

## CHARACTERIZATION OF TITANITE-RUTILE SAMPLES FROM IMICHIL (MOROCCO)

**Sample identification:** JF160804-13    **Requested by:** FMinerals.    **Date:** 9/08/2015

### General Description:

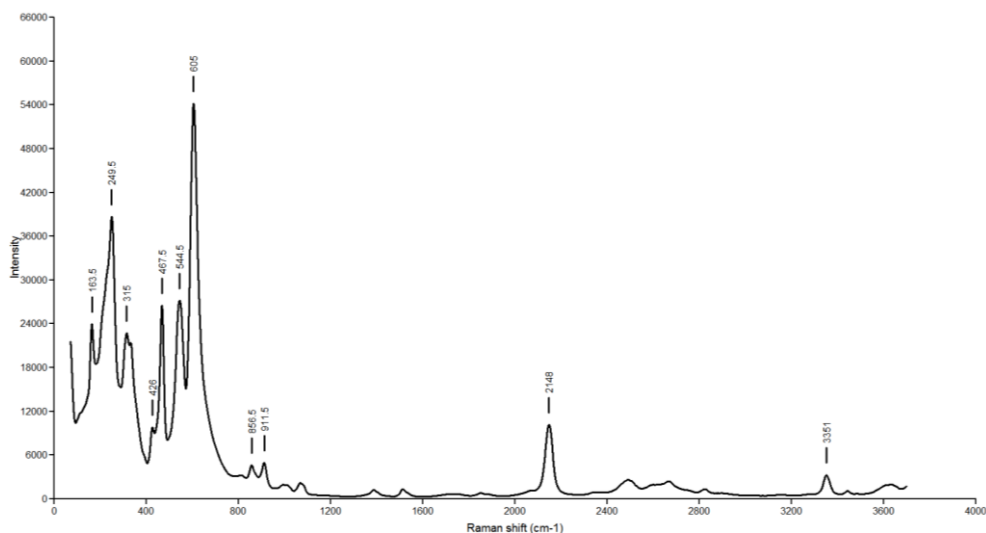
Characteristically platy of possible replaced Ilmenite crystals with irregular contour and completely pseudomorphed by apparent secondary Rutile, coated by very sharp Titanite crystals that are bright, with very well defined faces and edges, and with a very apparent pleochroism that shows a yellow color under led light but is greenish with natural or neon light. Titanite-Rutile is hosted by feldspar crystals with minor Tourmaline. Possible hydrothermal alteration of ilmenite leads to the Titanite-Rutile assemblage. Presence of clay minerals and chlorite suggests secondary hydrothermal alteration. Samples collected in 2016 in the Imilchil area, Anti-Atlas, Er Rachidia Province, Meknès-Tafilalet Region, Morocco.

### Titanite:



Green secondary Titanite crystals growth on previous Tourmaline, which shows hydrothermal alteration.

Titanite identification was confirmed by Raman spectroscopy (laser excitation wavelength= 535 nm)





Titanite crystals on hydrothermally altered Tourmaline. FOV 1 cm.

