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SIP development and QEMSCAN test analyses of U bearing samples

For Jeff Miller
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Executive Summary

Two U-bearing samples from a sandstone hosted U-deposit were analyzed by QEMSCAN for mineralogy, locking and liberation characteristics, mineral associations and grain size distribution.

The host rock is a porous sandstone with poorly sorted grains of quartz (40-45%), feldspar (12-18% K-feldspar and 6-10% plagioclase), muscovite (6%), biotite (4-5%), pyroxene (<1%), and amphibole (<1%) set in a porous, clay-fine (mainly kaolinite: 12%) matrix. This rock can be classified as arcosic sandstone (it is not an arcose yet, as the feldspar content is <25%), or almost as a feldspathic wacke (sandstones that contain more than 15% clay matrix in between framework grains and the modal abundance of quartz is <40% with feldspar being the second most abundant mineral).

The roll-front uranium mineralization contains coffinite, uraninite, and pitchblende (U minerals), and pyrite, REE -, and V-bearing minerals. Sample 3707b contains 2% coffinite, whereas sample 3707c2 contains 5% coffinite, 1% uraninite, and 2% pitchblende. U minerals in sample 3707b are smaller than 20 micron with the majority being 10-20 micron in size. In sample 3707c2, coffinite is <30 micron in size, and only few uraninite grains are >30 micron. Pitchblende grain sizes range between <10 and 60 micron, with the majority being 10-40 micron in size.

Locking and liberation characteristics for U minerals in the particulate sample 3707b are as follows: coffinite and uraninite are both completely locked; 65% of pitchblende is slightly liberated (10% liberated), the remaining 35% is completely locked as well. Coffinite grains are most often associated with muscovite, K feldspar, quartz, REE minerals, and other U minerals. Uraninite is predominantly associated with REE minerals, and other U minerals. Pitchblende mostly occurs in association with muscovite, pyrite, REE minerals, and other U minerals.

Project Background

In February 2012, Jeff Miller from AUC LLC came to the QEMSCAN Facility at Colorado School of Mines to discuss QEMSCAN analyses on 2 U bearing samples (one particulate and one rock sample). The aims of the analyses were to:

1. Test whether different U-minerals can be distinguished by QEMSCAN analysis
2. Quantify the modal mineralogy of the U-bearing minerals and gangue phases in the samples;
3. Understand the mineral associations, and quantify the locking and liberation characteristics of the ore (particulate sample); and
4. Calculate the grain size distribution of the U-bearing minerals.

Sample Preparation and Measurements

1. The particulate sample was split into representative aliquots using a rotary micro-riffler.
2. Sized graphite was added to mitigate particle agglomeration, preferred orientation and settling. Subsequently, the sample was mounted in a 30-mm block with epoxy-resin and left to cure. The rock sample was immediately mounted in a 30-mm block with epoxy resin.
3. The blocks were ground and polished to obtain a flat surface for X-ray analysis.
4. The blocks were carbon coated to establish an electrically conductive surface.
5. The samples were analyzed in Field Image Mode at a 5-µm (sample 3707b) and 10-µm (3707c2) resolution, respectively.

Results

Mineralogy

Host rock

The host rock is a porous sandstone with poorly sorted grains of quartz (40-45%), feldspar (12-18% K-feldspar and 6-10% plagioclase), muscovite (6%), biotite (4-5%), pyroxene (<1%), and amphibole (<1%) set in a porous, clay-fine (mainly kaolinite: 12%) matrix. This rock can be classified as arcosic sandstone (it is not an arcose yet, as the feldspar content is <25%), or almost as a feldspathic wacke (sandstones that contain more than 15% clay matrix in between framework grains and the modal abundance of quartz is <90% with feldspar being the second most abundant mineral). This is an indication for a fluvial sandstone as such ‘river sandstones’ tend to be less sorted and not as mature as marine and desert sandstones.

