Definition of Uranium Mineralogy of Jurassic-age, Sandstone-hosted Uranium Deposits of the Southeastern Colorado Plateau, New Mexico

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Applications of Uranium Mineralogy Study

There is new renewed interest in the Grants Mineral Belt as a source of inexpensive uranium. In-situ recovery (ISR) of uranium has been applied with success at other uranium localities. The large amount of reserves contained within the Grants region and the porosity of the host rock make the area a candidate for future ISR operations. Many of the mines in the region have poor mineralogy records. This project expands the known mineralogy for several areas in the region, and will be used in future tests to determine the leaching capacity for Grants ore.

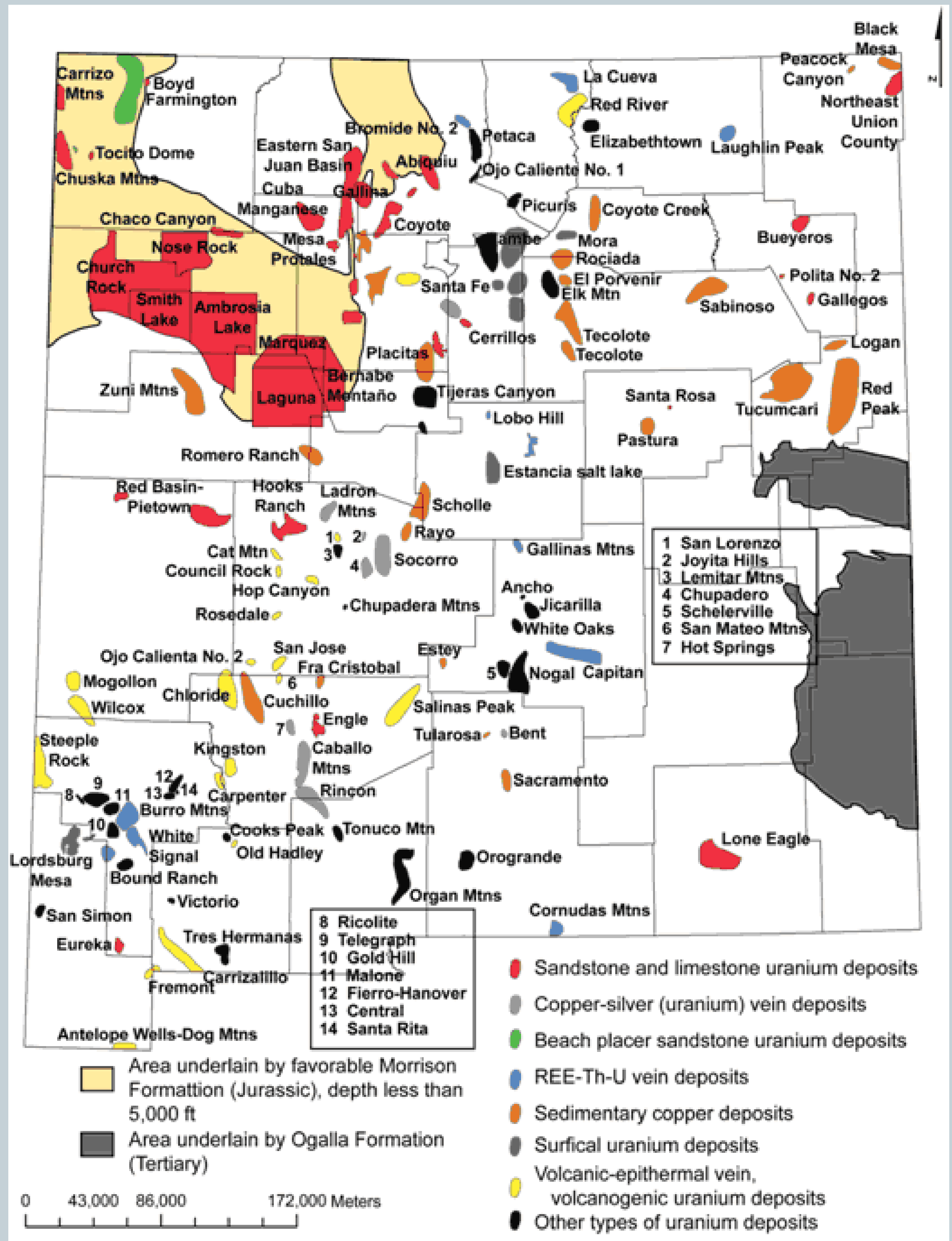


Fig. 1. Known uranium localities of New Mexico. New Mexico Bureau of Geology and Mineral Resources.

