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New technique for resolved shear identification: A case study at structurally bound uranium occurrences at Gabal Dara area, North Eastern Desert, Egypt

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Abstract-, The geological, radiometric, and structural properties of Gabal (the Arabic meaning for mountain (G.)) Dara alkali feldspar granite are investigated. The radioactive occurrences in the G. Dara region are structurally bound. These radioactive occurrences are determined at trachytic dyke trending NW-SE parallel to major faults in the investigated area; as well as, along shear zone trends N15°W with a dip of 85° to NE at younger granite of G. Dara area.
Directions of the maximum resolved shear stress (τ) of structurally bound radioactive occurrences are as the following:-1) Plunges 50º on bearing 350º (N-S) for the shear zone at younger granite.
2) Plunges 34º on bearing 314º (NW-SE) at the mineralized trachytic dyke. So that, the main tension stress trend which control the localization of radioactive minerals in the investigated area and along which the mineralized solution propagated is directed N-S to NW-SE direction.
Minerals containing uranium, thorium, and rare earth elements (REEs) such as zircon, columbite, fergusonite, and aeschynite, as well as ilmenorutile, hollandite, hyttsjoite, and Rosasite minerals, were obtained from G. Dara's mineralogical research.

Keywords- resolved shear, mineralogy, alkali feldspar G. Dara granite.

I. Introduction

G. Dara area is bounded by latitude 27o 55' to 28o 00' N and longitudes 32o 55' and 33o 00' E at the northern eastern desert of Egypt near Ras Gharib town along the Red Sea coast. The main rock types at G. Dara and G. Um Swassi are older granites represented by diorite with limited distribution and wide distribution of younger granite (Fig.1).

The diorite of the investigated area is vary in composition from diorite to quartz diorite [1]. This older rock is characterized by gneissose texture.

G. Dara granite is a late collision younger granite which was occurred during the late Pan-African orogeny that was followed by the Red Sea rifting and continental extensional regime [2]. G. Dara alkali feldspar granite magma could be due to partial melting of arc crust of Arabian–Nubian Shield in response to upwelling of hot asthenospheric mantle melts, which became in direct contact with lower Arabian–Nubian Shield continental crust material due to delamination [3] and this granite is peraluminous [4]. There is a coeval generation of calc-alkaline and alkaline melts, implying that magma genesis was influenced by the local source composition. [5]. Some major structures, especially the NNW–SSE fault system, which runs parallel to the Gulf of Suez pattern, have a strong influence on these granites [6]. The granites of W. Dara area are subjected to four main tectonic phases of deformations (compression and extension) [7].

Geophysical techniques for mapping alteration and/or mineralization zones in the granitic rocks of Gabal Dara area were used; the results revealed that NW–SE, NNW–SSE, E–W, and N–S are common faulting trends in the region, with NE–SW and NNE–SSW as minor faulting trends [8].