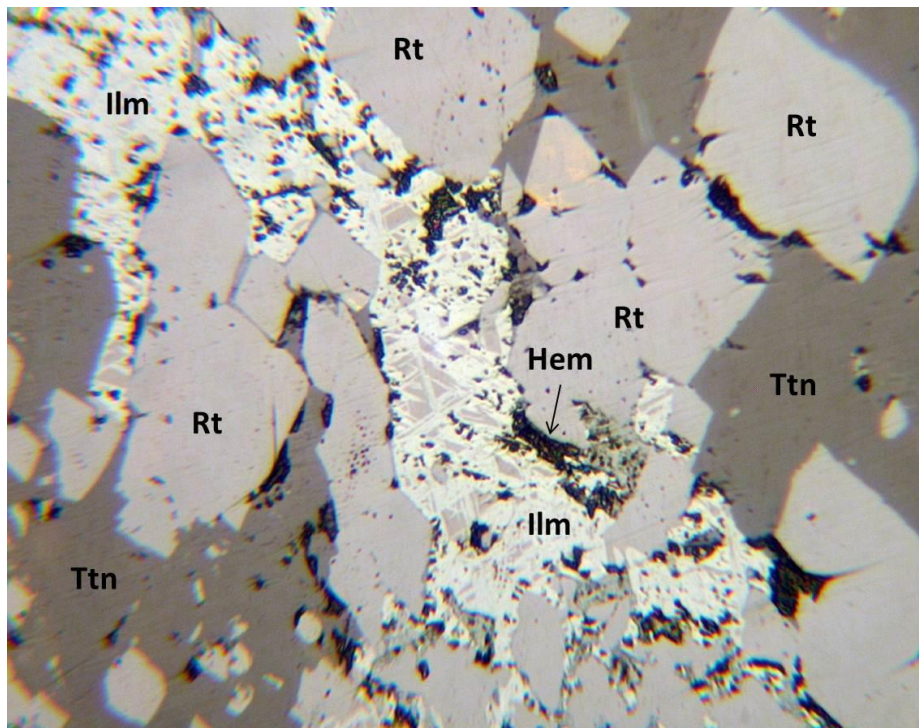
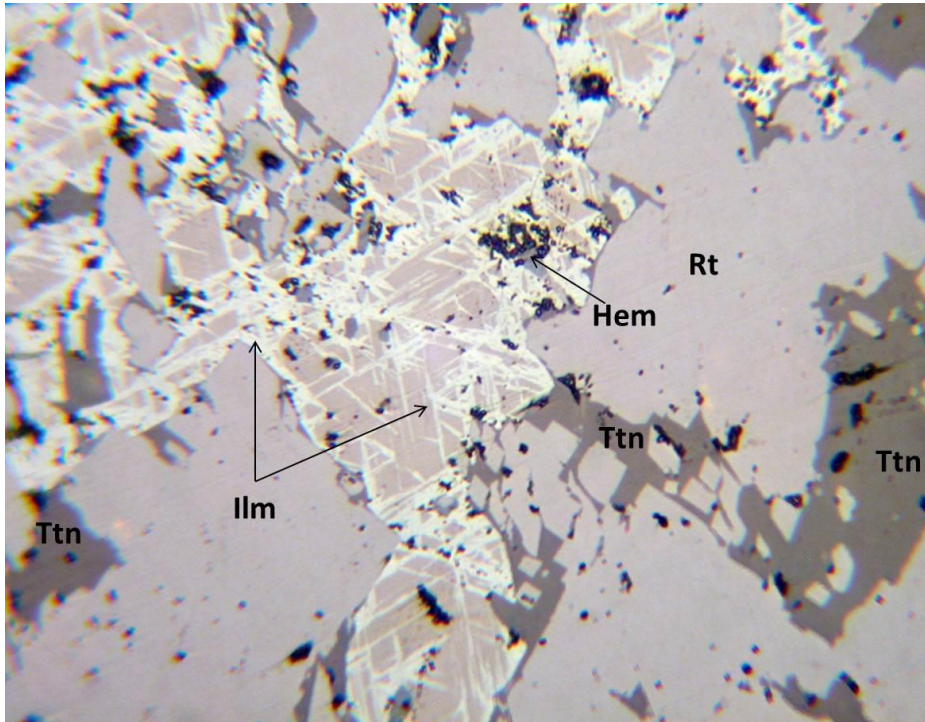


Titanite crystal on chlorite covered by clay minerals. In the sample, Clinocllore and Vermiculite were identified by Raman spectroscopy. FOV 1 cm.



### Rutile-Ilmenite. Textural study.

Idiomorphic, centimeter sized Titanite crystals growth covers a black metallic mineral, which constitute relicts of previous Ilmenite replaced and pseudomorphed by Rutile-Titanite.

