# The Ø 50 km Archean ( >3 Gyr ) Impact Structure ( NW-Australia / Pilbara )

## - Raman Spectra of selected Rock Samples - by Harry K. Hahn, 30.12.2021 -


## Summary :

The ≈ Ø 50 km Archean Impact Structure with an age of > 3 Gyr is located ≈150 km SE of Port Headland on the Pilbara Craton near Marble Bar / Western Australia. The impact structure is noticeable on a magnetic anomaly map and on a contrast-enhanced satellite map. It is a yet unknown impact structure !

This impact crater is very interesting, especially for Astrobiologists, because some of the earliest life-forms on Earth developed inside the crater-area after the impact ! The Dresser- and Strelley-Pool Formations inside the crater contain some of the oldest fosselized Stromatolites on Earth !

Please read my more detailed study about this Impact Crater here :

The 50 km Archean Impact Crater ( Age >3 Ga ) in the Pilbara Craton ( Australia ) – ( alternative : Link 2 )

I have analysed some rock samples which I have collected along a main-road which passes the crater just outside its northern crater-rim-area ( samples No: 14 to 21 ). Note that the original crater-wall was later deformed by an (expansion) tectonic process that obviously was caused by the impact. And the impact in all probability was an oblique impact, which means the impactor impacted in a relatively shallow angle of ≤ 30°. Because of the oblique impact and the tectonic-process, fragments of the original crater-wall ended up further north close to the road were I collected the samples. Therefore there is a good chance that the collected samples originate from the elevated crater-rim area.

**The Raman spectra of quartz from the sample sites 14, 16, 18 and 21-A** collected along the main-road **provide first evidence for an impact ( shock ) event** as the probable cause of the described structure.

**The shifts of the main Raman peaks, of analysed quartz grains from these sites, to the lower frequencies 463, 259/266, 125 $cm^{-1}$ and 463, 262, 125 and 463, 263, 204 and 463, 263, 126 are a clear first indication for an impact shock event that has caused a shock pressure of around 22 GPa !**

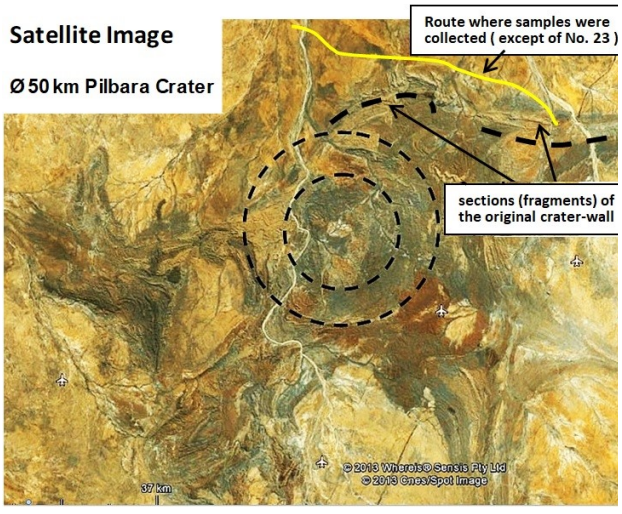
**Further indication comes from the Raman-spectrum of quartz from sample site 23** collected near the small town Marble Bar, that originates from the western crater-rim-area of the impact crater, **which also shows clear shifts of the main Raman peaks to the lower frequencies : 463, 262, 204 and 125 $cm^{-1}$**
(→ see explanation in **Appendix 1** at page **24** : Overview : The Raman bands (peaks) of shocked Quartz)

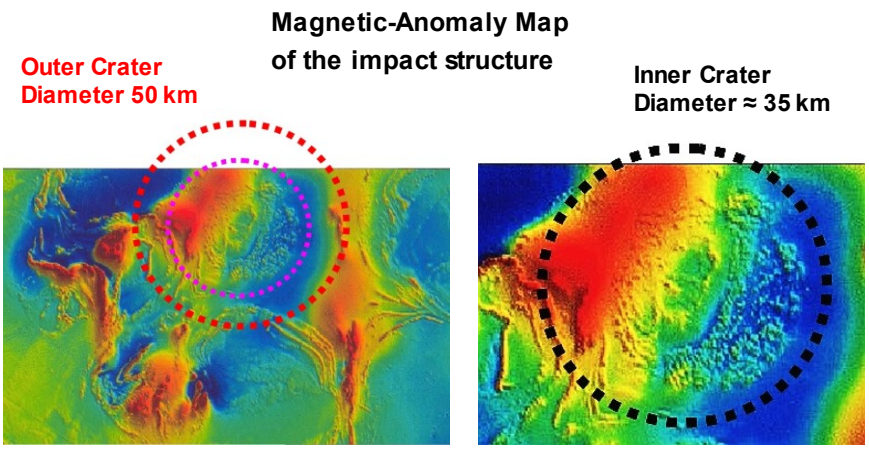
Microscopic images of some of the analysed quartz grains may provide further proof for a shock event. ( → see microscopic-Images on the **pages : 6, 7, 9, 10, 11** and **13** ).

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

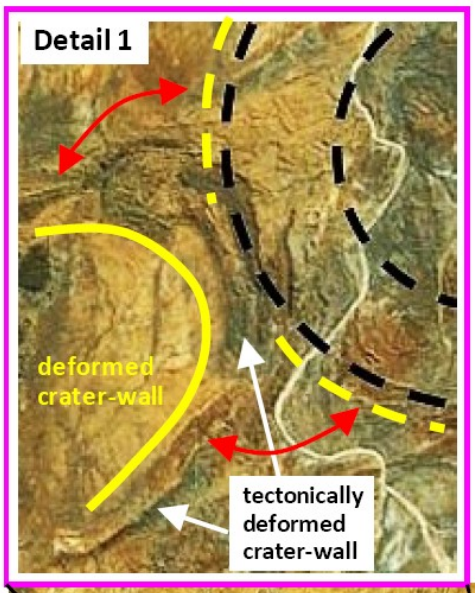
→ Images of the analysed rock samples and photos of the sample sites are in the Appendix at **page 18**.
→ More images of all sample sites are available on www.permiantriassic.de or www.permiantriassic.at
→ **References** to interesting studies regarding the described impact-crater area : **see page 25**

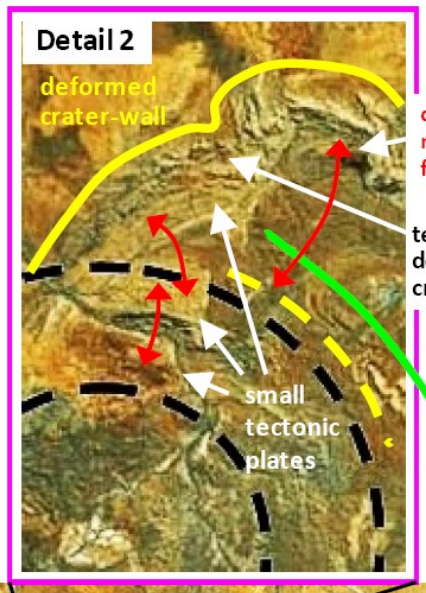
**Note :** A shock pressure of 20 GPa exceeds every pressure caused by normal terrestrial metamorphism. The indicated shock pressure of ≈ 20 GPa is lower than the shock pressure that occured in other large impact craters on Earth. This indicates that the "**Pilbara Crater**" was caused by an oblique impact and that the impactor impacted at a relatively shallow angle with relatively low velocity of probably <10 km/s.

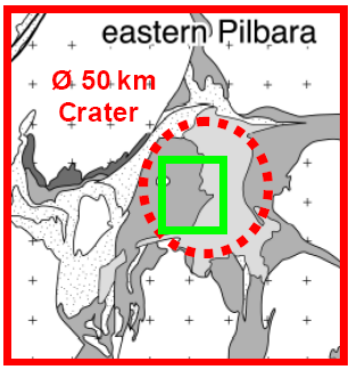



This yet unknown impact crater (impact structure) is very interesting, especially for Astrobiologists, because some of the earliest life-forms on Earth developed inside the crater area after the impact ! This area ( the impact structure ! ) probably is connected to the Barberton Greenstone Belt (BGB) Impact Event which happened 3.26 - 3.24 Ga ago in South-Africa ! , as the Geologist Andrew Y. Glikson pointed out. The Dresser- and Strelley-Pool Formations inside the crater contain some of the oldest fosselized Stromatolites on Earth ! There is a good chance that the impactor, possibly a carbon-rich (interstellar?) comet, has brought-in bacterial life-forms from outer space to Earth !

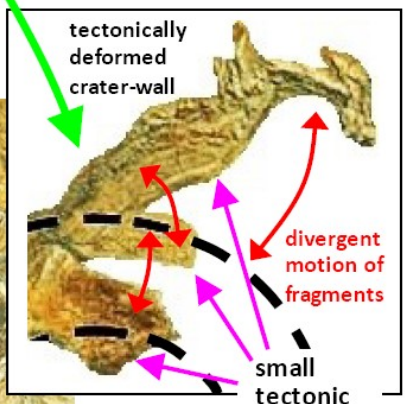


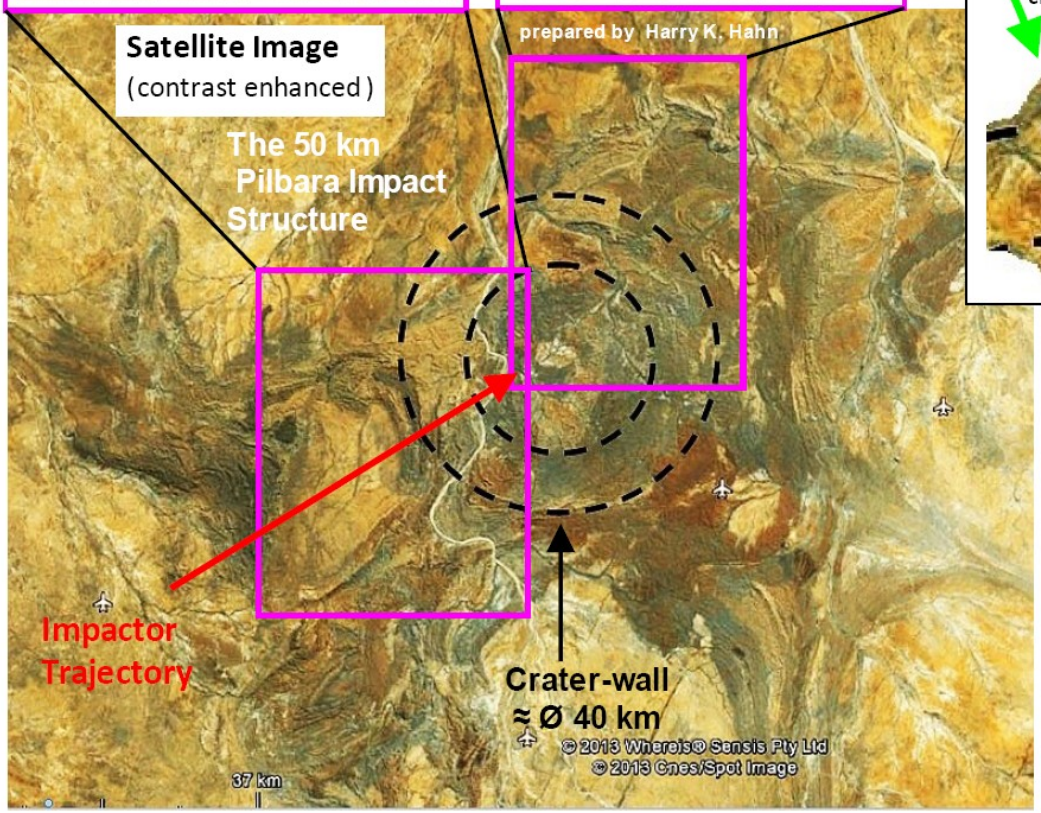




Dresser & Strelley Formations

The Dresser- & Strelley- Formations contain some of the oldest fosselized Stromatolites on Earth !

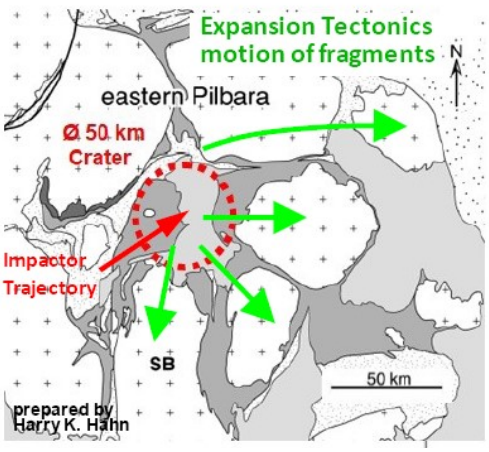


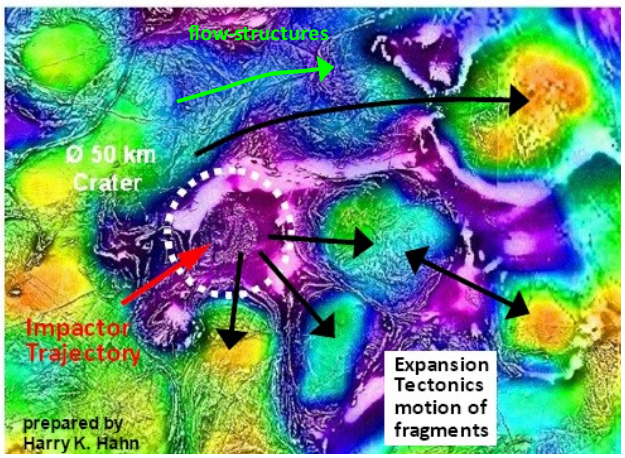

The impact caused around six larger and a number of smaller crust fragments as the gravity anomaly map ( see below ) & the satellite image indicates ! The crust fragments are marked in yellow/green color on the map below → positive anomalies ! negative anomalies → purple

Because Earth's crust was still very thin at the time of the impact >3 billion years ago, the impactor probably was releasing most of its energy below the thin (≈1 to 3 km thin ) crust Therefore bacteria from the comet could have survived this impact !!!

