geologic factors controling the radon emnation associated with uranium mineralization alongwadi belihned egypt

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Recent exploration activities carried out by the Nuclear Materials Authority on G. Gattar area revealed the presence of some uranium occurrences.G. Gattar area locates at the northern domain of the Eastern Desert of Egypt, between longitudes 33° 13’ 26” and 33° 25’ 47” E, latitudes 27° 02’ 00” and 27° 08’ 30” N. Several numbers of uranium occurrences are discovered through the northern portion of G. Gattar pluton along W. Belih. These uranium occurrences are namely, according to the date of discovery, as G-I, G-II, G-IV, G-V, ...etc. However, among all the previous occurrences, G-V uranium occurrence was chosen as a good target for detailed investigation, since most of its discovered uranium mineralization was recorded in the Hammamat sedimentary rocks rather than the intruded G. Gattar granite.The current work has two objectives. The first one is to study the geological, mineralogical and geochemical characteristics of the secondary uranium mineralization with insight on the physico-chemical conditions that affecting its localization and concentration. The second objective concerns with uranium exploration techniques, by using radon emanation as detection method for locating further potential uranium mineralized zones along the studied occurrence. At the same time the effect of the studied geological, structural, petrographical features and radioelements distribution on radon emanation were discussed.G-V uranium occurrence is approximately determined by the intersection of longitude 33° 17’ 42” E and the latitude 27° 07’18” N. It is restricted to the contact zone between the younger granite of G. Gattar and the older Hammamat sedimentary rocks of G. Um Tawat, to the north, along the southern bank of W. Belih. These rocks are classified and chronologically arranged, according to their field relations and petrographic studies, into Hammamat sedimentary rocks, acidic dikes, alkali feldspar granite and basic dikes.167The Hammamat sedimentary rocks are intruded by G. Gattar granite in a sharp normal intrusive contact. The granite mass sends long apophyses and offshoots into the older Hammamat sedimentary rocks. In some cases, the granite magma is forcefully injected into the Hammamat sedimentary rocks along cracks and fractures, forming veinlets with irregular pattern.At the contact, G. Gattar granite hosts large number of elongated xenoliths of the Hammamat sedimentary rocks. A local reverse fault is recorded bounding the southern contact of one of the Hammamat xenoliths. The fault extends about 120m, trending ENE-WSW and dipping from 45° to 65° SSE towards G. Gattar granite. The uranium mineralization is recorded at this part of the contact. Widespread deutric and post magmatic hydrothermal alterations associated with the uranium mineraliztion are recorded affecting both the Hammamat sedimentary rocks and G. Gattar granite. The common alteration features recorded along the contact zone are hematitization, kaolinitization, fluoritization, bleaching and episyenitization.The Hammamat sedimentary rocks and G. Gattar granite are traversed by many dike swarms of variable composition, size, dimensions and directions. The acidic dikes cut through the Hammamat sedimentary rocks and stop abruptly when countering G. Gattar granite. They are mainly granite porphyry and granophyre. The basic dikes cut through the two rock types, which are mainly doleritic or basaltic in composition. A multitude of quartz veins invade both the Hammamat sedimentary rocks and G. Gattar granite. They occur as straight or curved subparrellel swarms filling some joints, small fractures and tectonized zones.The structural framework of G-V uranium occurrence could be considered as an effective ground preparation for the uranium mineralization. The secondary structures, especially faults and joints, acquired their importance as being the passways for mineralizing solutions besides hosting secondary uranium mineralization.The statistical treatments and stereographic projection of the non-mineralized joints of the Hammamat sedimentary rocks indicate that the most predominant set168of joints are striking in the following directions: NE-SW, NNW-SSE, N-S and NW-SE. The measured mineralized joints of the altered mineralized Hammamat sedimentary rocks indicate that the NNE-SSW, NW-SE and ENE-WSW trends are the most predominant sets. For G. Gattar granite, the most predominant sets of joints are those trending NW-SE, NE-SW and NNW-SSE.The faults of strike-slip and dip-slip types are recorded in the mapped area