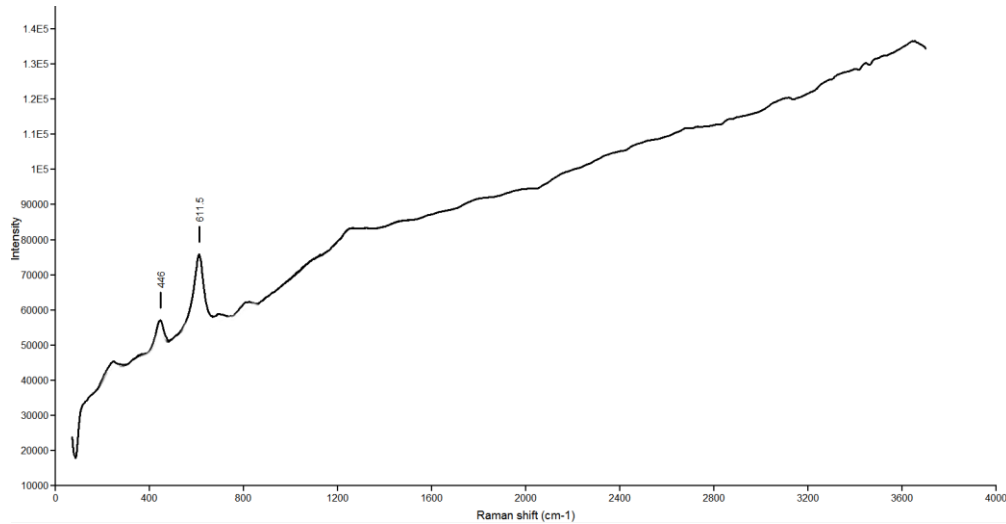


Figures obtained by reflected light microscopy on a polished section of the sample, shows primary Ilmenite (white-grey) with a classic alteration pattern and replaced by sub-euhedral

Rutile (Rt, medium grey) intergrown with Titanite (Ttn, brownish grey). The presence of Hematite (Hem) suggests the breakdown of Ilmenite, following this sequence:



Identity of Rutile was confirmed by Raman spectroscopy:

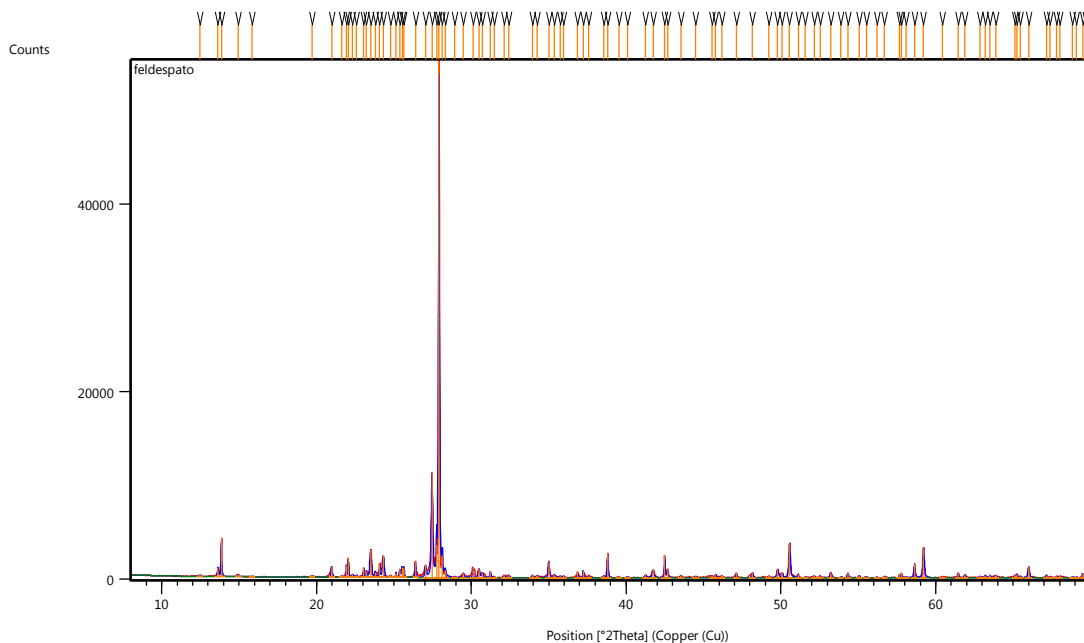


The Rutile shows intense fluorescence, but the distinctive Rutile bands are visible and confirms the identification of the black, metallic material.