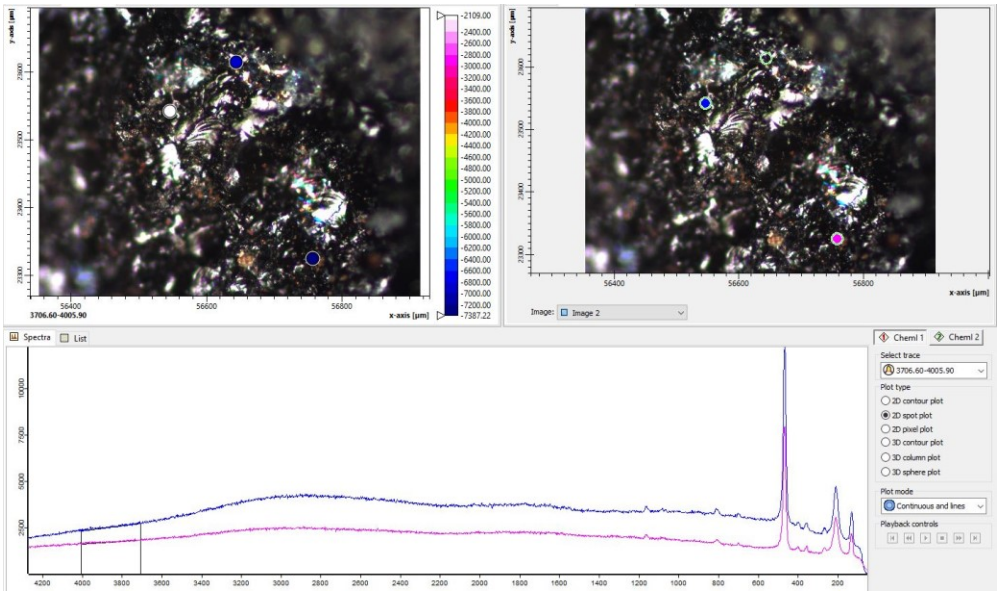
Geologic Map of Pilbara Crater




Gravity- & Magnetic-Anomaly Map of Pilbara Crater

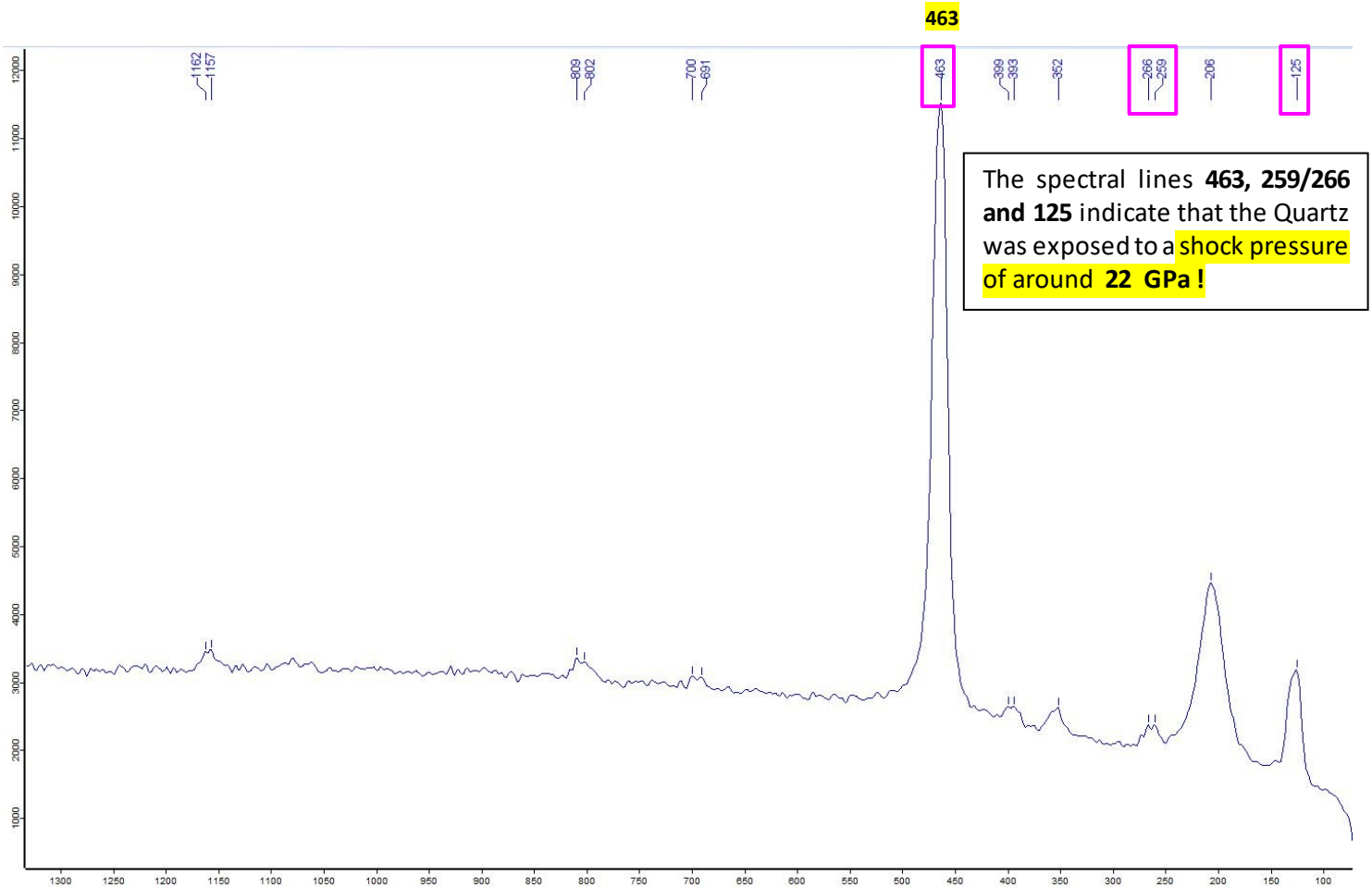


**Sample Site 14 : Stone 1_spectra 1 indicates : Quartz**

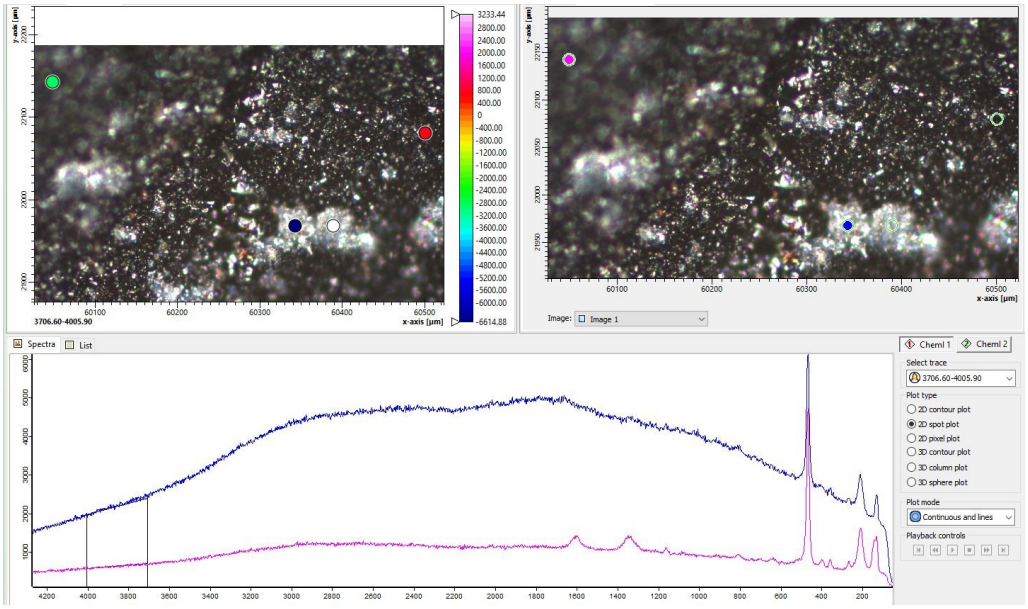


**Sample :**

**Indication for a shock event are the shifts of the marked Quartz spectral lines towards 463, 259/266 and 125**

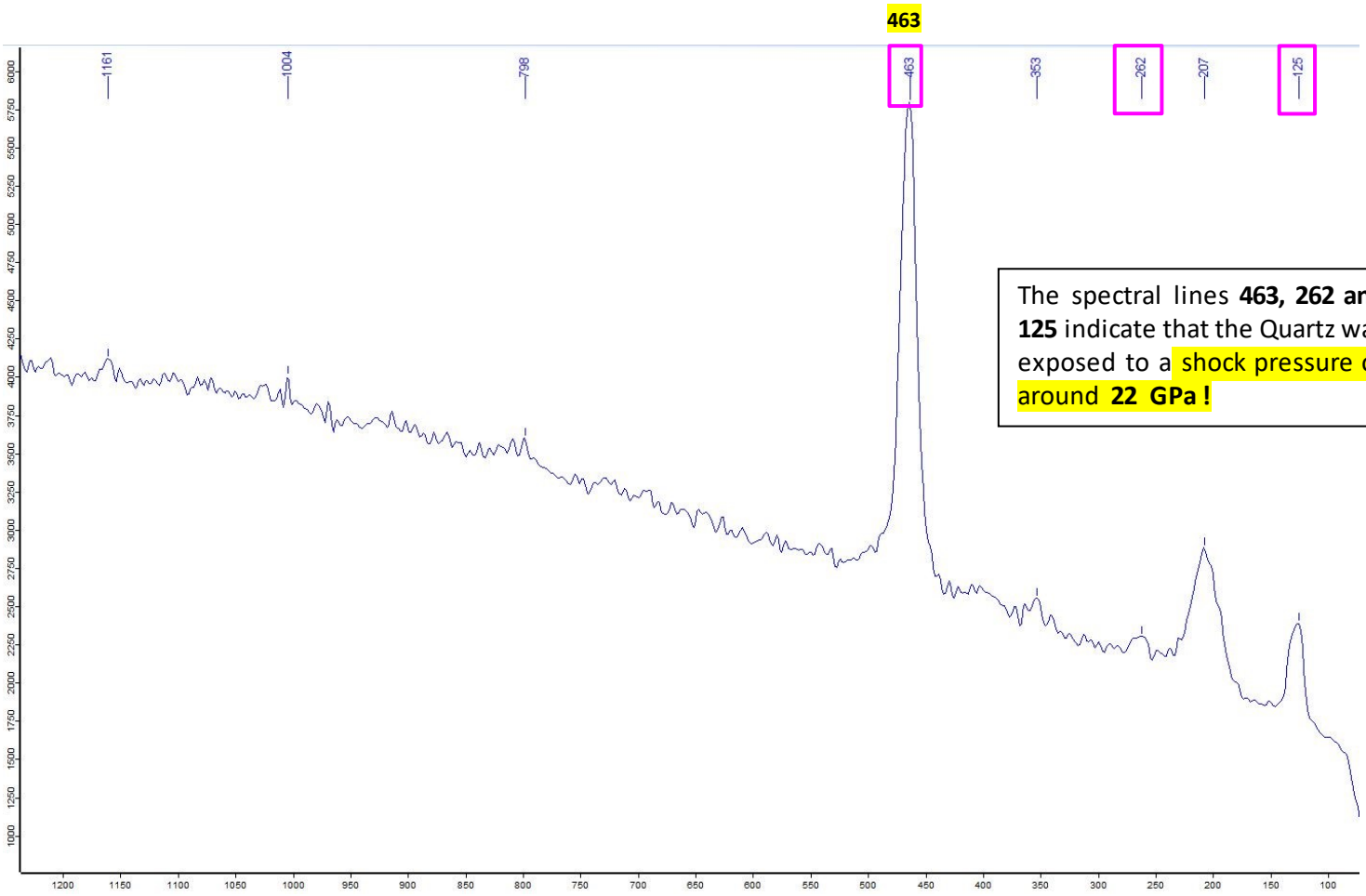


**Sample Site 16 : Stone 1_spectra-1_(blue) indicates : Quartz**



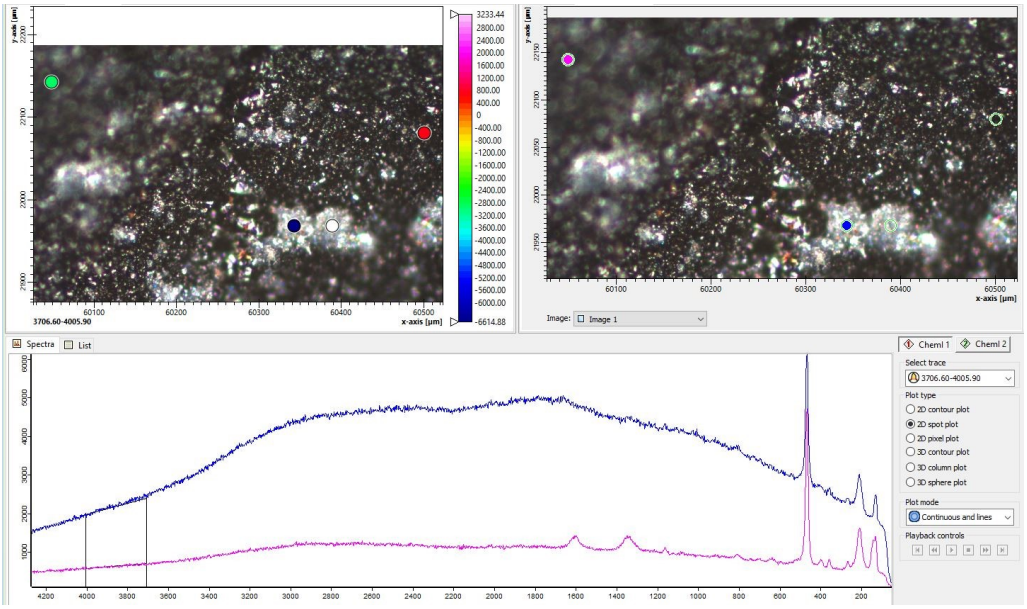
**Sample :**

**Indication for a shock event are the shifts of the marked Quartz spectral lines towards 463, 262 and 125**



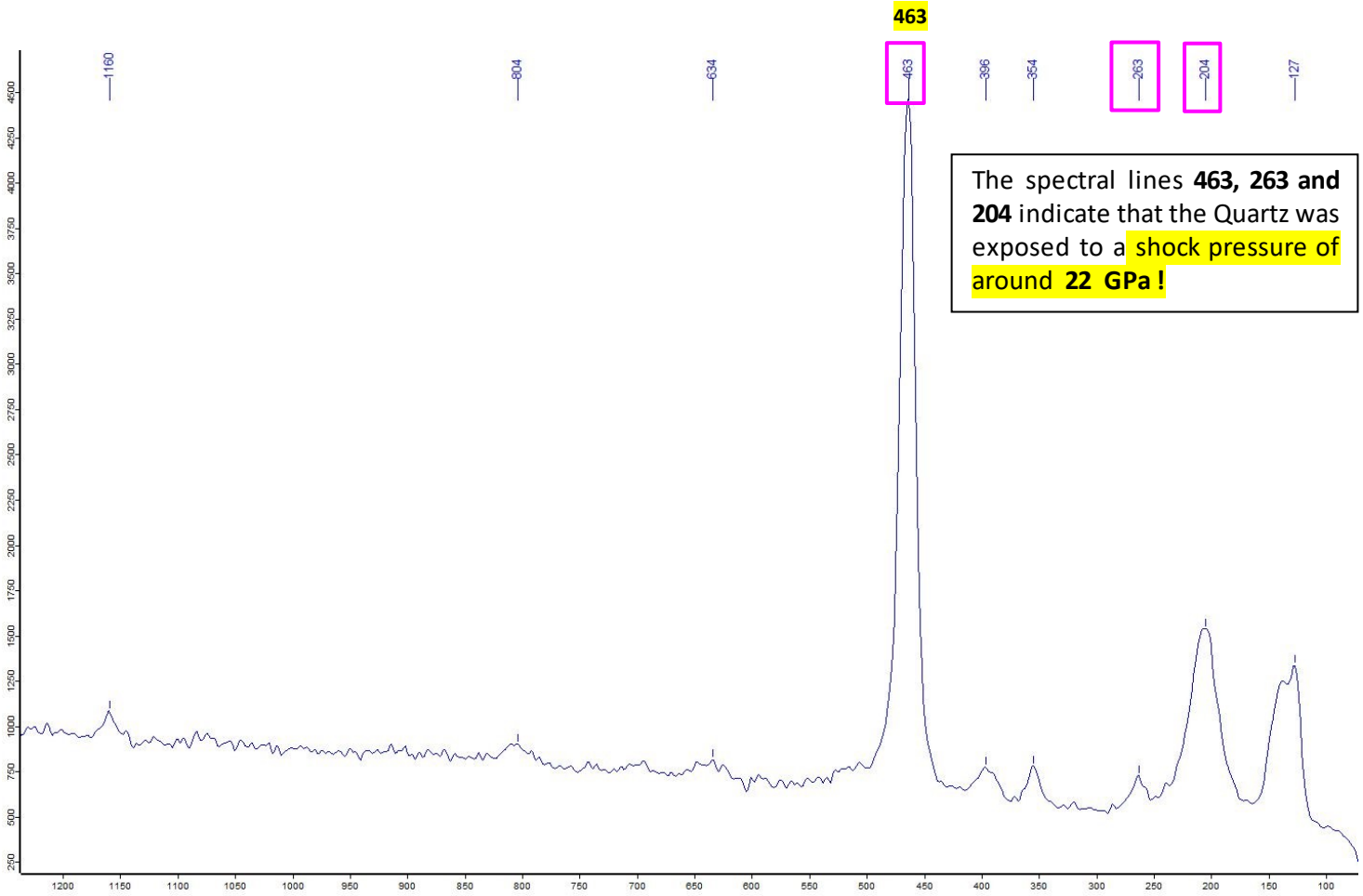

The spectral lines **463, 262 and 125** indicate that the Quartz was exposed to a shock pressure of around **22 GPa !**

**Sample Site 16 : Stone 1_spectra-2_(pink) indicates : Quartz**



**Sample :**

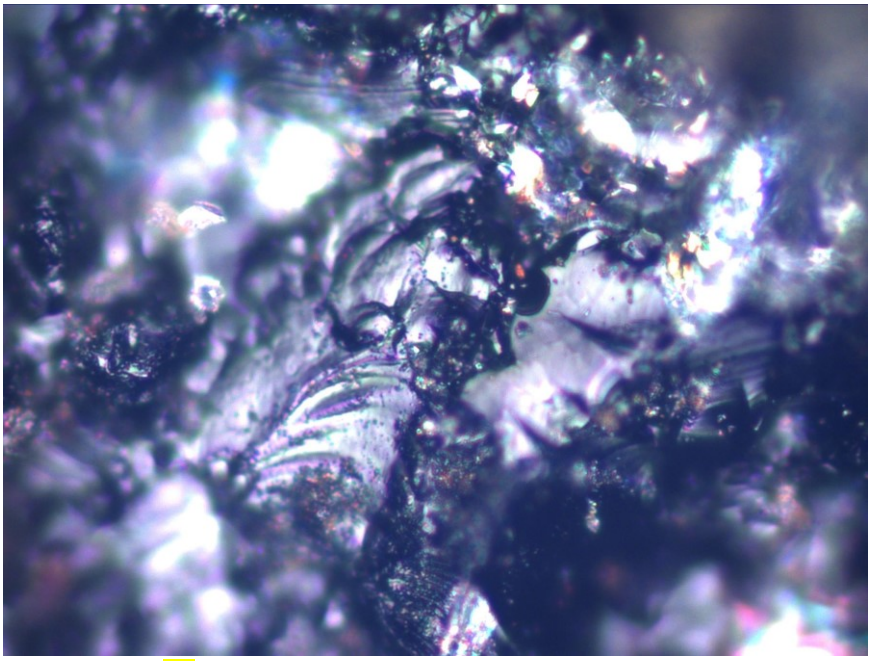
**Indication for a shock event are the shifts of the marked Quartz spectral lines towards 463, 263 and 204**



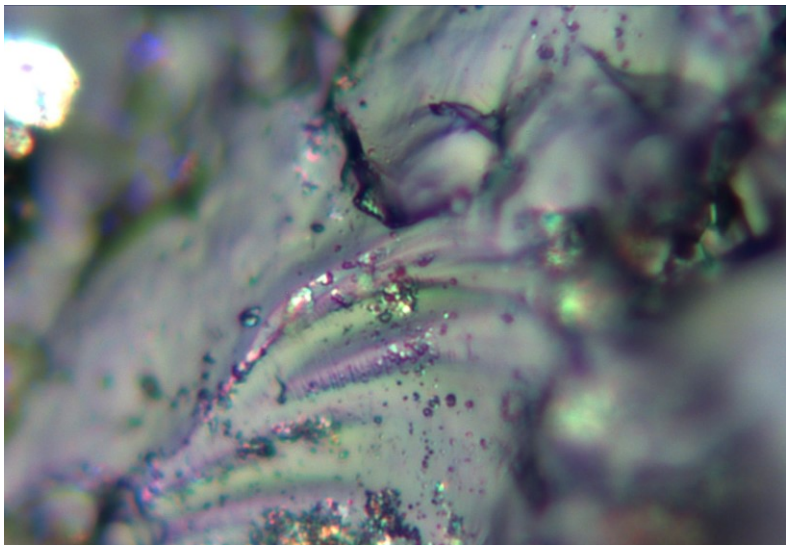

The spectral lines **463, 263 and 204** indicate that the Quartz was exposed to a shock pressure of around **22 GPa !**

