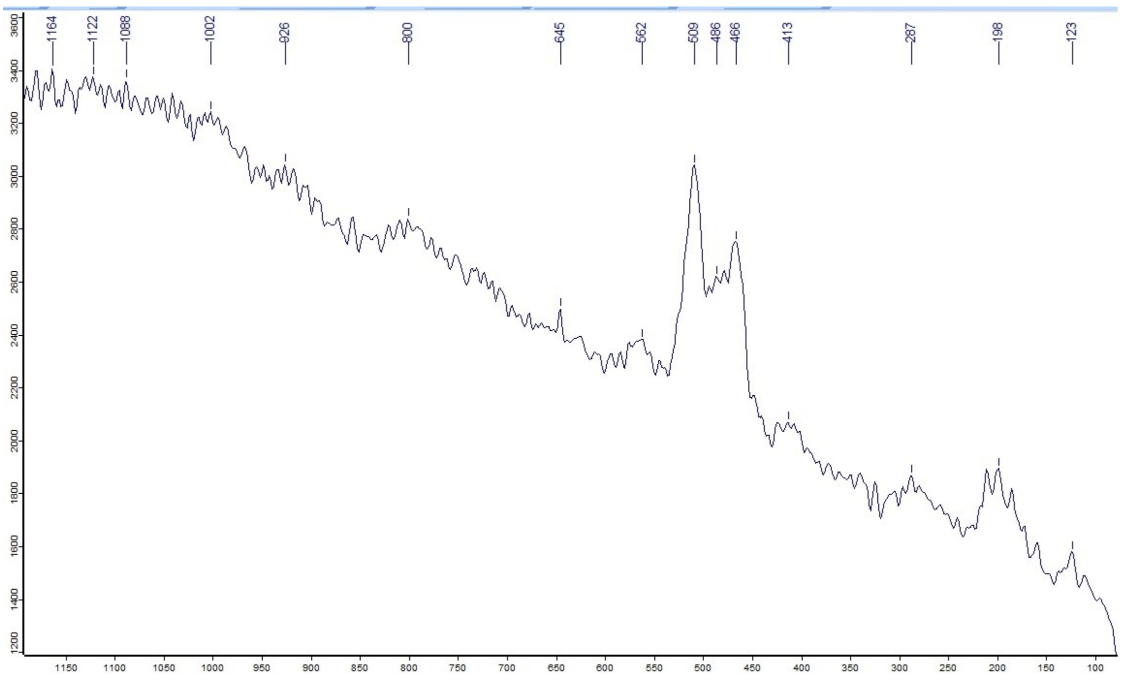


Sample Site 52 : Stone 3-B_spectra 4 (white mineral) indicates : Labradorite_Anorthoclase (→ RRUFF_CS)

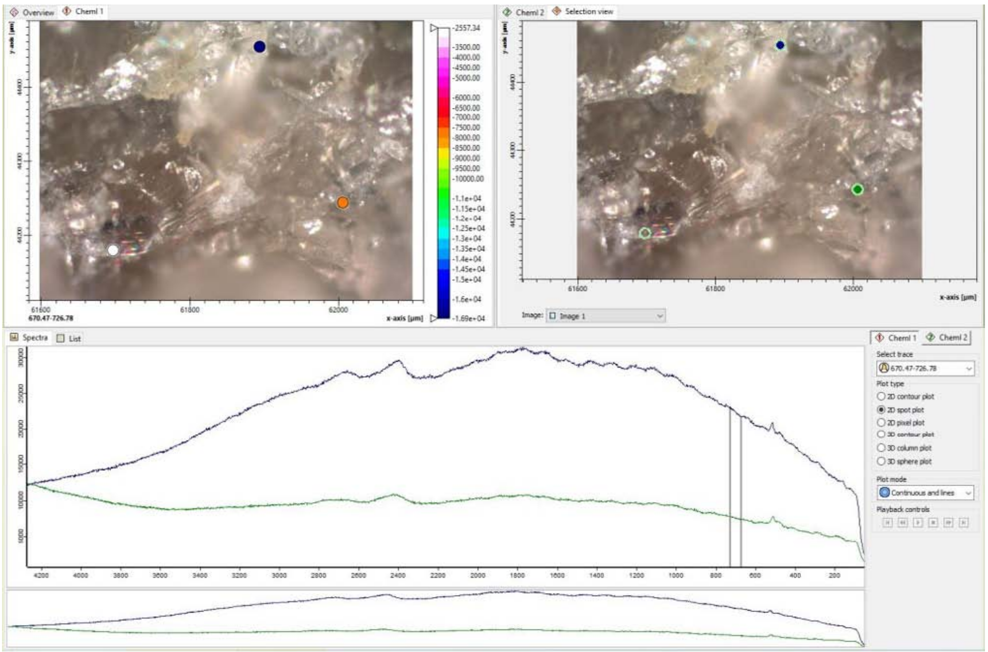


Sample :

