

Mineralogical Report on Sample TN211042: Poorly-consolidated Sandstone

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A drill core sample of poorly consolidated, friable, grey-brown coloured sandstone from a Cenozoic Basin overlying the Ngalia Basin (NT) was examined under the binocular microscope and the scanning electron microscope. The core material is radioactive and portable XRF readings indicate that about 200 ppm of uranium is present. Under the binocular microscope the sandstone appears porous and weakly cemented. The rock is composed mostly of angular to sub-angular quartz clasts up to about 1 mm size. Clasts are coated in a soft white to grey coloured material and in places are dusted by tiny orange particles. Black material, perhaps organic matter and/or pyrite, occurs sporadically.

As with the Cenozoic mudstone sample TN211040, the rock is too soft to allow preparation of conventional polished sections. Samples of interest were therefore selected from broken pieces of the core material and mounted on SEM stubs. This material was then carbon-coated and examined under the SEM. A series of illustrative backscattered electron (BSE) images are provided below.

Under the SEM it was found that the rock is dominantly composed of angular to sub-angular quartz clasts which are coated with a thin layer ("cement") of very fine (<3 micron size) particulate material made up of a mixture of anatase, clay and quartz (Figs 1-3; Table 1). Anatase typically makes up 50% or more of the cement. The clay in places is Mg, Fe and Na-bearing rather than potassic, suggesting the presence of smectite, however, this would need to be confirmed by XRD analysis.

Table 1. Analyses of coatings on quartz grains

	Bright coating on Qtz #1	Bright coating on Qtz #2	Bright pyrite-rich area	Bright Zr-rich area
SiO ₂	9.62	18.78	39.97	53.10
TiO ₂	64.29	51.08	14.74	30.13
Al ₂ O ₃	3.78	7.10	10.31	4.87
FeO	1.01	1.18	7.86	0.68
MgO	0.31	bdl	0.34	0.60
CaO	0.16	bdl	0.36	0.26
Na ₂ O	bdl	0.42	0.53	0.47
K ₂ O	bdl	bdl	1.74	0.35
P ₂ O ₅	0.52	bdl	bdl	bdl
SO ₃	bdl	bdl	22.88	1.29
ZrO ₂	bdl	0.80	bdl	1.35
UO ₂	bdl	bdl	bdl	bdl
Cl	0.16	0.12	bdl	bdl
Total	79.85	79.48	98.73	93.10

Some coatings on quartz with a bright BSE response were found to be pyrite-rich (Table 1) while other areas showed an enrichment in ZrO_2 suggesting the presence of anatase-zircon composite materials.

Various heavy mineral grains were identified under backscattered imaging, they include:

1. Zircon. Detrital zircon grains generally of a few microns up to about 100 microns in size are very common (Fig.4a). The zircon is chemically pure (no detectable U or Th is present) and unaltered.
2. Anatase . In addition to the fine grain coatings, ~2-10 micron sized individual grains of anatase are found scattered throughout the rock. Some grains may possibly be detrital rutile but the high impurity SiO_2 and Al_2O_3 content of the grains (Table 2) suggests anatase is most likely. Some anatase was found to be uraniferous and silica-rich (Table 2; Fig. 2) with UO_2 contents up to nearly 9%. The high SiO_2 content of some U-rich anatase (>20%) suggests it may be an alteration phase. Most of the anatase contains a small component of vanadium (~1% V_2O_3) and some anatase grains are finely intergrown with zircon (Table 2). Uraniferous anatase was the only uranium-bearing mineral identified in this sediment.
3. Fe-oxide. Iron oxide particles up to about 20 microns size are common. Some of this material contains minor chloride and sulphate contents.
4. Fe-Cr-Mn-Cu (~75% Fe, 12% Cr, 9% Mn, 2% Cu, 1% Ti) and Fe-Cr-Ni-Mn (~73% Fe, ~18% Cr, ~8% Ni, ~2% Mn) phases are found as tiny, irregular 2-10 micron particles often associated with anatase and clay (Fig. 3; Fig.4b). Analytical totals are high suggesting the phases are metal alloys not oxides, however, this would be rather unusual if natural. The compositions roughly correspond to two different types of stainless steel so are most likely contaminants introduced from the core drilling/reaming.
5. Xenotime. Rare.

