Traces of the PT-Impact Event found on the Islands Mallorca & Sardinia

- Raman spectra of selected Rock Samples -

by Harry K. Hahn / Germany - 15.4.2022

Summary :

Just a few kilometers offshore of the eastern coast-line of Mallorca there is a distinct linear step visible on the ocean-floor topography. This linear step on the ocean-floor represents a linear fracture in Earth's crust that was caused by the impact of ejecta-material, which was ejected by the **Ø1270x950km Permian-Triassic Impact Crater (PTI)** along the **PTI-Ejecta Ray R1**.

(→ see also explanation to the PTI-ejecta-rays on **page 21-30** of my **PTI-Hypothesis: Part 2** (or here: **P2**)

Parallel to the mentioned linear step on the ocean-floor, more such linear fractures were caused by the impact of Ejecta Ray R1, along the western side of Mallorca. These linear fractures and the impulse of the impacting PTI-ejecta-material have caused small crust-fragments which were inclined towards east. On their western side these crust-fragments were lifted upwards by the impact event, and in this way they formed the linear mountain range "**Serra de Tramuntana**" on the island Mallorca, which runs all along the west-side of Mallorca in NE to SW direction.

The mentioned linear fractures are the cause for the later break-off of the islands Mallorca, Menorca & Ibiza from the spanish mainland. One particular deep fracture, in combination with the expansion-tectonics process which was triggered by the PT-Impact Event, has caused this "break-off"-process.

On the spanish mainland the range "**Ports de Tortosa**", which has the same kind of linear structure and orientation, probably was formed in the same way. The impact of ejecta material from Ejecta Ray R1 has caused the same small crust-fragments, with an inclination towards east, which formed this range.
Originally the "Serra de Tramuntana"-range and the "Ports de Tortosa"-range laid side by side, before they drifted apart, caused by the mentioned expansion tectonics process, as my manipulated satellite image on the next page indicates. More evidence for the PTI-Ejecta-Ray R1 and the crater-chain caused by R1, comes from the Bay of Lyon Crater (or BLC) and other impact structures in Spain (or L2).

I found additional traces of the PT-Ejecta-Ray R1 on satellite images of the **island Sardinia** (→ see **page 4**)

I analysed rock-samples from selected sample areas in the Tramuntana Range with Micro-Raman-Spectroscopy, to find out if they were exposed to a shock pressure which may indicate an Impact Event.

The Raman-spectra of quartz from the Sample Sites 6-A and 6-B indeed provided first evidence for an impact event as the probable cause of the linear Tramuntana Range. The clear shifts of the main Raman-peaks, of the analysed quartz samples, to the lower frequencies 463, 261, 204 and 126 cm^{-1} (Site 6-A, stone 1) and to 263 and 126 cm^{-1} (Site 6-B, stone 1) provide first proof for an Impact Event !

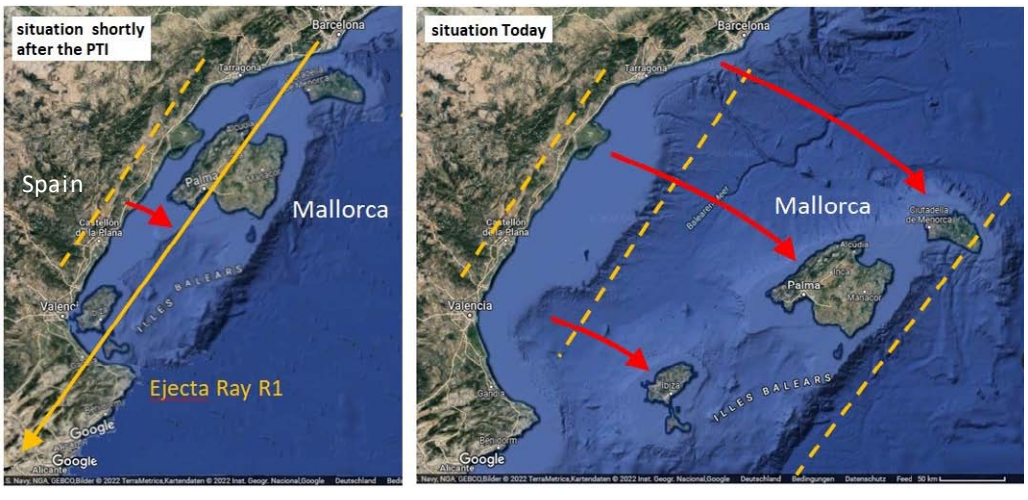
(→see explanation in **Appendix 1** at **page 28** : Overview : The Raman bands (peaks) of shocked Quartz)

Microscopic images of the analysed quartz grains **may provide further proof for an impact event.**

The mineral **Motukoreaite** found on sites 2,3,4 & 6 indicates that Ejecta-Ray R1 impacted on ocean ground

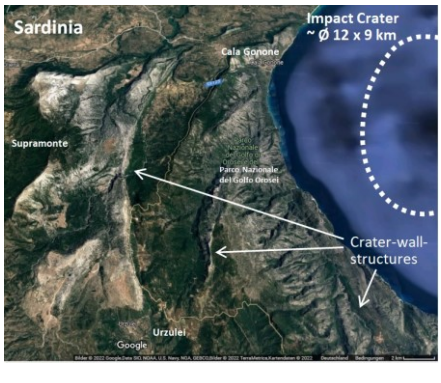
→ Images of the analysed rock samples and photos of the sample sites are in the Appendix at page **14**
→ A general summary to all analysed samples regarding my **PTI-hypothesis** (**P1**) → in **Part 6** (**P6**)
→ More images of all sample sites are available on www.permiantriassic.de or www.permiantriassic.at

The island Mallorca was cut-off from Spain by Ejecta Ray R1 (caused by the PT-Impact)



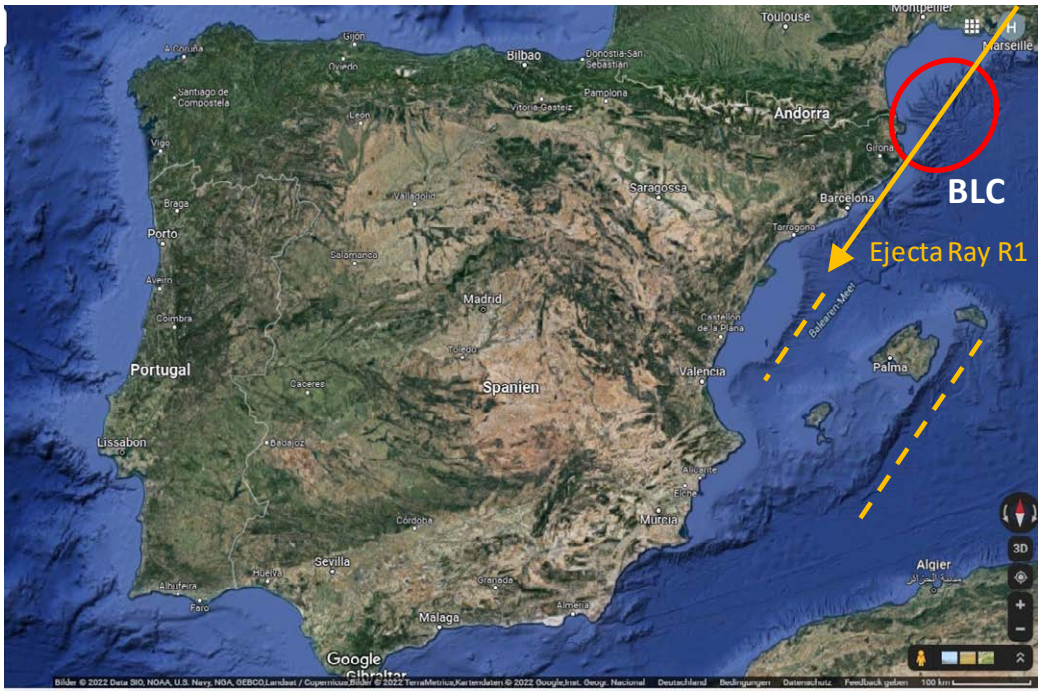
There is a secondary impact crater Ø 12 x 9 km visible on the island Sardinia, caused by Ejecta Ray R1

The crater-walls consisting of old mesozoic / paleozoic limestone

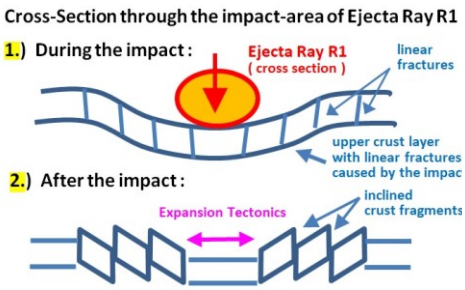


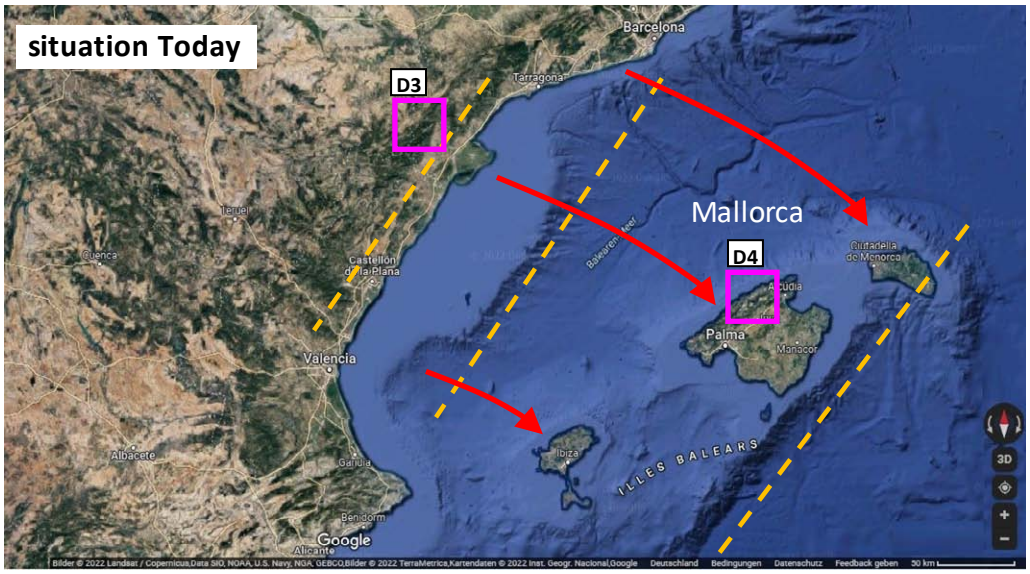
The linear Tramuntana Range on the Island Mallorca was caused by the impact of the PTI-Ejecta Ray R1

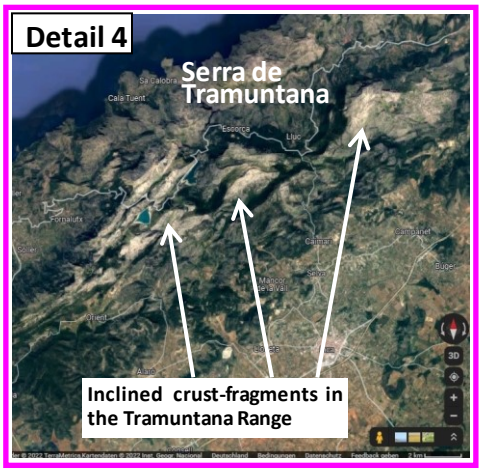
The **Permian-Triassic Impact Event (PTI)** left clear traces in Europe. The Bay of Lyon Impact Crater, which is a large secondary impact crater caused by the PTI, probably is one of the best examples of secondary impact structures caused by the PTI.
The **Bay of Lyon Crater (BLC)** is the northern starting-point of a (secondary) impact-crater-chain that was caused by the PTI. This impact-crater-chain was caused by the strong **Ejecta Ray R1** of the PTI (see pages **21-30** in Part 2). On the eastern coast-line of Spain, and on the ocean-floor further east, there are still clear traces of this Ejecta Ray R1 visible (see images below !).



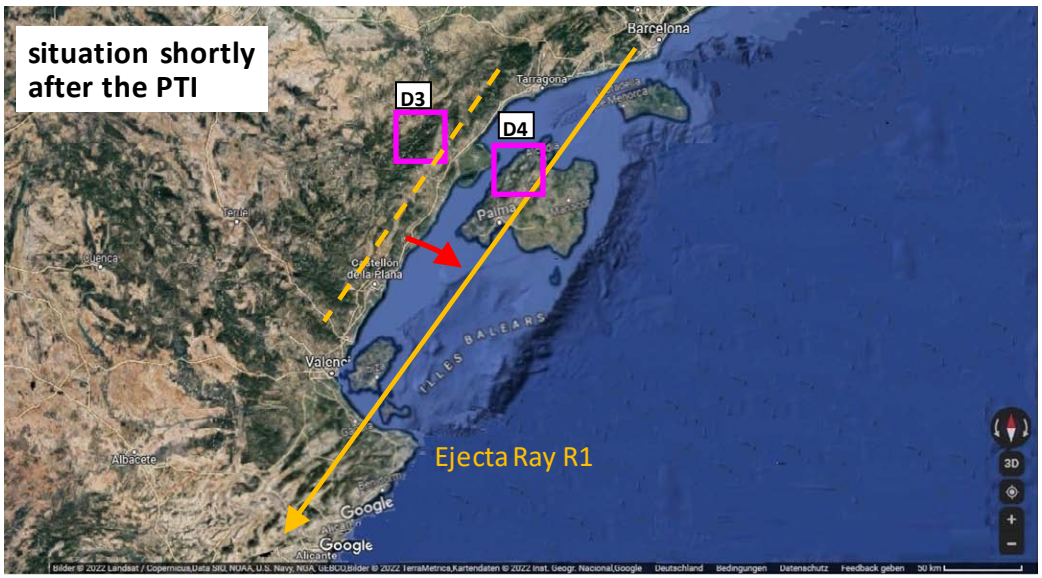
There are clear noticeable **linear edges (or steps) on the ocean-floor** visible. One along the east-coast of the Island Mallorca, and another one just east of the spanish mainland in the mid between Barcelona and Valencia. **This two steps were congruent (on the same position) shortly after the PTI**, and they are running in the same SW-direction as the **Ejecta Ray R1** that was caused by the PTI. The steps are linear fractures in Earth's crust which were caused by the impact of the ejecta material of Ejecta Ray R1.
The inclined crust-fragments parallel to the fractures are a result of the R1-impact as this sketch indicates :

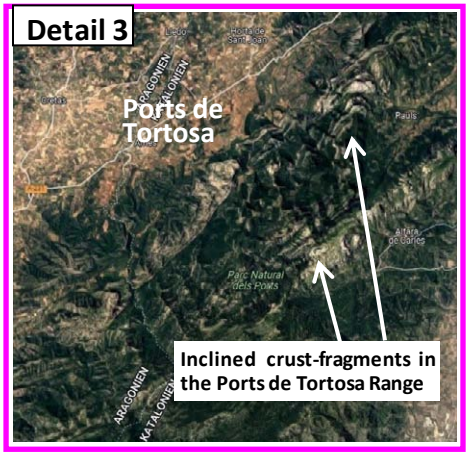






The Serra de Tramuntana (Range) on Mallorca and the range Ports de Tortosa on the spanish-mainland were formed by crust-fragments that were caused, and inclined towards east, by the impact of R1





The topograpic map of Mallorca and paleozoic rock (>250 Myr old) on Mallorca's north-coast indicate that the Tramuntana-Range was formed by the impact of Ejecta-Ray R1, which was caused by the PT-Impact Event

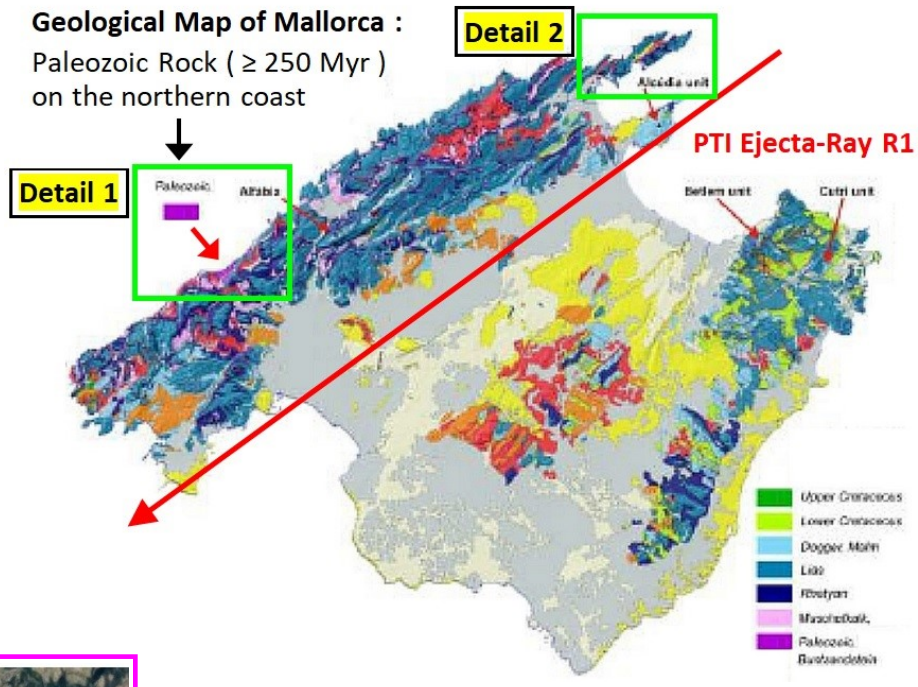
The nearly linear **Tramuntana Range** visible on the topographic map of **Mallorca** in all probability is the result of the impact of **Ejecta Ray R1**, which was caused by the **Permian-Triassic Impact (PTI)** ≈ 250 Myr ago.

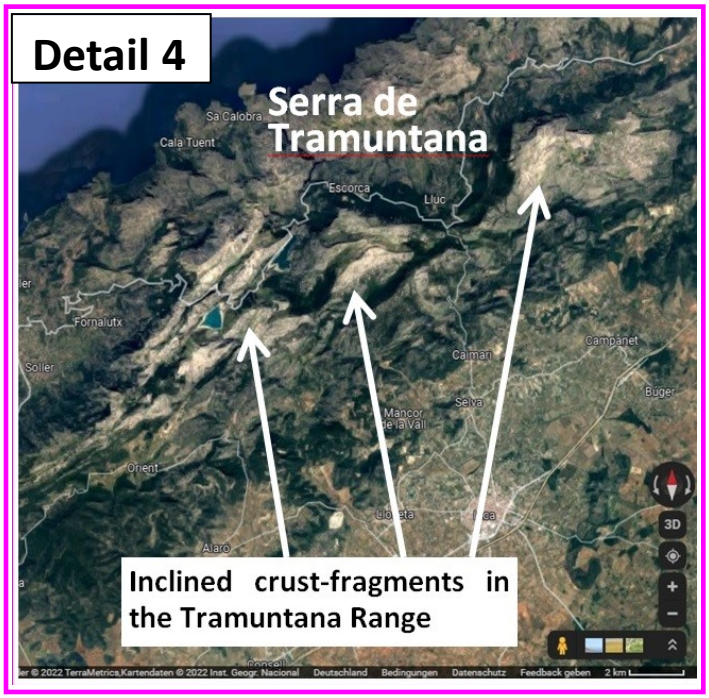
The **paleozoic rocks** on the sample sites **6-A** & **6-B** on Mallorca's north-coast (**Detail 1** on the geological map) with PT-boundary age show shock-metamorphic effects in quartz-grains caused by an impact shock event.