### Feldspar

Titanite-Rutile is hosted by unidentified feldspar. XRD analysis of a feldspar crystal shows Albite-Microcline (both indistinguishable using X-ray diffraction). Raman microscopy shows the characteristic pattern of Microcline and XRF confirms the presence of potassium.

XRD:

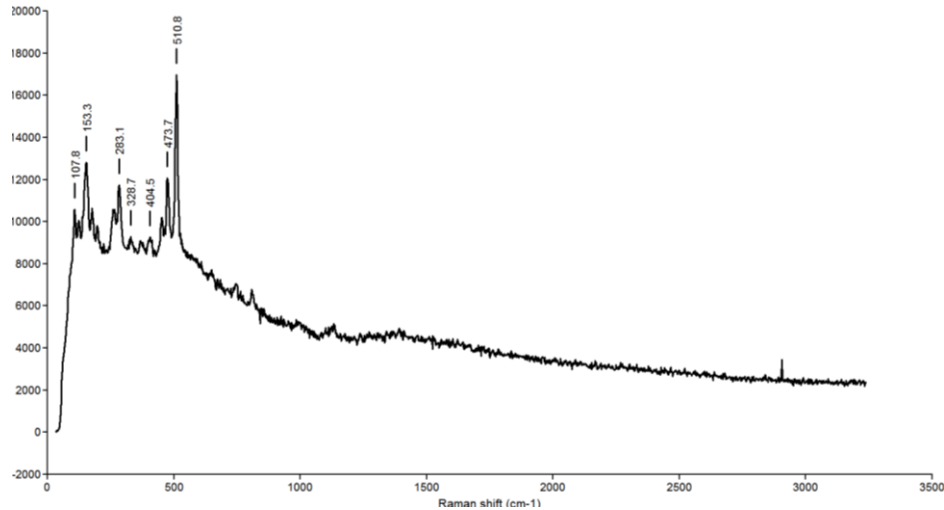


### Peak List:

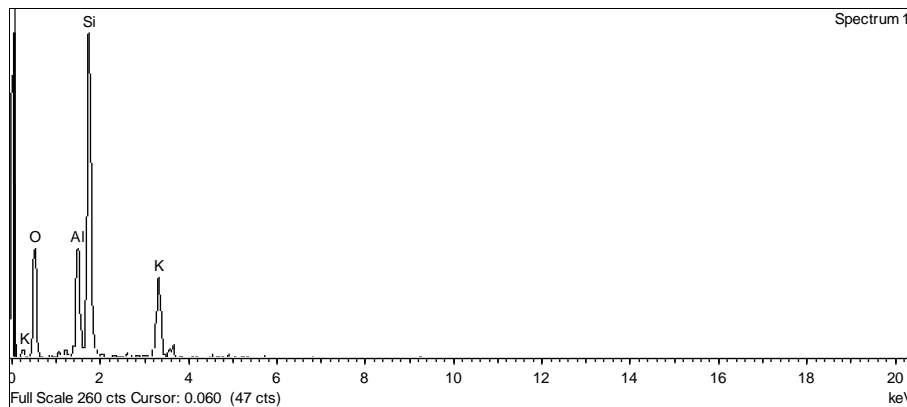
Pos. [°2Th.]	Height [cts]	FWHM Left [°2Th.]	d-spacing [Å]	Rel. Int. [%]	Tip Width
12.4619	116.92	0.1224	7.09717	0.21	0.1469
13.6358	947.34	0.0816	6.48870	1.70	0.0979
13.8582	4072.59	0.0612	6.38505	7.31	0.0734
14.9317	185.18	0.1632	5.92834	0.33	0.1958
15.8426	73.18	0.1224	5.58945	0.13	0.1469
19.7233	113.35	0.2448	4.49758	0.20	0.2938
20.9779	1133.06	0.1020	4.23135	2.03	0.1224
21.6150	149.60	0.0612	4.10804	0.27	0.0734
21.9339	1300.40	0.0408	4.04903	2.33	0.0490
22.0539	2069.39	0.0612	4.02727	3.71	0.0734
22.3310	285.43	0.1224	3.97792	0.51	0.1469
22.5737	199.16	0.1224	3.93570	0.36	0.1469
23.0571	979.66	0.0612	3.85426	1.76	0.0734
23.2286	637.28	0.0612	3.82620	1.14	0.0734
23.5009	2885.36	0.1224	3.78247	5.18	0.1469
23.8005	540.49	0.0816	3.73553	0.97	0.0979
24.0812	1504.13	0.0612	3.69262	2.70	0.0734
24.3220	2319.22	0.1224	3.65661	4.16	0.1469
24.7854	298.05	0.0612	3.58929	0.53	0.0734
25.1274	474.15	0.0408	3.54119	0.85	0.0490