**Microscopic Images : Sample from Site 14 and 16 → original state ( no preparation for analysis )**

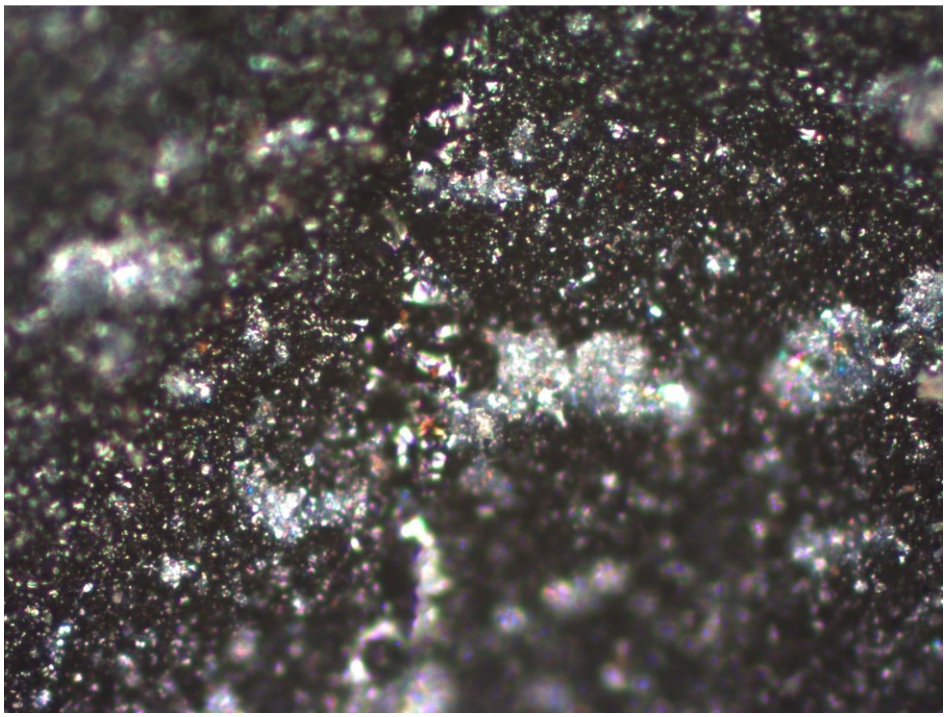
**Sample Site 14 : Stone 1 : Quartz ( Image ~ 280 x 220 µm )**



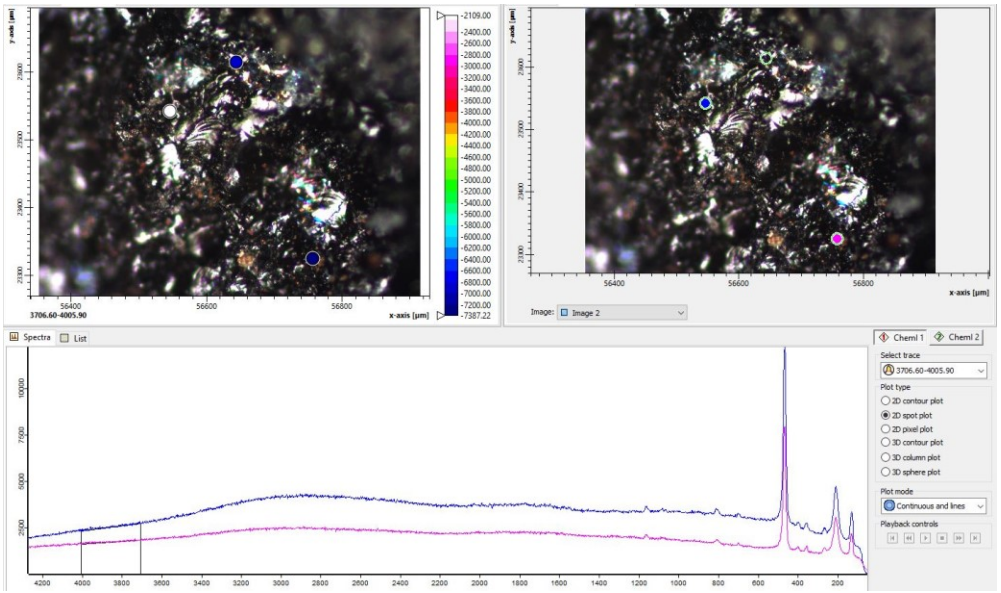
**Sample Site 14 : Stone 1 : Quartz - Detail of above image ( Image size : ~ 100 x 70 µm )**



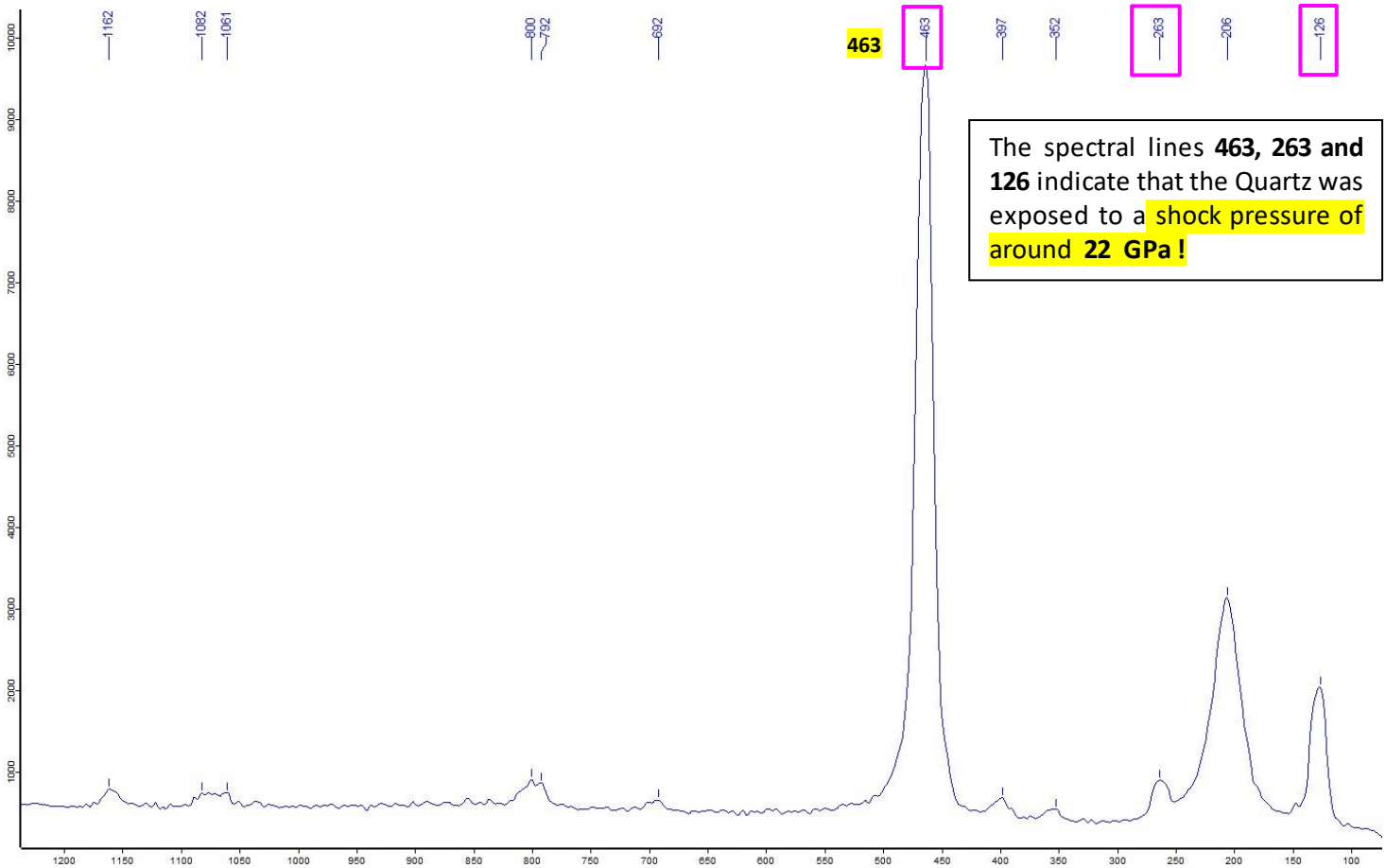
**Sample Site 16 : Stone 1 : Quartz - Image size : ~ 500 x 400 µm**



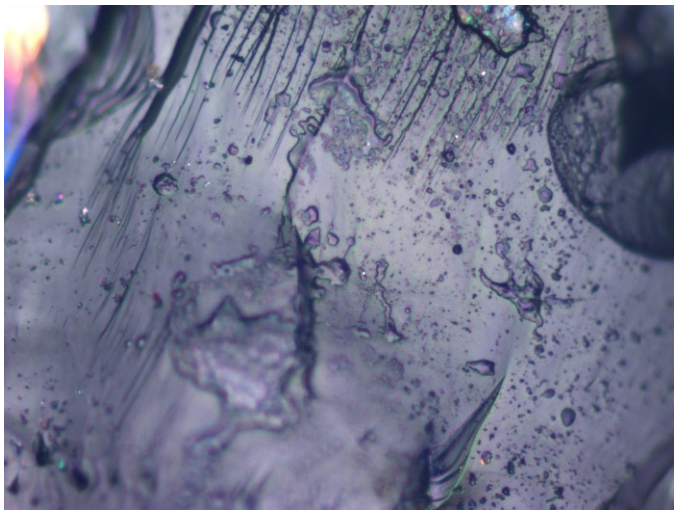
**Sample Site 18 : Stone 1_spectra 1 indicates : Quartz**



**Sample :**




The spectral lines **463, 263 and 126** indicate that the Quartz was exposed to a shock pressure of around **22 GPa !**

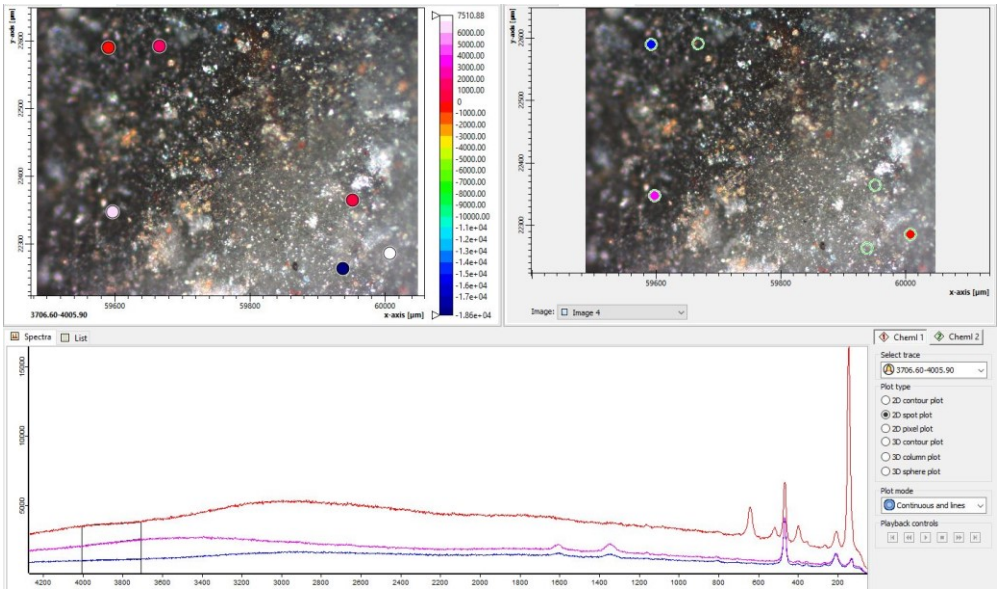


**Sample Site 18: Stone 1 : Quartz**

Detail of Microscopic Image

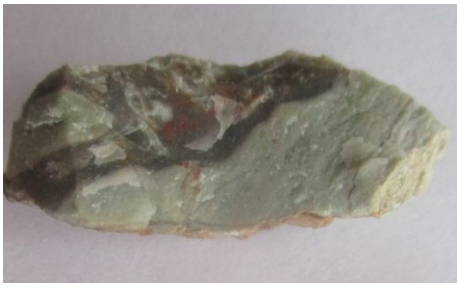
Image size : ~ 300 x 200 µm

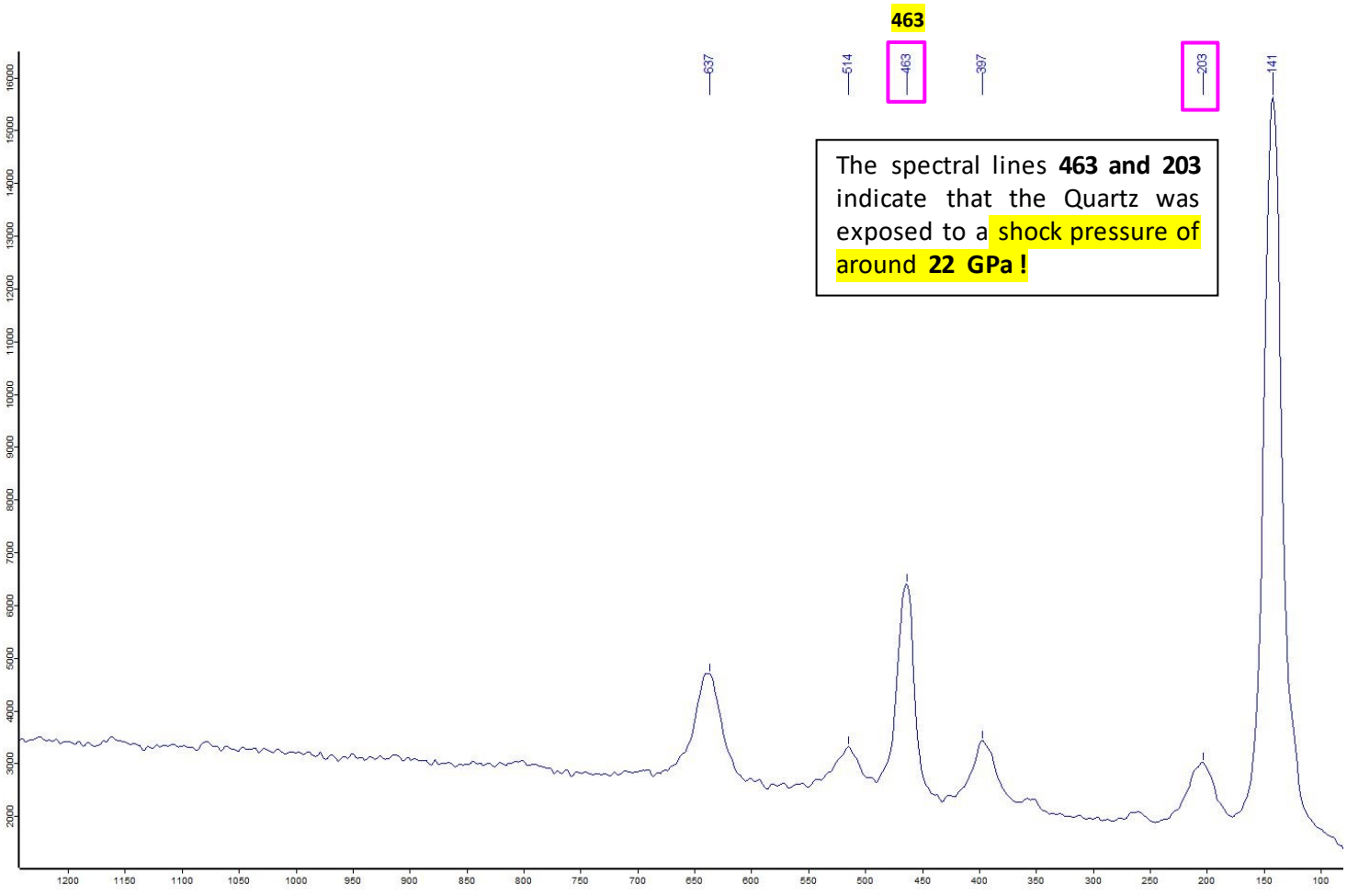
**Sample Site 21-A : Stone 1_spectra 1 indicates : Quartz**



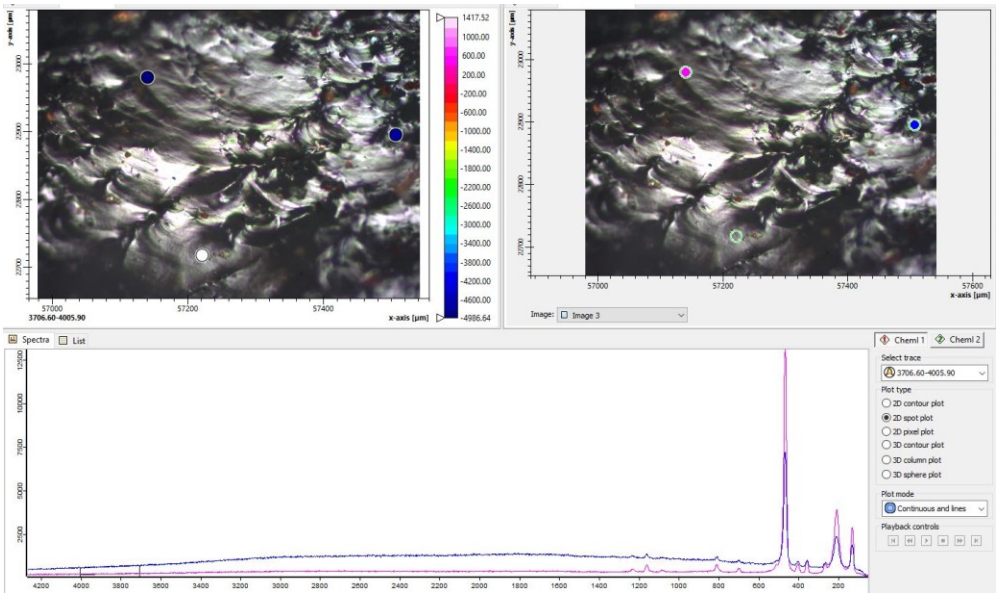
Beside Quartz, there are other minerals present in the sample. e.g. feldspar ( spectral line 514 )