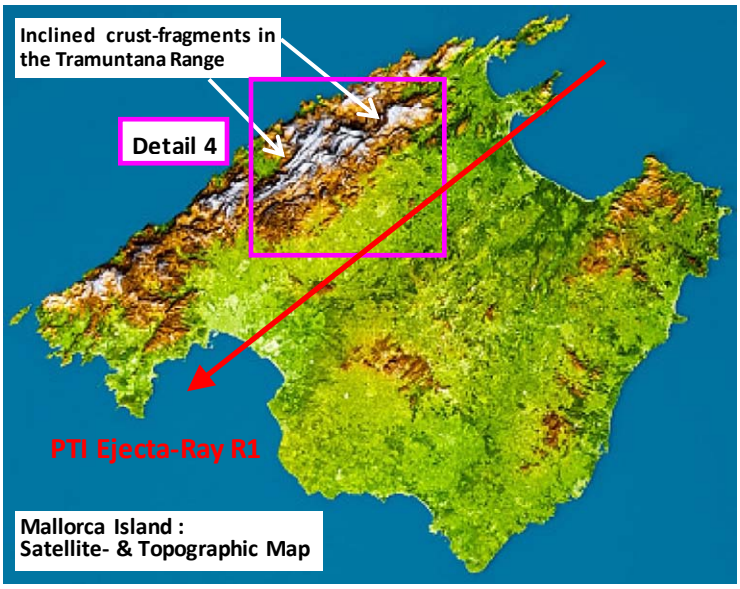
→ **see Raman Spectroscopic analyses of quartz grains from site 6-A & 6-B**

→ **Digital Geological-Map of Spain :**
Magna 50 - 1:50000 GEO-Maps

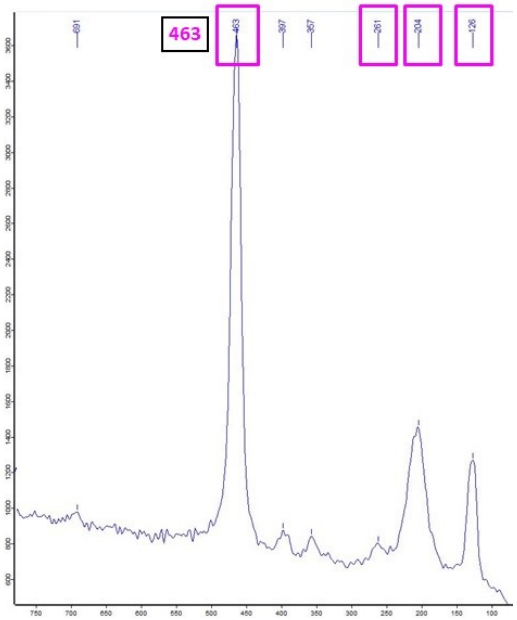
→ **zoom-in to Mallorca Island**







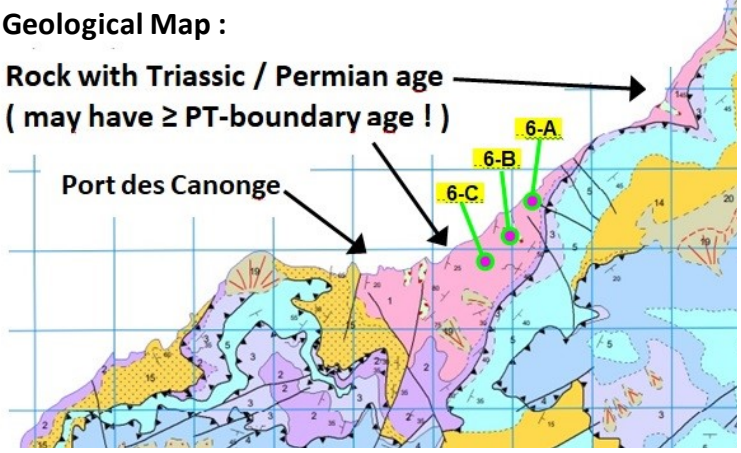
Raman Spectroscopic analysis of quartz from site 6-A :



The spectral lines **463, 261, 204 and 126** indicate that the Quartz from **site 6-A** was exposed to a shock pressure of around **22 GPa**

Detail 1 : Sample sites 6-A to 6-C with paleozoic age (possible PT- boundary age) on Mallorcas North-Coast

Geological Map :



The linear east-coast of the Island Sardinia ist a result of the impact of Ejecta Ray R1 too

The satellite image with ocean-floor topography of the islands **Corsica** and **Sardinia** shows the same kind of linear step (or edge) on the ocean-floor east of these two islands, as the linear step on the ocean-floor east of the island **Mallorca**.

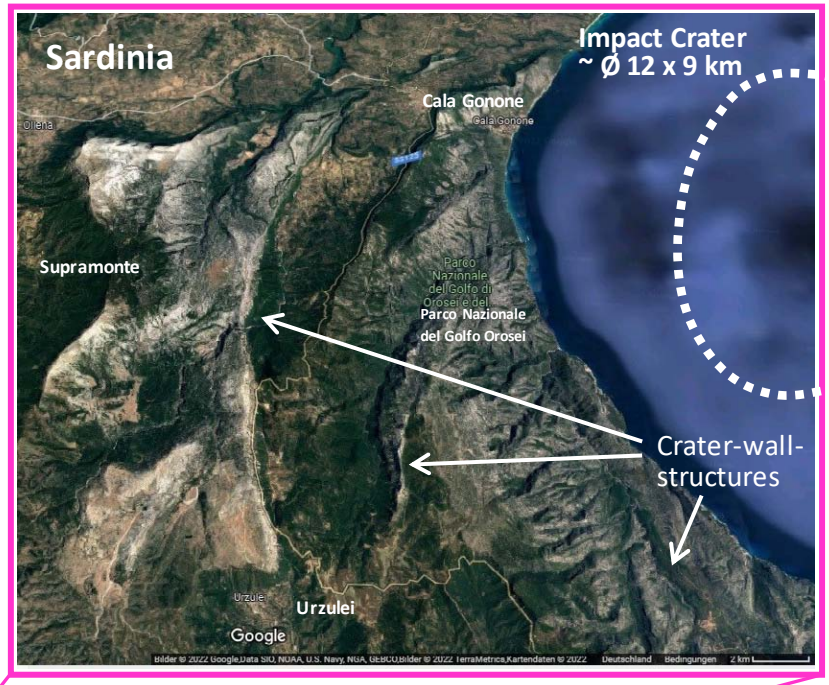
This linear step (or edge) on the ocean-floor was congruent with the linear step east of the Island Mallorca and the linear step on the spanish mainland, shortly after the PTI-event.

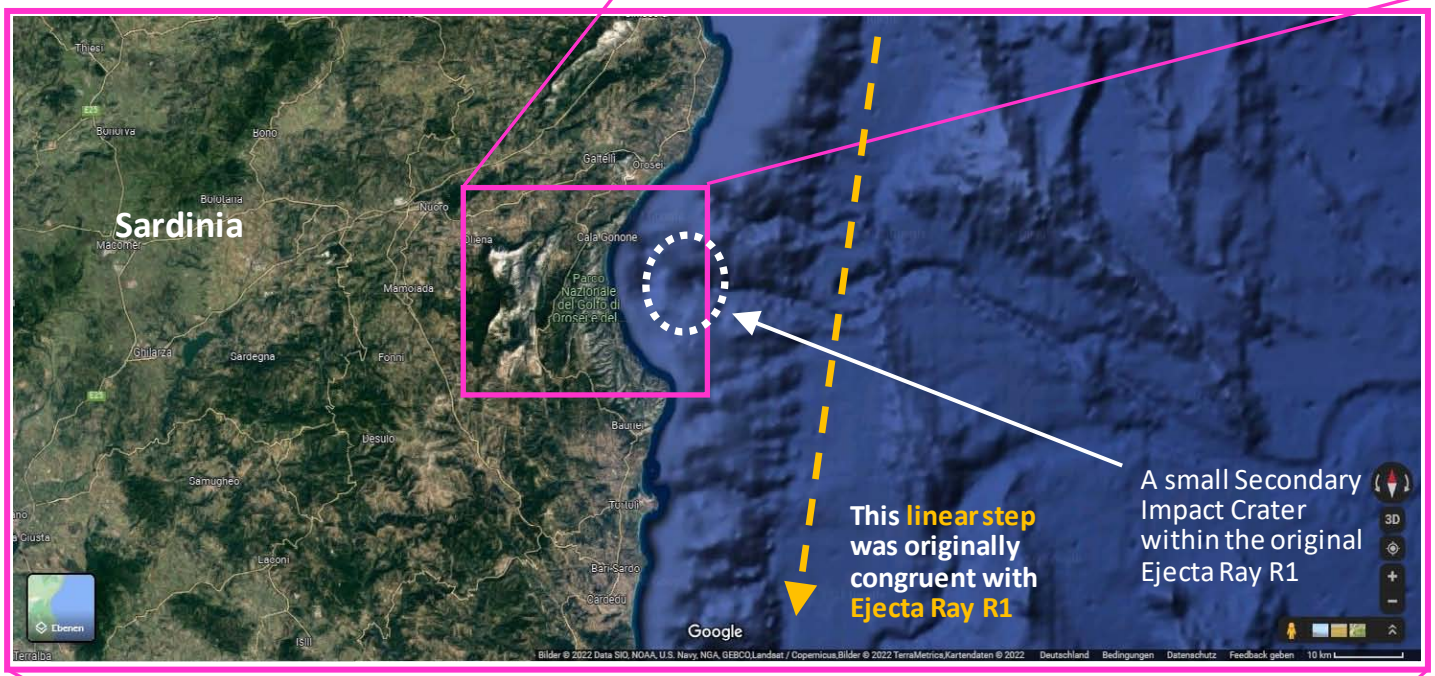
It represents **the same linear fracture in Earth's crust**, which was caused by the impact of the material that was ejected by the **PTI** along **Ejecta Ray R1**. (→ see explanation on pages **21-30** in **Part 2** of my PTI - Hypothesis).

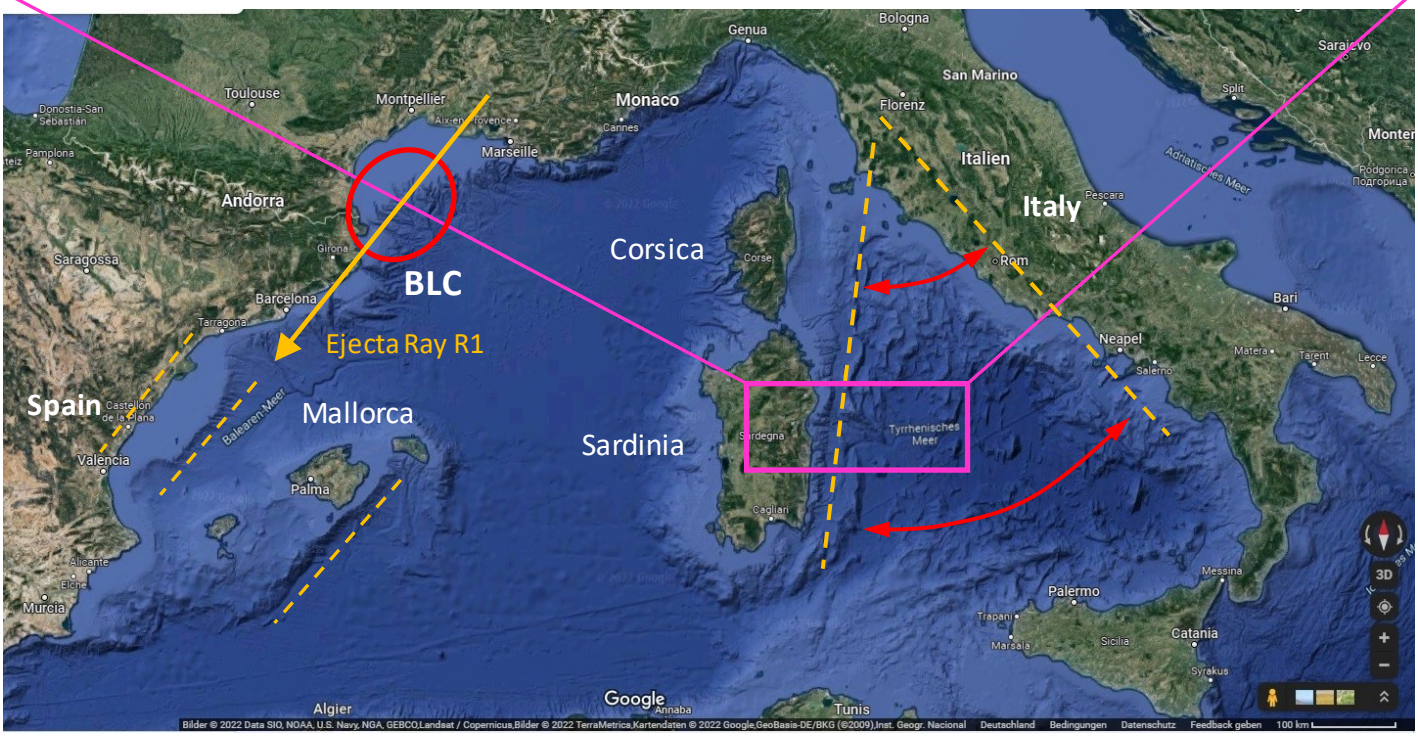
A small secondary impact crater is visible in the area between the villages **Cala Gonone** & **Urzulei**

I haven't collected rock samples in this area, but I am sure this is a secondary crater of the **PTI** too

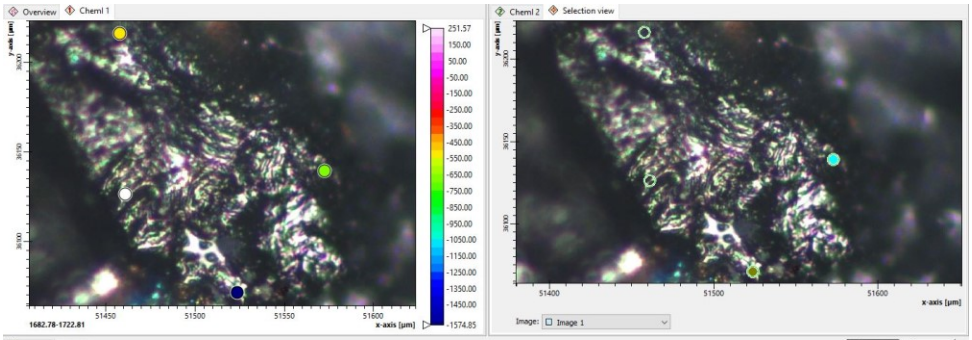
The craterwalls consist of mesozoic/paleozoic limestone rock (see Supramonte & Gennargentu)



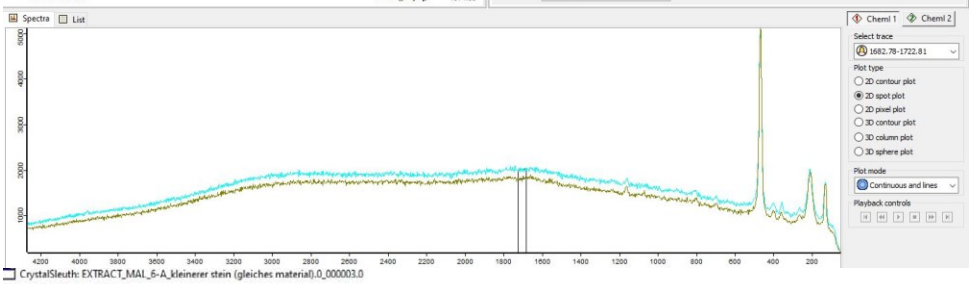


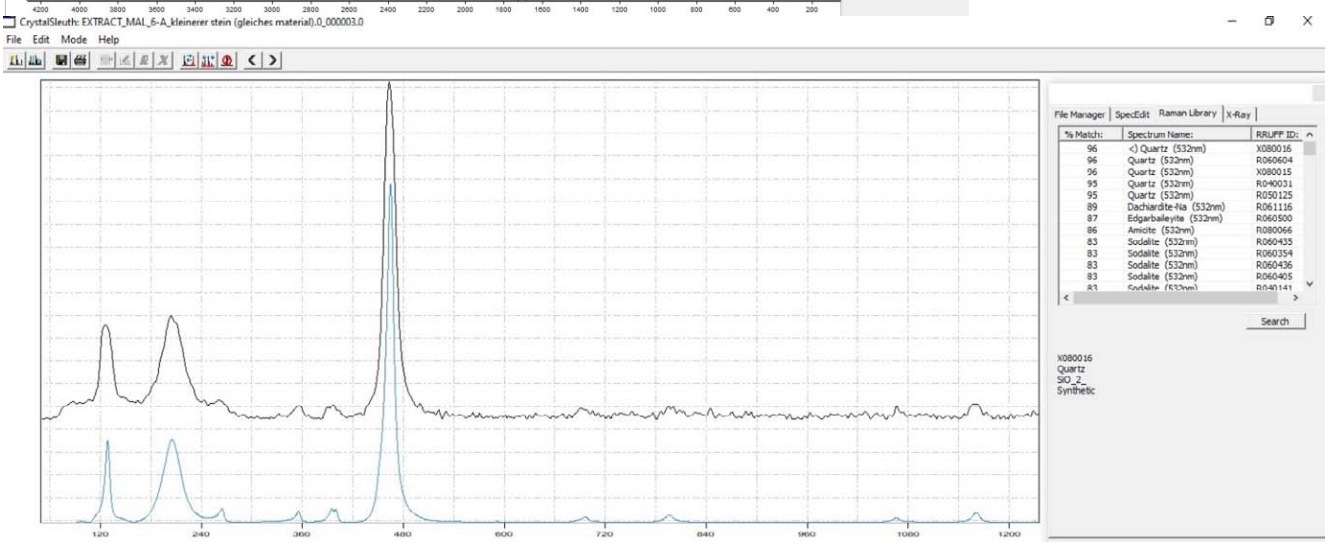


Sample Site 6-A : Stone 1_spectra 1 indicates : Quartz (→ see RRUFF_CS search)



Sample :





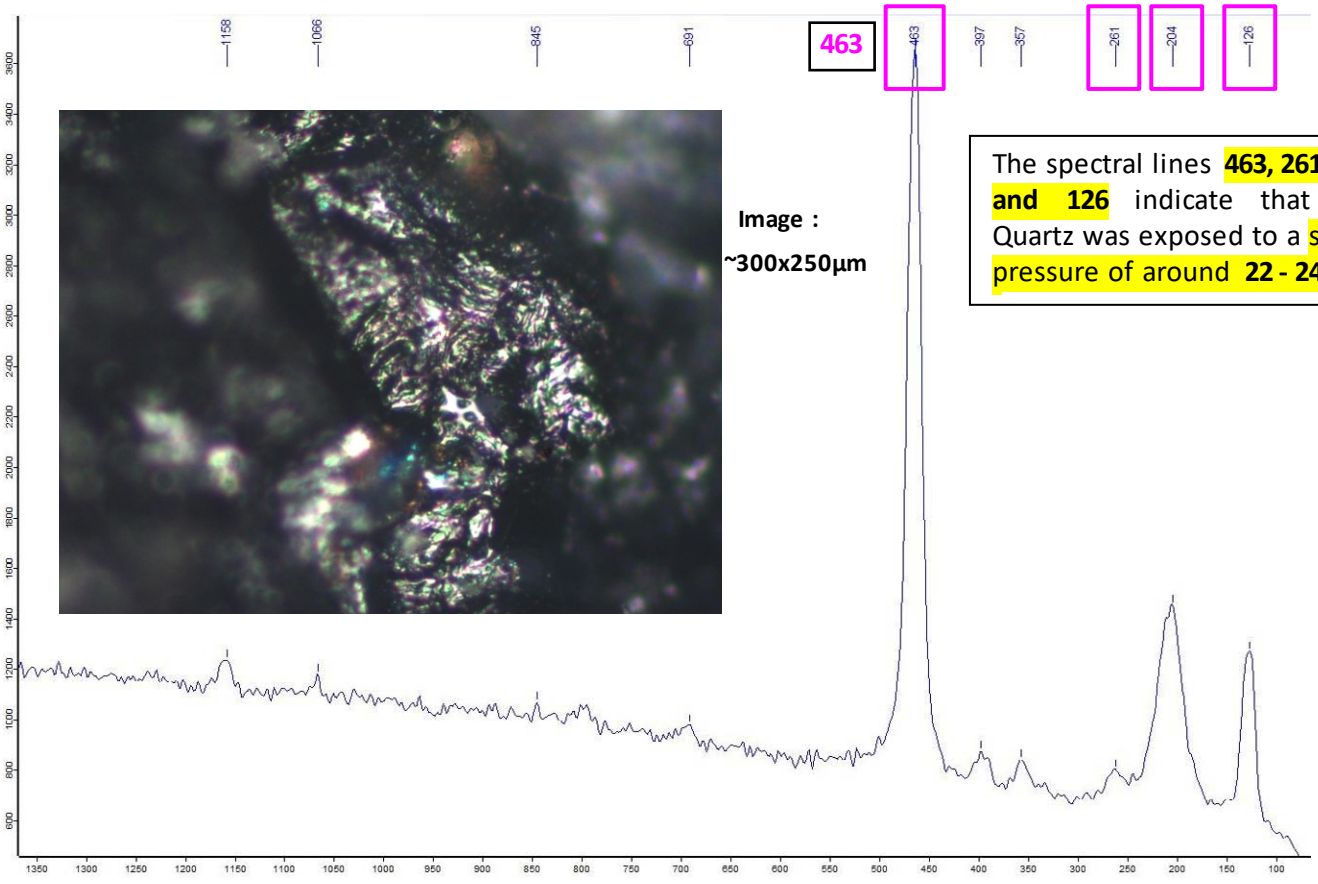
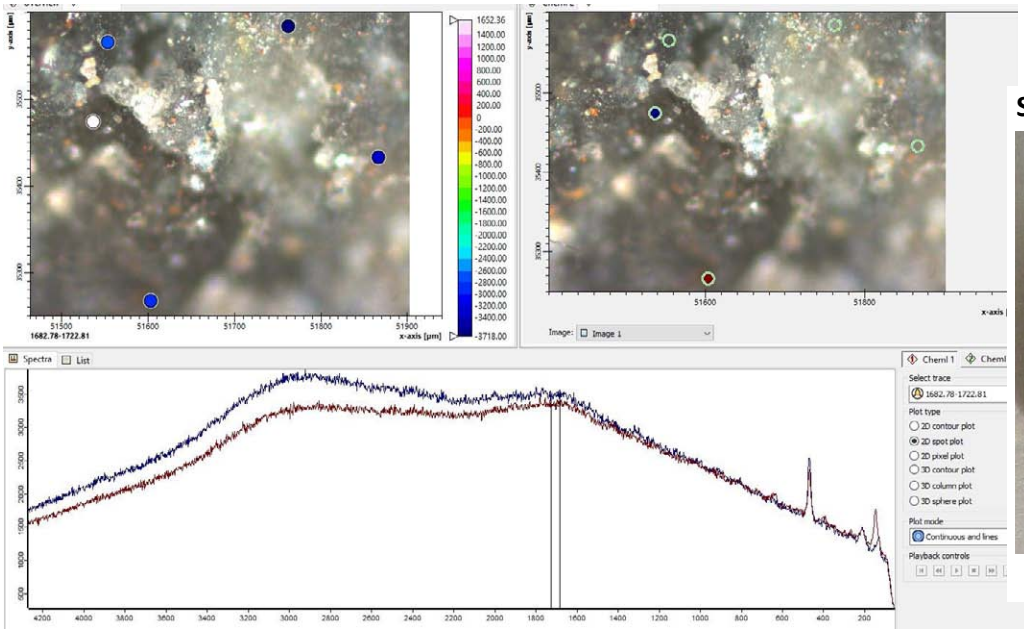