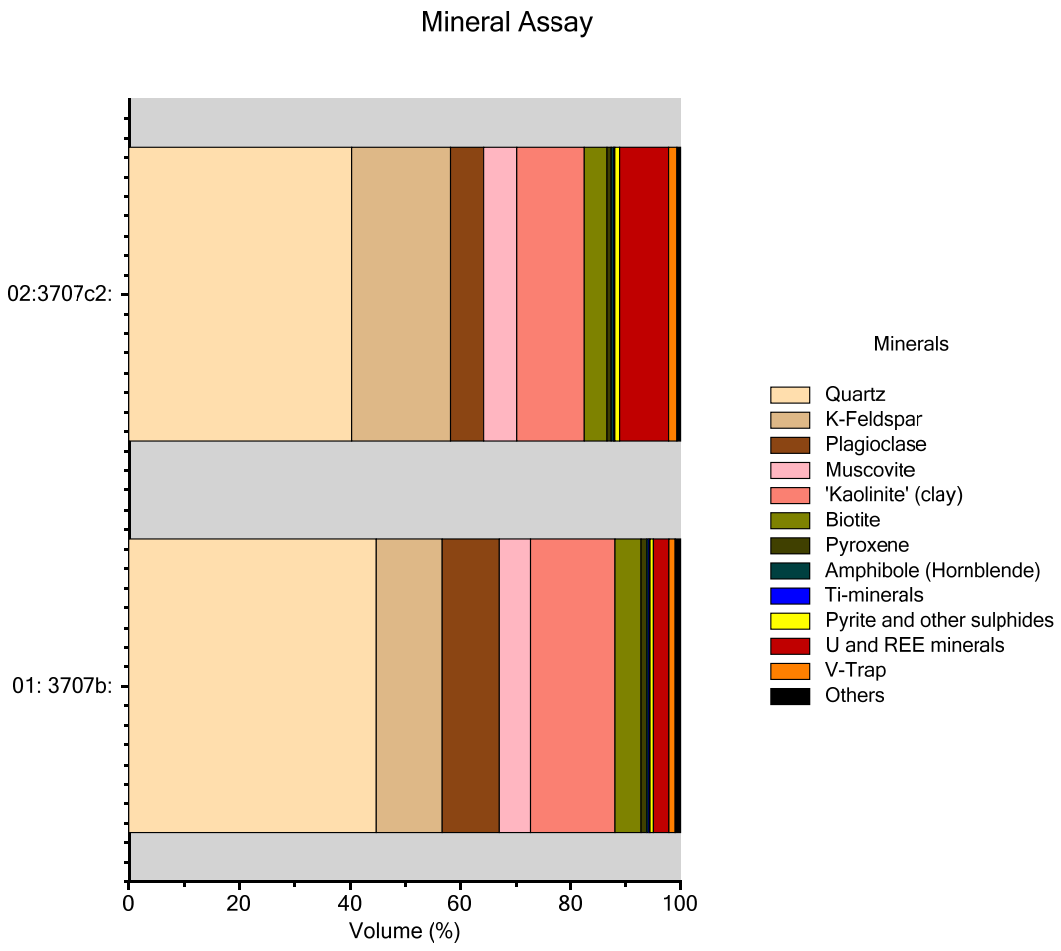


Fig. 1: Modal abundance (Sandstone) in volume% in sample 3707b and sample 3707c2

Mineralization

The roll-front uranium mineralization contains coffinite, uraninite, and pitchblende (U minerals), and pyrite, REE -, and V-bearing minerals. Sample 3707b contains 2% coffinite, and sample 3707c2 contains 5% coffinite, 1% uraninite, and 2% pitchblende. U minerals in sample 3707b are smaller than 20 micron with the majority being 10-20 micron in size. In sample 3707c2, coffinite is <30 micron in size, and only few uraninite grains are >30 micron. Pitchblende grain sizes range between <10 and 60 micron, with the majority being 10-40 micron in size.