Project Background

The Grants region in northwestern New Mexico is the second largest source of uranium in the United States following Wyoming (Kelley al, 1967). The region was mined from the 1940s until the late 1980s. There is an estimated 300 million lbs of resource U_3O_8 remaining in the Grants region (McLemore al., 2013). The focus of this study is to identify the uranium mineralization hosted in the sandstone of the Morrison Formation and the limestone of the Todilto Formation.

Geology of Sandstone and Limestone-Hosted Uranium

Uranium mineralization in the Grants region occurs predominantly in the Westwater Canyon and Jackpile members of the Morrison Formation. These quartz-arkosic arenites are of fluvial, continental origin (Fitch, 1980). Uranium transported in groundwater precipitates in the pore space of the rock and occurs as fractures fillings. The deposits of Grants are either primary (tabular) or redistributed (roll-type), and are mined for the reduced mineralization. The limestone of the Todilto Formation is continental, and hosts dominantly oxidized mineralization as fracture-fillings and replacements of calcite (Moench, Schlee, 1967).

Multiple Migration-Accretion and Geochemistry

Uranium can occur in many environments, but transpires in greater amounts in felsic volcanic material. Devitrification of the volcanic material liberates uranium into groundwater, were it will complex with oxyanions (preference is given to carbonate) and can be transported. Precipitation occurs at the Redox zone, and is often facilitated by carbonaceous material. Fossil trash decomposition produces humic and fulvic acids, which create local reducing conditions favorable for the precipitation of reduced uranium minerals. These acids can also be transported and precipitated as carbonaceous material, and are responsible for the reduction down-dip of initial uranium precipitation. This process of repeated reduction-oxidation is referred to as Multiple Migration Accretion, and is the cause of the large, sinuous, redistributed or "roll-type" deposits observed in the Grants region (Gruner, 1969).

Other metals observed in uranium sandstone deposits include vanadium, selenium, molybdenum, iron, and copper. Vanadium an iron are the only identified metals in this study. Iron occurs as pyrite in the reduce ore horizons, an vanadium occur with uranium in the oxidized mineral phases.

Methods of Analysis

The dominant method of mineral identification used for this project is powder X-Ray Diffraction (XRD). This data is complemented by thin and polished section analysis, and early microprobe results.

Figures 2 and 3 were both sample from the St. Anthony mine. STA1 was collected during operations, and does not have a known location. STA 21 was sampled during the 10/2018 sampling visit to the south pit and was collected post-mining. Photo 1 shows the diverse mineralogy of the sample, while photo 2 establishes the single phase of the sample.