Table 2. Analyses of anatase and uraniferous anatase grains

	Zircon-Anatase intergrowth 2 microns	Anatase Grain; 5 microns	Uraniferous Anatase Grain; 4 microns	Uraniferous Anatase Grain; 2 microns	Uraniferous Anatase Grain; 4 microns	Uraniferous Anatase Grain; 2 microns
SiO_2	34.93	2.00	7.11	6.96	21.12	22.37
TiO_2	28.55	95.22	75.02	73.50	68.30	56.27
Al_2O_3	6.07	1.51	0.68	0.85	1.52	5.17
V_2O_3	0.66	bdl	1.20	1.35	0.84	bdl
FeO	0.85	bdl	2.05	1.92	0.61	2.15
MgO	0.41	bdl	bdl	bdl	bdl	bdl
CaO	1.14	bdl	bdl	bdl	bdl	0.30
CuO	bdl	bdl	bdl	bdl	bdl	0.74
ZrO_2	26.51	bdl	bdl	bdl	bdl	bdl
UO_2	bdl	bdl	6.66	7.57	3.20	8.63
Total	99.12	98.73	92.72	92.15	95.59	95.63

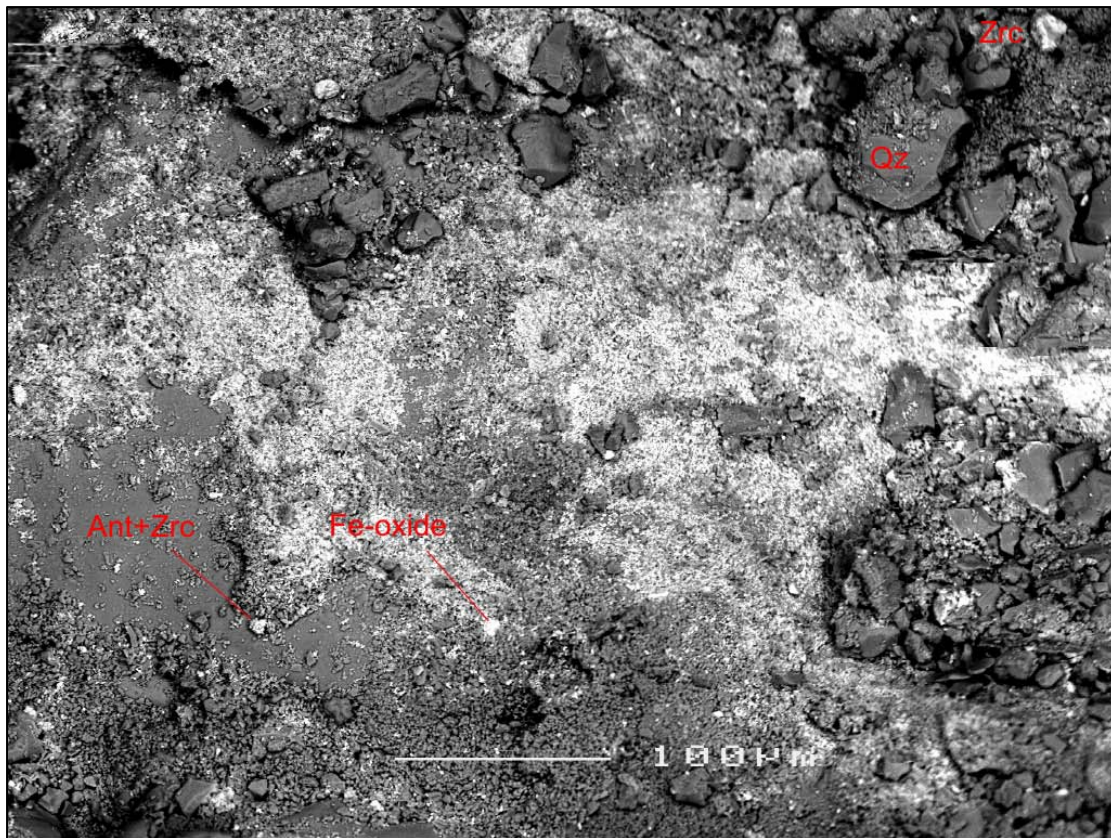


Fig.1. Surface of a large quartz grain (~0.5mm) covered with a coating ("cement") of anatase + clay (white) together with abundant fragments of fine quartz. Some small 5-10 micron sized clasts of Fe-oxide, zircon (Zrc) and a composite anatase + zircon grain (Ant+Zrc) are identified.