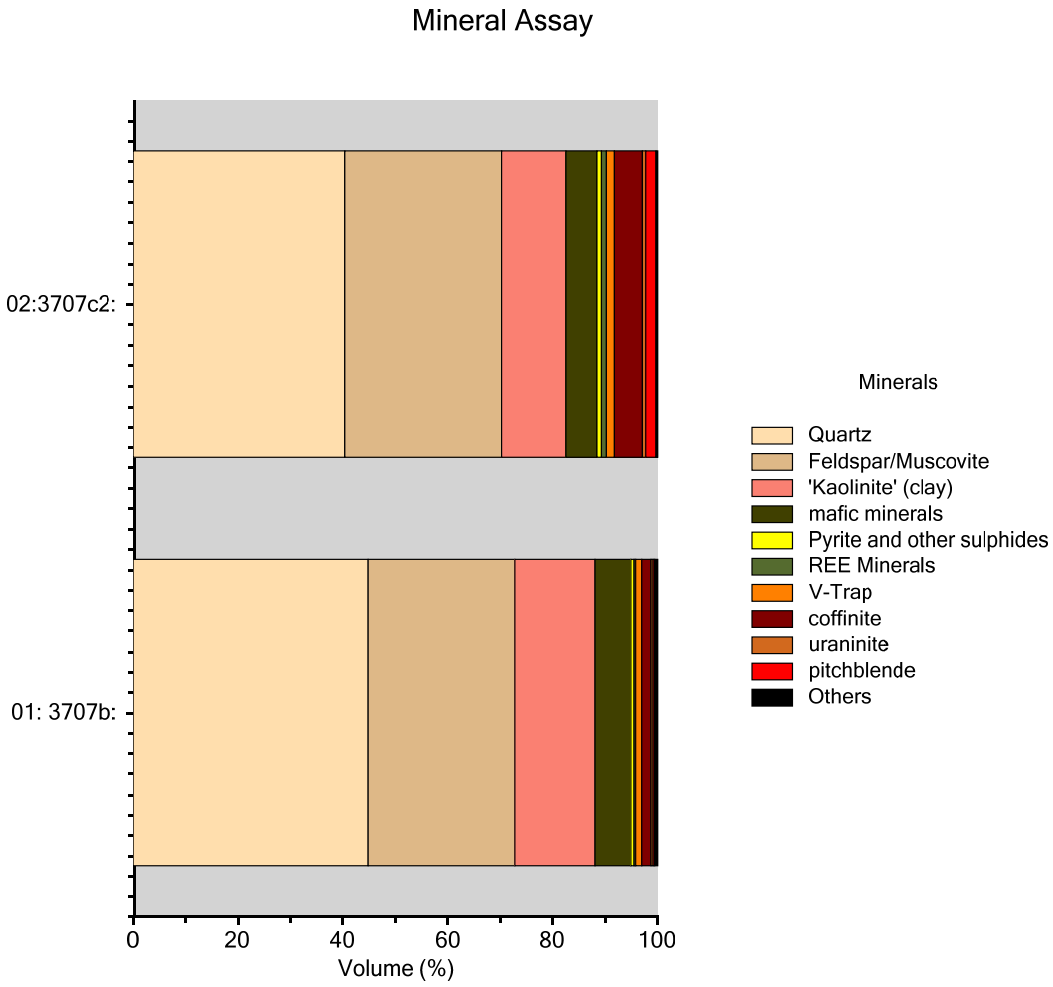


Fig. 2: Modal abundance (mineralization) in volume% in sample 3707b and sample 3707c2