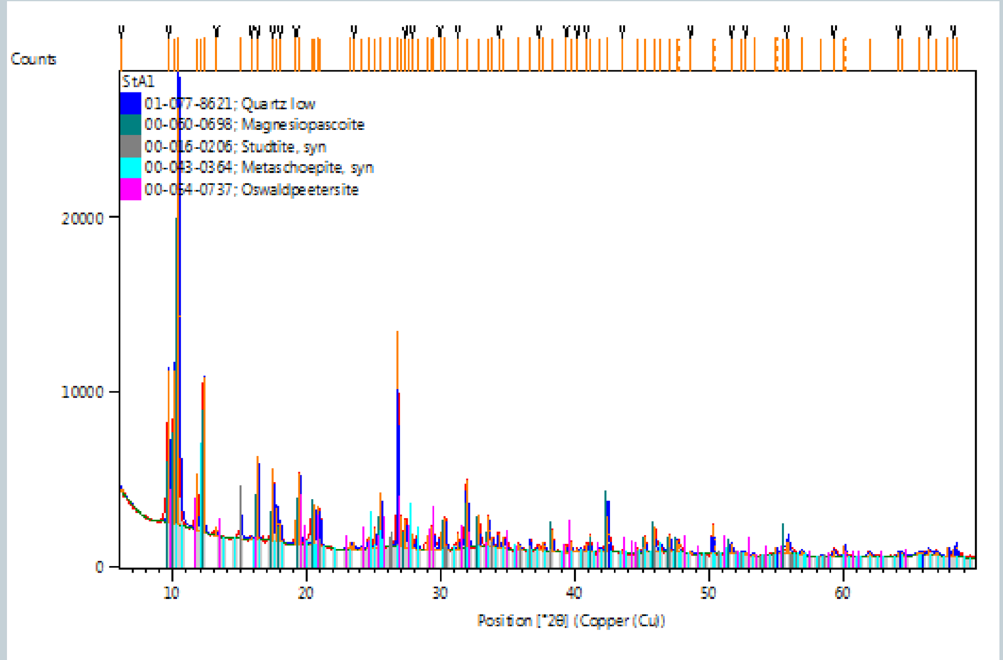
Minerals: Reduced vs. Oxidized

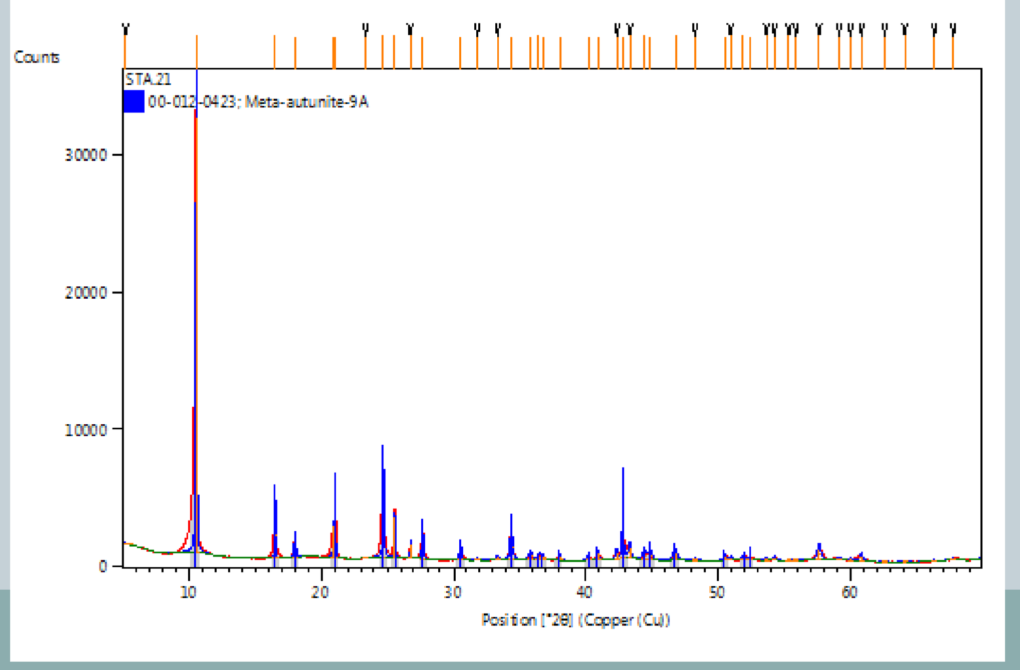
There are over 250 species of uranium minerals known, the majority being the oxidized variety (Hazen al, 2009). The reduced mineralization occurs as coffinite, uraninite, or pitchblende, an constitutes the bulk of mined uranium.

