Contribution ID: **49** Type: **ORAL**

EXPLORATION AND RESOURCE DEVELOPMENT OF URANIUM MINERALIZATION IN CENTRAL JORDAN

Tuesday, June 26, 2018 12:20 PM (20 minutes)

INTRODUCTION

Uranium mineralisation has been known within the central areas of the Hashemite Kingdom of Jordan for a long time [1], however uranium resources were only estimated in 2014 [2]. The exploration success has become possible because of detailed geological studies that has allowed to better understand the geological control of uranium mineralisation in central Jordan. Based on these studies the exploration model was revised and implemented by Jordanian Uranium Mining Company (JUMCO) for delineating mineralisation and estimated resources.

REGIONAL GEOLOGICAL CONTROL

Most of Jordan's territory is covered by platform sedimentary rocks of Cretaceous and Paleogene age. Uranium mineralisation was discovered within the platform cover where it is confined mainly to the Upper Cretaceous rocks, in particular the MCM (Muwaqqar Chalk Marl) formation. Uranium minerals, found in the weakly lithified friable sediments of the MCM formation are represented mainly by uranium vanadates colloquially termed carnotite [2]. Uranium mineralisation is distributed as fine-grained disseminations forming areas of variable size and shape that have impregnated the host sedimentary rocks and also coating the surfaces of the joints and fractures.

The faults possibly also played a role in distribution of the uranium mineralisation in central Jordan where higher grade mineralisation and associated gamma anomalies are broadly coincident with the location of regional faults, mainly the East-West and North West–South East striking splays of the Dead Sea Transform fault.

PYROMETAMORPHISM

Unique feature of the surficial uranium mineralisation in central Jordan is its close spatial relationship with pyrometamorphic marbles that are hosted by unmetamorphosed marls, chalks and limestones. The marbles are varicoloured, commonly brown, greenish, reddish, white and locally black. They are cut by hydrothermal veins and have experienced different degrees of low temperature alterations. A unique feature of these rocks is the widespread distribution of high- and ultra-high temperature (up to 1500℃) low-pressure metamorphic mineral assemblages including spurrite, wollastonite, ellastadite, diopside and garnet [3-5]. The contacts of marble with the unmetamorphosed host sequence are sharp, although contact outlines are often irregular.

The formation of marbles in central Jordan is commonly explained by pyrometamorphism, either caused by the burning of bituminous marls [5] or alternatively by the combustion of deep reservoirs of hydrocarbon gases relating to mud volcanoes [3-4].

Another unique geological feature of the uranium deposits in Jordan is occurrences of the exotic paramagmatic dykes that cut pyrometamorphic marbles. These dykes were identified in exploration trenches and marble quarries in central Jordan. These are similar to the dykes found in the in Israel and Palestine, where they also associate with high-temperature metamorphic rocks [3]. The dykes are interpreted as paralavas that have been formed as a result of the host rocks melting during high-temperature combustion metamorphism [2-4].

Dating of these pyrometamorphic rocks has identified several episodes of combustion metamorphism that have occurred in Miocene (˜16 Ma), Pliocene (˜ 3 Ma) and Pleistocene (1.7 –1.0 Ma) [6]. These ages broadly coincide with the age of mafic magmatism that occurred in Jordan during the Miocene (23.8 - 21.1 and 12.05 - 8.08 Ma) and Pleistocene (3.2 - 1.5 Ma) [7-8], suggesting that this basaltic magmatism could have triggered the rapid combustion of hydrocarbons, or at least that these processes are part of the same tectono-magmatic event.

SUPERGENE PROCESSES

Within the MCM formation the uranium mineralisation is hosted by near-surface weathered chalks and marls and concentrated in a narrow layer, approximately 4.5m thick, distributed close to the topographic surface. Vertical profile of uranium distribution in central Jordan was studied in high details using 2188 trenches and 5691 drill holes [2]. It was noted [2] that the degree of weathering varies from complete alteration, when rocks have been converted to saprolite, to mildly weathered sedimentary rocks and the highest uranium concentrations were found located along the contact between saprolite and mildly weathered/fresh rocks.

Near surface distribution of uranium mineralisation which was characterized by highly variable degree of isotopic disequilibrium has required using of exploration trenches for obtaining representative samples and estimating uranium resources [9]. Mapping of the trench walls have shown that uranium mineralisation is not controlled by phosphorite layers.

SUMMARY AND CONCLUSIONS

In general, the uranium mineralisation that is hosted by the weathered chalk and marl of the MCM formation in central Jordan has many common characteristics with the conventional surficial-type uranium mineralisation [10]. However, a close spatial relationship of uranium in central Jordan with the pyrometamorphic rocks suggests that this is a special type of surficial uranium mineralisation which has resulted from the interplay of the different processes, where combustion metamorphism has played a very important role in facilitating leaching of uranium from the host rocks. The liberated uranium was eventually redistributed by supergene processes towards the surface, where uranium minerals were precipitated along the contact between saprolite and fresh to weakly weathered rocks. This mineralization should not be confused with synsedimentary accumulations of uranium in the phosphorite beds which also present in Jordan [2].

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Session Classification: Applied Geology and Geometallurgy of Uranium and Associated Metals

Track Classification: Track 3. Applied geology and geometallurgy of uranium and associated metals