Table 1: Modal mineral abundance in Volume%

Minerals	Chemical composition	3707b	3707c2
Quartz	SiO_2	45	40
K-Feldspar	$KAlSi_3O_8$ - $NaAlSi_3O_8$	12	18
Plagioclase	$NaAlSi_3O_8$ – $CaAl_2Si_2O_8$	10	6
Muscovite	$KAl_3Si_3O_{10}(OH)_{10}$	6	6
'Kaolinite' (clay)	$Al_2Si_2O_5(OH)_4$	15	12
Biotite	$K(Mg,Fe)_3AlSi_3O_{10}(OH)_2$	5	4
Pyroxene	$Mg_2Si_2O_6$ - $Fe_2Si_2O_6$ - $FeCaSi_2O_6$	1	1
Amphibole (Hornblende)	$Ca_2(Mg,Fe,Al)_5(Al,Si)_8O_{22}(OH)_2$	tr	tr
Ti-minerals	sphene ($CaTiSiO_5$), rutile/anatase (TiO_2)	tr	tr
Pyrite and other sulphides	pyrite (FeS_2), sphalerite (ZnS)	1	1
REE Minerals	bastnasite, REE-Epidote, REE-feldspar	tr	1
V-Trap	V and REE have a strong peak overlap	1	2
Coffinite	$U(SiO_4)_{1-x}(OH)_{4x}$	2	5
Uraninite	UO_2 (BSE > 69)	tr	1
Pitchblende	UO_2 (BSE < 69)	tr	2
Others	individual unidentified pixels	1	1

tr = <0.5%

Grain Size Distribution of U minerals

- U-minerals in sample 3707b are smaller than 20 micron with the majority being 10-20 micron in size (Table 2, Fig. 2).
- In sample 3707c2, coffinite is <30 micron in size, and only few uraninite grains are >30 micron. Pitchblende grain sizes range between <10 and 60 micron, with the majority being 10-40 micron in size.

Table 2: Grain size distribution

	3707b			3707c2		
	coffinite	uraninite	pitchblende	coffinite	uraninite	pitchblende
<10 um	32	19	28	0	0	4
10-20 um	68	81	72	23	34	24
20-30 um	0	0	0	77	62	15
30-40 um	0	0	0	0	3	28
40-50 um	0	0	0	0	0	19
50-60 um	0	0	0	0	0	10
60-70 um	0	0	0	0	0	0
70-80 um	0	0	0	0	0	0
80-90 um	0	0	0	0	0	0
90-100 um	0	0	0	0	0	0
>100 um	0	0	0	0	0	0