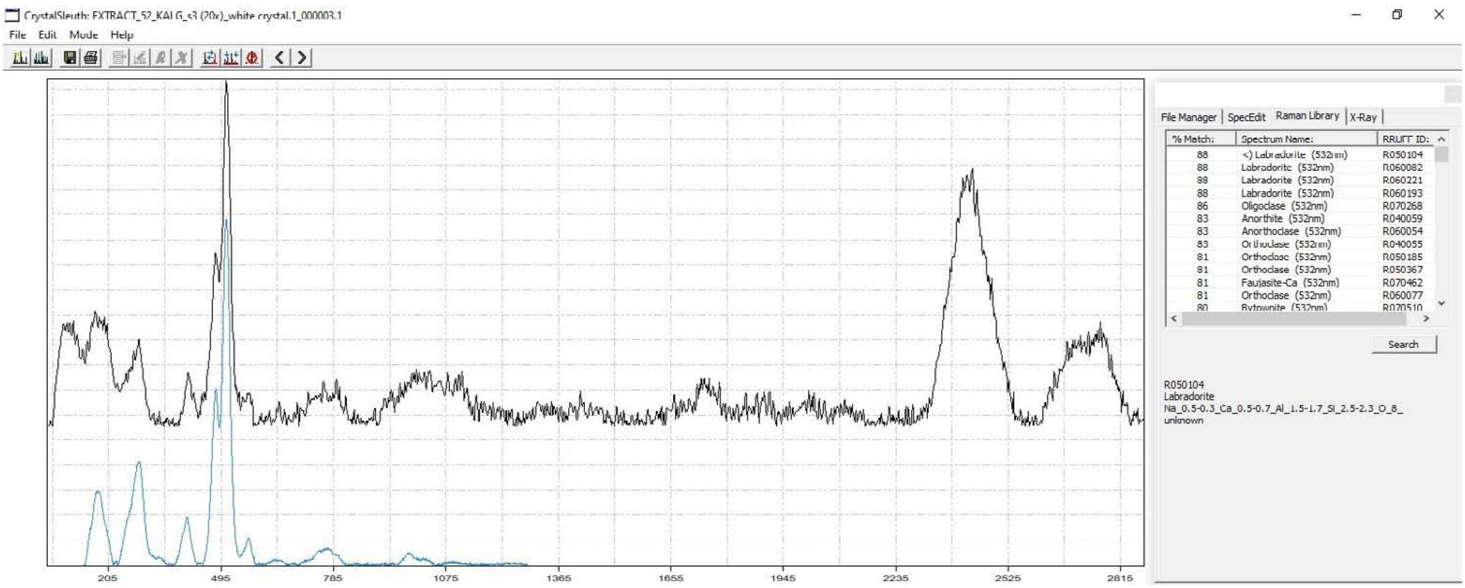


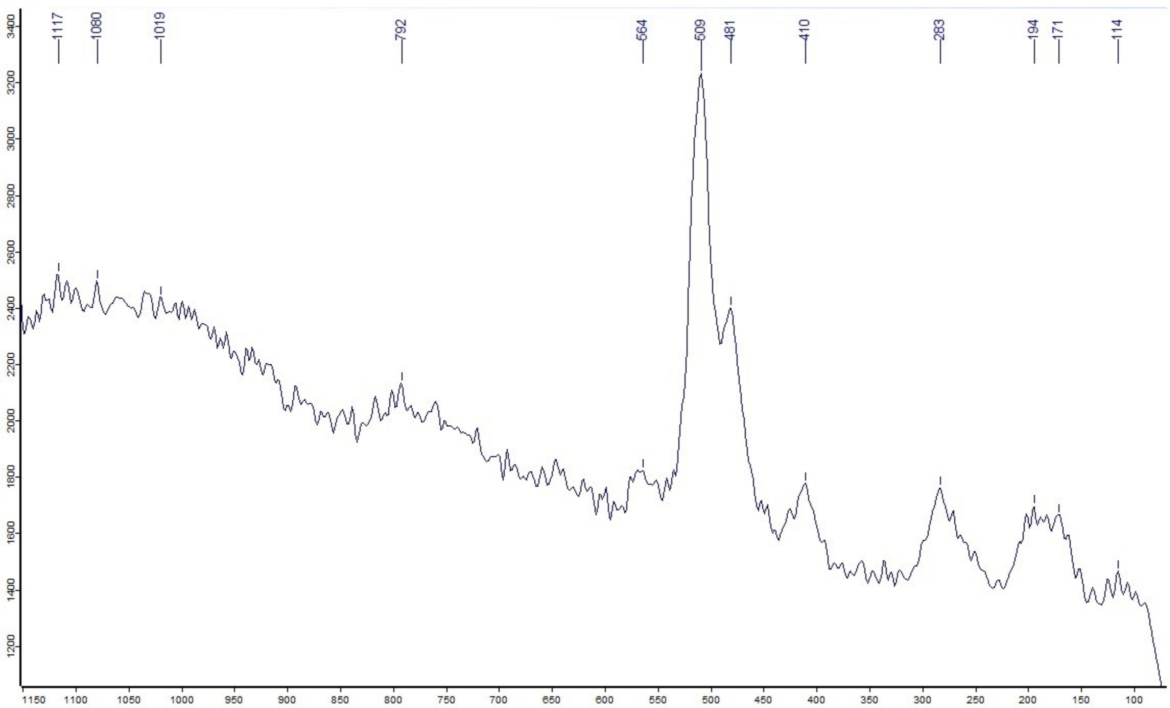


Sample-Site 52 : Stone 