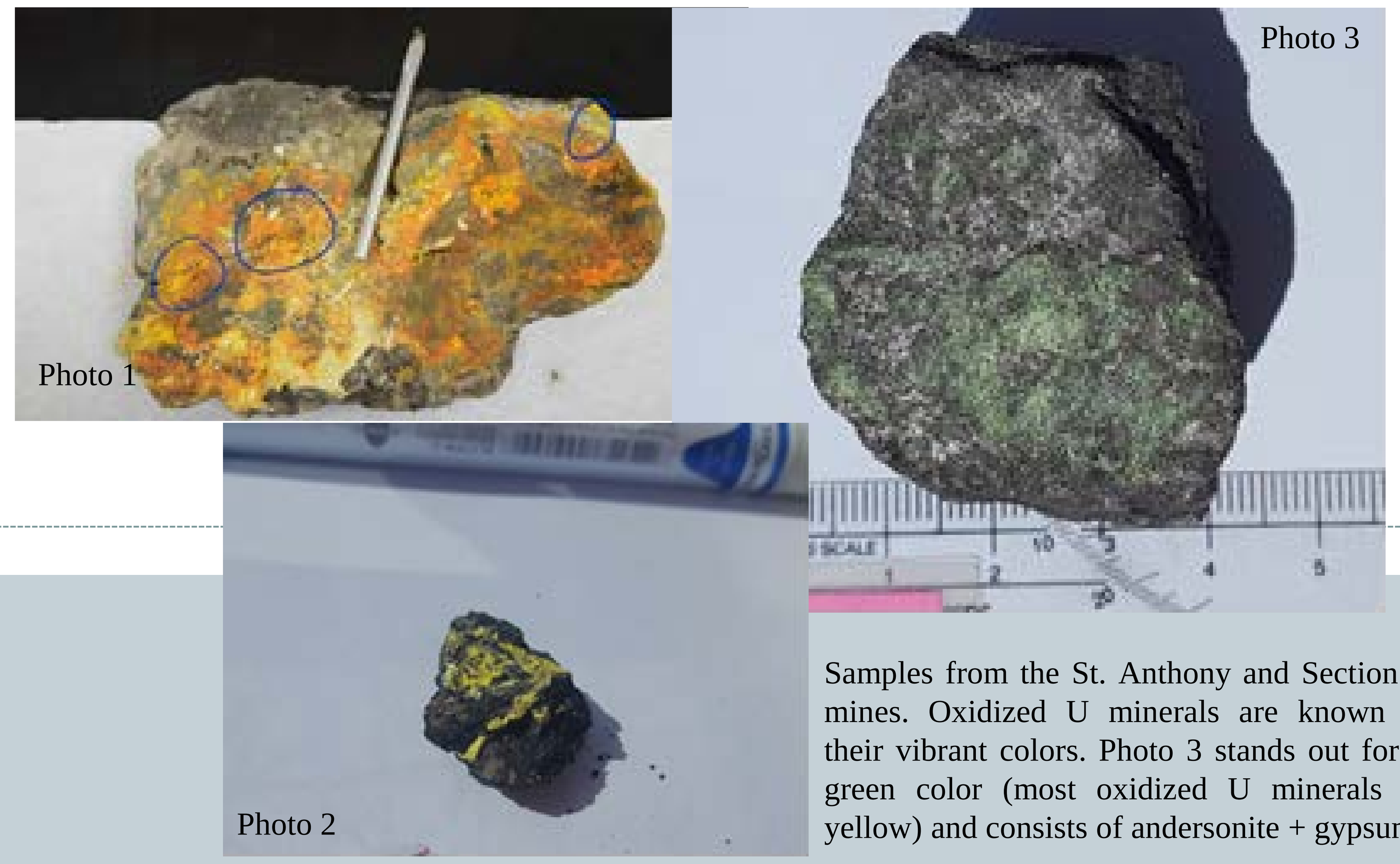
Oxidized minerals have greater diversity of constituents, and can precipitate as oxides, carbonates, sulfates, phosphates, and have any number of attached water. These minerals are further complicated by alkali metals (Ca, Na, Mg, and K) that are part of the structure.

Interpreting Diffractograms: Similar Minerals Have Similar Peaks

The diffractogram below analyzes a hand sample taken from the St. Anthony mine. This sample contains complex mineralogy, an requires detailed scrutiny of individual peaks to confirm or remove minerals suggested by the software. Fig. 3 highlights the benefit of having a sample with a single phase, an is also from the St. Anthony mine.







Samples from the St. Anthony and Section 31 mines. Oxidized U minerals are known for their vibrant colors. Photo 3 stands out for its green color (most oxidized U minerals are yellow) and consists of andersonite + gypsum.

Identified Minerals

Reduced

Coffinite $USiO_2$ Pitchblende Amorphous $USiO_2$
Uraninite UO_2

Oxidized

Oxides

Schoepite $(UO_2)_8O_2(OH)_{12}\bullet 12(H_2O)$ Meta-Schoepite $UO_3\bullet 1\text{-}2(H_2O)$

Carbonates

Andersonite $Na_2Ca(UO_2)(CO_3)_3\bullet 6(H_2O)$ Cejkaite $Na_4(UO_2)(CO_3)_3$
Oswaldpeetersite $(UO_2)_2CO_3(OH)_2\bullet 4(H_2O)$

Sulfates

Zippeite $K_4(UO_2)_6(SO_4)_3(OH)_{10}\bullet 4(H_2O)$ Jachymovite $(UO_2)_8(SO_4)(OH)_{14}\bullet 13(H_2O)$
Natrozippeite $Na_4(UO_2)_6(SO_4)_3(OH)_{10}\bullet 4(H_2O)$

Phosphates

Autunite $Ca(UO_2)_2(PO_4)_2\bullet 10\text{-}12H_2O$ Sabugalite $HAl(UO_2)_4(PO_4)_4\bullet 16(H_2O)$
Phurcalite $Ca_2(UO_2)_3O_2(PO_4)_2\bullet 7(H_2O)$ Meta-Ankoleite $K_2(UO_2)_2(PO_4)_2\bullet 6(H_2O)$

Vanadates

Meta-Tyuyamunite $Ca(UO_2)_2V_2O_8\bullet 3(H_2O)$ Magnesiopascoite $Ca_2Mg(V_{10}O_{28})\bullet 16(H_2O)$

Citations
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