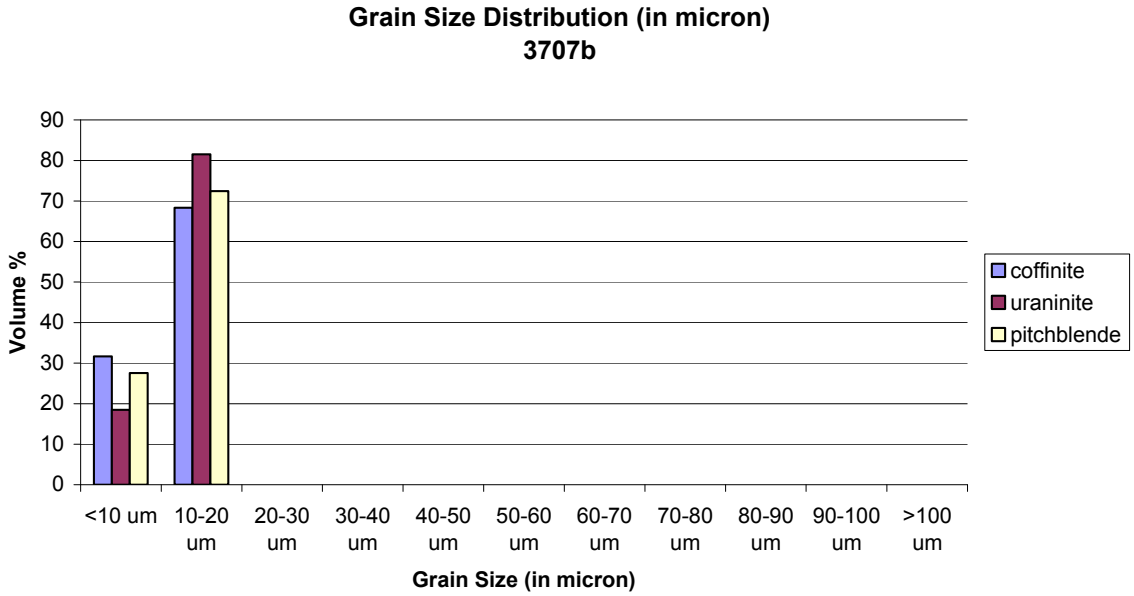


Fig. 2: Grain size distribution in sample 3707b

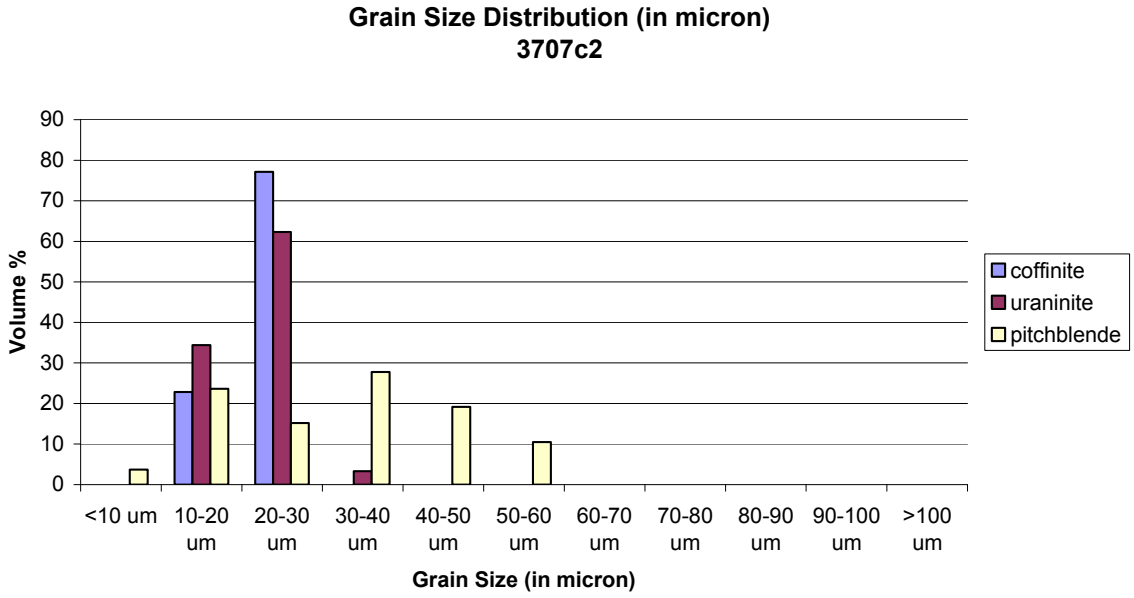


Fig. 3: Grain size distribution in sample 3707c2

Locking/liberation characteristics and mineral associations of U minerals

A mineral is completely liberated if the entire particle only consists of the respective mineral. A mineral is 'locked' if the area of the respective mineral is <30% in the entire particle, everything in between is called 'middlings'. These numbers do not reflect how easy it is to liberate a mineral by e.g., grinding the material. Locking and liberation characteristics for U minerals in the particulate sample 3707b are as follows: coffinite and uraninite are both completely locked; 65% of pitchblende is slightly liberated (10% liberated), the remaining 35% are completely locked as well.

Table 3: Locking and liberation of U-minerals in sample 707b

	3707b		
	coffinite	**uraninite**	**pitchblende**
<10%	100	100	35
10%	0	0	65
20%	0	0	0
30%	0	0	0
40%	0	0	0
50%	0	0	0
60%	0	0	0
70%	0	0	0
80%	0	0	0
90%	0	0	0
Liberated	0	0	0