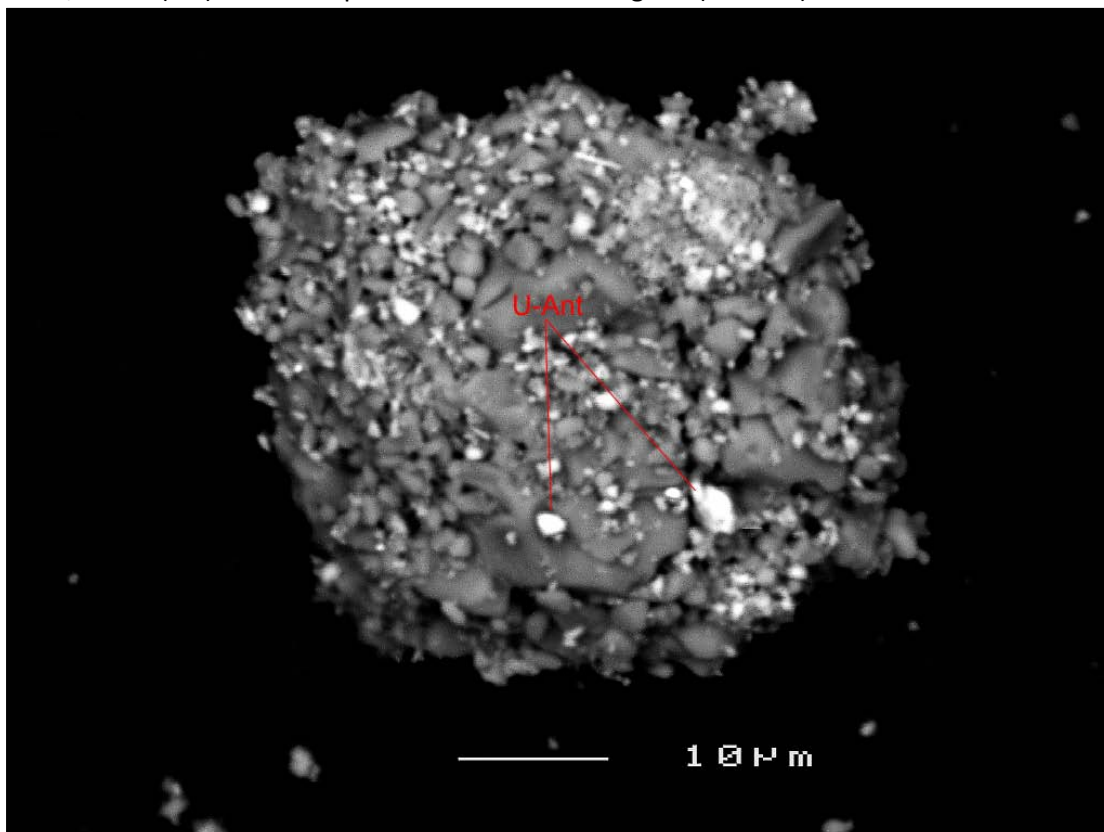


Fig.2. Cluster of quartz grains (~1-20 microns size; grey) associated with particles of uraniferous anatase (U-Ant; <1-4 microns size; bright under BSE imaging).