**Sample :**

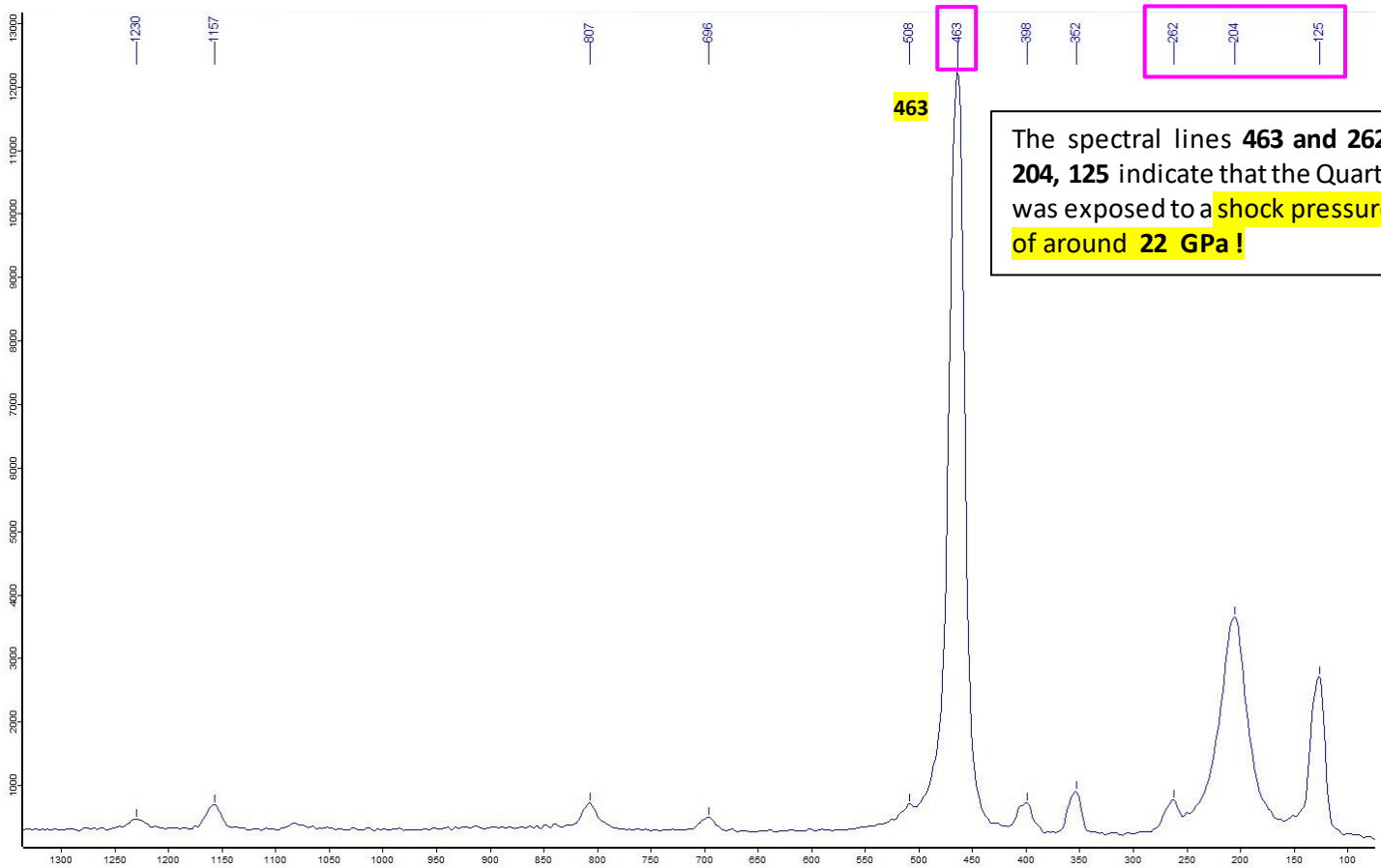




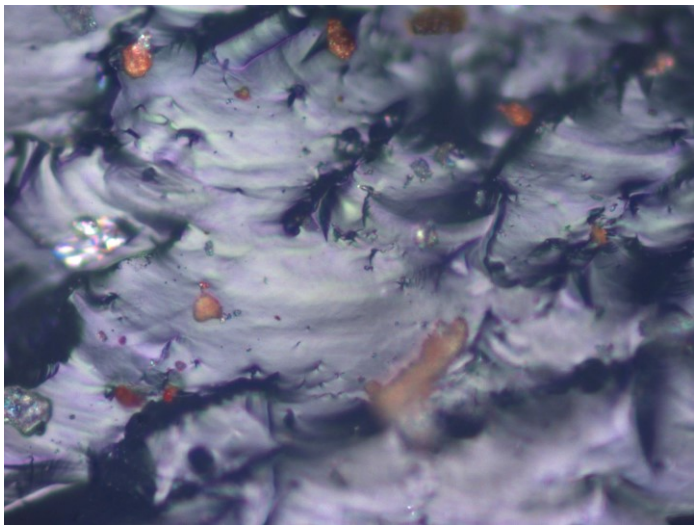
**Sample Site 23 : Stone 1_spectra 1 indicates : Quartz**



**Sample :**




The spectral lines **463 and 262, 204, 125** indicate that the Quartz was exposed to a shock pressure of around **22 GPa !**



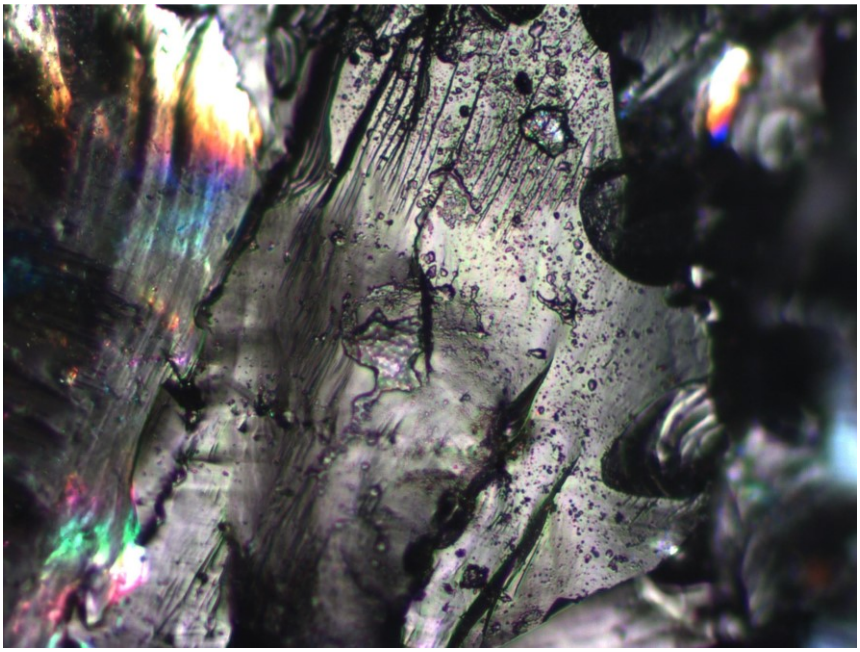
**Sample Site 23 : Stone 1 : Quartz**

Detail of Microscopic Image

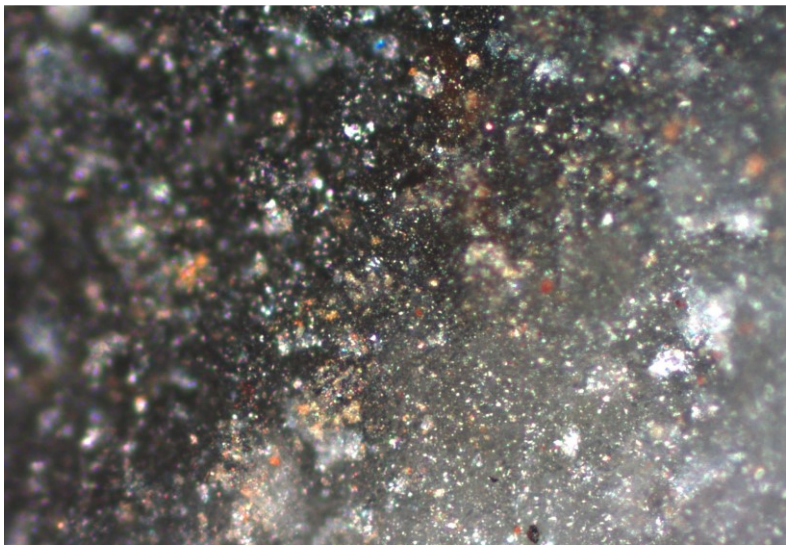
Image size : ~ 300 x 200 µm

**Microscopic Images : Sample from Site 18, 21-A and 23 → original state ( no preparation for analysis )**

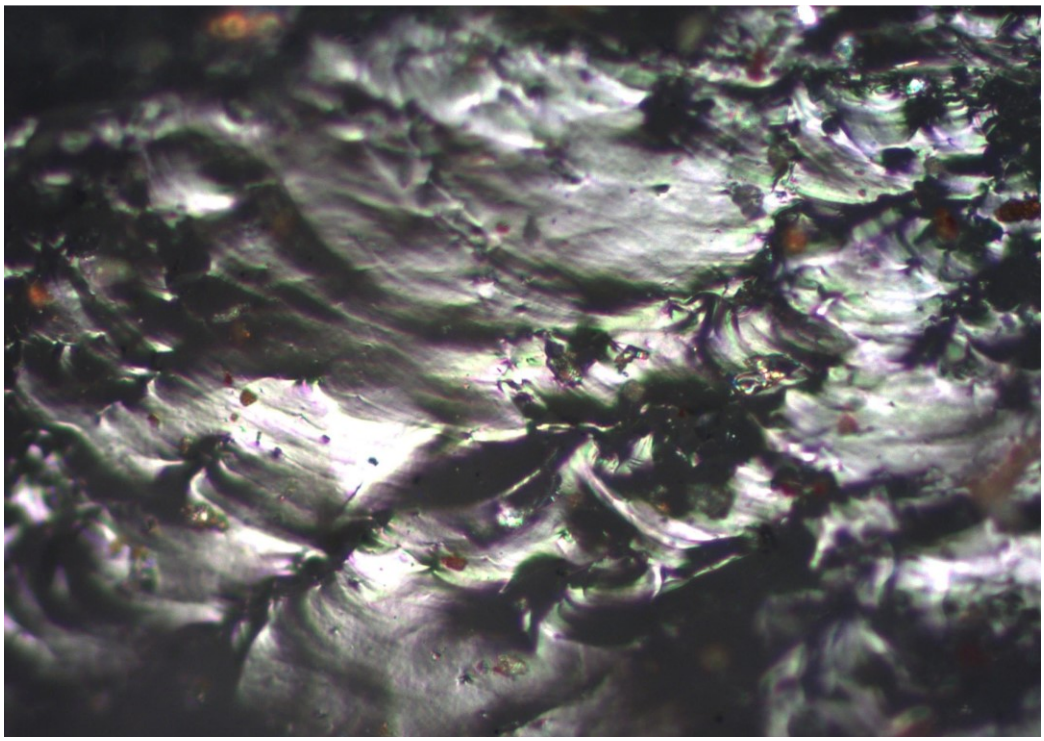
**Sample Site 18 : Stone 1 : Quartz ( Image ~ 500 x 350 µm )**



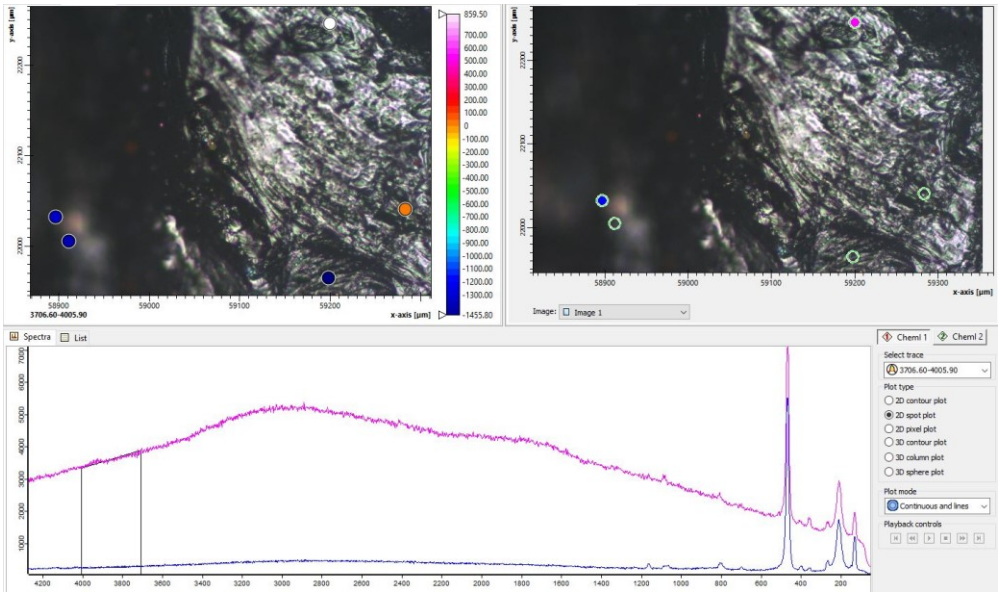
**Sample Site 21-A : Stone 1 : Quartz ( Image size : ~ 500 x 350 µm )**



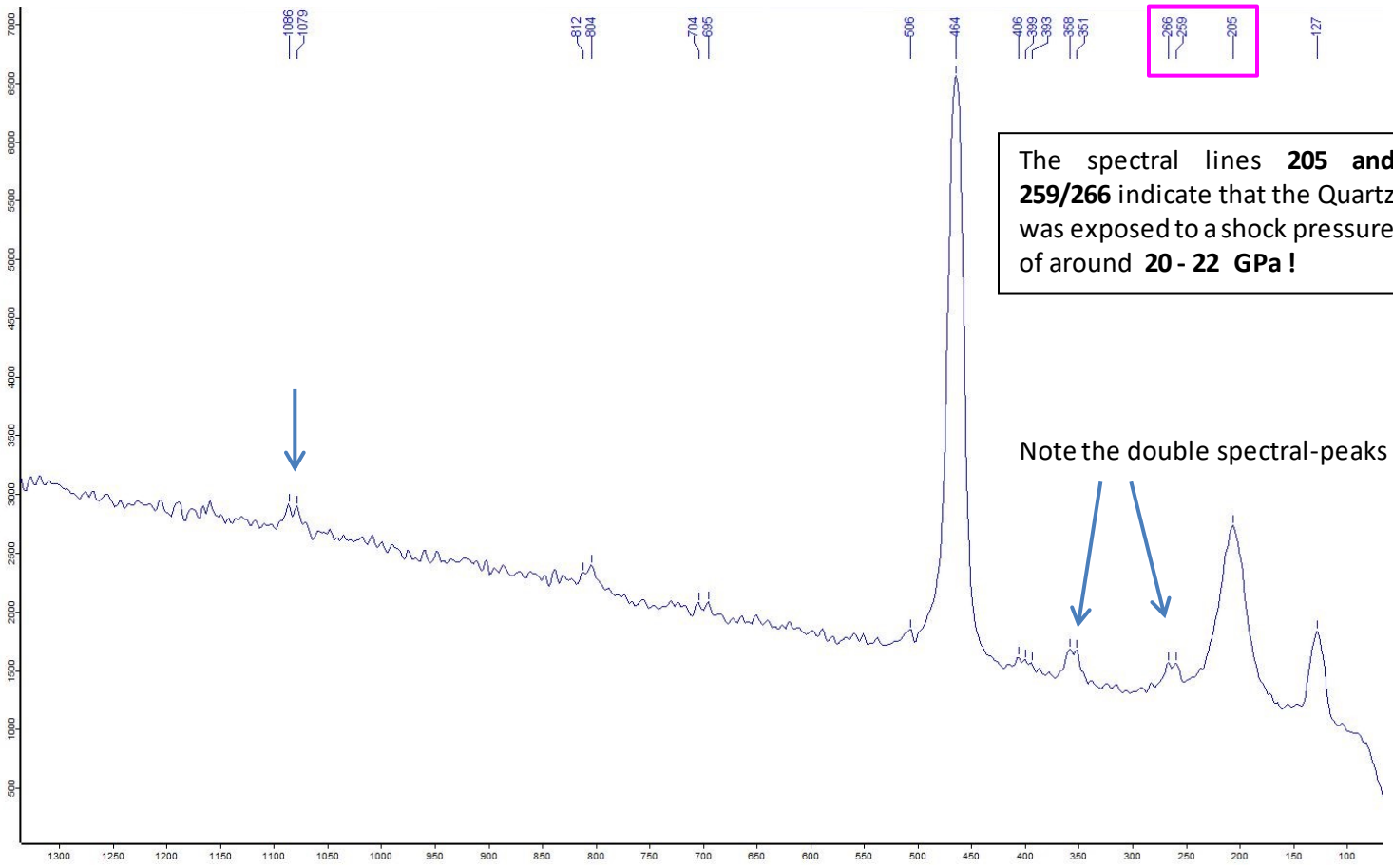
**Sample Site 23 : Stone 1 : Quartz - ( Image size : ~ 550 x 450 µm )**