Image :

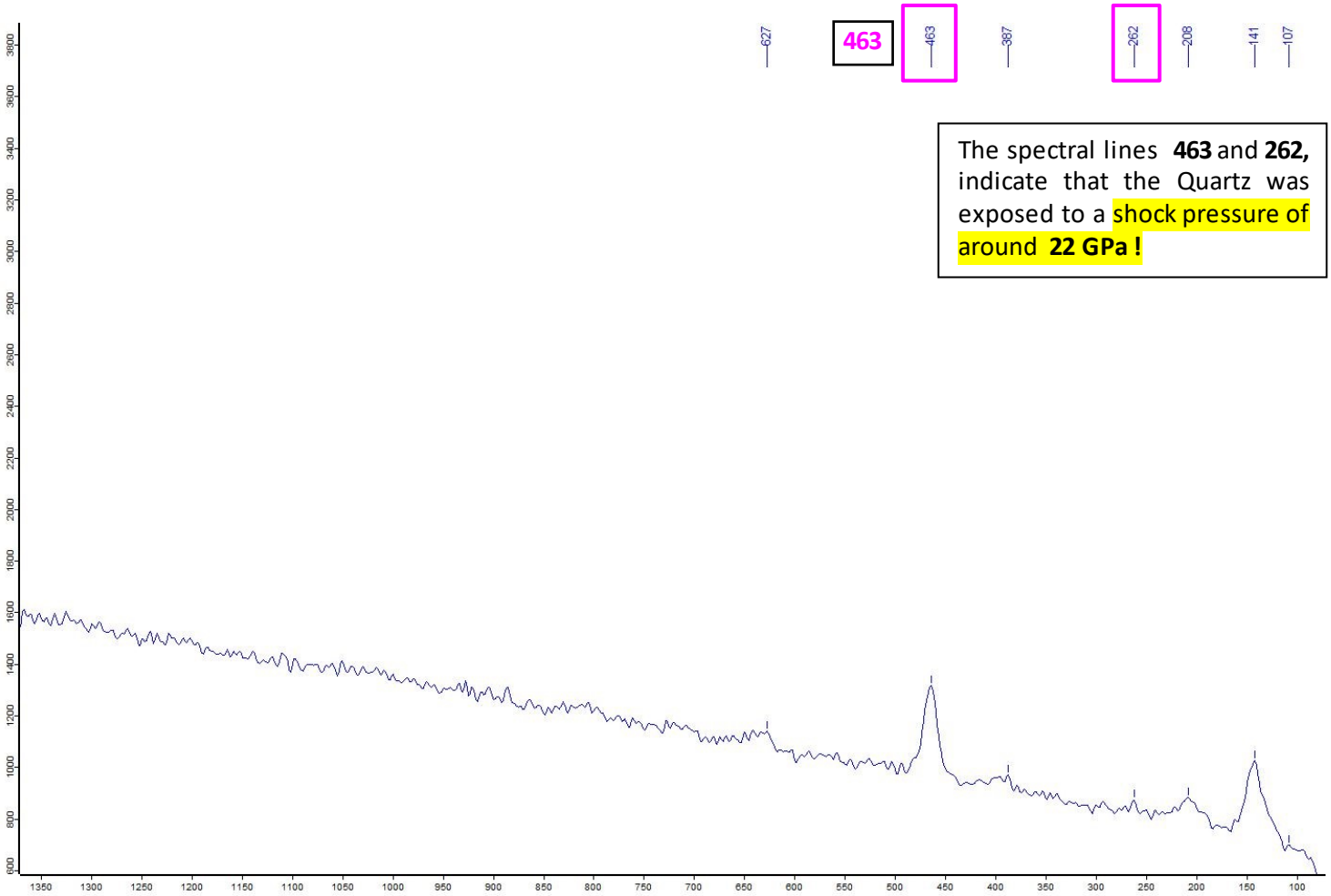
~300x250µm

The spectral lines **463, 261, 204 and 126** indicate that the Quartz was exposed to a shock pressure of around **22 - 24 GPa**

Sample Site 6-A : Stone 1_spectra 2 indicates : Quartz (→ see RRUFF_CS search)

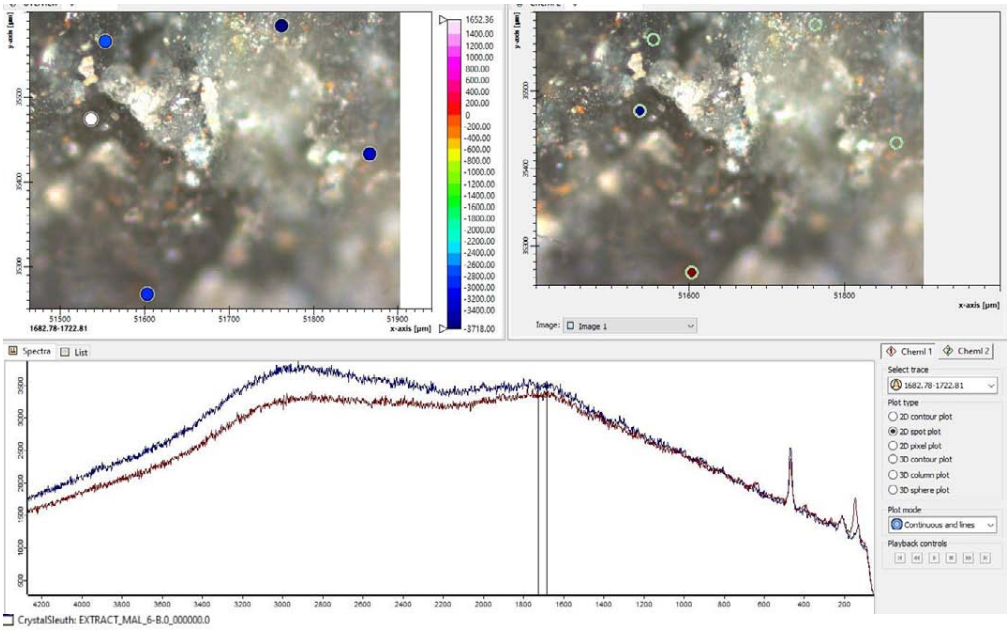


Sample :

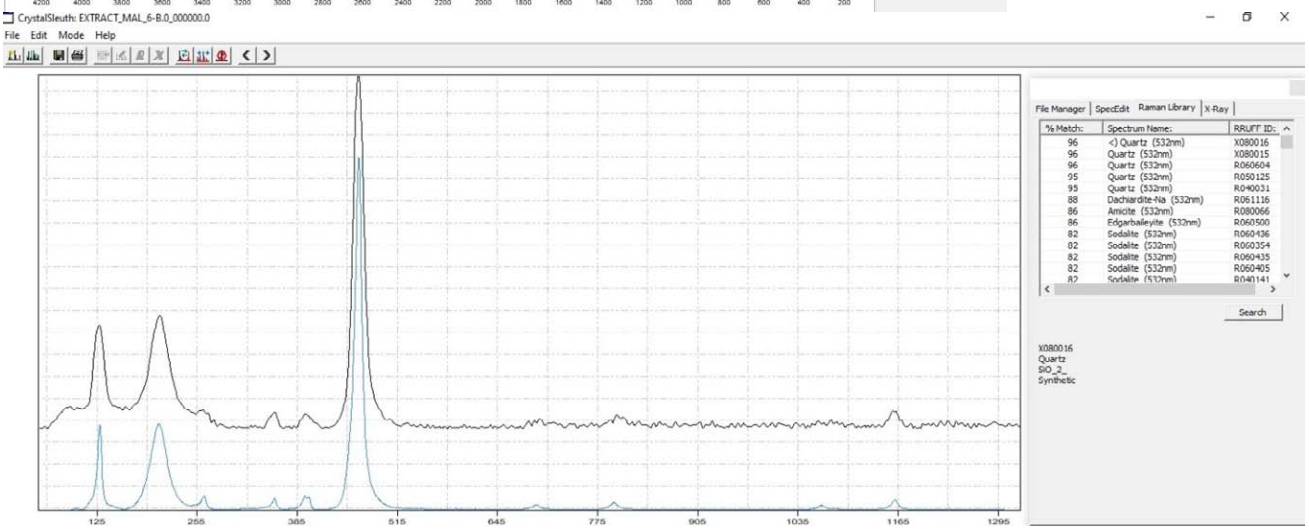


The spectral lines **463** and **262,** indicate that the Quartz was exposed to a shock pressure of around **22 GPa !**

Sample Site 6-B : Stone 1_spectra 2 indicates : Quartz (→ see RRUFF_CS search)



Sample :



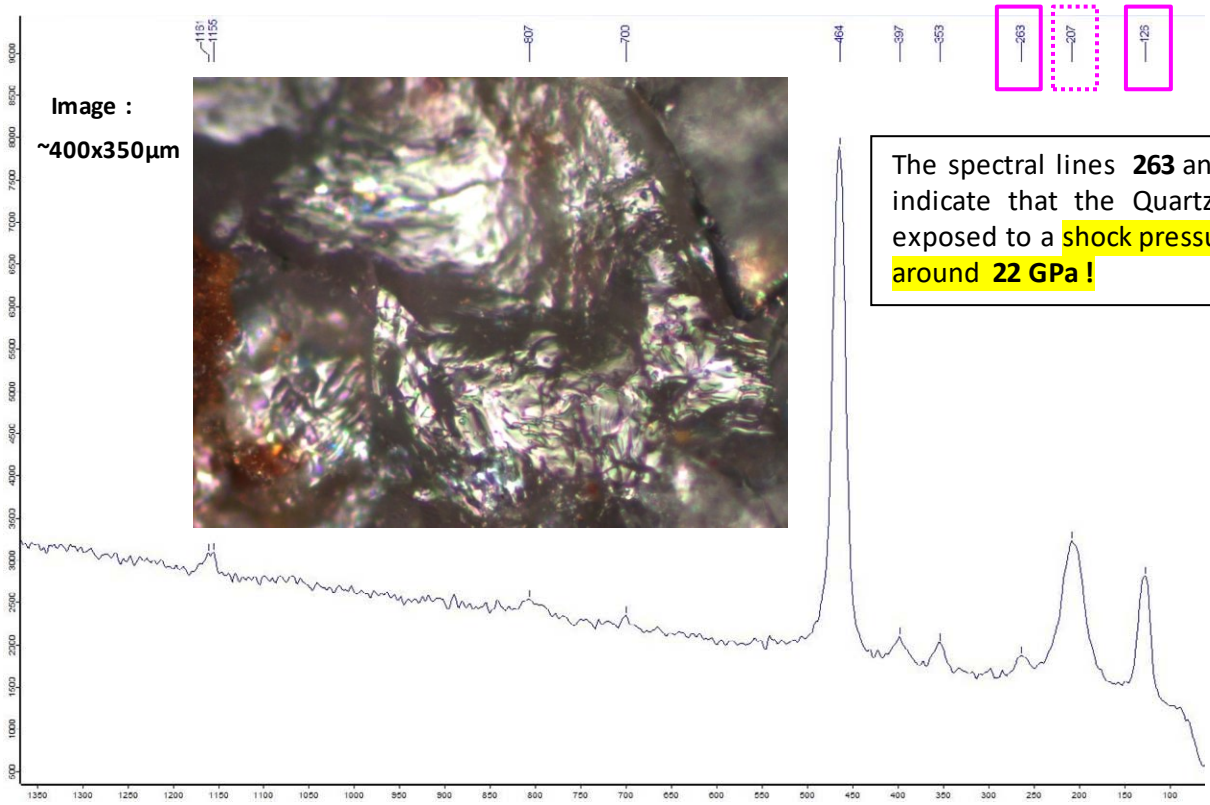
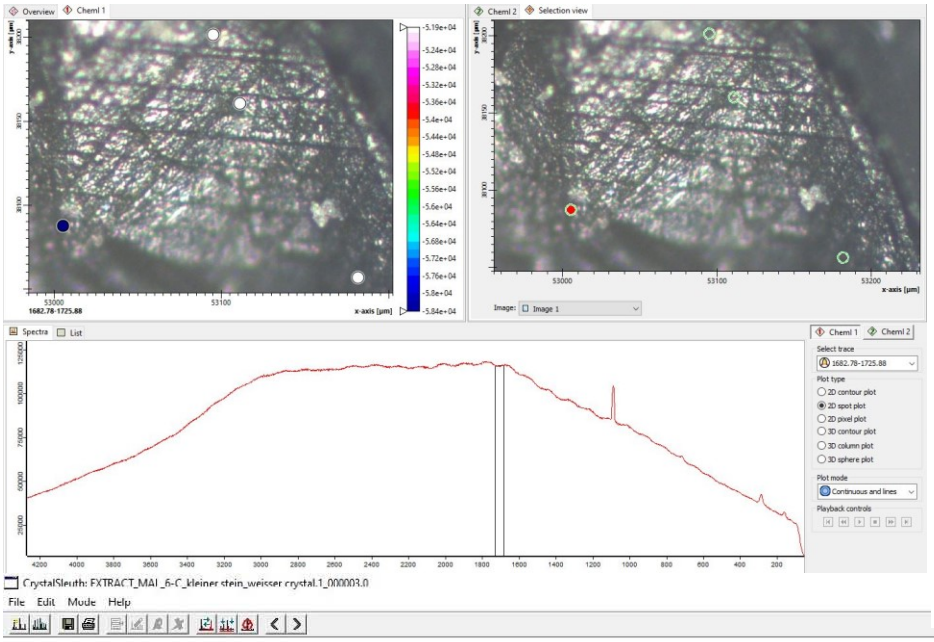


Image :

~400x350µm

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

Sample Site 6-C : Stone 1_spectra 1 indicates : Kutnohorite, (Motukoreaite) (→ see RRUFF_CS search)

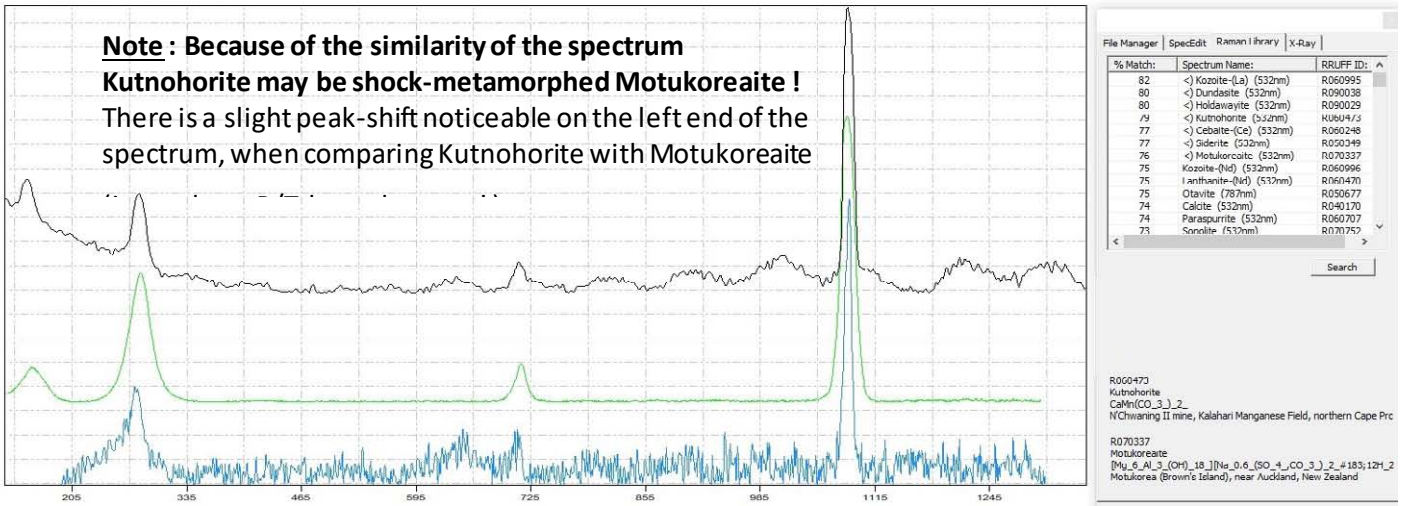


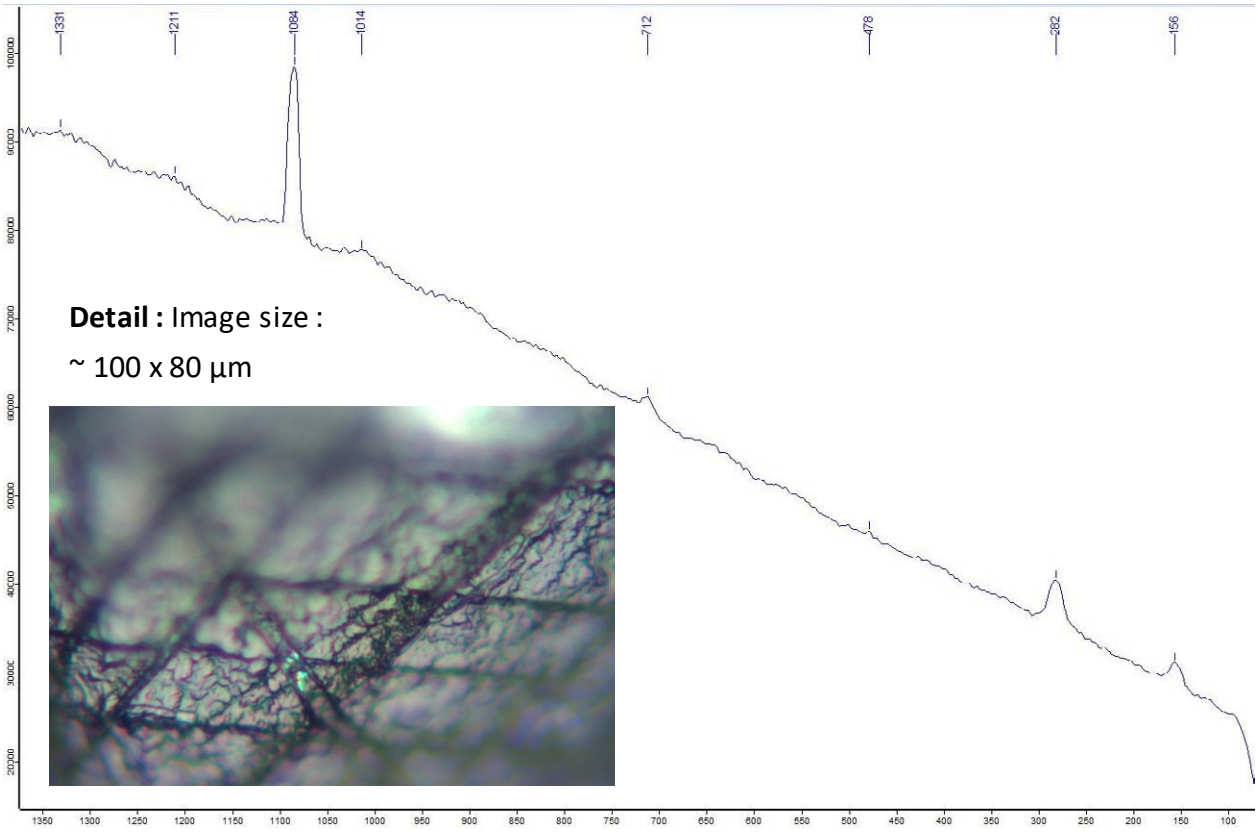
Note : Motukoreaite is metamorphed ocean sediment (below 150°C)

(it may have P/T-boundary age !)