of G-V uranium occurrence. Both major and minor faults were measured and statistically treated. It is revealed that the N-S, NW-SE, NNW-SSE, NE-SW are the most predominant fault trends. The uranium mineralization is mainly increased at the intersection zone of ENE-WSW local reverse fault with the N-S and NNW-SSE trending fracture.The Hammamat sedimentary rocks outcropping in the study area are composed of alternated immature greywackes and siltstones. Under the microscope, the least altered greywackes consist of subangular to subrounded quartz grains, altered feldspar, rock fragments and matrix rich in sericite, fine grained quartz and iron oxides. The least altered siltstones consist of wide varieties of fine angular to subrounded grains of quartz in silt size, feldspar, microcrystalline chlorite, sericite, detritus mica, all are densely packed in a dark hematitic matrix.The least altered Hammamat sedimentary rocks are affected by hydrothermal solutions at the contact with G. Gattar granite. The uranium mineralization is detected through the altered siltstones and mostly associated with the hematitization and bleaching.The secondary uranium mineralization detected in the altered mineralized siltstones is generally of brighter yellow color and in some cases yellowish brown as a result of mixing with Fe and Mn oxides. Uranophane and beta-uranophane are the most abundant secondary uranium minerals. The identification was confirmed by X-ray diffraction of hand picked grains. Mandy et al. (1990) identified additional secondary uranium minerals such as soddyot, tyuyamnnite and schreckingerite. In the studied samples uranophane and beta-uranophane occur in a169variety of forms; i) patches or clusters associate hematite,

ii) Dispersed and clustered around the pseudomorphosd pyrite, iii) filling the interstial spaces of quartz and iv) late stage fracture filling.Under the microscope, G. Gattar granite is coarse to medium grained; it is mainly composed of potash feldspar and quartz with subordinate amount of plagioclase. The accessory minerals are biotite, muscovite, zircon, fluorite, opaques and some apatite. Chlorite, kaolinite, sericite and epidote, which could be considered as secondary minerals, are also appearing in this granite. The mafic minerals are scarce giving rise to leucogranite character for the studied granite.The dissolution of magmatic quartz (episyenitization) is the most predominant alteration feature in the studied granite, where it produces vugs whose volumes and shapes coincide with that of the dissolved quartz crystals. The vugs left after the dissolution of quartz may be filled with authigenic minerals, such as quartz, white mica, kaolinite and hematite.The geochemical features of the two dominant facies of the least altered Hammamat sedimentary rocks; siltstones and greywackes are markedly similar. Such similarity may reflect a common source, but different energies of depositional agents. According to (Blatt et al., 1980), these rocks are characterized by sodic enrichment. The application of the two discrimination functions proposed by Roser and Korsch (1988) suggests that these rocks were derived dominantly from Dokhan volcanics and other granitoids. The chemical index of alteration (CIA) proposed by Nesbitt and Young (1982), range from 48.83 to 55.95, suggesting that the source rocks underwent slight chemical weathering, high erosion rate and rapidsedimentation.The chemical analyses data reflect high homogeneity of the least altered granite of a Gattar, with Si02 over 70%, Ca0 less than 1% and fairly low saturation of Al203 (Av. 12.43%). Generally, G. Gattar granite is rich in alkali elements (the average of Na20 and K20 is 4.10% and 4.30%, respectively). G_. Gattar granite as a whole is best classified as metaluminous to slightly170peraluminous leucogranite. Because of’ the low [Ca] and high alkali, the studied granite is very depleted in [Sr and Ba] (18 and 83ppm, in average). The low [Ba and Sr] and the high [Y] contents, reflect highly fractionated (low P) A-type granite.The calculations of the mass-balance as a measuring for changes in mass, volume or concentration during metasomatic alteration of the Hammamat sedimentary rocks and G. Gattar granite are carried out according to Grant (1986).The calculations for the altered mineralized Hammamat sedimentary rocks indicate that major elements are lost as a result of alteration. The enrichment in K20 may reflect presence of the secondary sericite. The hematitized mineralized rocks commands better accumulation of [U, Y, V, Zn and Cu]. The depletion in the content of [Sr and Ba] points to the breakdown of the feldspars.The obtained data of the mass-balance