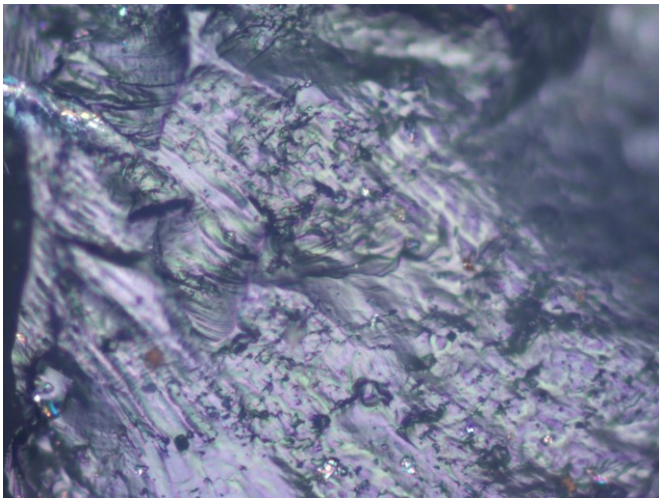


**Sample Site 22 : Stone 1_spectra 1 indicates : Quartz**



**Sample :**



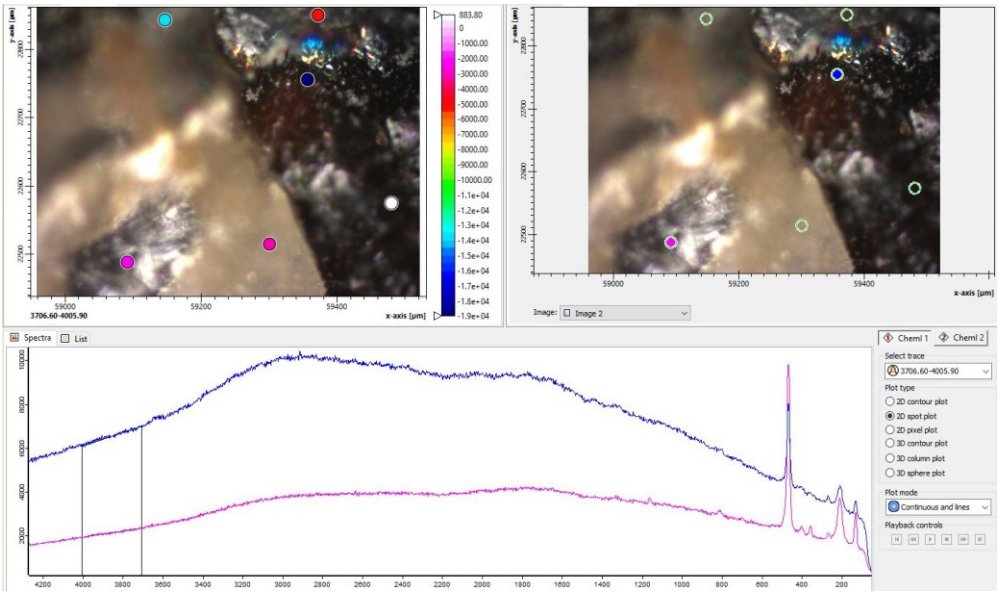



**Sample Site 22 : Stone 1 : Quartz**

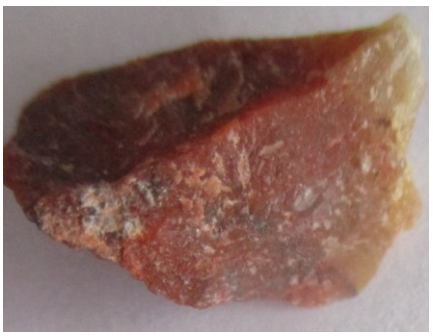
Detail of Microscopic Image

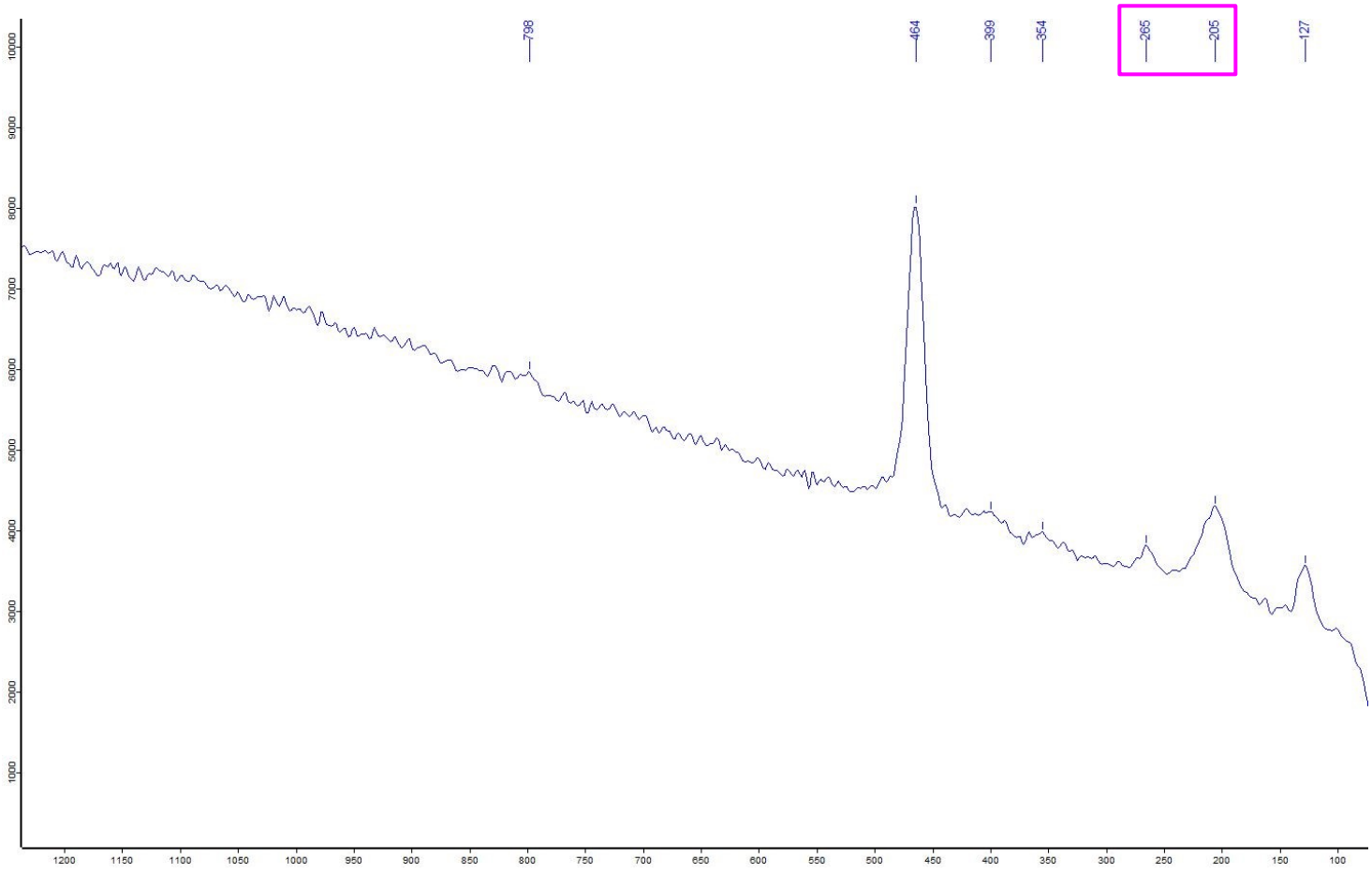
Image size : ~ 300 x 200 µm

**Sample Site 18 : Stone 2_spectra 1( blue spectra ) indicates : Quartz**

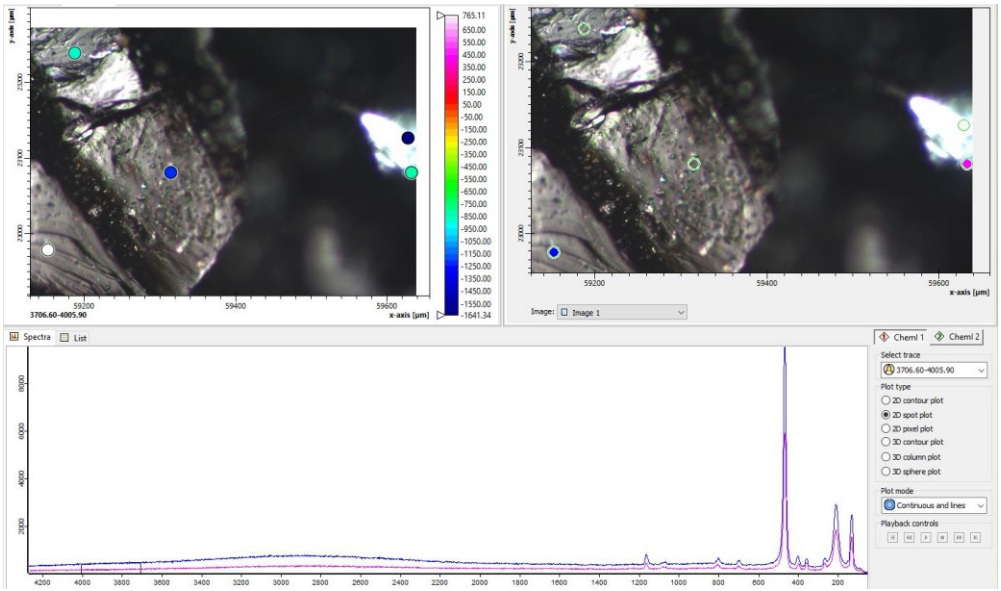


**Sample :**

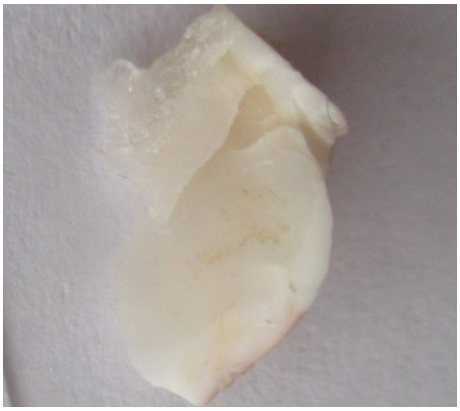


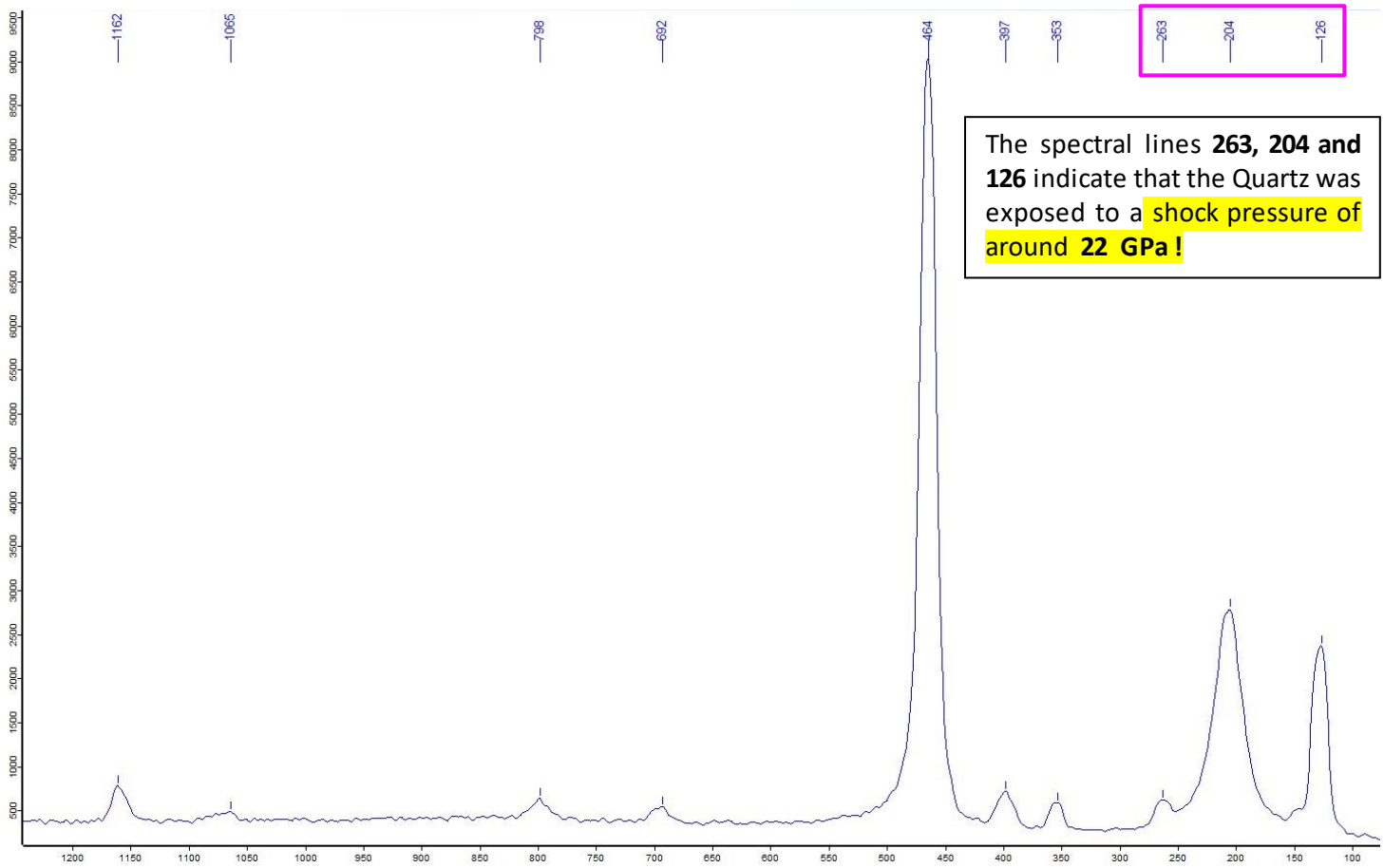


**Sample Site 21-A : Stone 2_spectra 1 indicates : Quartz**

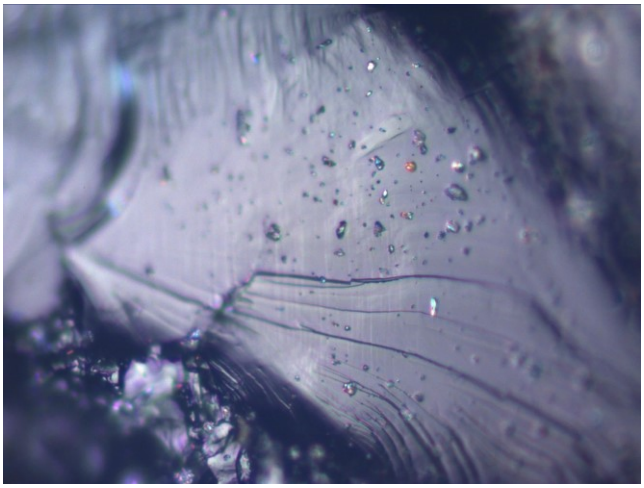


**Sample :**






The spectral lines **263, 204 and 126** indicate that the Quartz was exposed to a shock pressure of around **22 GPa !**