Sample :

Note : Because of the similarity of the spectrum Kutnohorite may be shock-metamorphed Motukoreaite !
There is a slight peak-shift noticeable on the left end of the spectrum, when comparing Kutnohorite with Motukoreaite



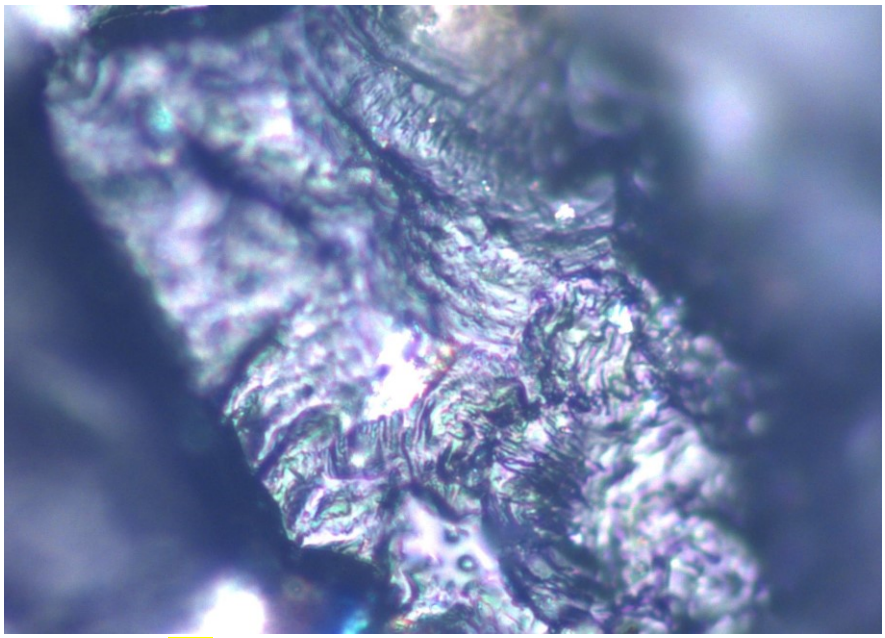


Detail : Image size :

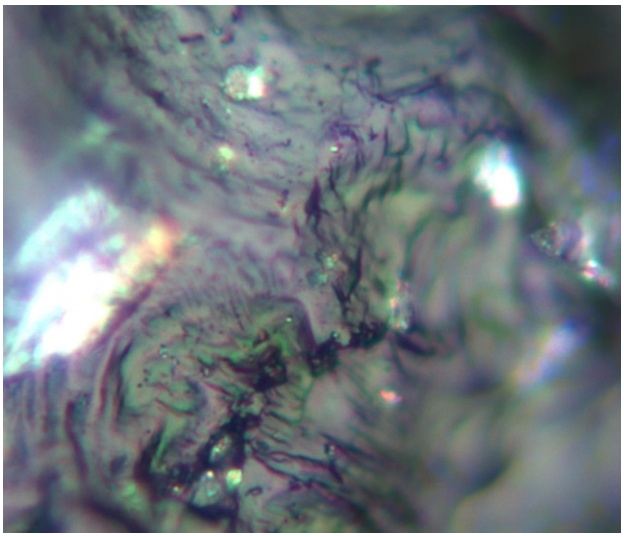
~ 100 x 80 µm

Microscopic Images : Samples from Sites 6-A, 6-B & 6-C (→ no preparation for analysis)

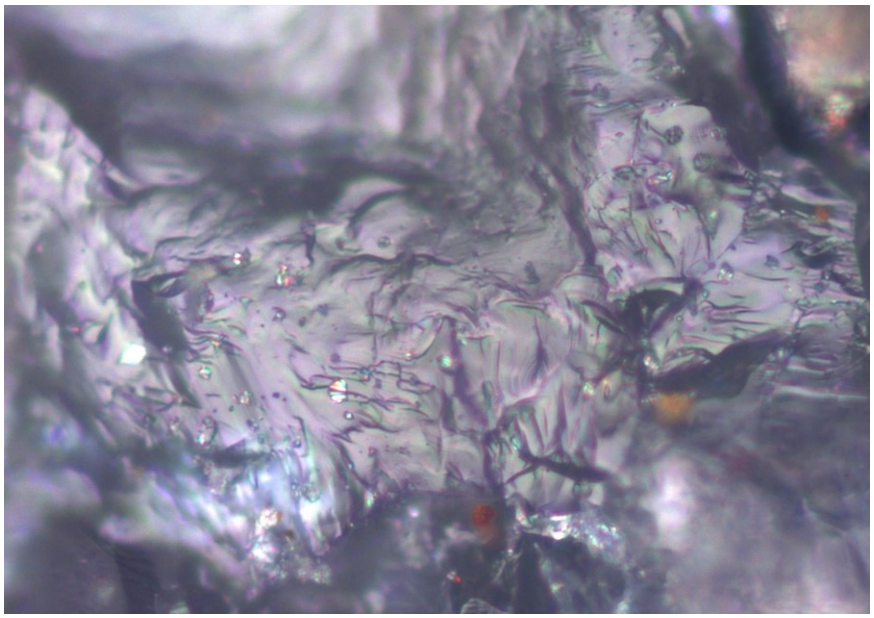
Sample Site 6-A : Stone 1 : Quartz (Image ~ 200 x 150 µm)



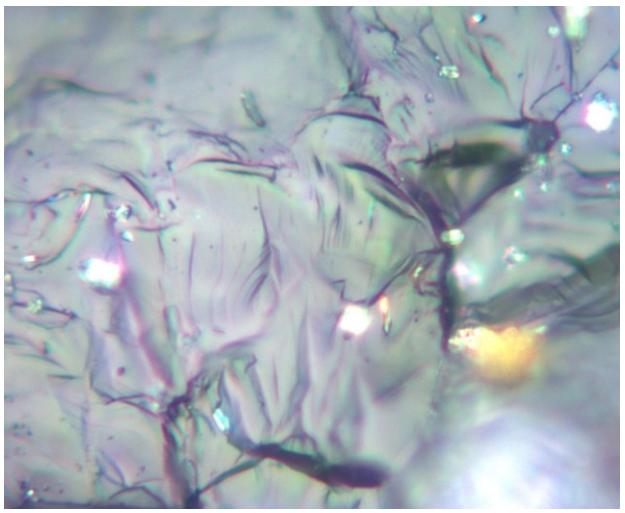
(Detail-Image ~ 100 x 100 µm)



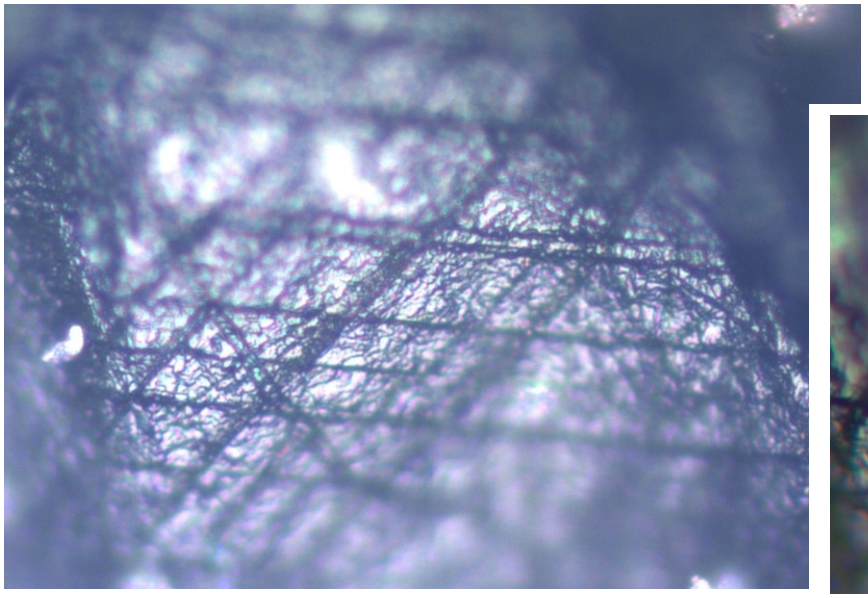
Sample Site 6-B : Stone 1 : Quartz (Image ~ 200 x 160 µm)



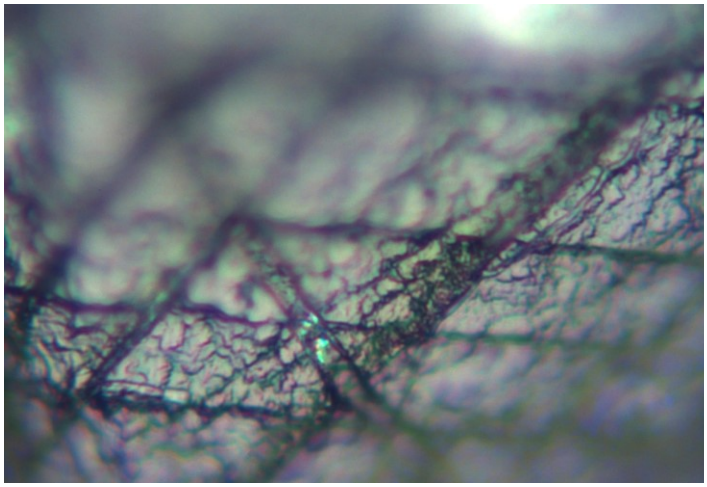
(Detail-Image ~ 100 x 100 µm)



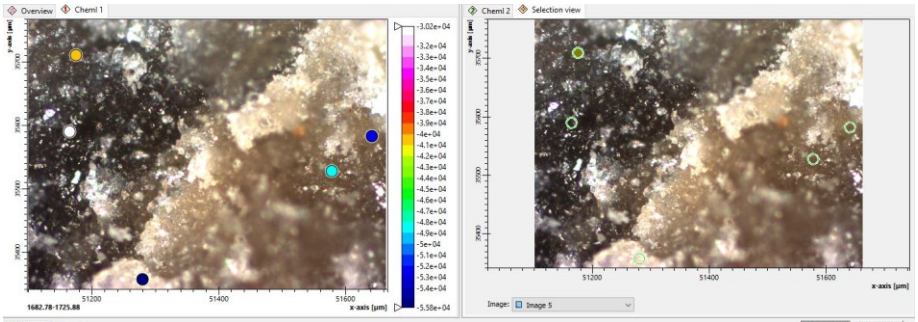
Sample Site 6-C : Stone 1 : Kutnohorite (Motukoraite) (Image: ~ 200 x 150 µm)

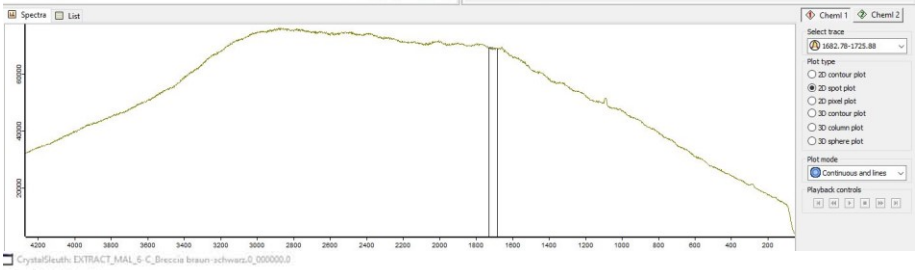


Detail : Image size : ~ 100 x 80 µm



Sample Site 6-C : Stone 2_spectra 1 indicates : Motukoreaite (→ see RRUFF_CS search)

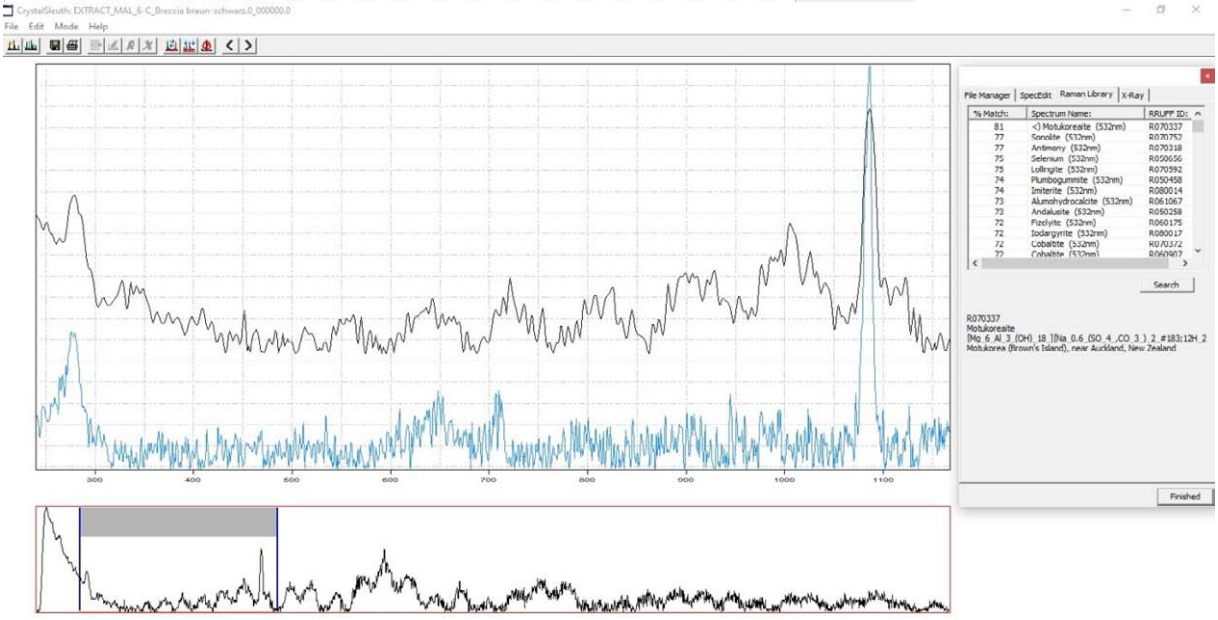


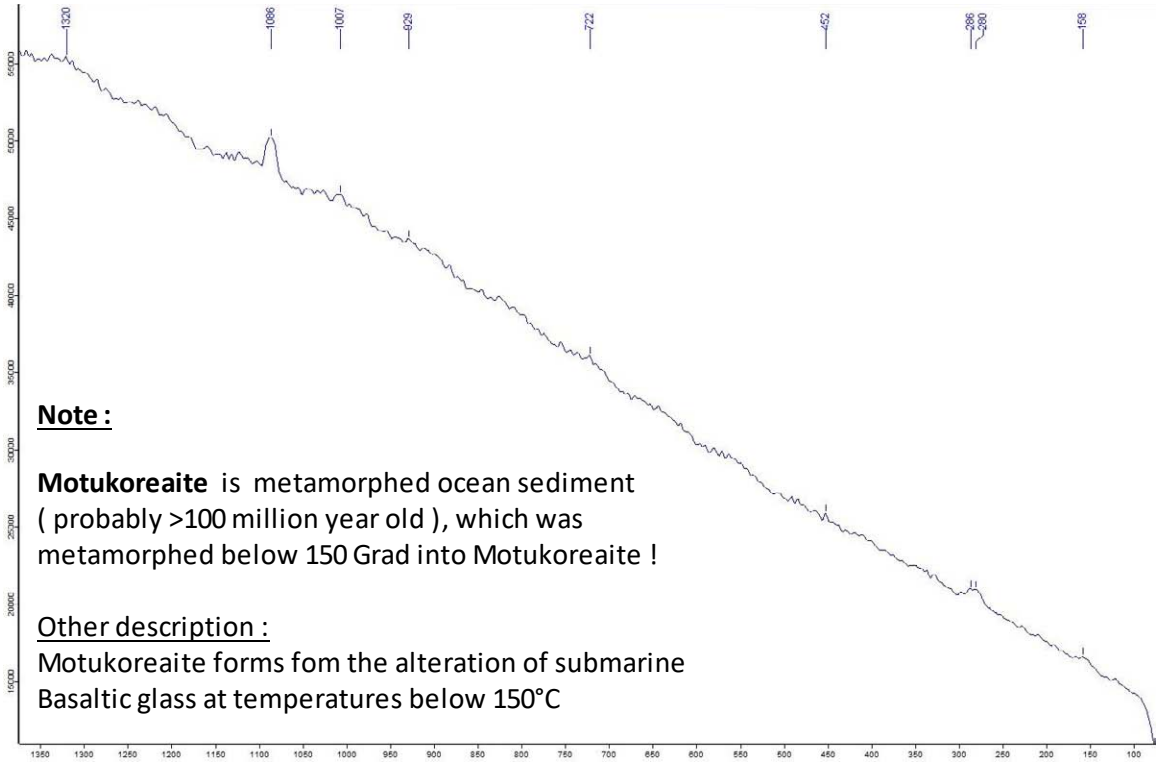


Motukoreaite is metamorphed ocean sediment (below 150°C)

(probably >100 million year old maybe P/T-age ?)

Sample :



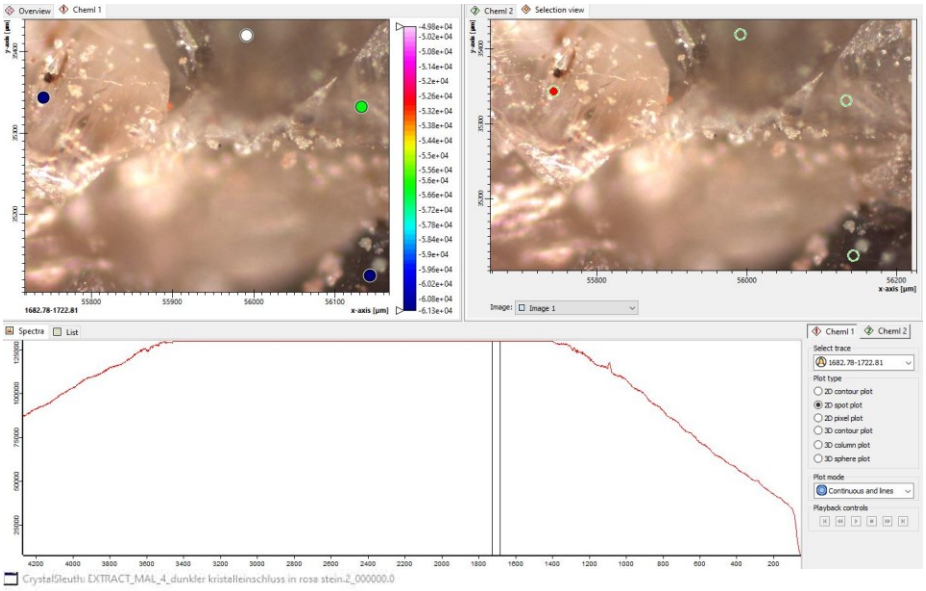


Note :

Motukoreaite is metamorphed ocean sediment (probably >100 million year old), which was metamorphed below 150 Grad into Motukoreaite !