25.3771	843.62	0.0612	3.50692	1.51	0.0734
25.5418	1091.58	0.1224	3.48468	1.96	0.1469
25.6445	982.85	0.0612	3.47095	1.76	0.0734
26.3955	1674.14	0.0816	3.37388	3.01	0.0979
27.0405	1310.32	0.1020	3.29485	2.35	0.1224
27.4667	11287.21	0.1020	3.24468	20.26	0.1224
27.7622	3467.73	0.0408	3.21081	6.22	0.0490
27.9104	55711.26	0.0816	3.19410	100.00	0.0979
28.1279	2391.31	0.0612	3.16989	4.29	0.0734
28.3154	722.32	0.1020	3.14933	1.30	0.1224
28.9271	128.00	0.0612	3.08411	0.23	0.0734
29.4777	488.90	0.1224	3.02774	0.88	0.1469
30.0971	1127.09	0.0612	2.96683	2.02	0.0734
30.4990	948.33	0.1224	2.92864	1.70	0.1469
30.7180	473.95	0.1020	2.90826	0.85	0.1224
31.2339	718.14	0.0816	2.86138	1.29	0.0979
31.4633	140.95	0.0816	2.84105	0.25	0.0979
32.1322	247.31	0.1224	2.78341	0.44	0.1469
32.4248	277.28	0.1020	2.75896	0.50	0.1224
33.9415	297.69	0.0816	2.63906	0.53	0.0979
34.2567	217.84	0.2040	2.61550	0.39	0.2448
35.0058	1734.49	0.1020	2.56123	3.11	0.1224
35.3657	279.25	0.1632	2.53598	0.50	0.1958
35.7336	168.18	0.1224	2.51071	0.30	0.1469
35.9420	189.84	0.1020	2.49663	0.34	0.1224
36.8699	674.84	0.0612	2.43590	1.21	0.0734
37.2319	736.71	0.0816	2.41304	1.32	0.0979
37.5610	240.24	0.1020	2.39265	0.43	0.1224
38.5674	190.66	0.1020	2.33250	0.34	0.1224
38.8090	2610.12	0.0816	2.31854	4.69	0.0979
39.5322	151.62	0.0612	2.27777	0.27	0.0734