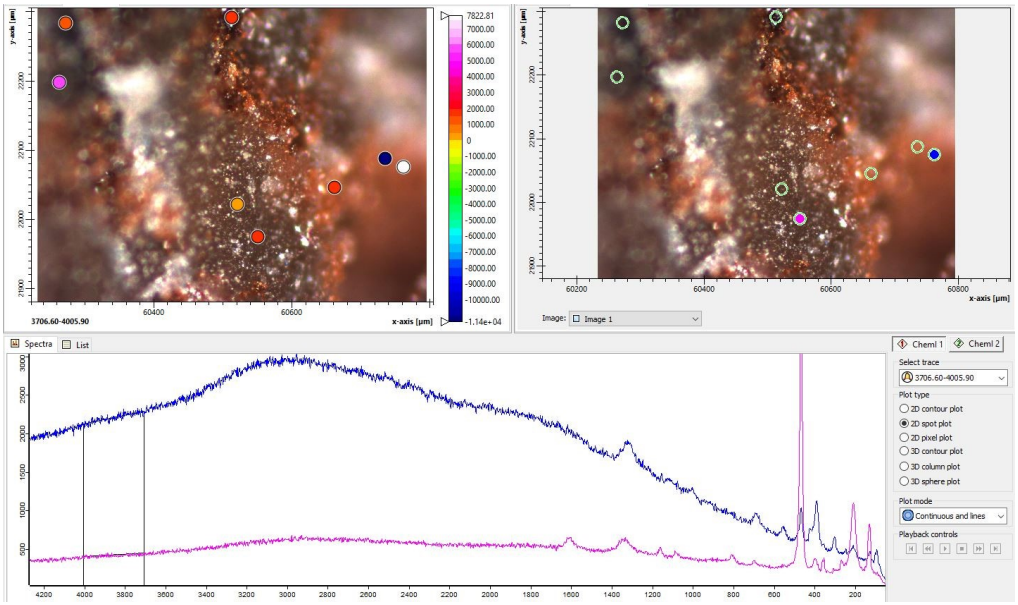


**Sample Site 21-A : Stone 2 : Quartz**

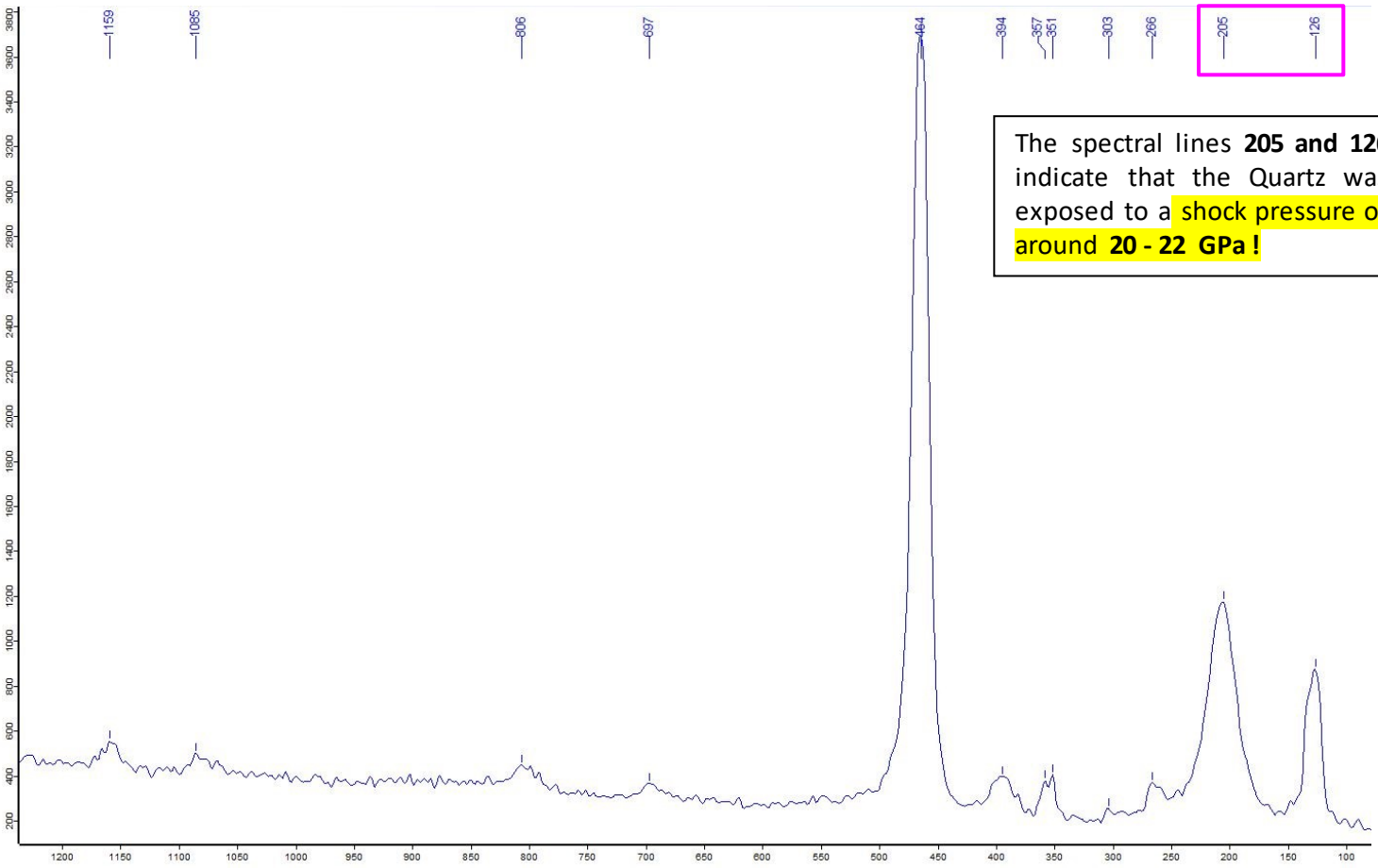
Detail of Microscopic Image

Image size : ~ 300 x 200 µm

**Sample Site 21-A : Stone 3_spectra 1(pink) indicates : Quartz**

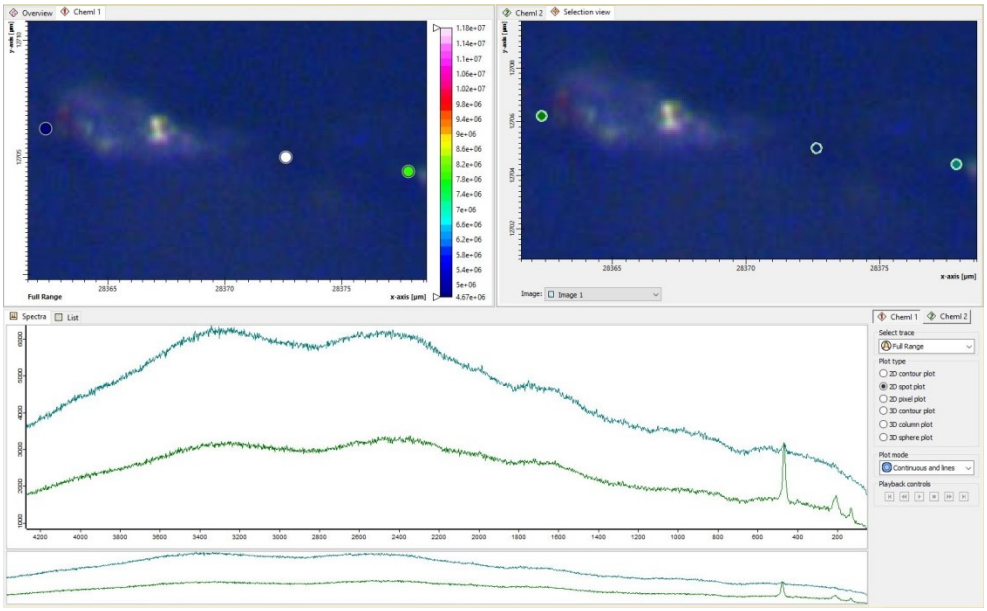


**Sample :**

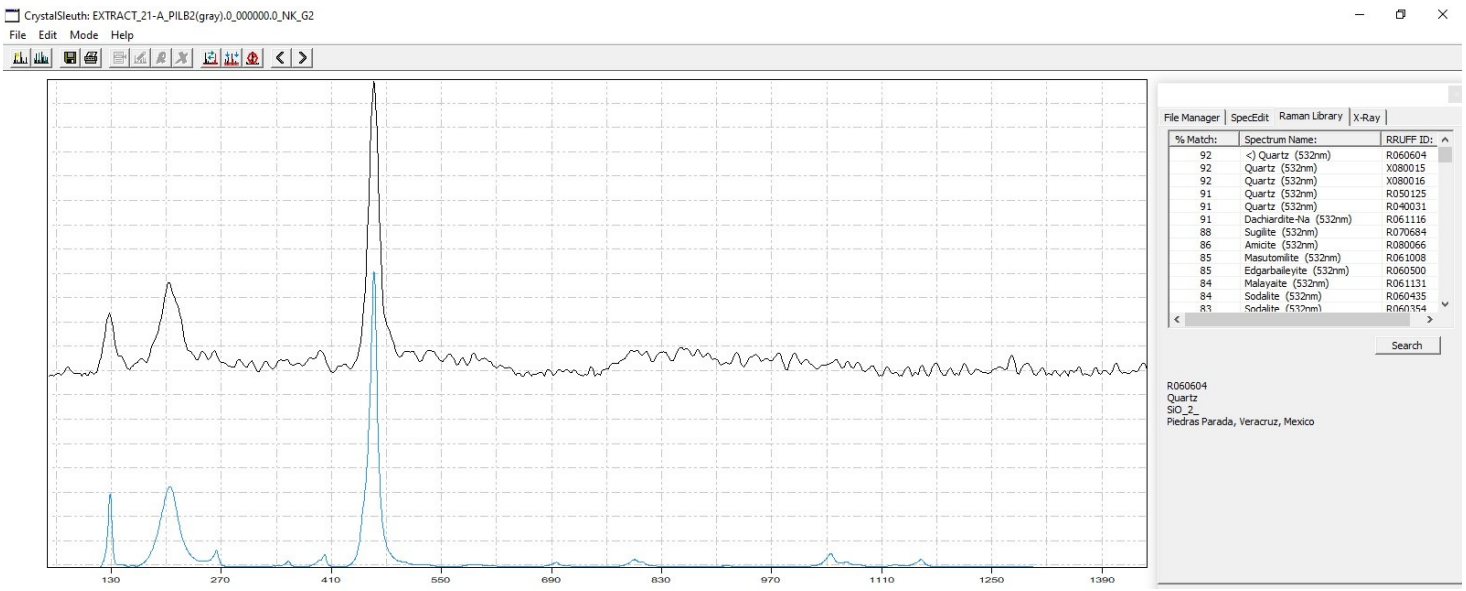


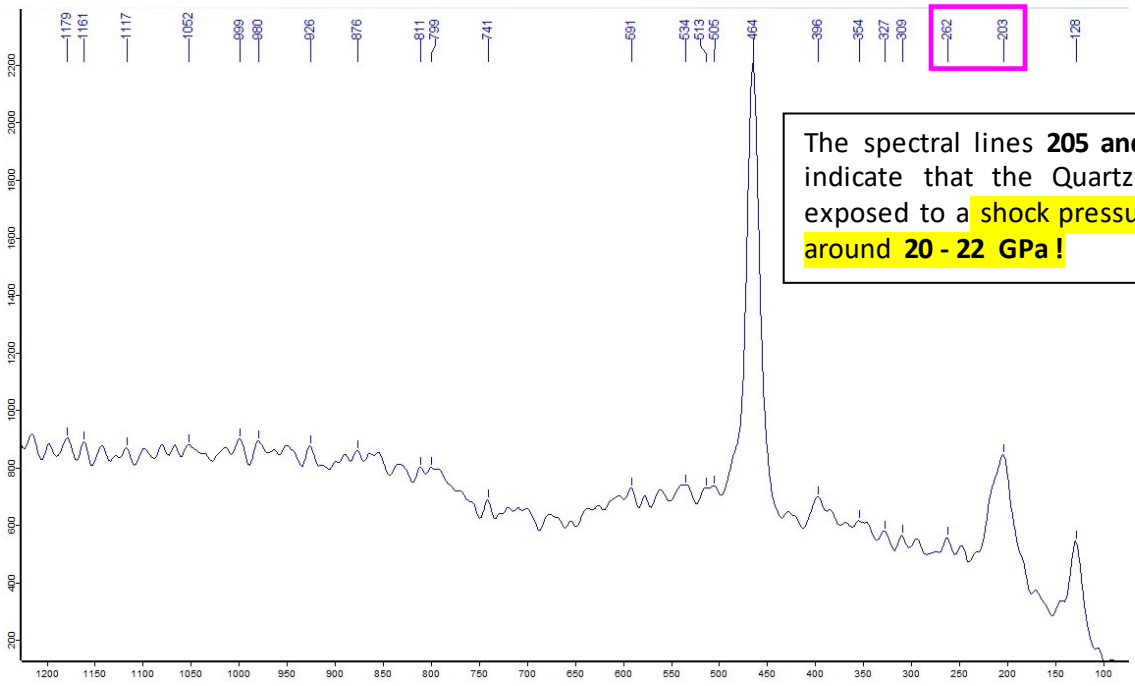

The spectral lines **205 and 126** indicate that the Quartz was exposed to a shock pressure of around **20 - 22 GPa !**

**Sample Site 21-A : Stone 4_spectra 1 ( grey mineral ) indicates : Quartz** (→ see RRUFF_CS results )



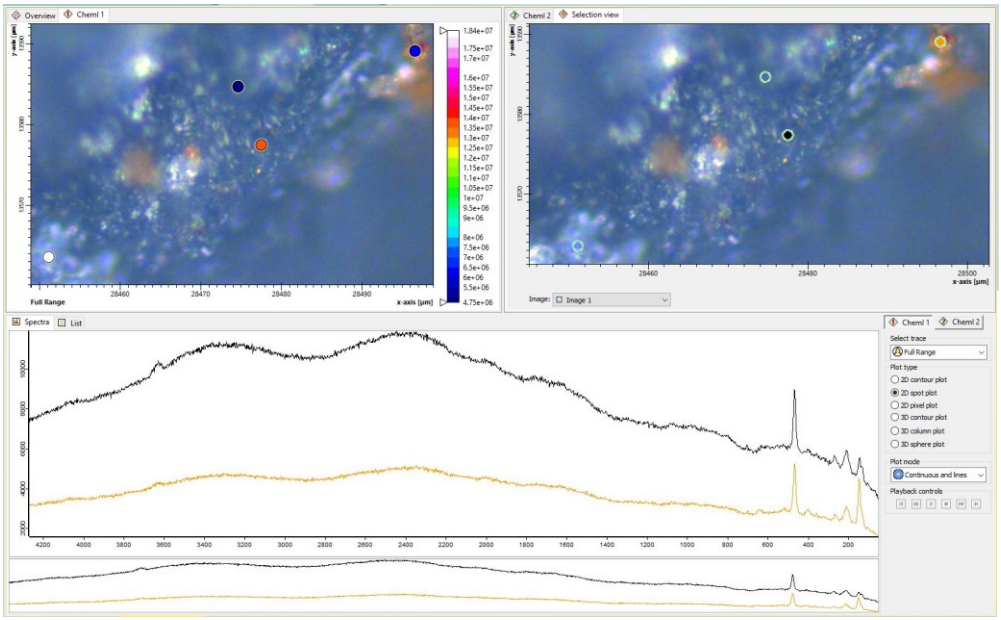
**Sample :**



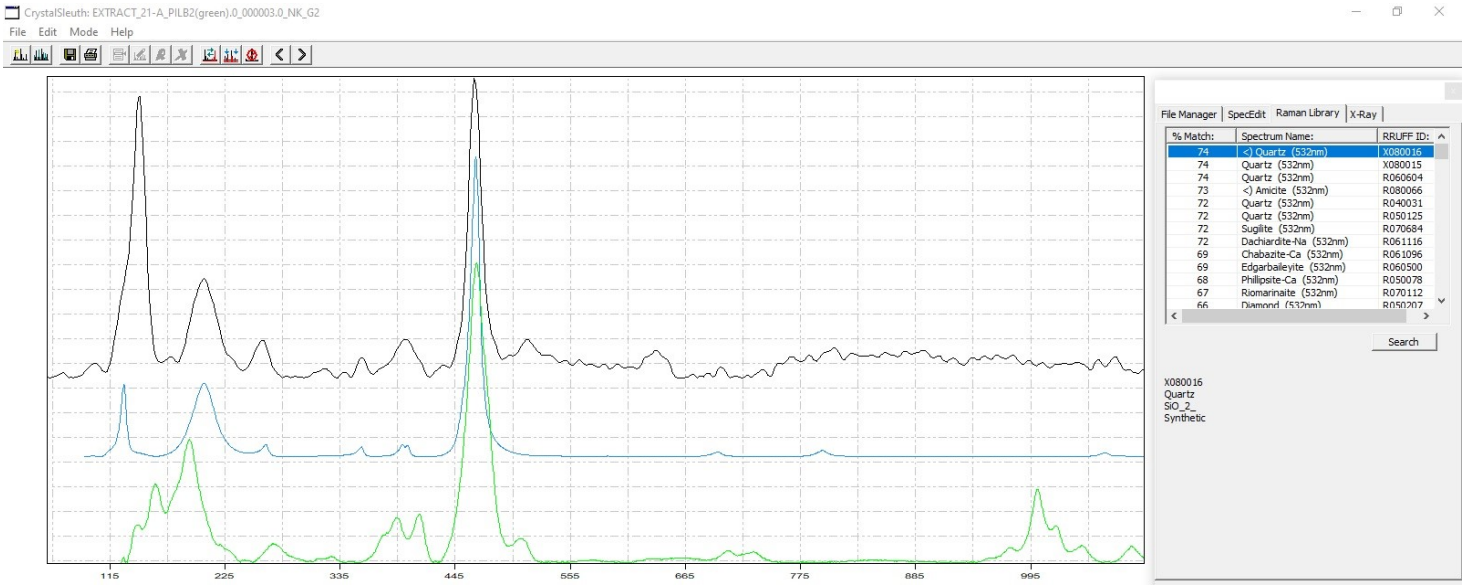



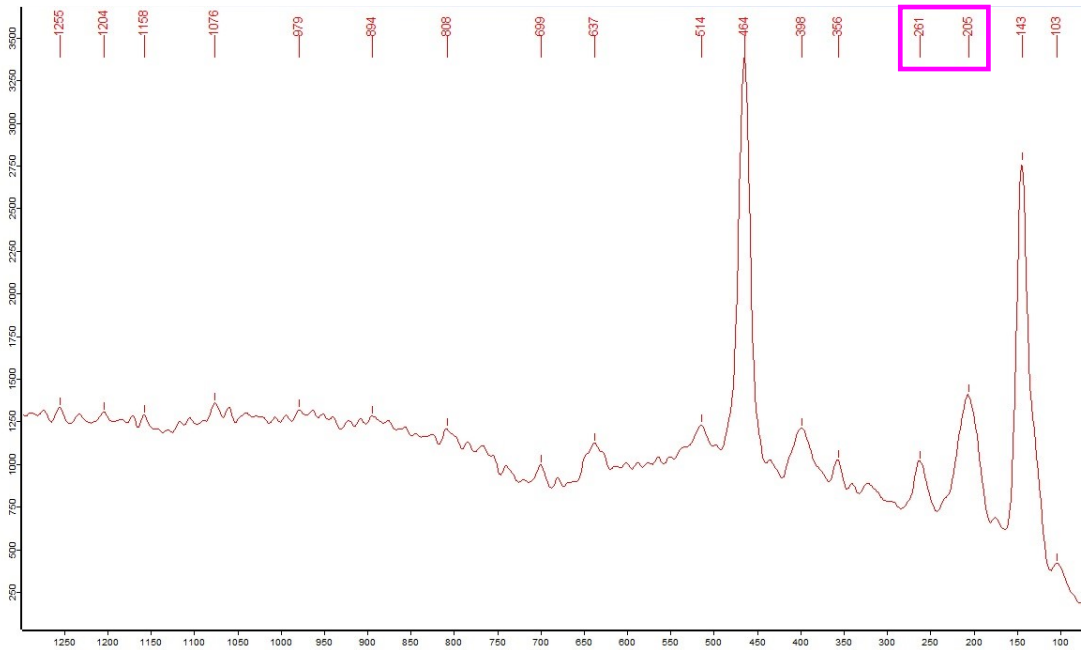

The spectral lines **205 and 126** indicate that the Quartz was exposed to a shock pressure of around **20 - 22 GPa !**