Other description :
Motukoreaite forms fom the alteration of submarine Basaltic glass at temperatures below 150°C

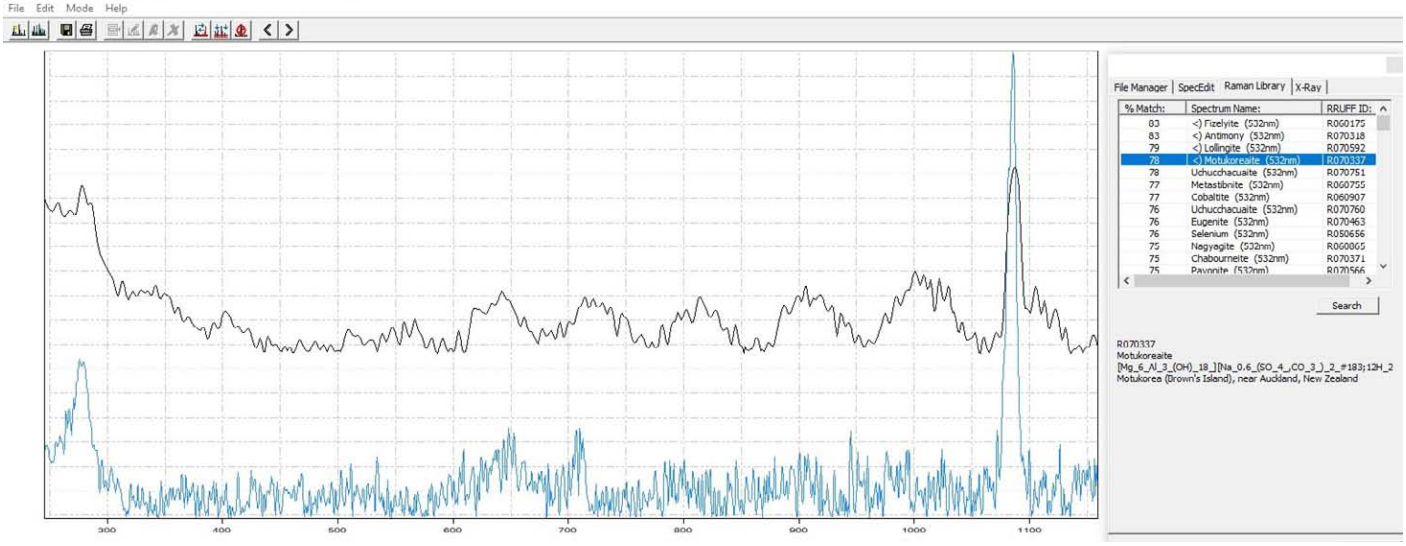
Sample Site 4 : Stone 1_spectra 1 indicates : Motukoreaite (→ see RRUFF_CS search)

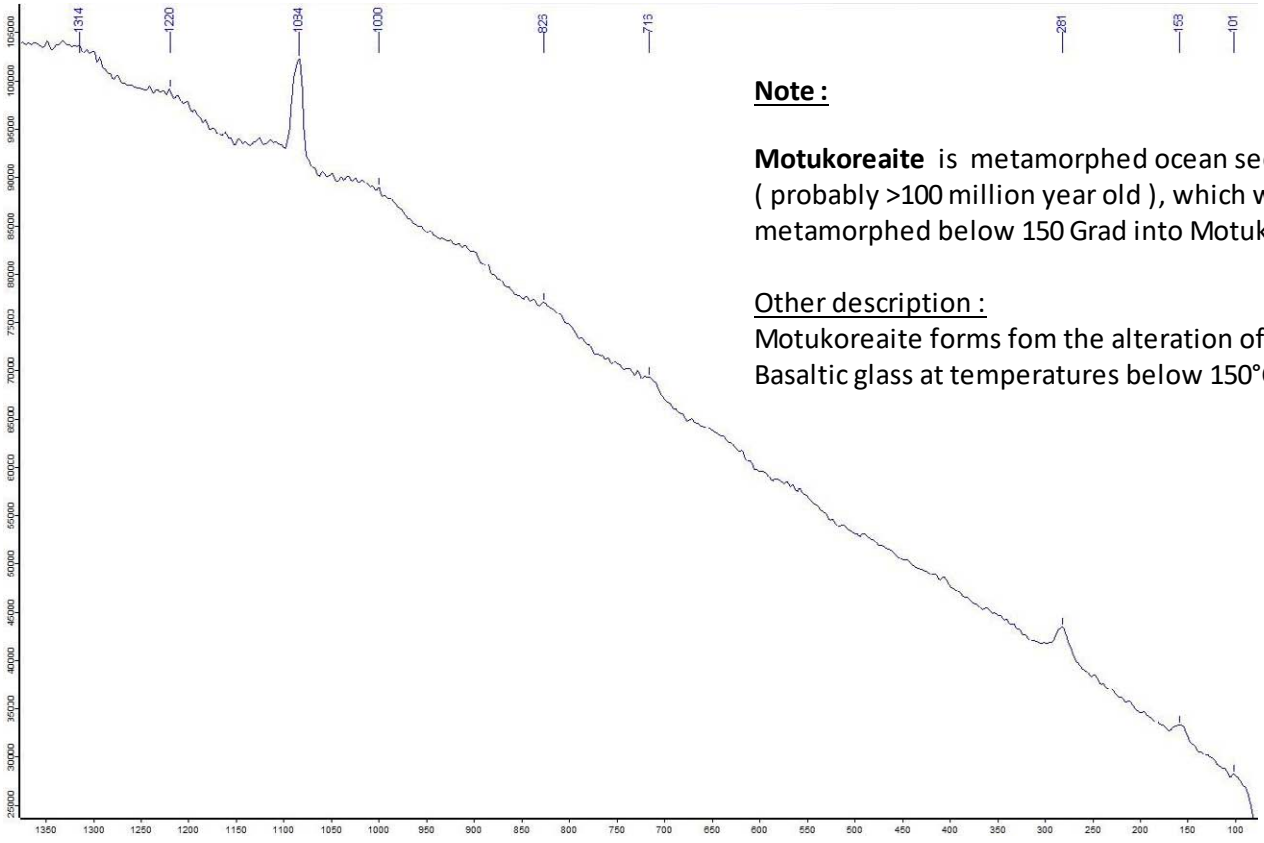


Motukoreaite is metamorphed ocean sediment (below 150°C)

(probably >100 million year old maybe P/T-age ?)

Sample :





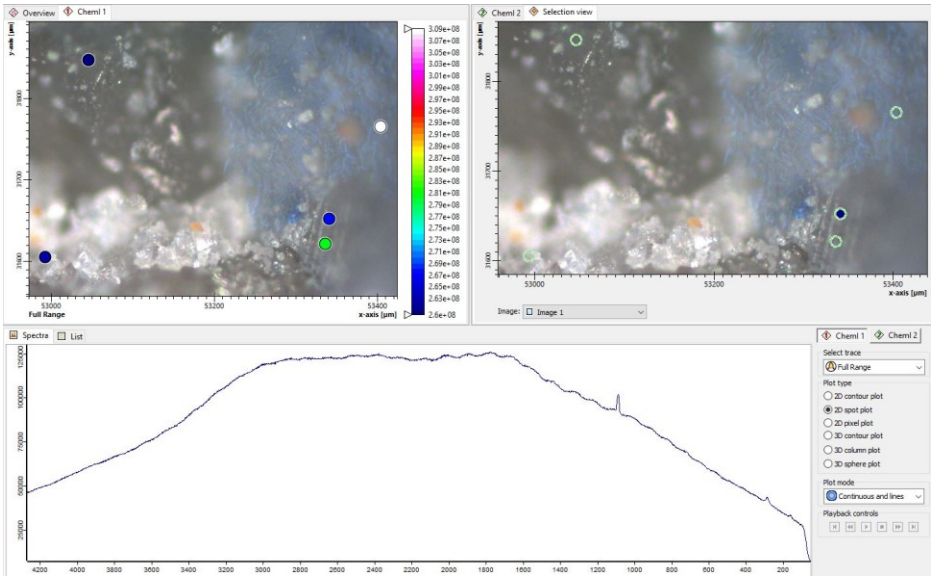
Note :

Motukoreaite is metamorphed ocean sediment (probably >100 million year old), which was metamorphed below 150 Grad into Motukoreaite !

Other description :

Motukoreaite forms fom the alteration of submarine Basaltic glass at temperatures below 150°C

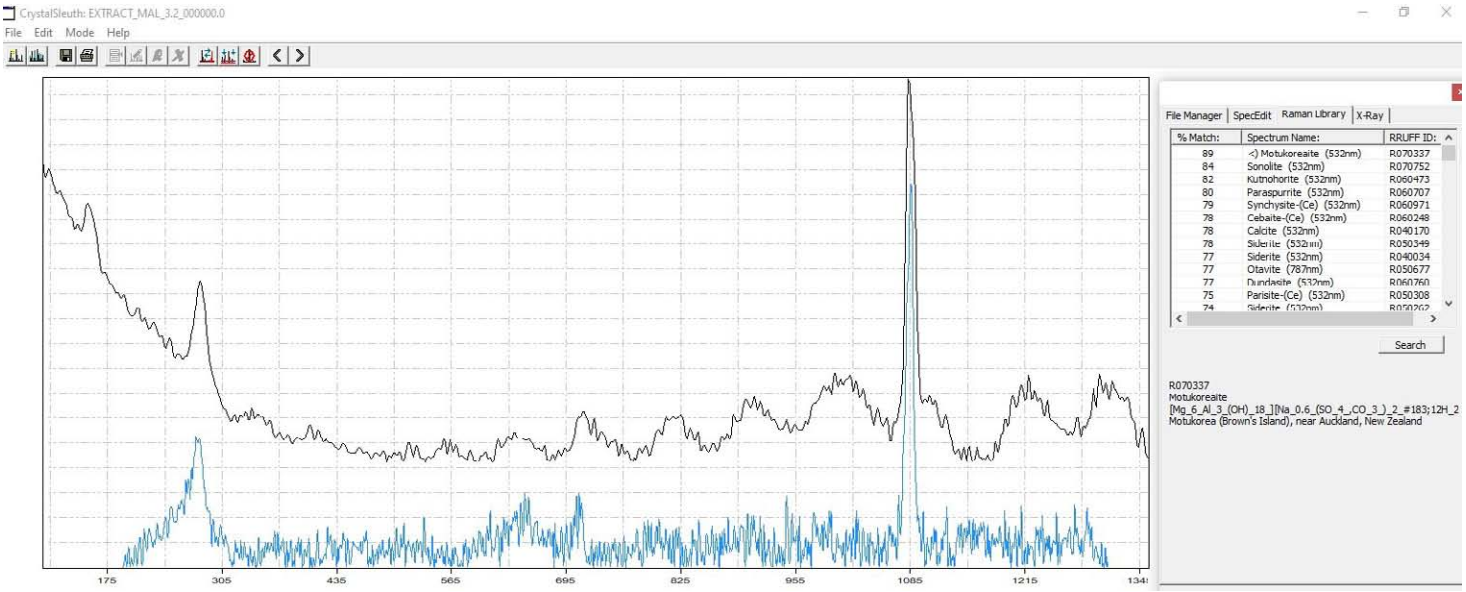
Sample Site 3 : Stone 1_spectra 1 indicates : Motukoreaite (→ see RRUFF_CS search)

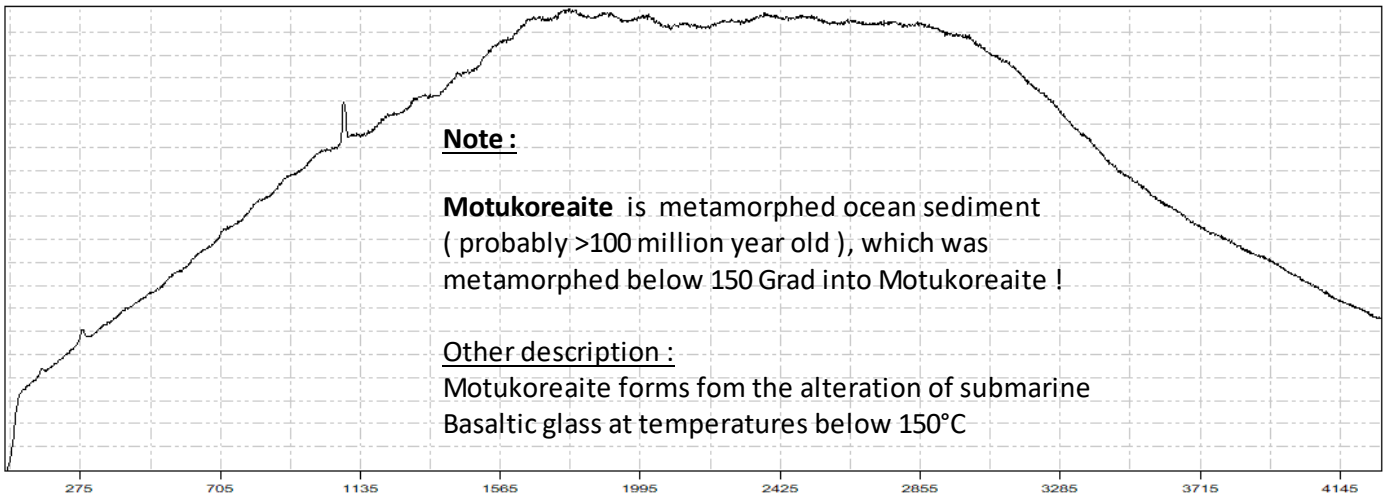


Motukoreaite is metamorphed ocean sediment (below 150°C)

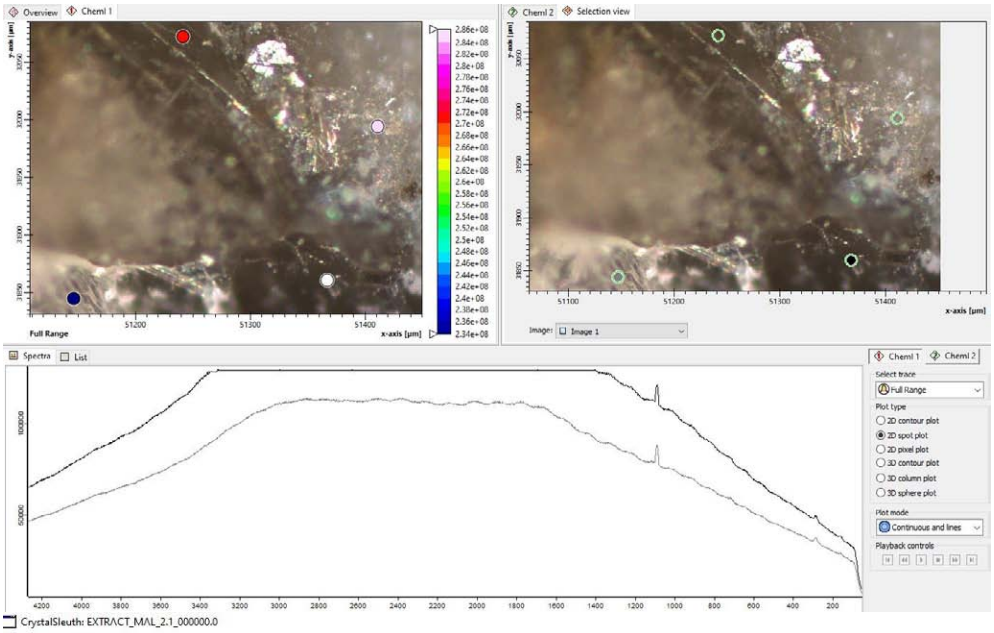
(probably >100 million year old maybe P/T-age ?)

Sample :





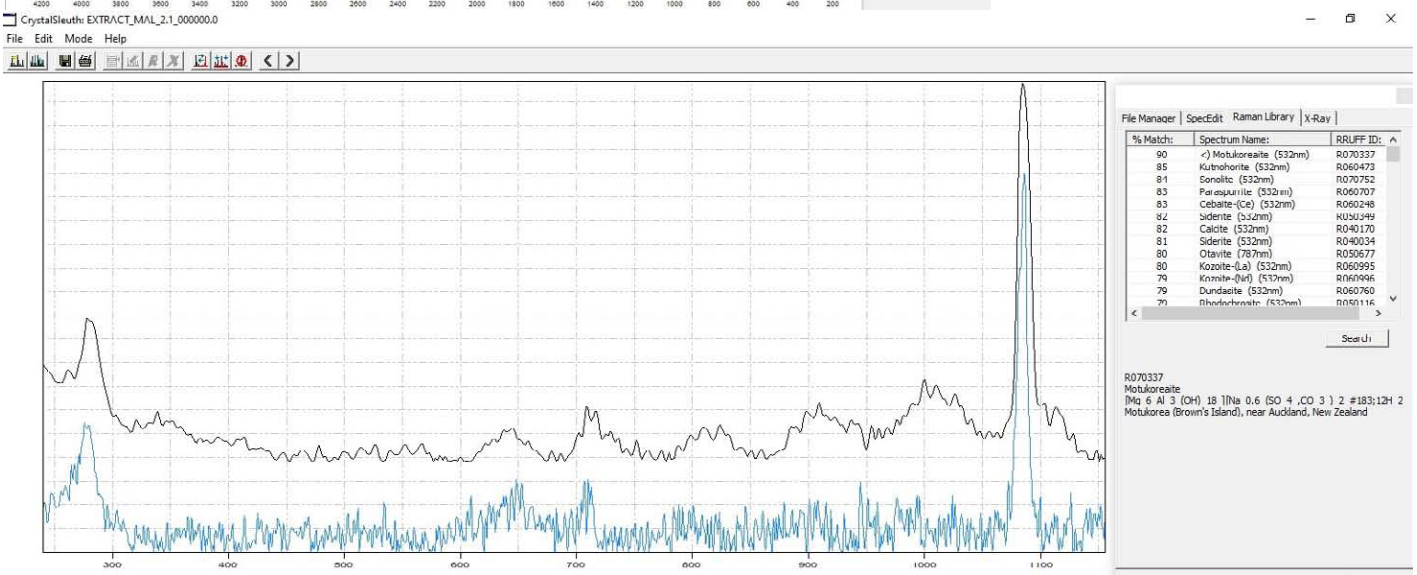
Sample Site 2 : Stone 1_spectra 1 indicates : Motukoreaite (→ see RRUFF_CS search)

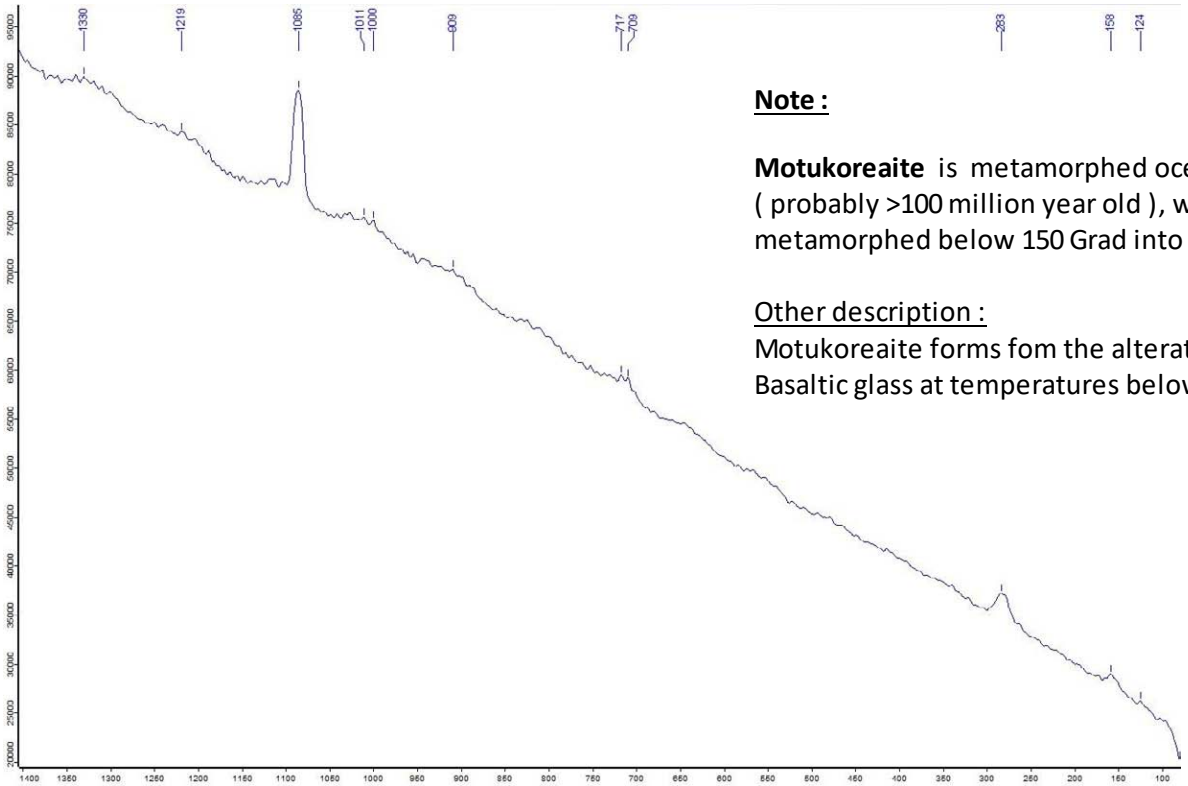


Motukoreaite is metamorphed ocean sediment (below 150°C)

(probably >100 million year old maybe P/T-age ?)

Sample :





Note :

Motukoreaite is metamorphed ocean sediment (probably >100 million year old), which was metamorphed below 150 Grad into Motukoreaite !