3-B_spectra 5 (white mineral) indicates : Labradorite (→ RRUFF_CS)

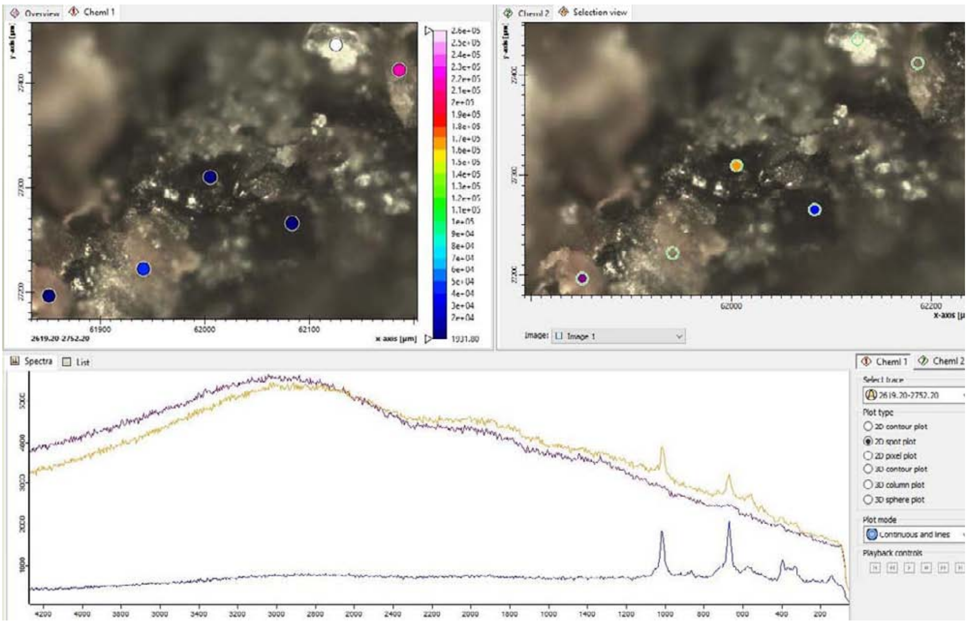


Sample :