**Sample Site 21-A : Stone 4_spectra 2 ( Green mineral ) indicates : Quartz, Amicite** ( see RRUFF_CS results )

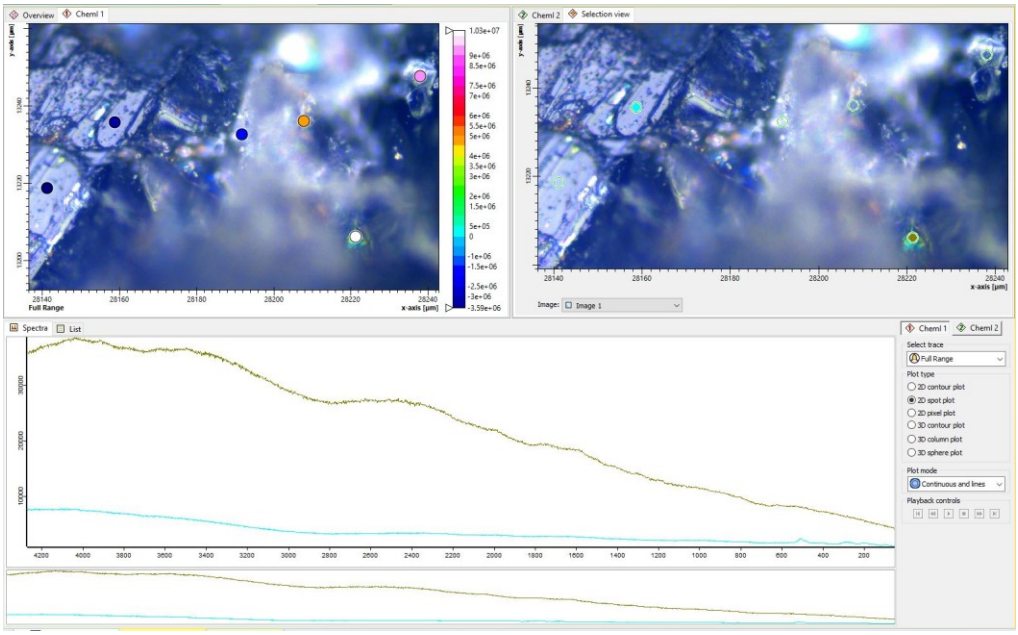


**Sample :**

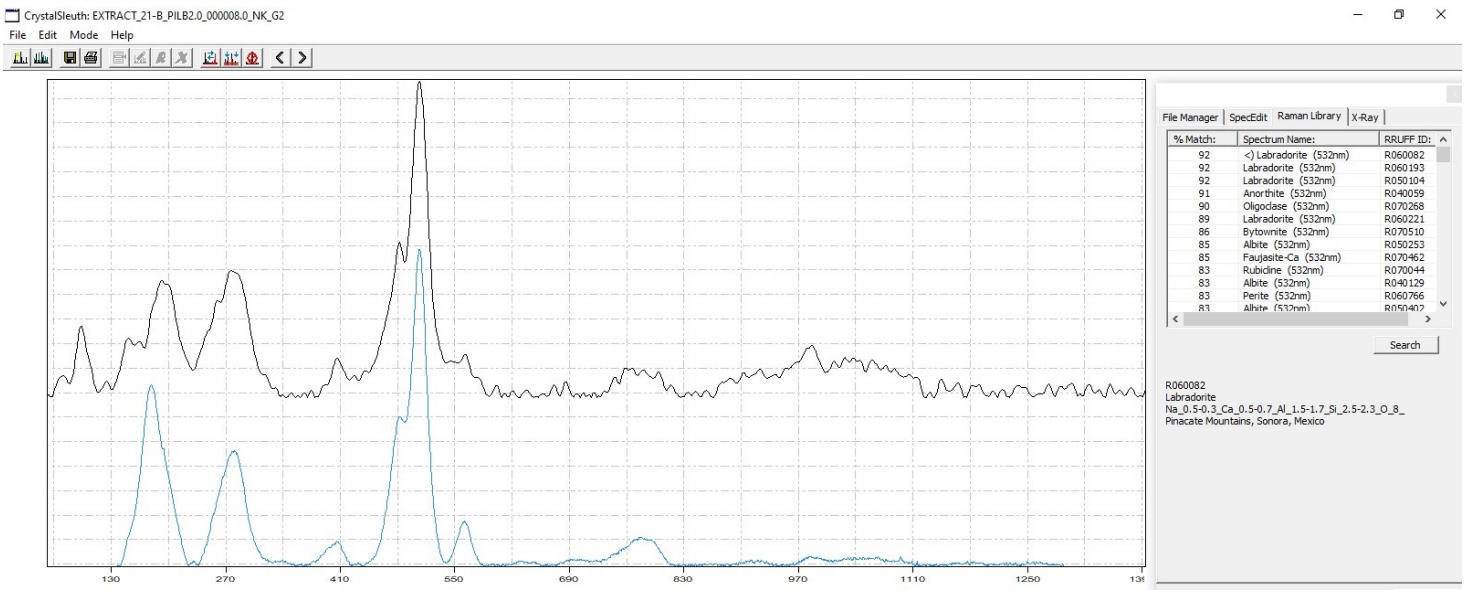


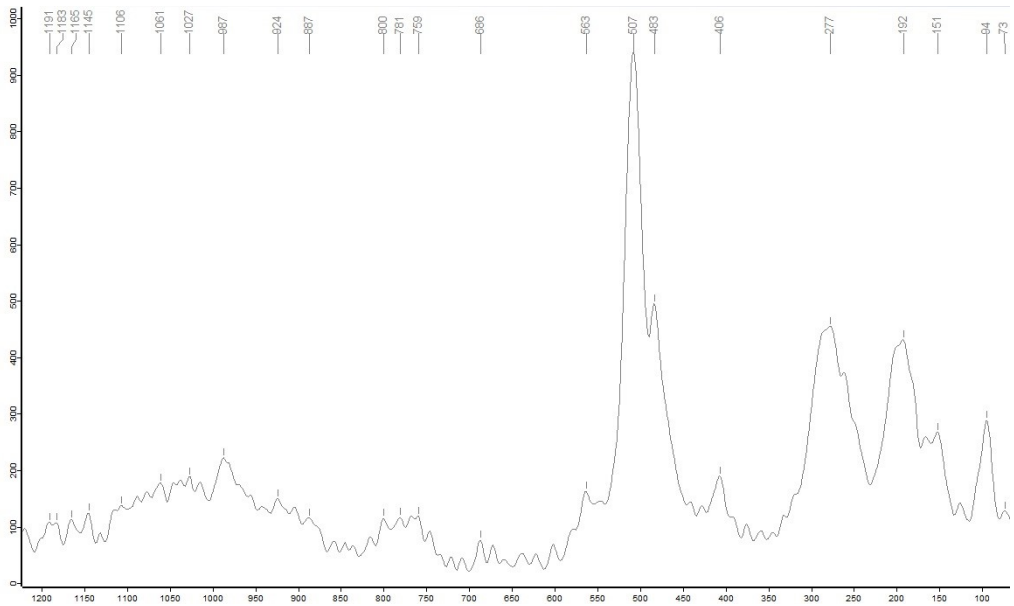



**Sample Site 21-B : Stone 3_spectra 1 indicates : Labradorite** ( → see RRUFF_CS results )



**Sample :**



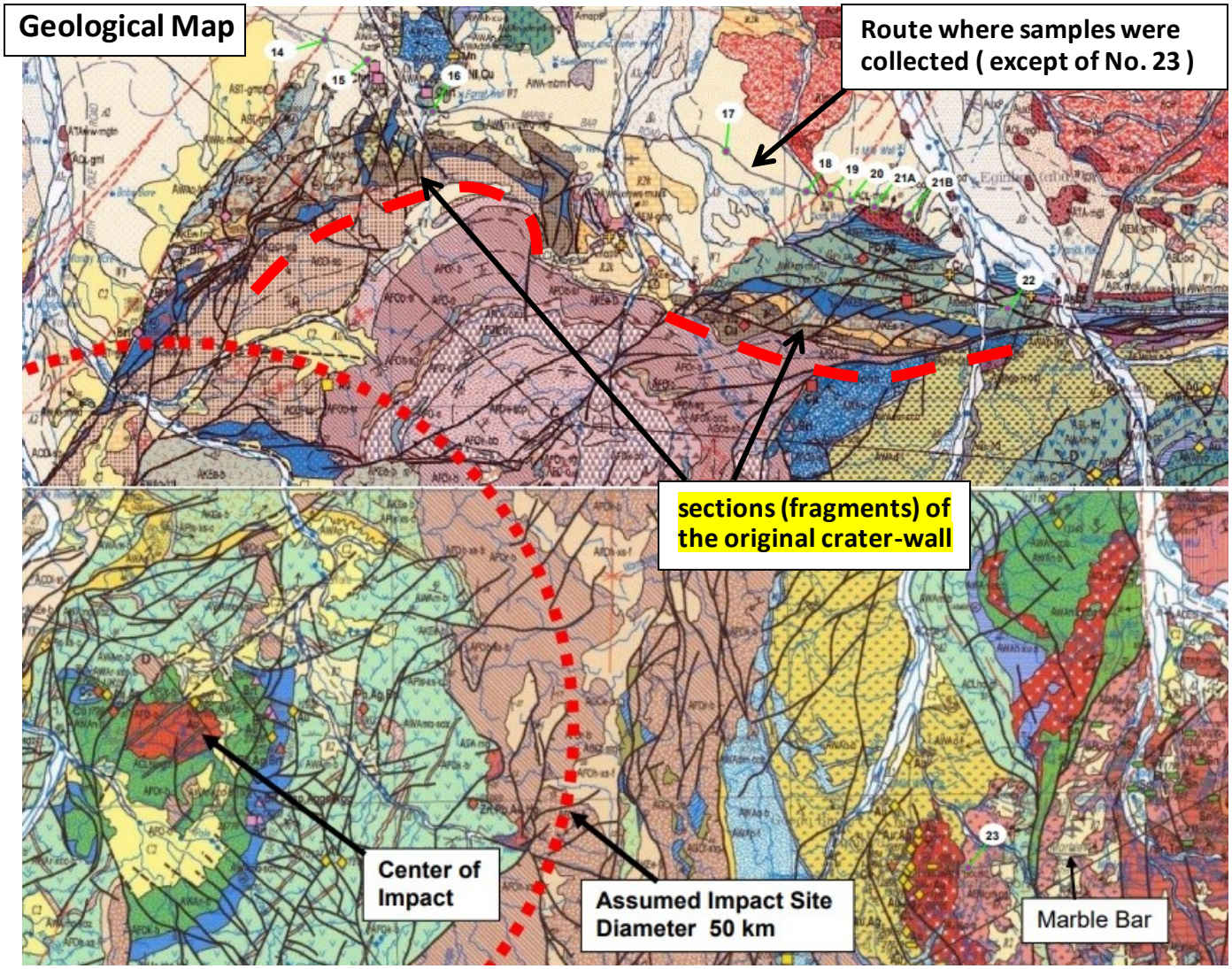



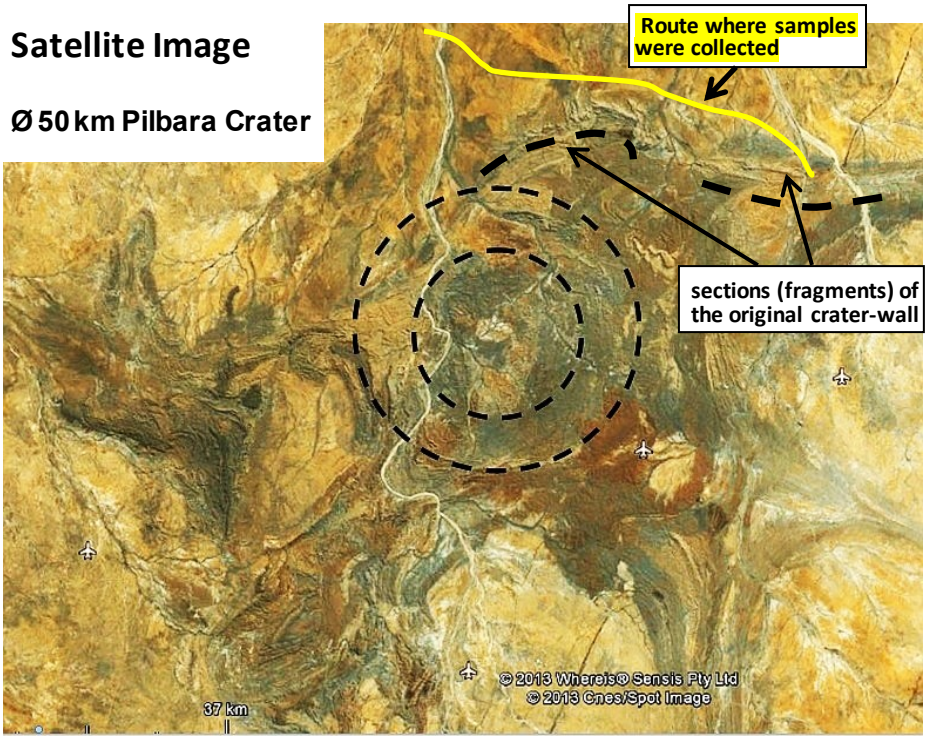
**Appendix 1 :** **Photos of the rock samples from the analysed sample sites :**