Other description :

Motukoreaite forms fom the alteration of submarine Basaltic glass at temperatures below 150°C

Appendix 1 : Photos of the rock samples from the sites : 2, 3, 4, 5, 6-A, 6-B and 6-C

→ **See next pages**

→ **Weblink to the :**
Digital Geological-Map (IGME) of Spain :
Magna 50 - 1:50000 GEO-Maps
→ **zoom-in to Mallorca Island**

GPS datas of collected rock samples :

Samples from possible Impact Structures of PT-Ejecta Ray R1
(East-coast of the Mallorca (Island) - Spain)

Sample No.	Photo of place of origin (X = yes)	coordinates of sample origin						Height in m	precision of position	collection date
		Latitude			Longitude					
		deg.	minutes		deg.	minutes				
1	X	39°	37,921	N	2°	25,559	E	201	12 m	21.10.2021
2	X	39°	54,952	N	3°	6,451	E	91	20 m	23.10.2021
3	X	39°	55,811	N	3°	6,651	E	201	30 m	
4	X	39°	55,839	N	3°	6,945	E	179	15 m	
5	X	39°	57,732	N	3°	12,817	E	165	20 m	
6-A	X	39°	42,036	N	2°	33,932	E	115	20 m	24.10.2021
6-B	X	39°	41,685	N	2°	33,776	E	164	20 m	24.10.2021
6-C	X	39°	41,540	N	2°	33,808	E	177	30 m	24.10.2021

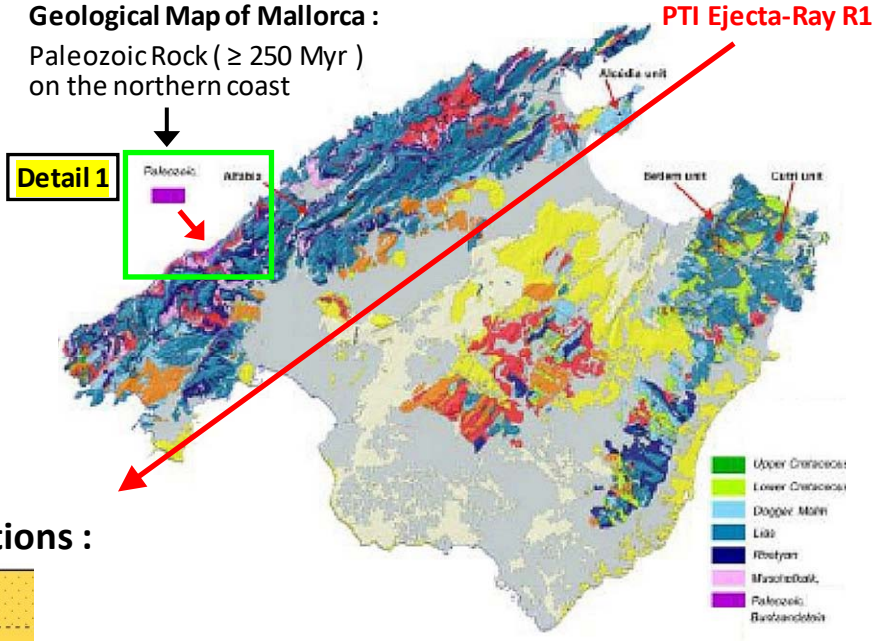
On the Geological Map of Mallorca there is one location with **Paleozoic Rock** (≥ 250 Myr) indicated on the north-facing coast, in the Tramuntana Mountain Range, near the small village **Port des Canonge**.

The nearly linear Tramuntana Range in all probability **is the result of the impact of Ejecta Ray R1, which was caused by the Permian-Triassic Impact (PTI) ≈ 250 Myr ago.**

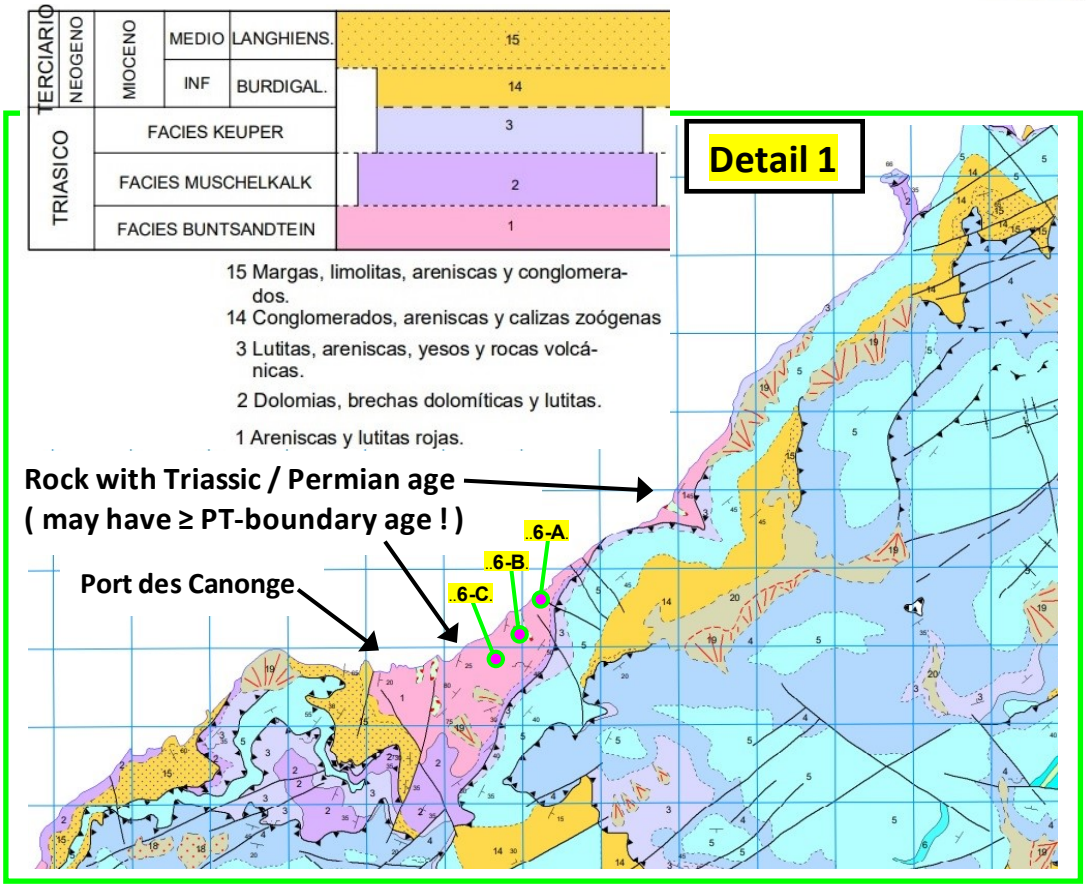
The rocks on this sample site (6-A to 6-C) with PT-boundary age should show shock-metamorphic effects caused by the PTI (R1).

see Raman Spectroscopic analysis of site 6-A !

Geological Map of Mallorca :
Paleozoic Rock (≥ 250 Myr)
on the northern coast



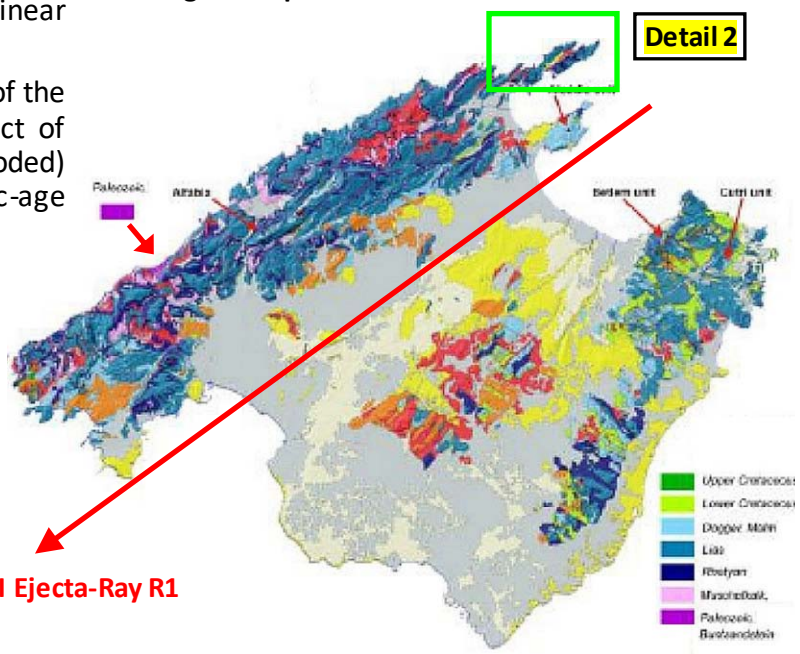
Geological Map with sample site positions :



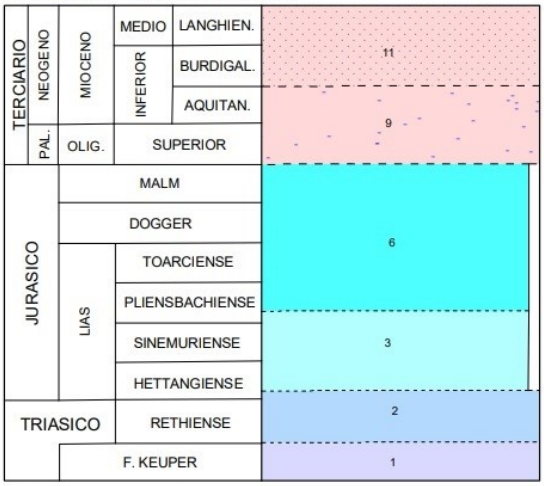
On the Formentor peninsula there are **sections of Triassic (+Permian?) Rock** which follow the nearly linear orientated Tramuntana Range.

From the **lookout at sample site 3** the inclination of the crust-fragments which were caused by the impact of Ejecta Ray R1 is good visible. The uplifted (erroded) edges of the crust fragments show the oldest triassic-age

Geological Map of Mallorca :

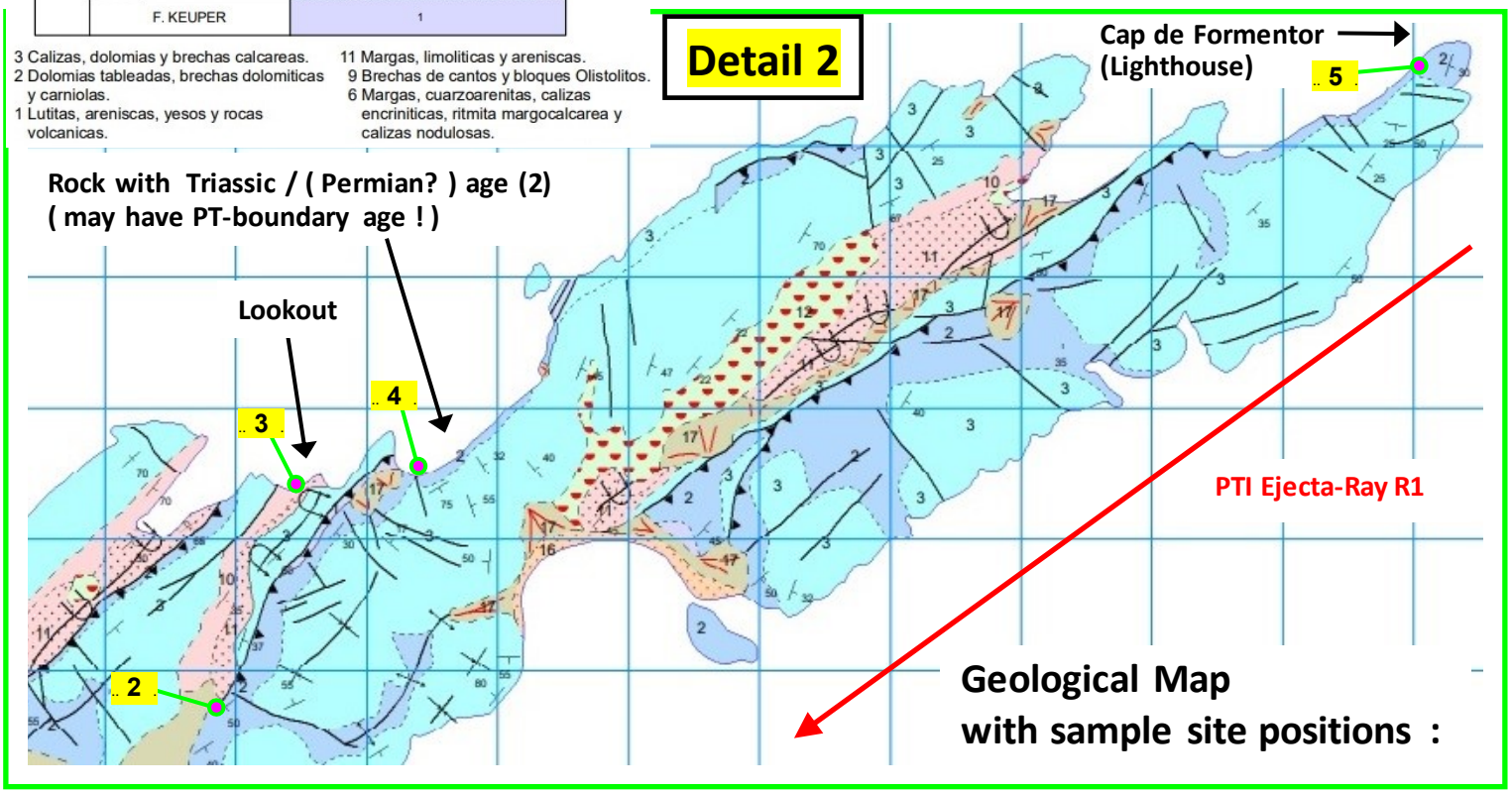


UNIDAD GEORGE SAND - LA CALOBRA

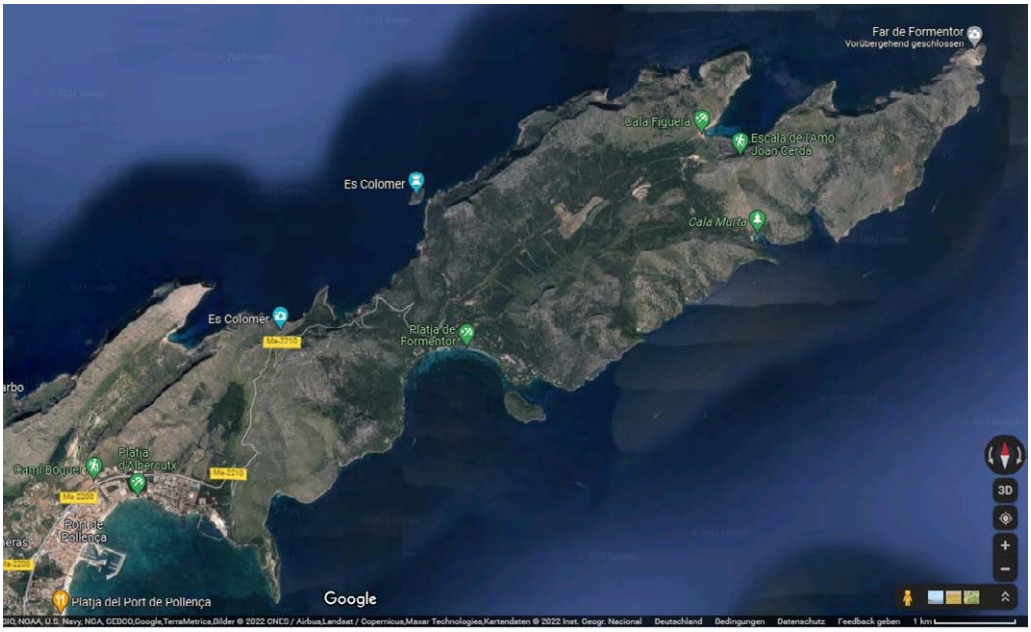


3 Calizas, dolomias y brechas calcareas.
2 Dolomias tableadas, brechas dolomiticas y carniolas.
1 Lutitas, areniscas, yesos y rocas volcanicas.

11 Margas, limoliticas y areniscas.
9 Brechas de cantos y bloques Olistolitos.
6 Margas, cuarzoarenitas, calizas encriniticas, ritmita margocalcarea y calizas nodulosas.

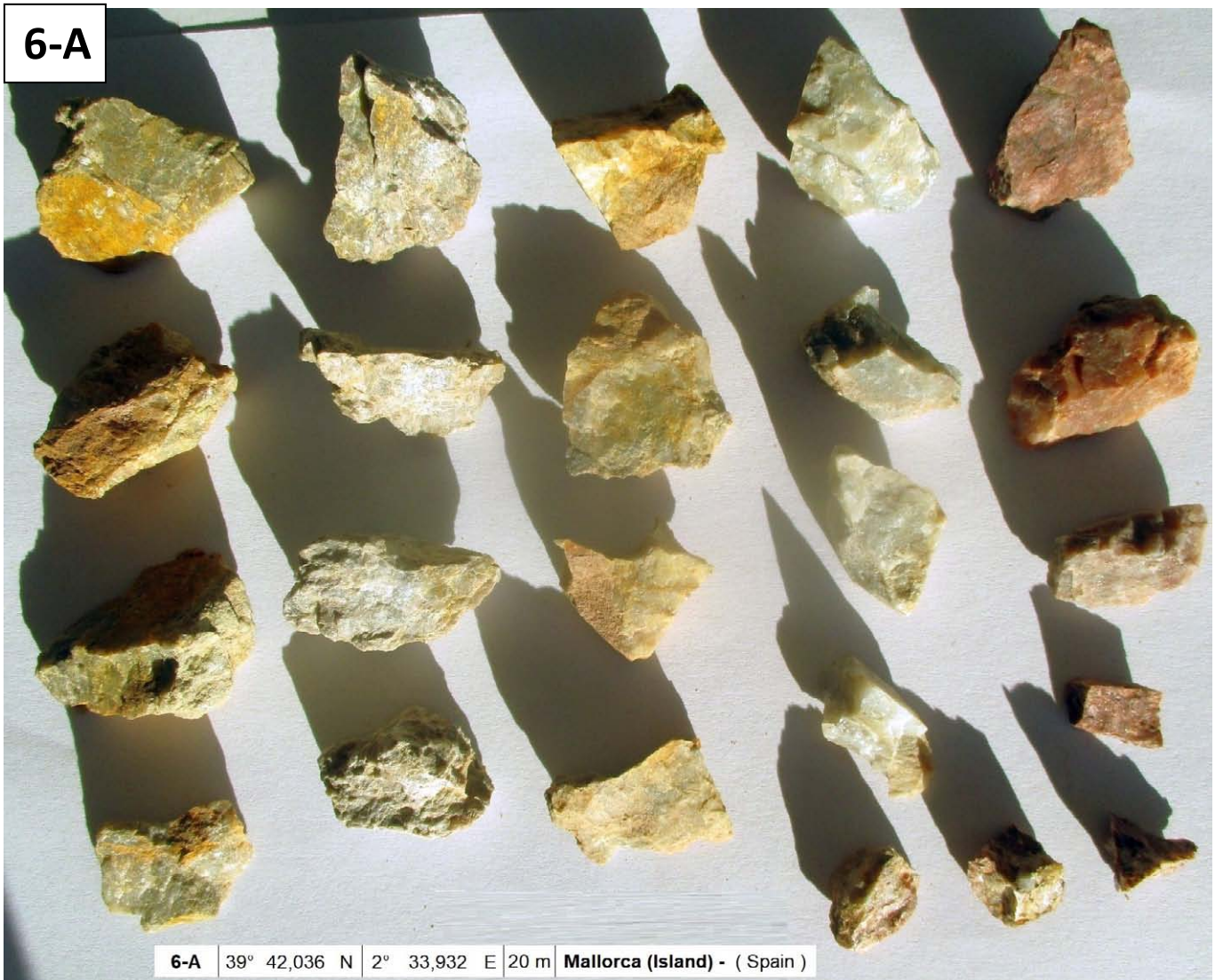


Satellite Image of the Cap de Formentor peninsula :