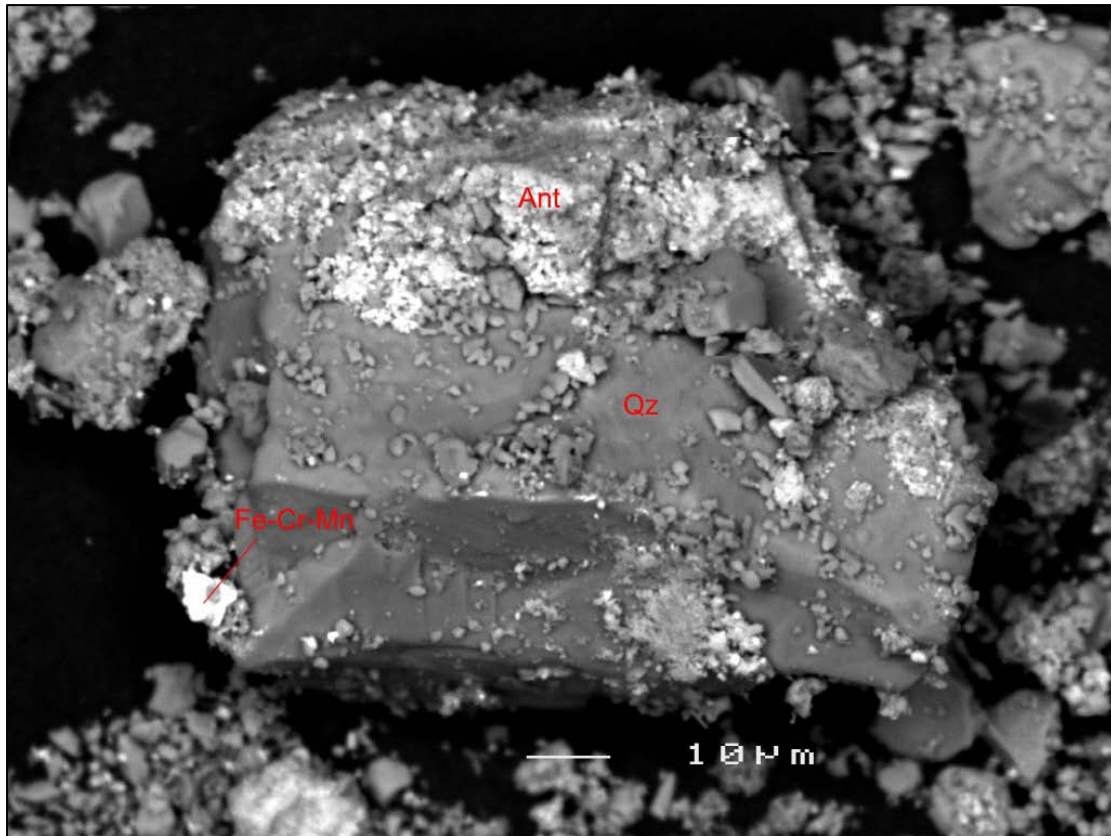


Fig.3. Quartz clast (~80 microns size; grey) with a coating of fine, particulate anatase (Ant; bright under BSE imaging) and quartz. A particle of an Fe-Cr-Mn-Cu phase occurs at lower left (bright).

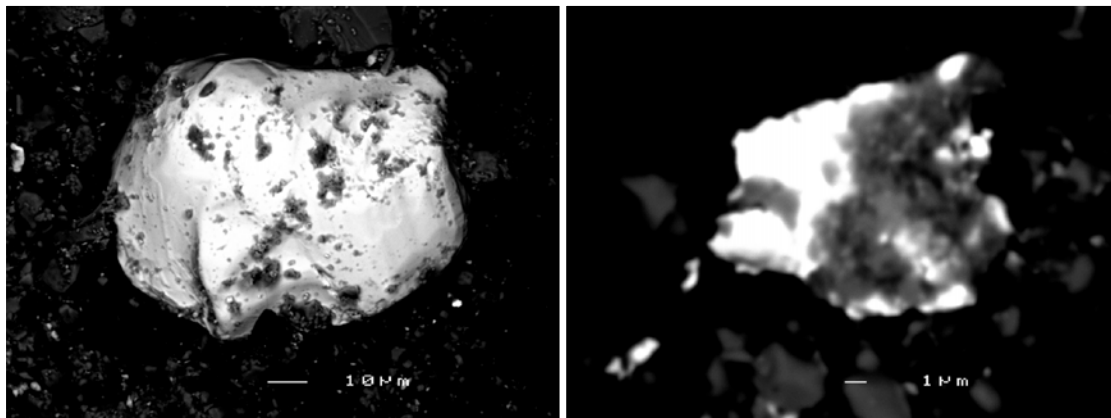


Fig.4a. (left) Zircon clast of ~100 microns size; 4b. (right) composite grain of an Fe-Cr-Ni-Mn phase (bright) with a coating of anatase, quartz and clay (light and dark grey).

Area Scans.

Area scans are provided in Table 3. While somewhat variable due to the uneven distribution of cement coatings on quartz grains, the scans suggest the rock is composed of roughly 75% quartz, 15% anatase/rutile and 10% clay with 0-1% pyrite.

Table 3. Area Scans

	Area scan #1	Area scan #2	Area scan #3
SiO ₂	78.25	76.32	65.60
TiO ₂	16.28	15.32	26.98
Al ₂ O ₃	2.10	4.63	3.81
FeO	bdl	0.73	bdl
MgO	0.83	bdl	0.43
CaO	bdl	bdl	bdl
Na ₂ O	1.00	bdl	0.75
K ₂ O	bdl	0.35	bdl
P ₂ O ₅	bdl	bdl	bdl
SO ₃	bdl	2.11	0.35
ZrO ₂	bdl	bdl	bdl
UO ₂	bdl	bdl	bdl
Cl	bdl	bdl	bdl
Total	98.46	99.46	97.92

Conclusions.

Uranium occurs in this poorly consolidated Cenozoic sandstone as a solid-solution component of anatase and altered, silica-rich anatase. No other uranium minerals have been found. The sandstone is a little unusual in that the thin intergranular cement that coats quartz grains is composed of anatase and clay. Cements of this kind are common in silcretes and other silcretized sediments where the TiO₂ is sourced from the chemical weathering of detrital heavy minerals such as rutile and ilmenite but such cements are not very common in sandstones, particularly poorly consolidated ones. The anatase contains ~1% vanadium oxide so rocks of this kind are likely to be important contributors of both U and V in the formation of secondary carnotite mineralization. The occurrence of iron-chromium bearing particles in the rock are most likely drilling-related, stainless steel contaminants.

This rock contains abundant refractory minerals such as zircon and anatase so that geochemical assay by conventional acid digestion may result in poor recoveries for certain elements (Zr, Ti, U). This rock should be analysed either by XRF or peroxide fusion digest/ICP methods.