Mineral Association

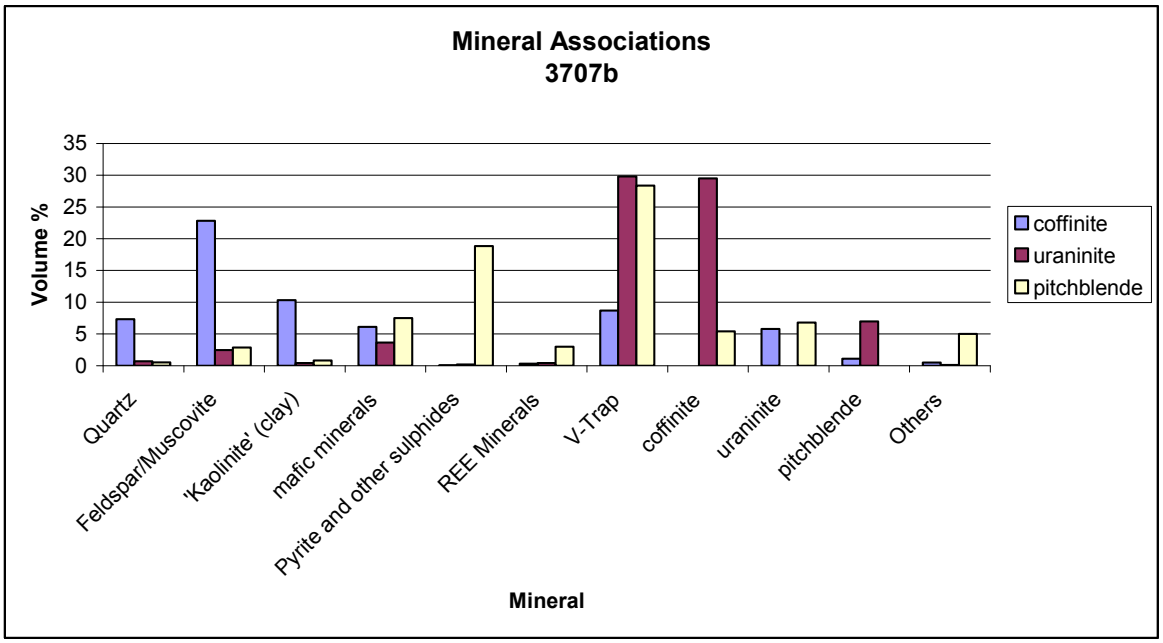


Fig. 4: Mineral association for coffinite, uraninite, and pitchblende in sample 3707b