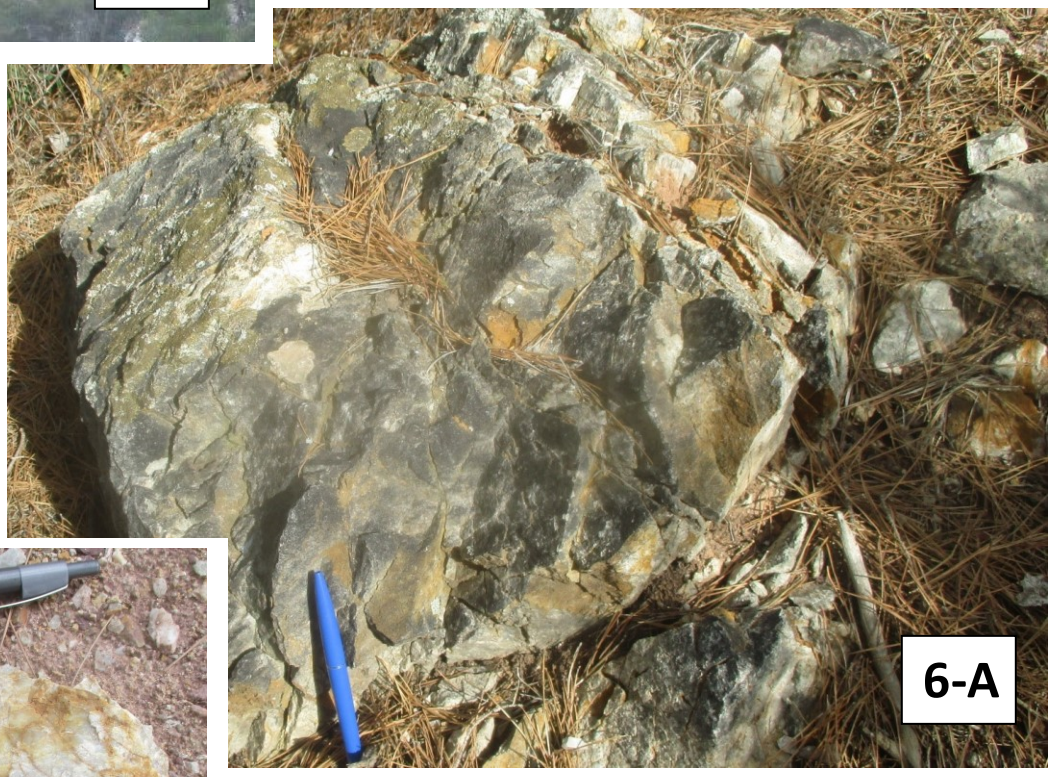


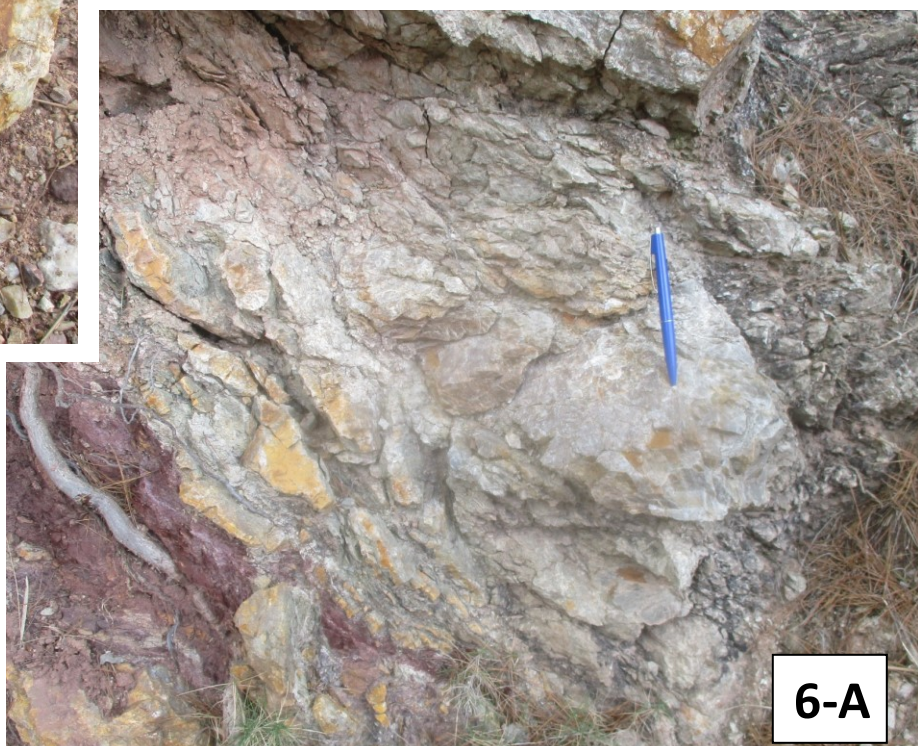
Sample Site 6-A

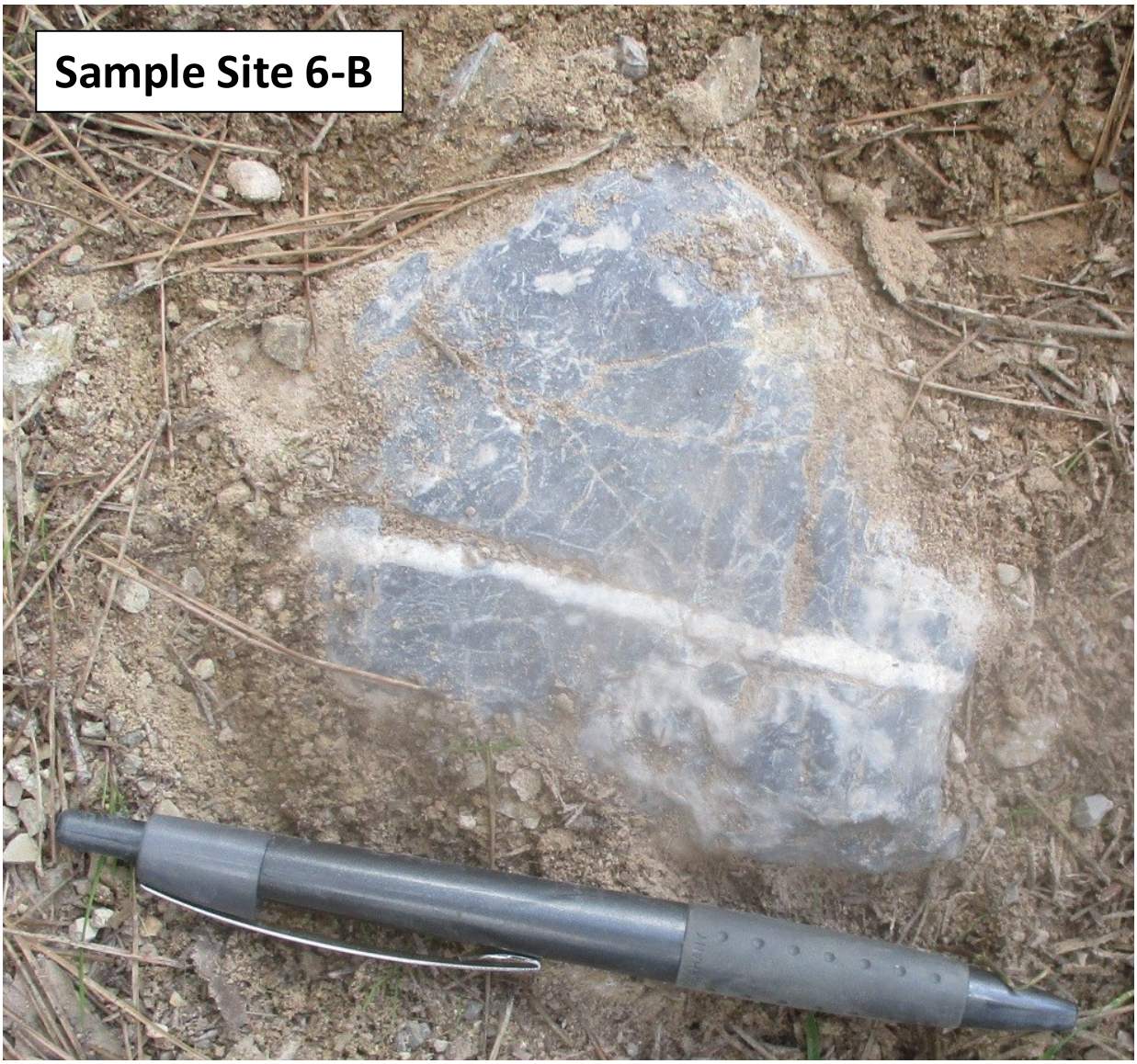
6-A



Detail Images from the Sample Site 6-A :






Sample Site 6-B


6-B
6-B 39° 41,685 N 2° 33,776 E 20 m Mallorca (Island) - (Spain)

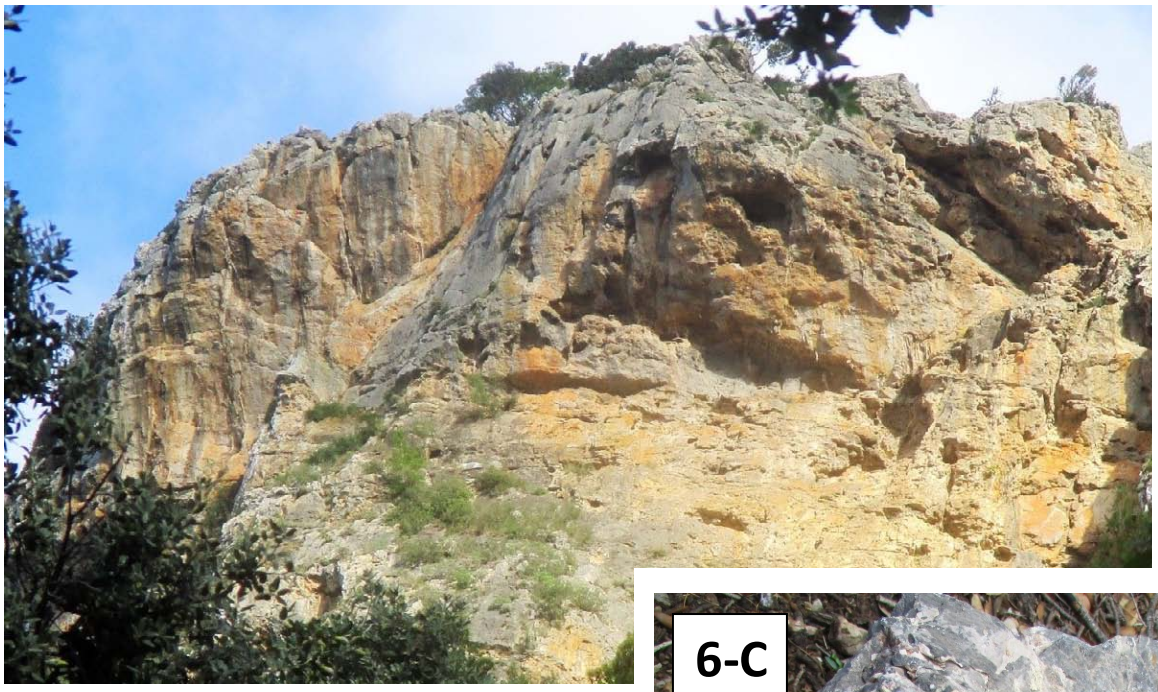
Note that these Breccia-samples are identical to samples which I have collected in Andalusia/Spain

➔ **see Sample Site 50 (Ø 30 km impact structure)**

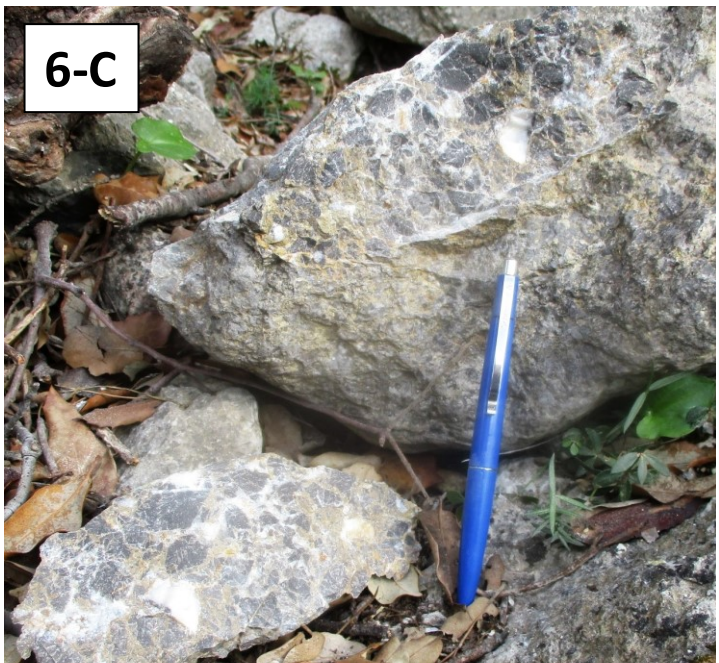
Please also see **Raman-spectra of sample site 50** in Andalusia which also indicates an impact shock event !!

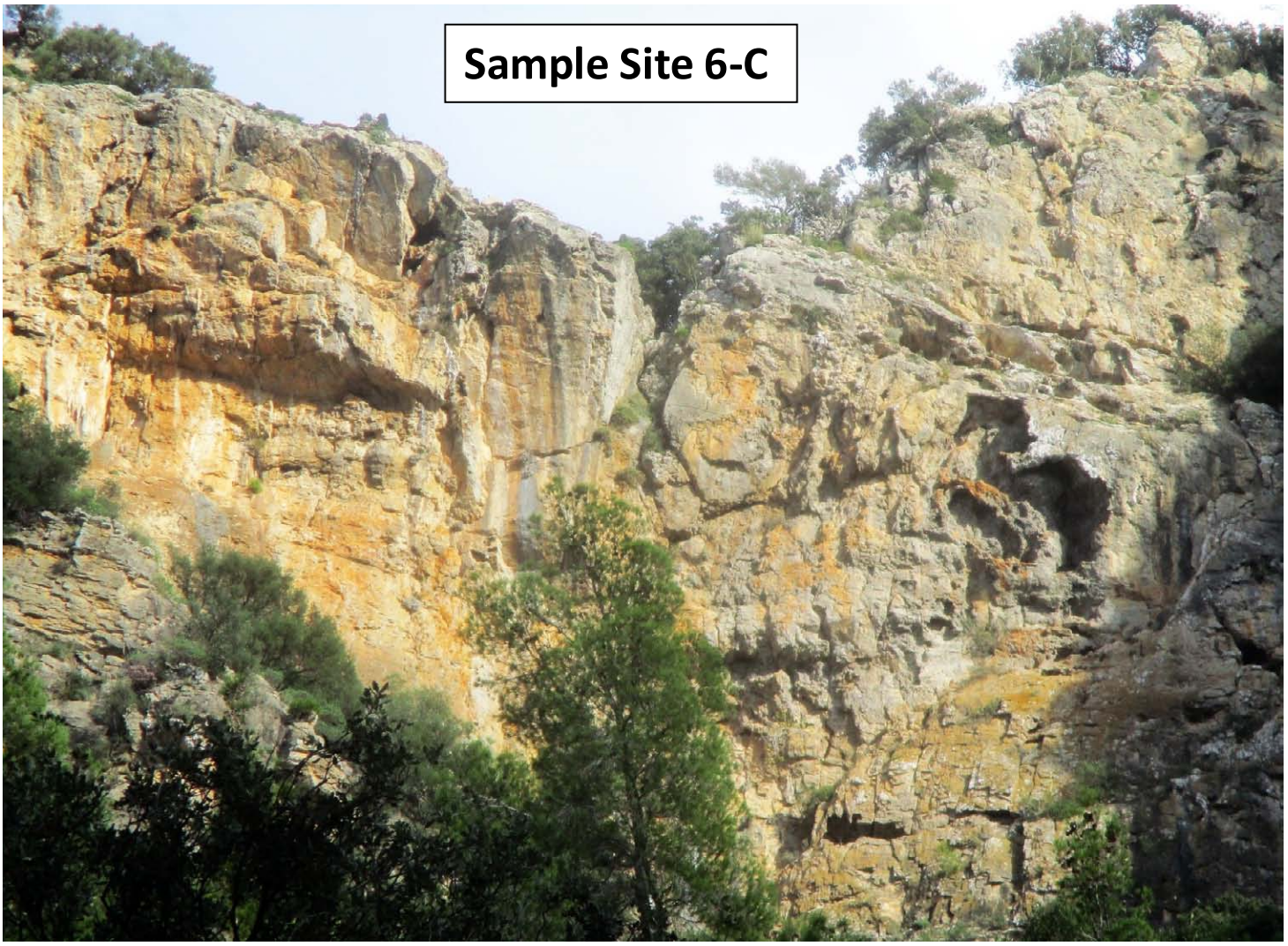
A 30 km Impact Structure in Southern Spain (→ or here)