for the episyenitized parts of the studied granite, suggest losses -for Si02, [Rb] and remarkable gains for [U, Y, V, Zn and Cu], due to both Na- and K metasomatism. The Na-metasomatism seems to be better accumulator for [U and Y], which increase in parallel with [Ca], probably due their coexistence in secondary fluorite.The background average values of [U and Th] for the least altered Hammamat sedimentary rocks are 7.5 and 4.2ppm, respectively and 11.6, 20.6ppm for the least altered granite. The mutual distribution of the two elements along the mineralized zone suggests a preferential precipitation of [U] in the Hammamat sedimentary rocks rather than in G. Gattar granite. The Th/U ratio in the least altered Hammamat sedimentary rocks is relatively low (Av. 0.56). The ratio decrease dramatically in the altered mineralized Hammamat sedimentary rocks (Av. 0.0019).The petrographical and geochemical studies suggested that the studied least altered granite is characterized by elevated background of [U] (11.6ppm), relatively high coefficient of variation (21.12%) and low Th/U ratio (less than 3). If these data are compared with those of the Hammamat, may refer to derivation of uranium171from this granite. The concerned granite probably has lost its uranium to the Hammamat sedimentary rocks, which serve as suitable trap for secondary uraniummineralization.The course of mineralization within the altered Hammamat sedimentary rocks and G. Gattar granite can be concluded in the following sentences:1-The ENE-WSW and NE-SW fault regime in the study area, allowed an alkaline, oxidizing, uranium-enriched hydrothermal solution to pervade upwardly both the Hammamat sedimentary rocks and G. Gattar granite.2-The petrographic observations and the geochemical relationships suggest transportation of uranium in an aqueous oxidized state from large granitic volume at relatively elevated temperature. The mass transfer calculations suggest possible mobilization of some trace elements from G. Gattar granite to the Hammamat sedimentary rocks during alteration. Mixing of hot ascending solutions with meteoric water may have taken place.3-Changing in physico-chemical conditions of the hot fluids due to their mixing with meteoric water and continuous interaction with wall-rock caused a complicated series of alteration processes. These include quartz dissolution and/or precipitation, sericitization, chloritization, muscovitization, hematitization and pseudomorphic oxidation of pyrite precursor. Kaolinitization and oxidation reactions have taken place by late weatheringprocesses.4-Sulphides (mainly pyrite) in the Hammamat sedimentary rocks and G. Gattar granite are major cause of uranium reduction and precipitation.The use of radon as an exploration tool for hidden uranium mineralization has been carried out in the studied area. The alpha track etch method constitutes one of the most important methods for detecting radon emanation. from the application of this method at the studied area, it is evident that the uranium mineralization is mainly controlled by the contact zone, mainly, the Hammamat-episyenite contact. High radon measurements is recorded at the contact172zone, revealed relative increasing of the subsurface extension of the uranium mineralization in G-V uranium occurrence.It is apparent from the application of alpha track technique that often several mechanisms work in combination to give strong radon surface anomalies. The type of the bedrocks and its geological features, in the studied area, are affecting radon emanation. Thus, the least altered Hammamat sedimentary rocks display low emanation of radon than the least altered granite of G. Gattar. On the other hand, the contact zone showing high increase in radon emanation, where these rocks are altered and mineralized with secondary uranium.The potential source minerals of radon in the studied rocks are examined by using alpha track etch method and their couesponding cross sections indicating that zircon and iron oxides are the major accessory minerals containing uranium and thorium. Thus, the abundance of these minerals in G. Gattar granite may enhance the radon measurements among this rock. The effect of the secondary structures on radon emanation is confirmed by the high level of radon measurements that distributed along the ENE-WSW fault trend and some transect fractures. Also, the joints increase the radon haloes around the hidden uranium deposits. A key factor controlling radon emanation is the distribution of [U and Th] within the studied rocks. The gradation from low to high radon emanation is documented along the contact zone, where [U and Th] contents increase towards the altered rocks.