➔ **See next page !**

**Please note :** **Photos of all Sample Sites & Rock Samples are available on my website :**

➔ Samples Ø 50 km Pilbara Crater or alternatively here : Pilbara Crater



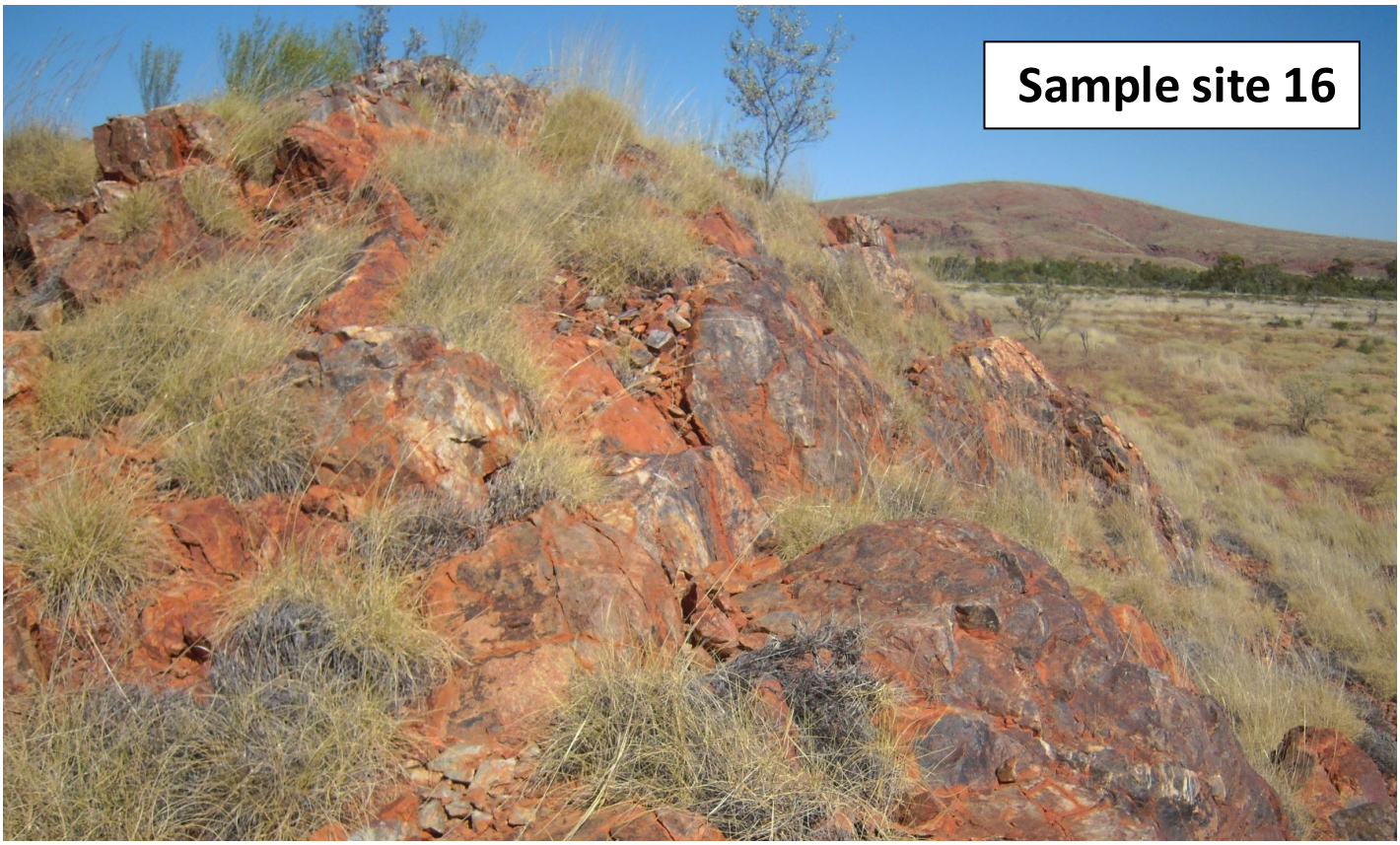



**14**


14 20° 47.655 S 119° 28.058 E 18 m Pilbara 2

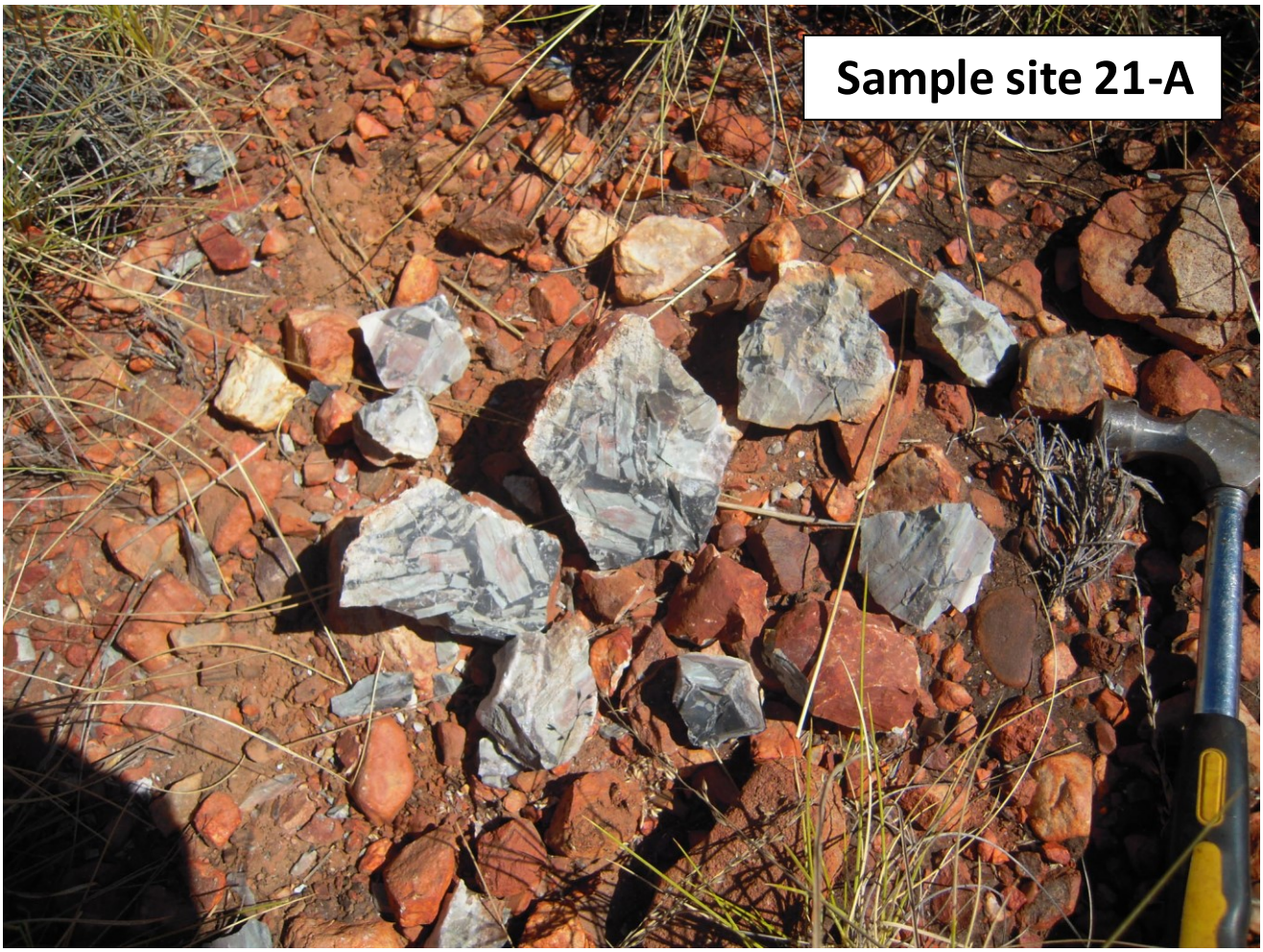
**16**

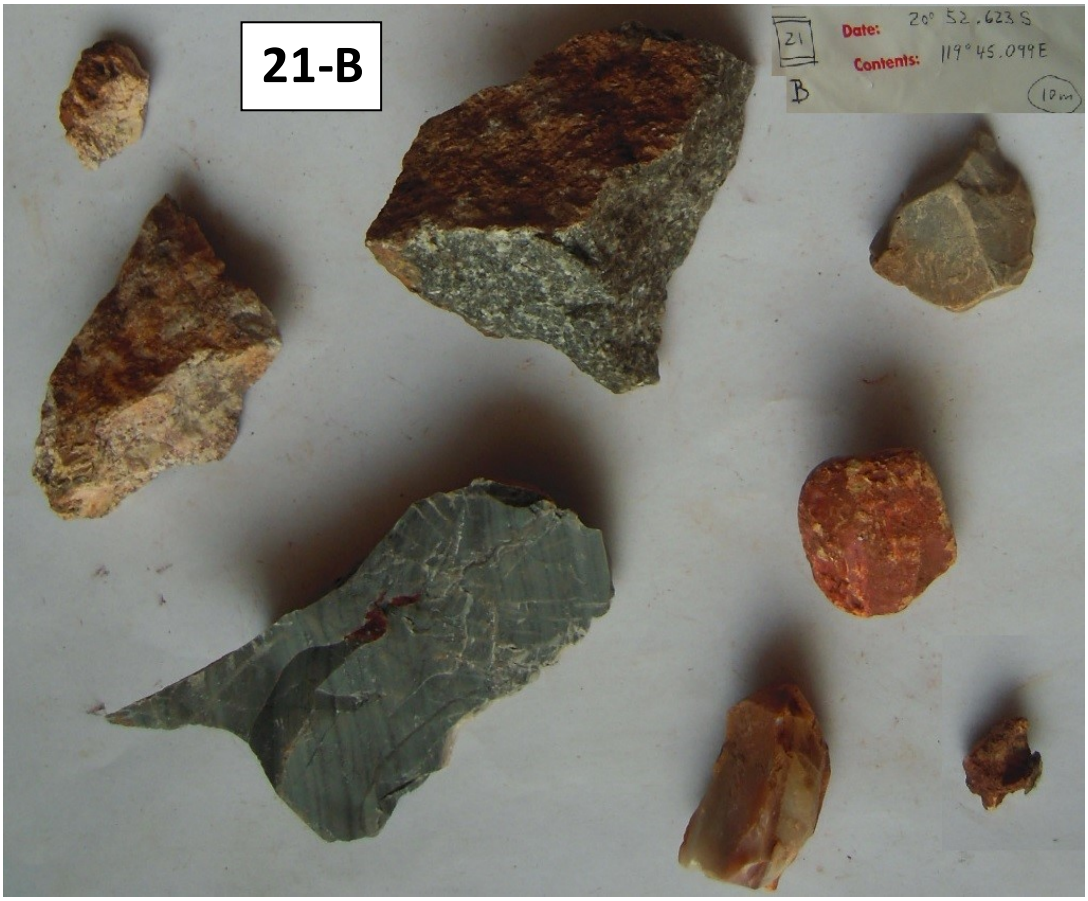

16 20° 49.832 S 119° 31.218 E 18 m Pilbara 2


Sample site 16

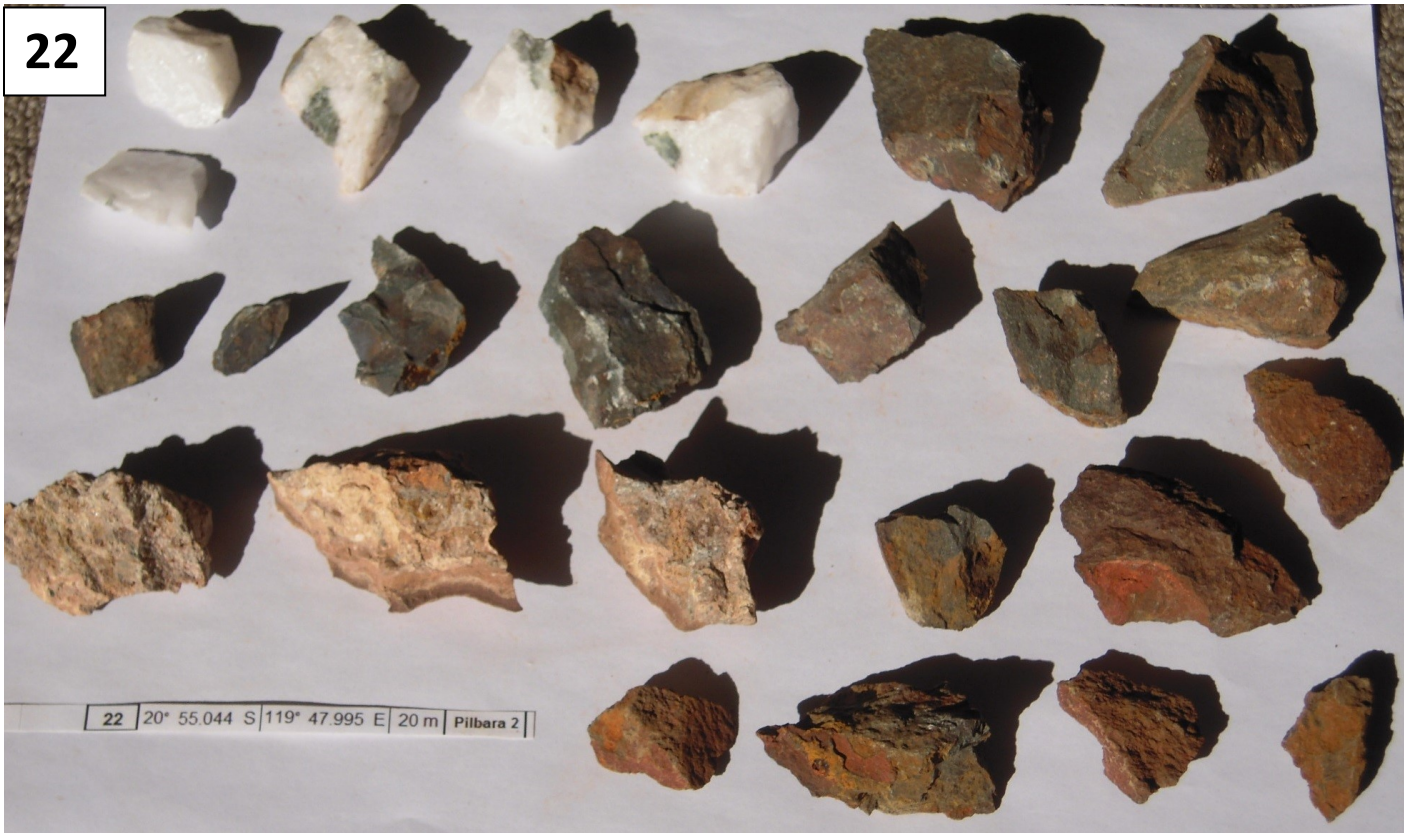

18
18 20° 51.953 S 119° 42.032 E 10 m Pilbara 2


21-A
21-A 20° 52.349 S 119° 43.985 E 6 m Pilbara 2


Sample site 21-A




**Sample site 21-B**
**“A boulder hill“**




## Sample site 23

Accessability to this site was a bit difficult, because there were aggressive gold-diggers on this land !

I lost most samples from this site near Marble Bar !

There were interesting structures in the rocks visible which probably showed fosselized stromatolite-like life-forms ! **Probably an interesting site for Archean-Paleontologists and Astrobiologists !**

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

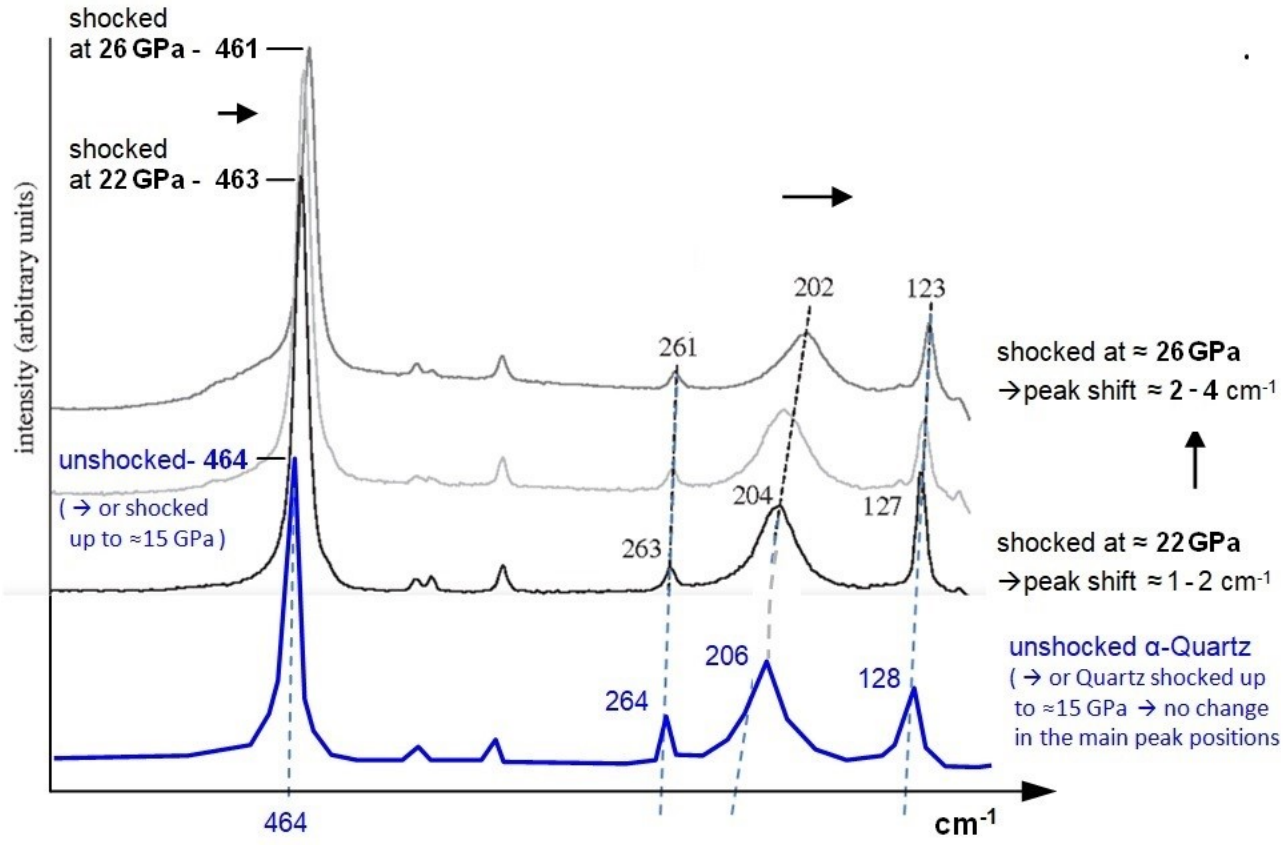
In order to verify a sample site as an impact site or impact structure, shock-metamorphic effects must be discovered in the rocks of the sample site. This can be done by different methods.

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.

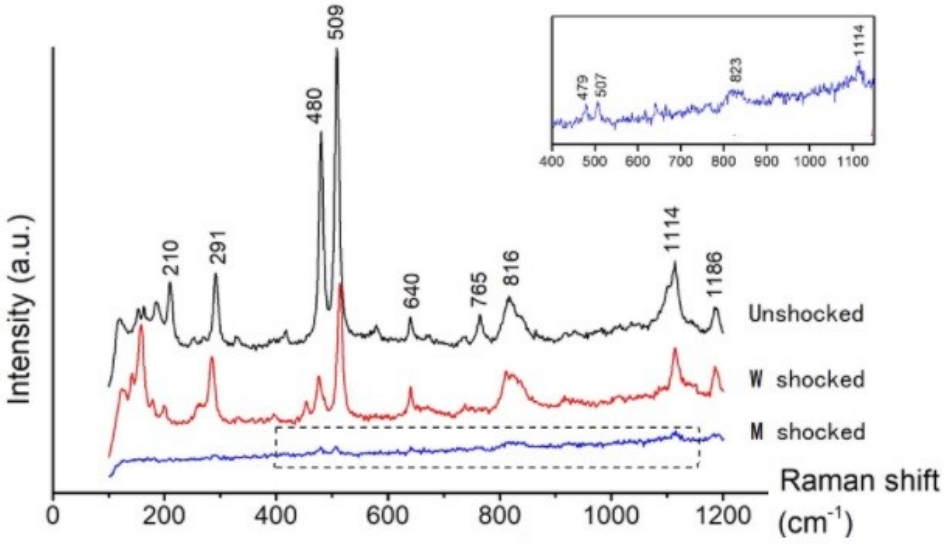
Mc Millan et al. (1992) and others have shown that the main RAMAN-peaks of Quartz shift towards lower frequencies if the Quartz was exposed the a shock-pressure > 15 GPa. → see diagram below

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 are available on :** Samples Ø 50 km Pilbara Crater ( or : Pilbara Crater )

**The 50 km Archean Impact Crater ( Age >3 Ga ) - Pilbara/Australia - A place where life on Earth started** - by Harry K. Hahn
https://vixra.org/abs/2101.0160 alternative : https://archive.org/details/the-50-km-archean-impact-crater-age-3-ga-in-the-pilbara

**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

**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