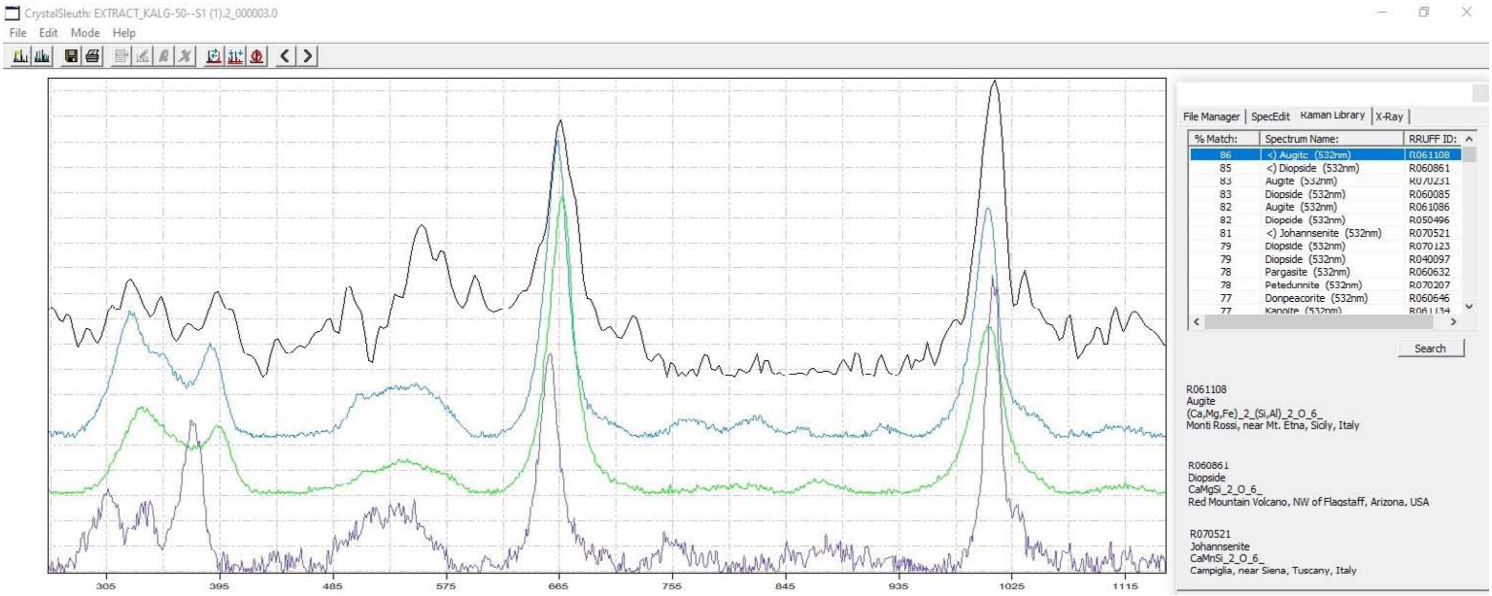


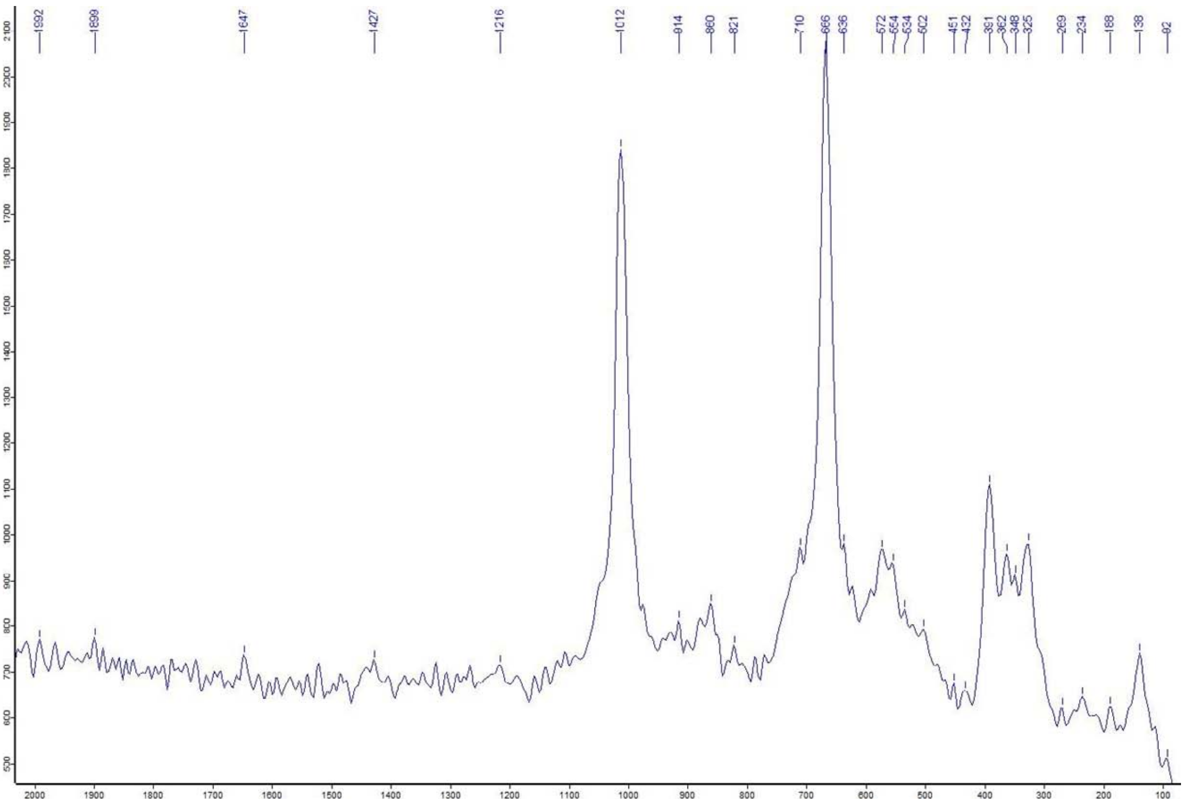


Sample-Site 50 : Stone 2_spectra 3 indicates : Augite, Diopside, Johannsenite (→ see RRUFF_CS results)