40.0747	59.20	0.2448	2.24818	0.11	0.2938
41.2531	319.71	0.1224	2.18664	0.57	0.1469
41.7404	859.65	0.1428	2.16223	1.54	0.1714
42.4968	2412.30	0.0612	2.12548	4.33	0.0734
42.6772	912.60	0.1020	2.11691	1.64	0.1224
43.5332	241.35	0.1224	2.07725	0.43	0.1469
44.4694	148.86	0.1632	2.03567	0.27	0.1958
45.5359	225.98	0.1428	1.99044	0.41	0.1714
45.7802	356.79	0.1020	1.98038	0.64	0.1224
46.1800	180.89	0.1428	1.96416	0.32	0.1714
47.1252	558.01	0.0816	1.92695	1.00	0.0979
48.1648	499.03	0.1224	1.88776	0.90	0.1469
49.2092	246.33	0.0816	1.85011	0.44	0.0979
49.7808	907.16	0.1224	1.83019	1.63	0.1469
50.0748	567.70	0.1020	1.82014	1.02	0.1224
50.5579	3693.86	0.1224	1.80387	6.63	0.1469
51.1214	372.42	0.0816	1.78530	0.67	0.0979
51.5806	164.93	0.0612	1.77048	0.30	0.0734
52.1518	205.01	0.0816	1.75243	0.37	0.0979
52.5309	229.06	0.0816	1.74067	0.41	0.0979
53.2090	521.98	0.1224	1.72007	0.94	0.1469
53.8768	71.96	0.1632	1.70032	0.13	0.1958
54.3218	474.97	0.1020	1.68744	0.85	0.1224
55.0604	227.44	0.1020	1.66654	0.41	0.1224
55.5063	62.93	0.2448	1.65420	0.11	0.2938
56.1858	69.79	0.1224	1.63579	0.13	0.1469
56.6957	121.91	0.2040	1.62228	0.22	0.2448
57.6644	357.93	0.0612	1.59731	0.64	0.0734
57.7892	537.30	0.0612	1.59416	0.96	0.0734
58.0713	84.63	0.1632	1.58709	0.15	0.1958
58.6327	1491.10	0.0816	1.57322	2.68	0.0979
59.2073	3228.42	0.1224	1.55932	5.79	0.1469
60.4233	153.21	0.0612	1.53082	0.28	0.0734
61.4458	472.29	0.1020	1.50777	0.85	0.1224
61.8824	332.05	0.1224	1.49818	0.60	0.1469
62.8546	141.93	0.1632	1.47732	0.25	0.1958
63.1970	239.99	0.1224	1.47014	0.43	0.1469
63.4936	282.73	0.1020	1.46398	0.51	0.1224
63.8603	251.13	0.2040	1.45646	0.45	0.2448
65.0979	286.92	0.1224	1.43173	0.52	0.1469
65.2510	379.25	0.0612	1.42874	0.68	0.0734
65.4623	163.00	0.1224	1.42464	0.29	0.1469
66.0059	1188.15	0.1224	1.41422	2.13	0.1469
67.1503	267.87	0.1020	1.39287	0.48	0.1224
67.3771	137.66	0.1224	1.38873	0.25	0.1469
67.8041	169.75	0.1020	1.38102	0.30	0.1224
68.0324	179.92	0.1224	1.37694	0.32	0.1469
68.8257	99.30	0.1224	1.36300	0.18	0.1469
69.0848	76.11	0.1224	1.35851	0.14	0.1469
69.4858	442.78	0.0816	1.35165	0.79	0.0979
69.6621	643.54	0.0816	1.34866	1.16	0.0979

Raman spectrum:



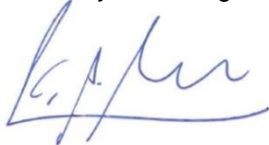
Spectrum is diagnostic of Microcline, showing a distinctive band at  $450\text{ cm}^{-1}$  and Raman shifts characteristic of the potassium feldspar. Species confirmed by EDS analysis:



### Conclusion:

A last generation of idiomorphic Titanite crystals, covering relicts of Ilmenite replaced by Rutile-Titanite-Hematite by hydrothermal alteration, also evidenced by the presence of Clinocllore, Vermiculite, altered Tourmaline and clay minerals. The described minerals are hosted by Microcline, which forms white, idiomorphic crystals.

On Tuesday, 20th August 2016



Dr. César Menor Salván

Analytical Chemist and Mineralogist- Geospectra Analytics

Research Scientist- Georgia Institute of Chemistry (GA, USA)