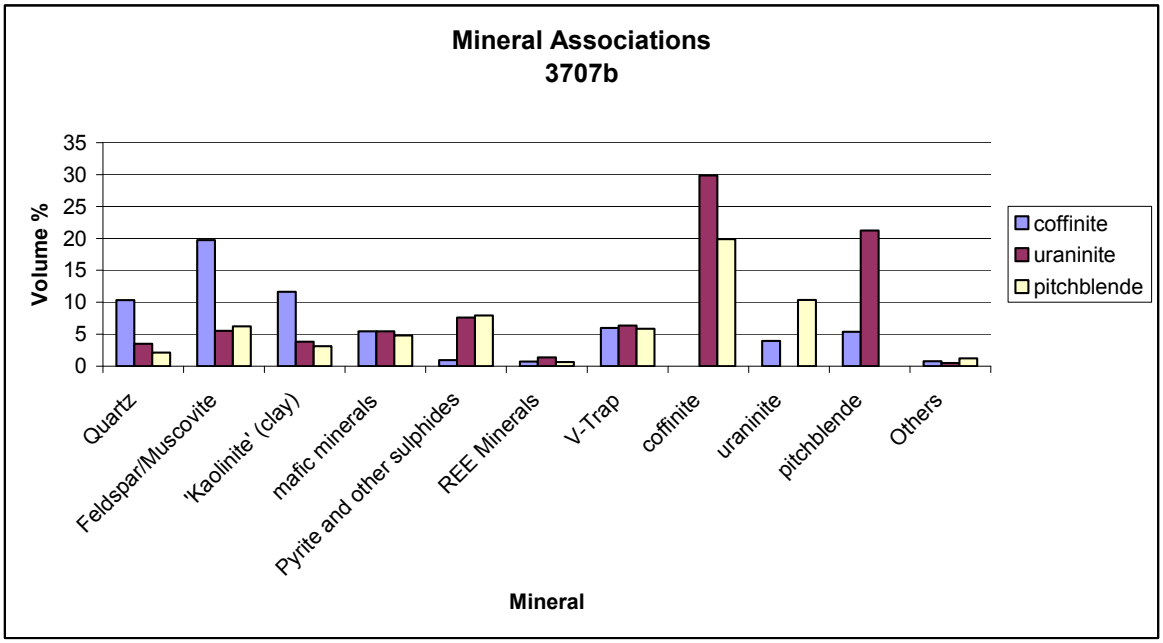
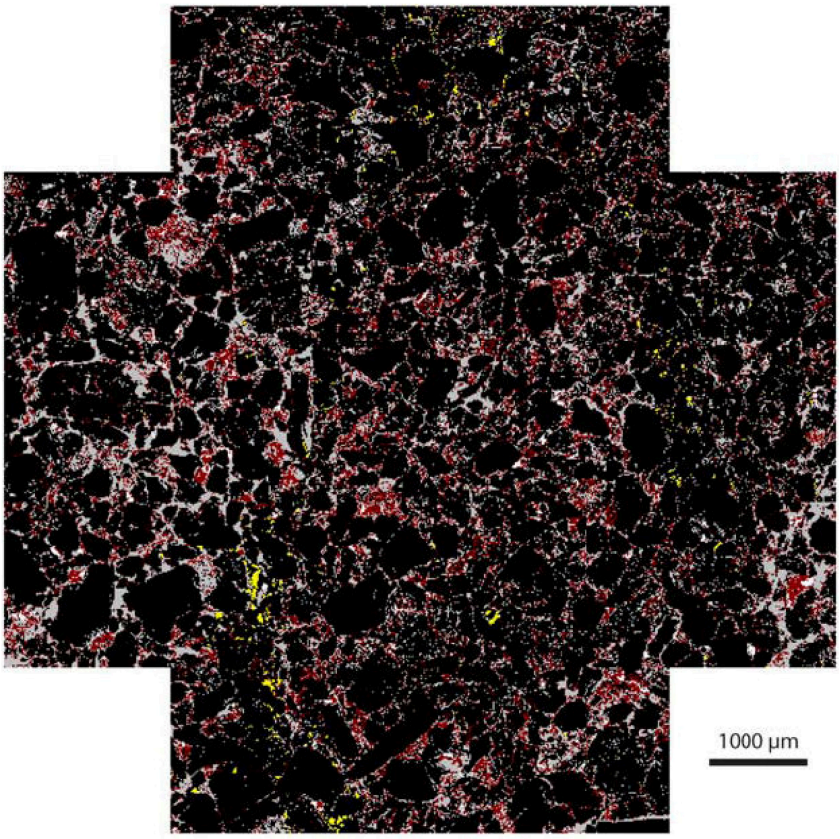


Fig. 5: Mineral association for coffinite, uraninite, and pitchblende in sample 3707c2

Porosity and organic matter scan



Mineral Name	Area%
Porosity	14.47
orgmat1	7.71
Pyrite	0.42
Others	77.40

According to the porosity and organic matter scan (at 15 kV), the porosity in this rock is about 14% and the amount of organic matter is about 8%.

The mineralogical data reported in this study directly reflect the best possible analysis of the materials provided. All efforts were made to ensure the highest level of quality control for the materials provided. Certain factors beyond the control of this laboratory may include: sample selection and representivity of materials, sample preparation by other laboratories, small sample size, small grain size close to the resolution of the system, and statistical representation of trace phases. The QEMSCAN Facility is not responsible for any further interpretation or application of the data other than that contained herein, and application to larger sample populations may not be valid without further analysis. Information regarding laboratory operations, quality control and quality assurance is available on request.