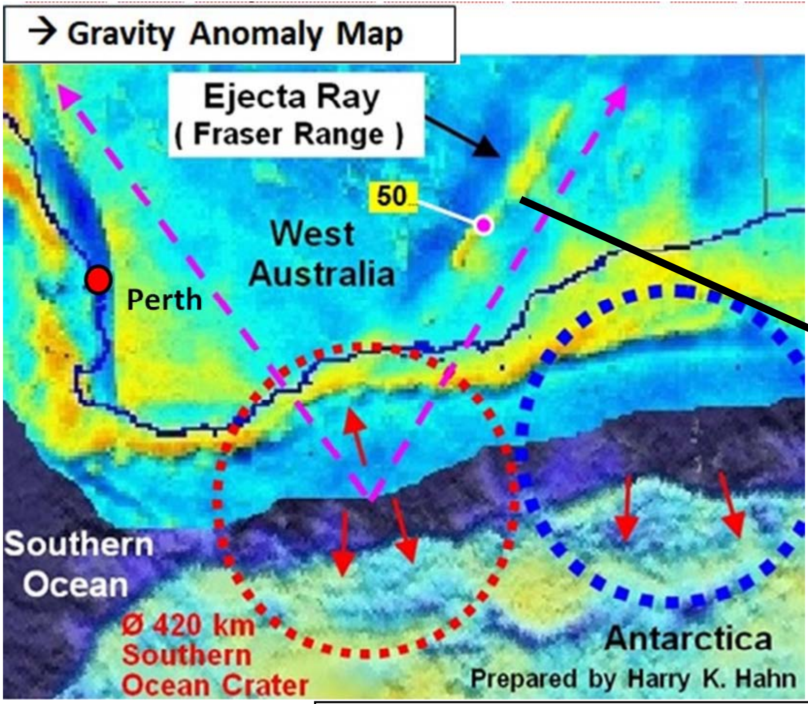
Sample :





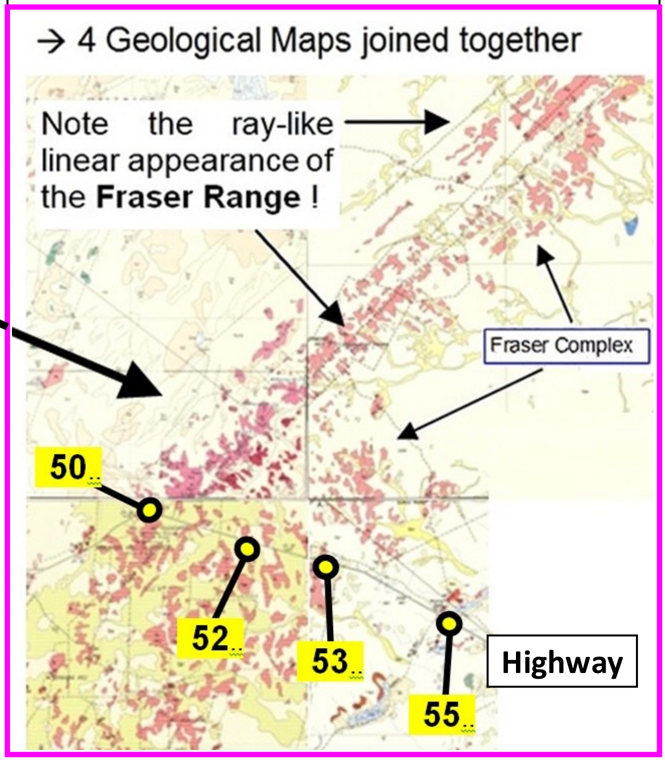
Appendix 1 : Photos of rock samples from sample sites 50 to 55 → see next page !