Sample Site 6-C




6-C

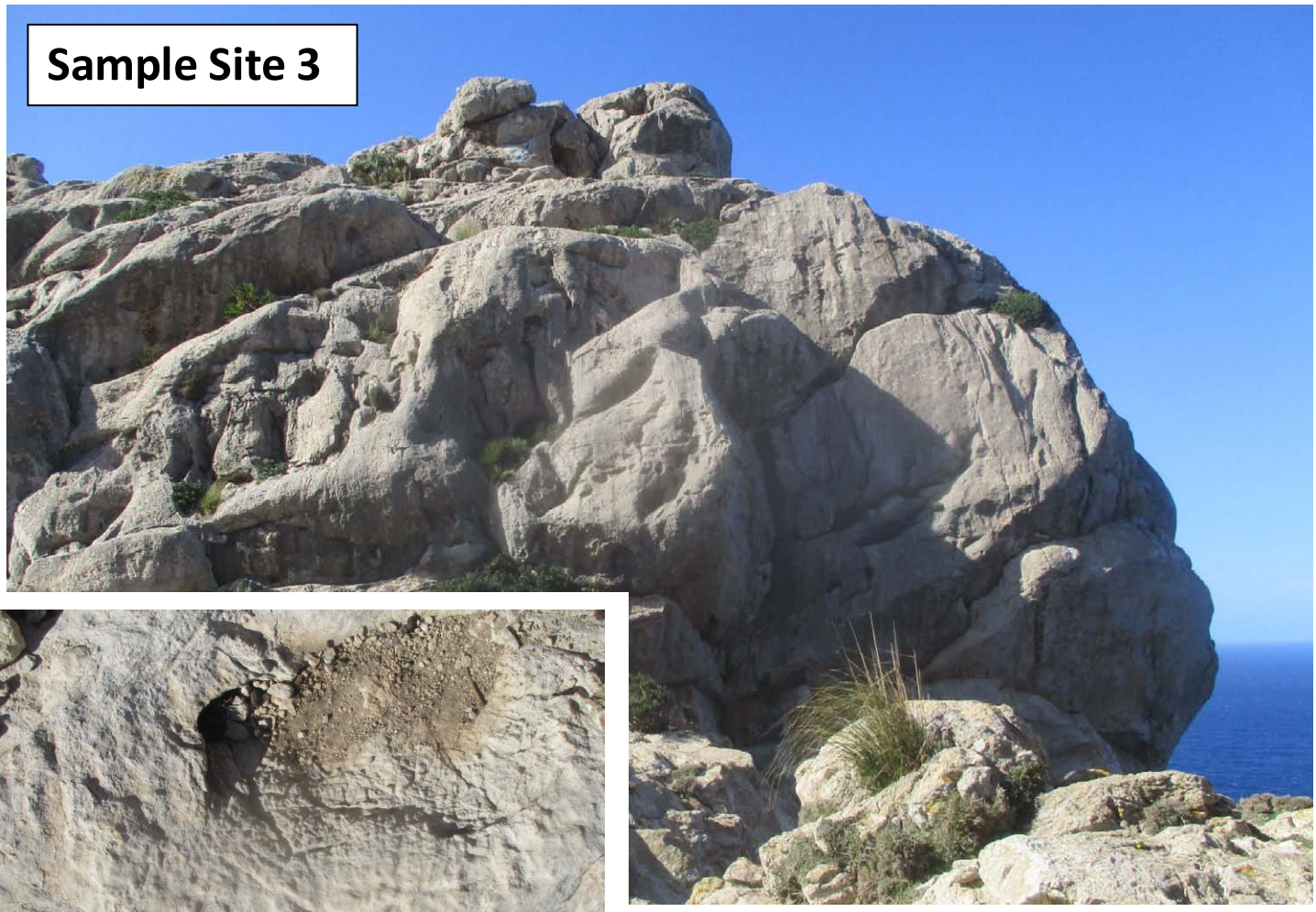

6-C

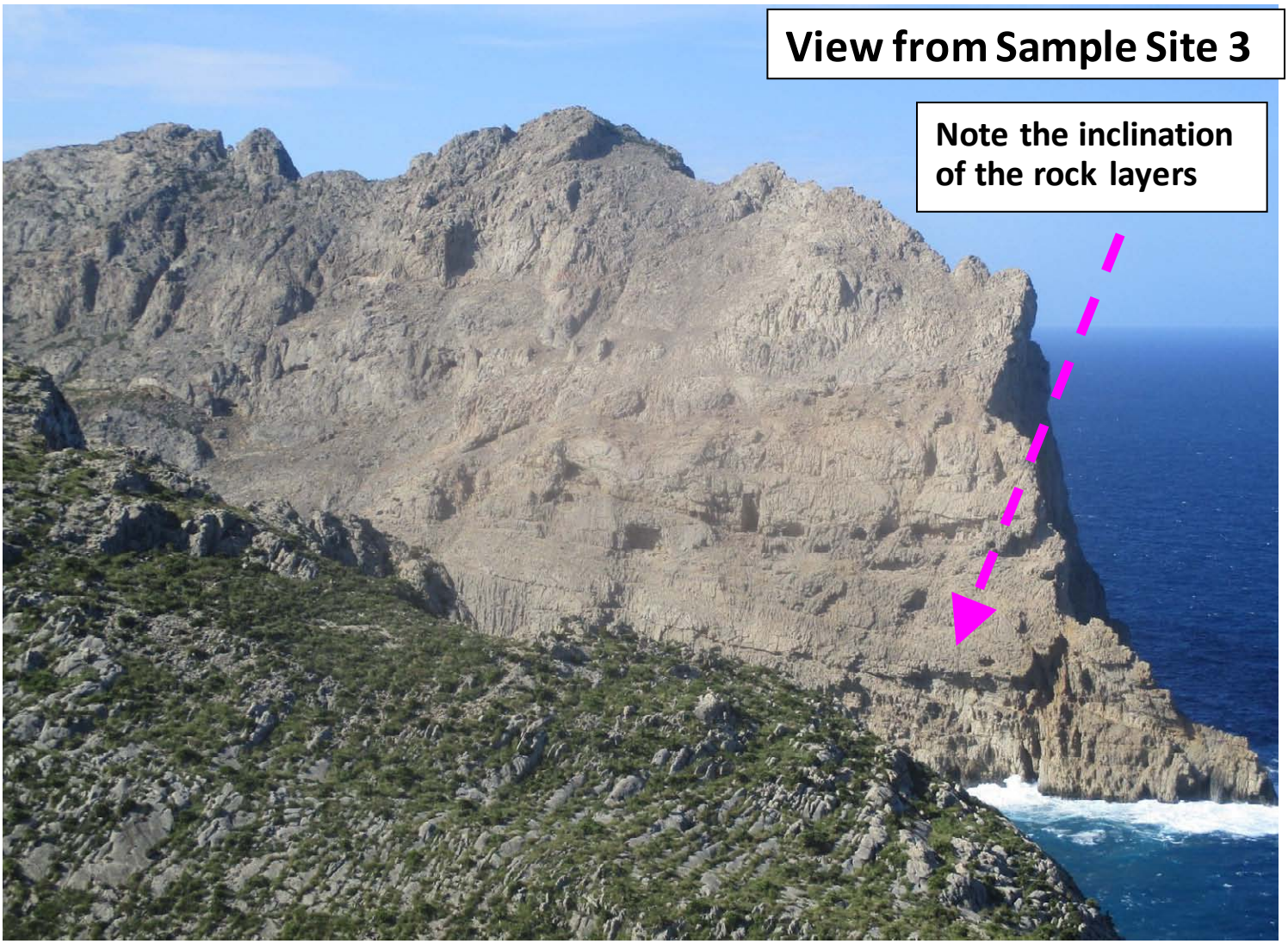

Sample Site 6-C


6-C

Sample Site 4

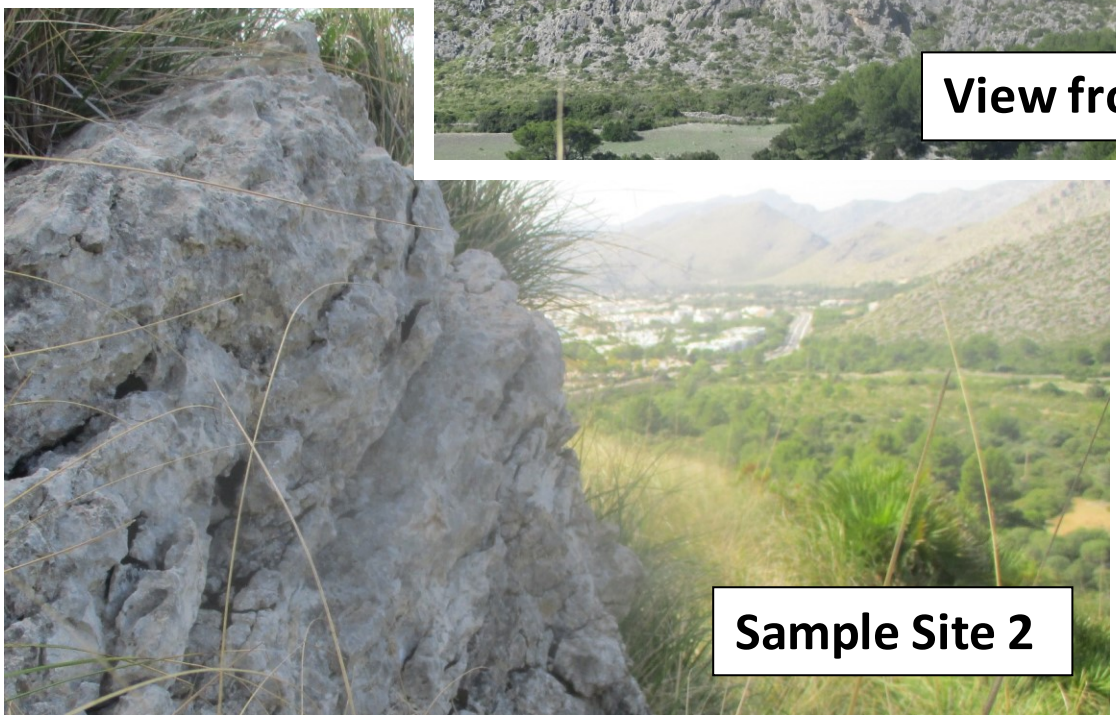
Sample Site 3




View from Sample Site 3
Note the inclination of the rock layers

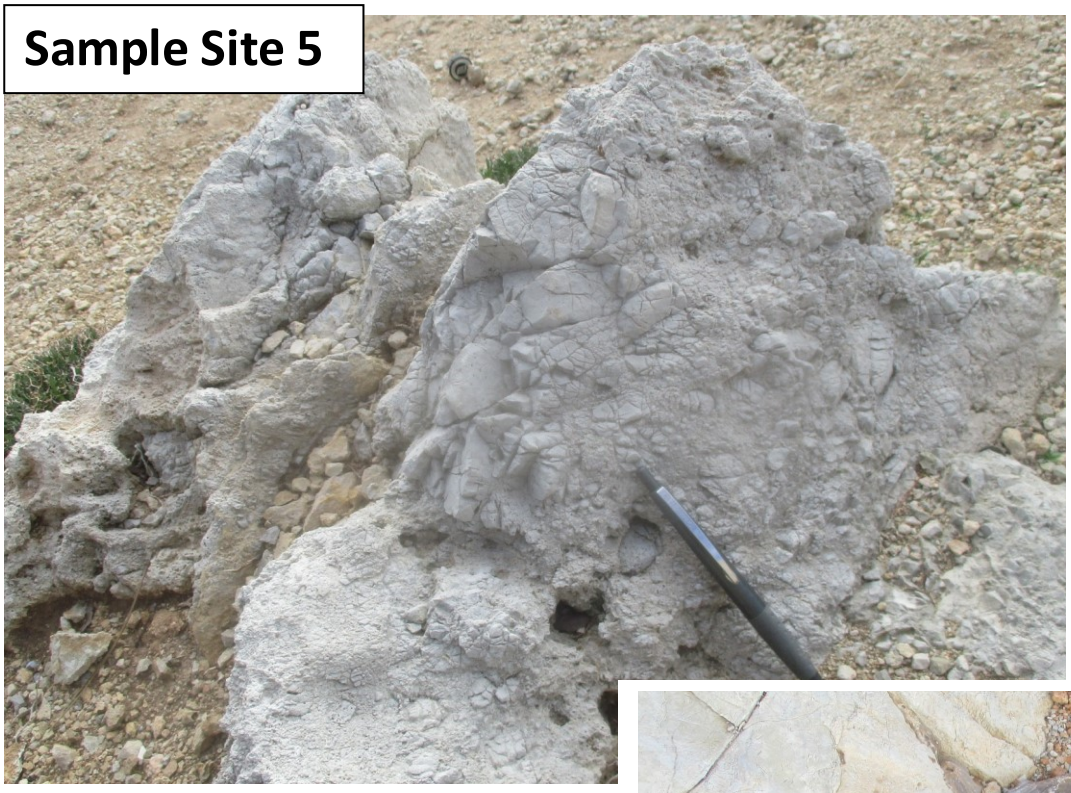

View from Sample Site 3


View from Sample Site 2


Sample Site 2

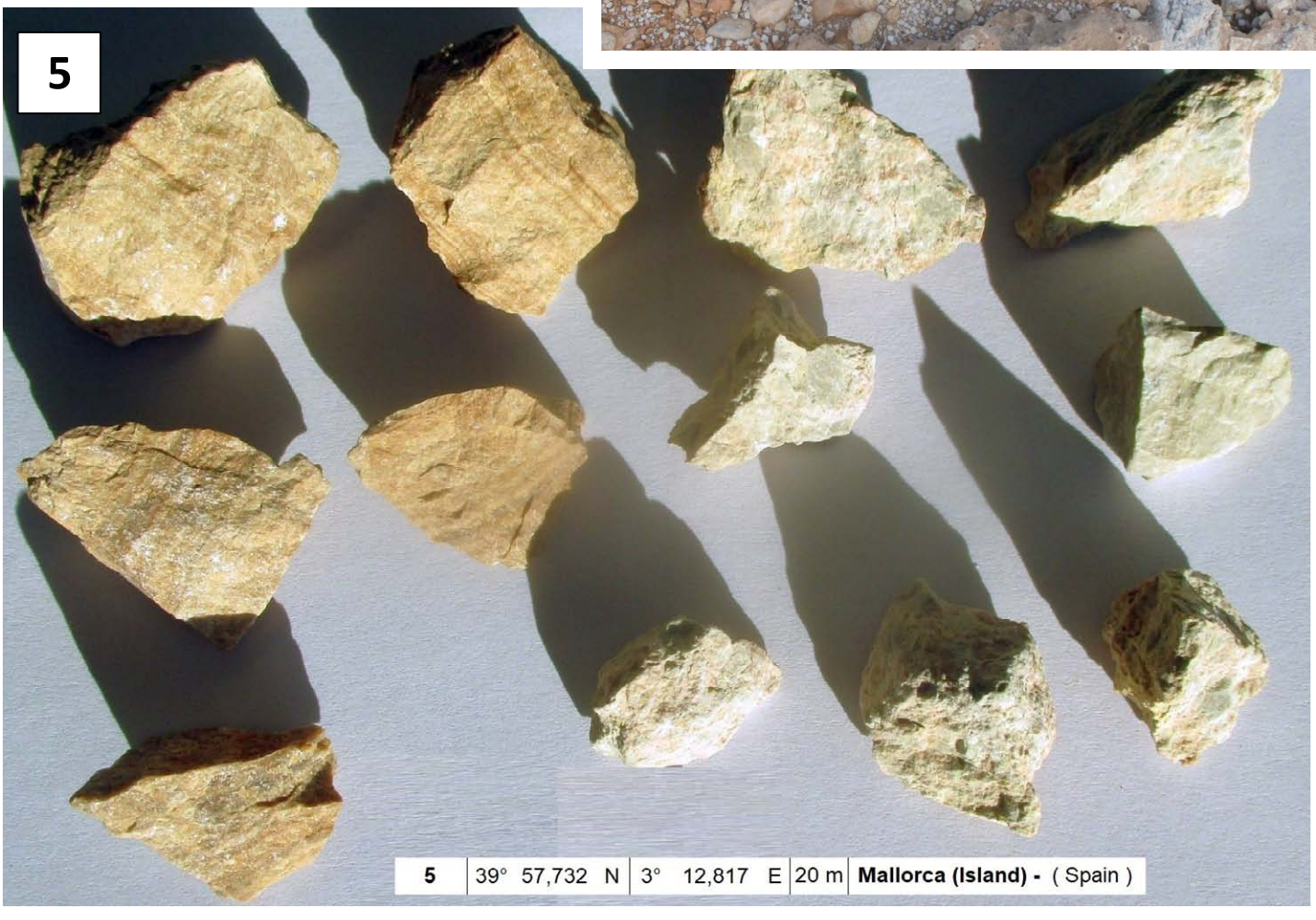

2
2 | 39° 54,952 N | 3° 6,451 E | 20 m | Mallorca (Island) - (Spain)

Sample Site 5

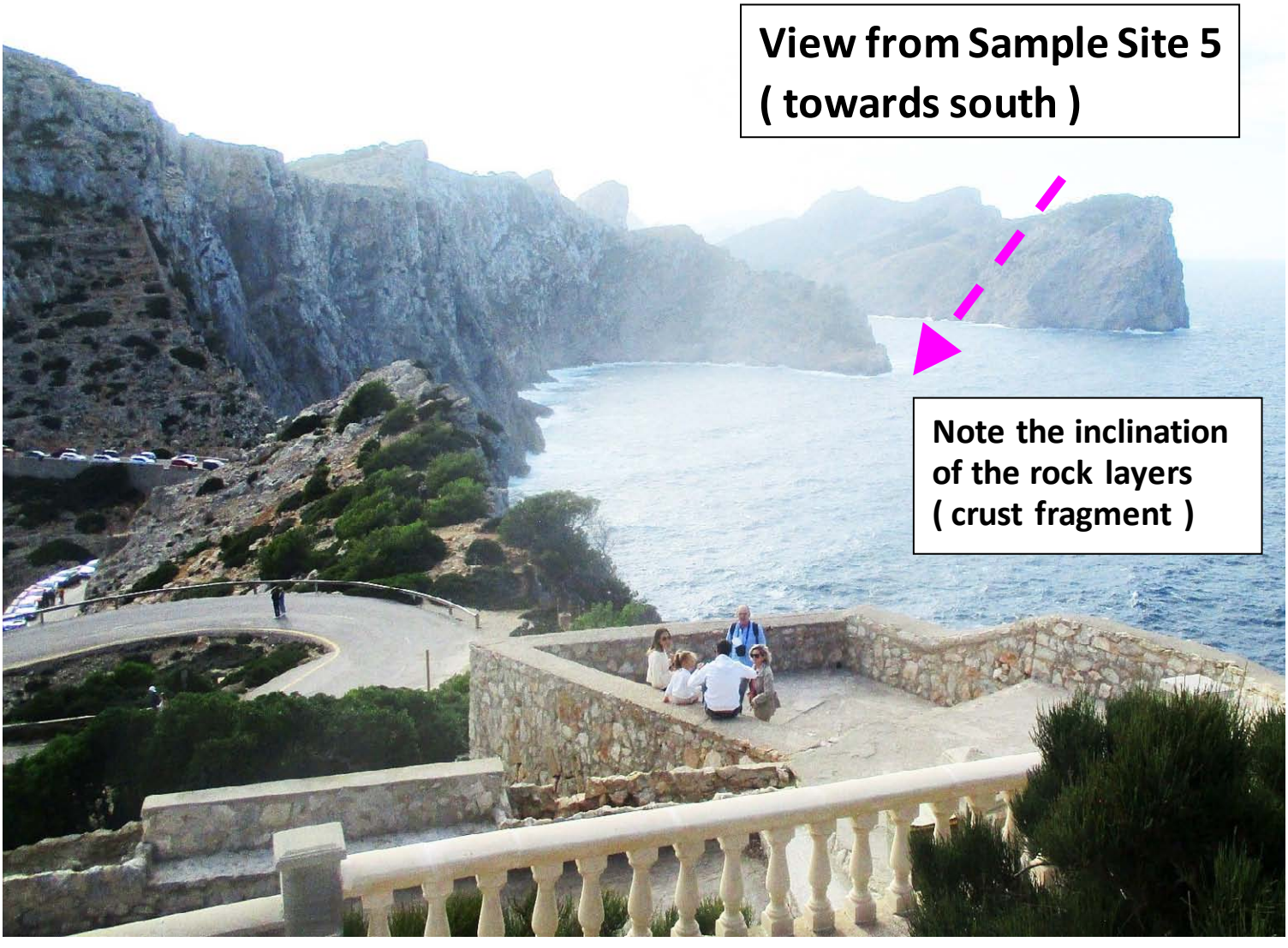


<u>Note</u> : The samples from the site No. 5 didn't produce any usable Raman-spectra.

glass-like shocked minerals ?




Sample Site 5
Far de Formentor
(Formentor lighthouse)


View from Sample Site 5
(towards south)
Note the inclination
of the rock layers
(crust fragment)

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

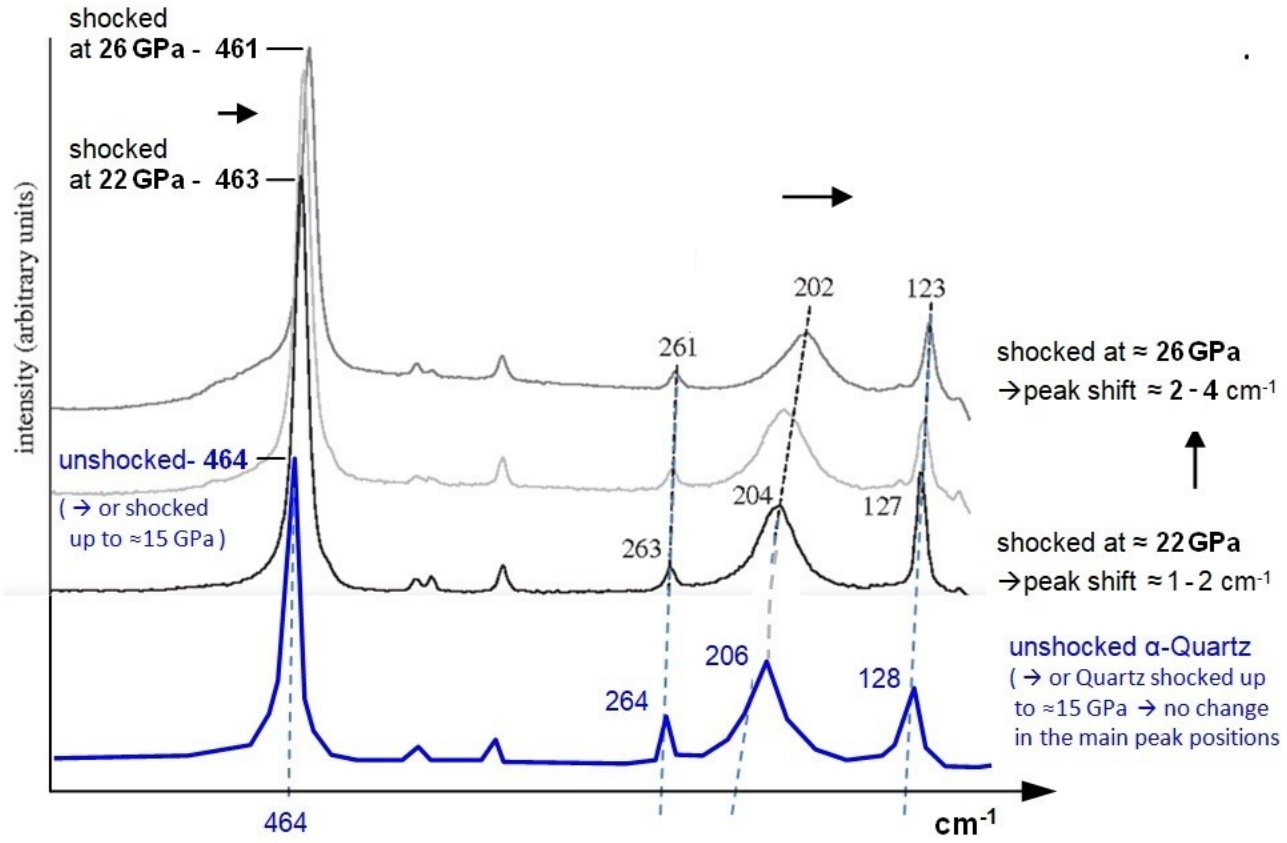
In order to verify a sample site as an impact site or impact structure, shock-metamorphic effects must be discovered in the rocks of the sample site. This can be done by different methods.

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.

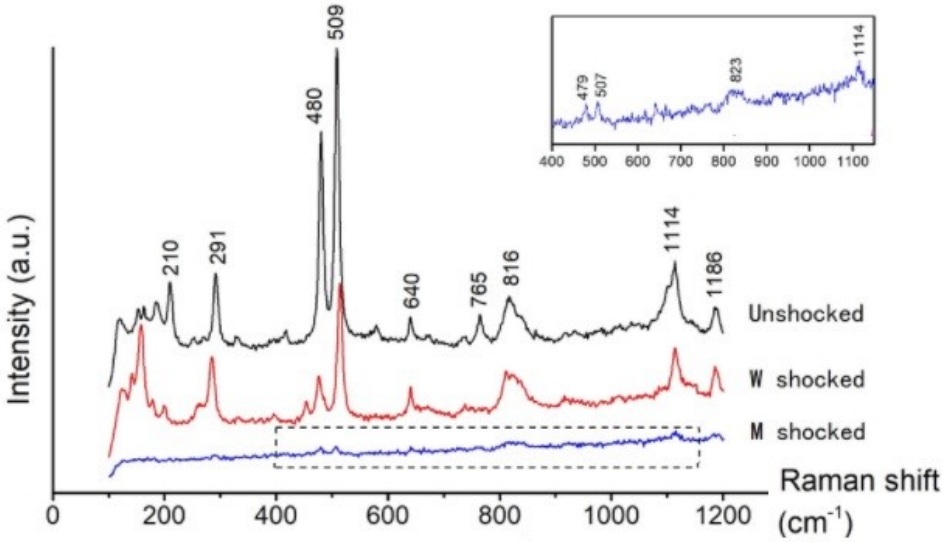
Mc Millan et al. (1992) and others have shown that the main RAMAN-peaks of Quartz shift towards lower frequencies if the Quartz was exposed the a shock-pressure > 15 GPa. → see diagram below

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 :

The following Impact-Craters & -structures belong to the same large-scale secondary impact event caused by the PTI :

The 130 x 110 km Bay-of-Lyon Impact Crater (France)_Raman spectra of selected Rock Samples (or here)

A 30 km Impact Structure and a 1.6 x 1.2 km Elliptical Crater in Southern Spain_Raman Spectra of Rock Samples (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**

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
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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