Note : Photos of all Samples Sites 50, 52, 53 and 55 and other sample sites are available on my website. → see : Sample Sites - Ejecta Ray of the 420 km SOC



Geological Maps :
→ go to : "Geology" – 1:250K maps
then select : Norseman / Balladonia

Geological Map with Sample Sites 50 to 55

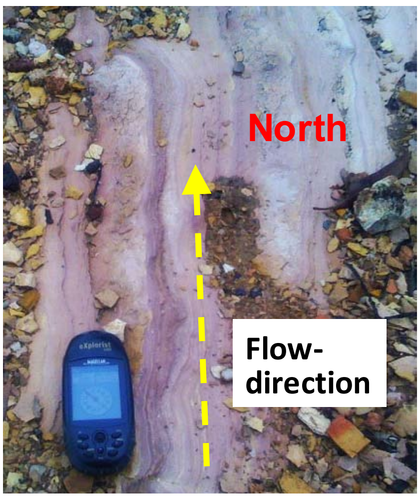


Sample site 50 is accessible from the Highway. It is part of the Fraser Range and it is elevated ≈ 30 m above the sediment area. It seems to consist of one coherent mass of solidified material (ejecta from the SOC ?) It consists of onion-like layers of rock. Similar areas like this can be found in the Cooktown-area near the Cape York Crater ! Note : site 50 lies on a fenced pasture. Permission may be required !

Photos of all Samples Sites 50, 52, 53 & 55 and other sites are available here :
Sample Sites - Ejecta Ray of the 420 km SOC

Sample site 52 → a big (ejecta?) boulder →

The ground on sample site 55 seems to mainly consist of one coherent mass of ceramic-like material with linear flow-texture and a low density like wood ! Flow direction along Center Line of Fraser Range !



Please read the analysis to this material on page 14 & 15

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

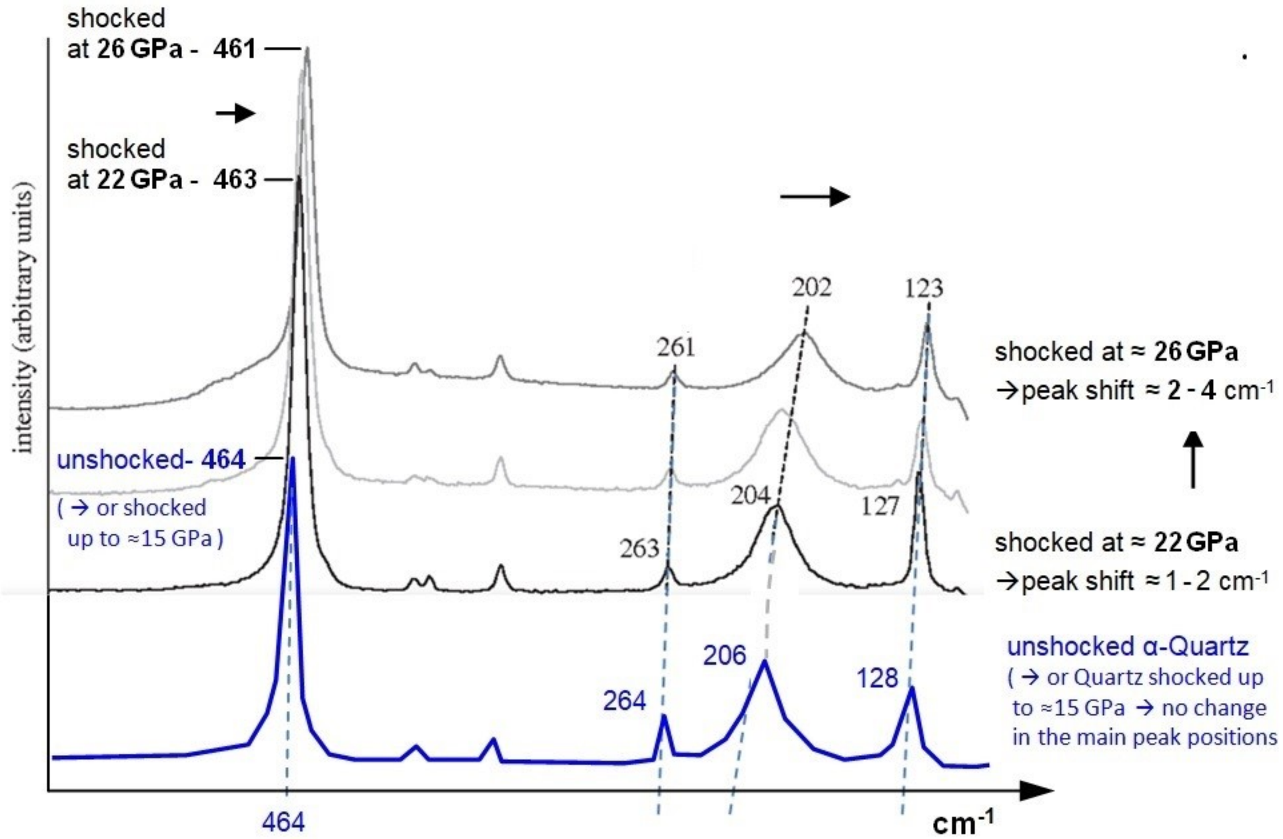
In order to verify a sample site as an impact site or impact structure, shock-metamorphic effects must be discovered in the rocks of the sample site. This can be done by different methods.

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.

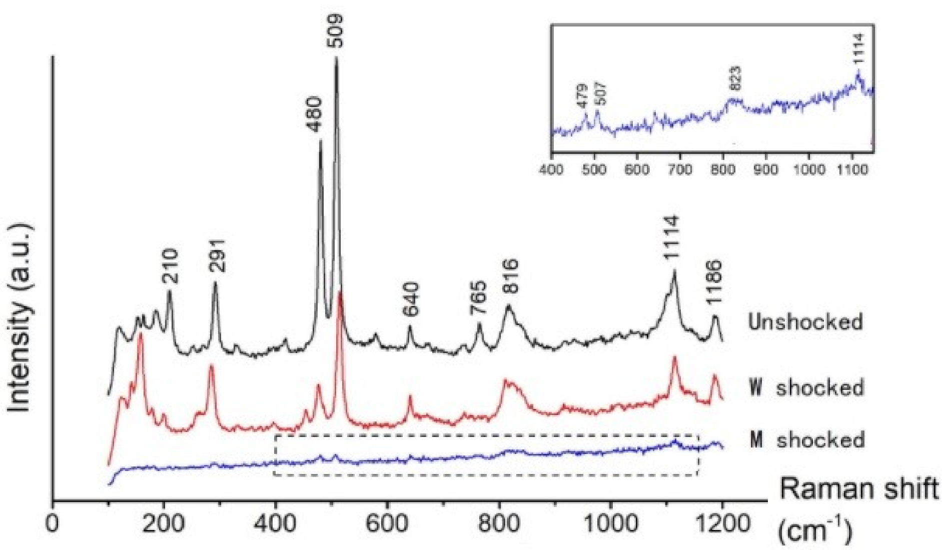
Mc Millan et al. (1992) and others have shown that the main RAMAN-peaks of Quartz shift towards lower frequencies if the Quartz was exposed the a shock-pressure > 15 GPa. → see diagram below

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^{-1} 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 : → weblink : Sample Sites - Ejecta Ray of the 420 km SOC (or: **here**)

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** or **www.permiantriassic.at**

The geological framework of the Albany-Fraser (Range) Orogen - weblink to lecture → : Slide 1 (dmp.wa.gov.au)

Information about a mining project for the mining of Nickel, Copper and Gold in the Fraser Range:
1.) Australian exploration - Orion Minerals
2.) Fraser Range Project | Orion Minerals | Nickel-copper & gold project, Australia

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

Shock-induced irreversible transition from α-quartz to CaCl2-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

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
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

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