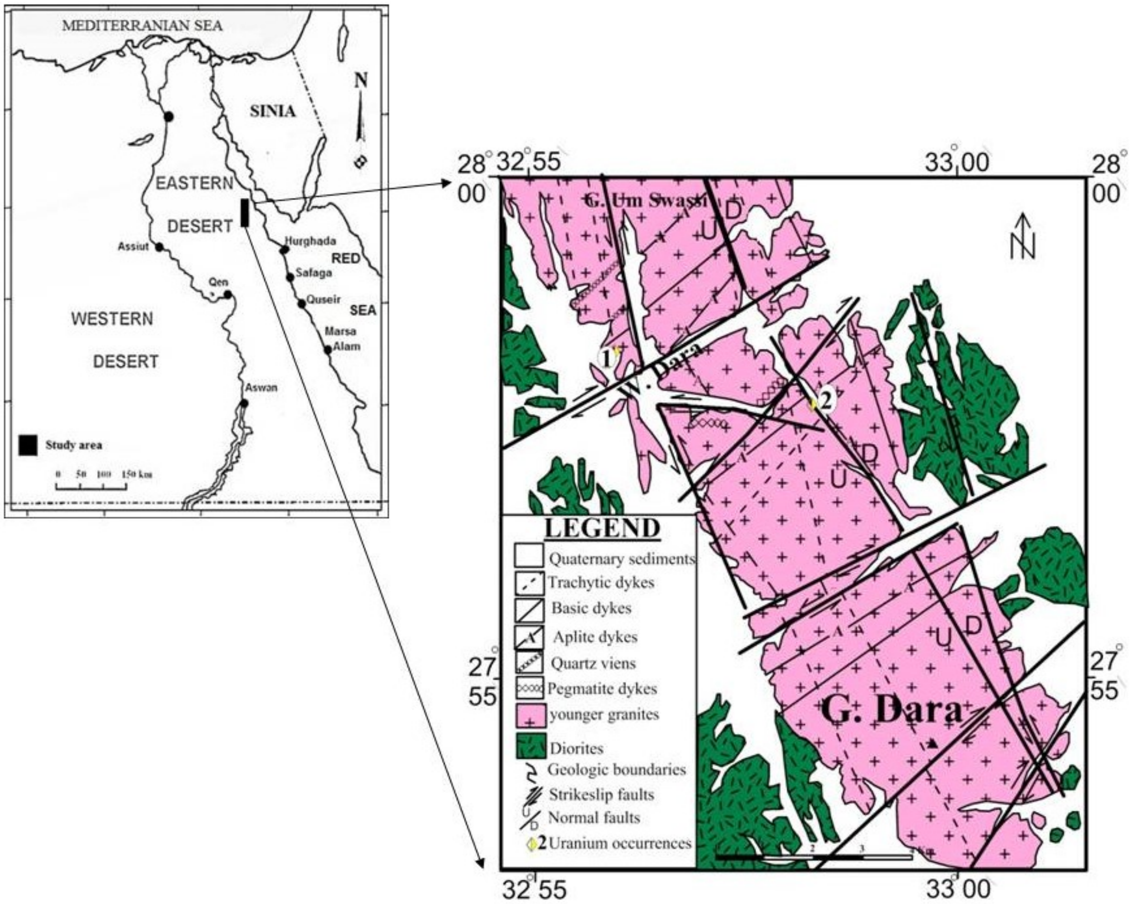

Figure 1. Location, structural and geological map of G. Dara area, North Eastern Desert. Egypt.

II.GEOLOGICAL SETTING

G. Dara and G. Um Swassi are homogeneous alkali feldspar granite of medium to coarse-grained pink to reddish colour granite .G. Dara is an oval shaped pluton with rough topography (Fig.2) elongated parallel to the major trend of the Gulf of Suez (NNW-SSE trend)(Fig.1); it is contact with the surrounding older diorite rocks is a sharp intrusive contact; and enclose xenoliths of older diorite with different sizes (Fig. 3) and there is some roof pendant of diorite above younger granite of G. Dara at some localities. The most characteristic feature along the periphery of G. Dara granite is the presence of pegmatite pockets, lenses, sometimes recorded as dykes and bosses (Fig.4). It is highly jointed and fractured.

Dykes traverse and run parallel to some faults and fracture patterns in the investigated area. So that, they are structurally controlled in the area under consideration. Dykes are of different lithological compositions. Aplite dykes are thin leucocratic of whitish to pinkish colour extend following the ENE-WSW trend. Basic dykes are massive hard basaltic dykes with black colour; it is run generally in NW-SE and ENE-WSW directions (Fig.5).

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Figure 2. General View for the G. Dara younger granites looking NE, G. Dara area.

Figure 3. Xenoliths of gneissose diorite in younger granite of G. Dara looking S to SW, G. Dara area.

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Figure 4. Unzoned pegmatite boss at the periphery of younger granite of G. Dara looking NE, G. Dara area.

Figure 5. ENE-WSW basic dyke traversed younger granite of G. Dara, looking ENE, G. Dara area.

The trachytic dykes are widely distributed at the investigated area and run in the NNW-SSE direction. They are brownish red to brick red and sometimes are porphyritic (Fig, 6). They are extending for ten kilometers with a width reach to 15 m and in parallel sets (Fig.7).

Figure 6. NNW-SSE brownish red trachytic dyke dissected G. Dara younger granites looking NE, G. Dara area.

Figure 7. Trachytic dyke swarm dissected G. Dara younger granites looking N, G. Dara area.

Quartz veins are milky white and nearly three meters wide, extending for hundreds of meters in a NE-SW direction. Joints and fractures were packed with quartz veins. The veins in Gabal Dara are well exposed and made up of pegmatite and quartz veins. Quartz, albite, potash feldspar, and mica make up the pegmatite veins.

The granite of G. um Swassi is found in the northern part of the study region (Fig.1). This granite has a pink to whitish pink colour and is medium to coarse grained. Many faults run through it, mostly in the NNW-SSE direction. Also running through G. um Swassi granite are the above mentioned dykes.

III. MATERIAL AND METHODS

Field photographs were taken for the investigated area. Structure and field studying for the radioactive zones were followed by the analysis of data by using [9] win Tensor computer program and Graphical analysis method of [10]. Representative radioactive specimens were collected including two different radioactive rock types are trachytic dyke and radioactive Dara granite was followed by heavy mineral isolation, picking with a binocular stereomicroscope, and mineralogical studies with the Environmental Scanning Electron Microscope ((ESEM). A detailed radiometric survey is achieved by using the gamma ray scintillometer model RS-320. The radioactivity of the rock is measured in parts per million (ppm) by this instrument.

IV. RESULTS AND DISCUSSION

A. Structural bound mineralization

G. Dara area is detailed radiometrically survived during field measurements. The radioactive occurrences are structurally bound as it is recorded along trachytic dyke that is traversed and run parallel to NW-SE faults and fracture trends in the investigated area and along normal fault or shear zone within the younger granite of G. Dara area. The radioactivity value measured along the normal fault zone is with an average equal 2375 ppm; while, the radioactivity value at the trachytic dyke reaches 1200 ppm.

The trachytic dyke is a porphyritic brownish red dyke traversed at the granite of G. Dara area. It is striking N35°W with a dip amount 74° to SW. The radioactive measurements equal 1200 ppm (Fig.8).

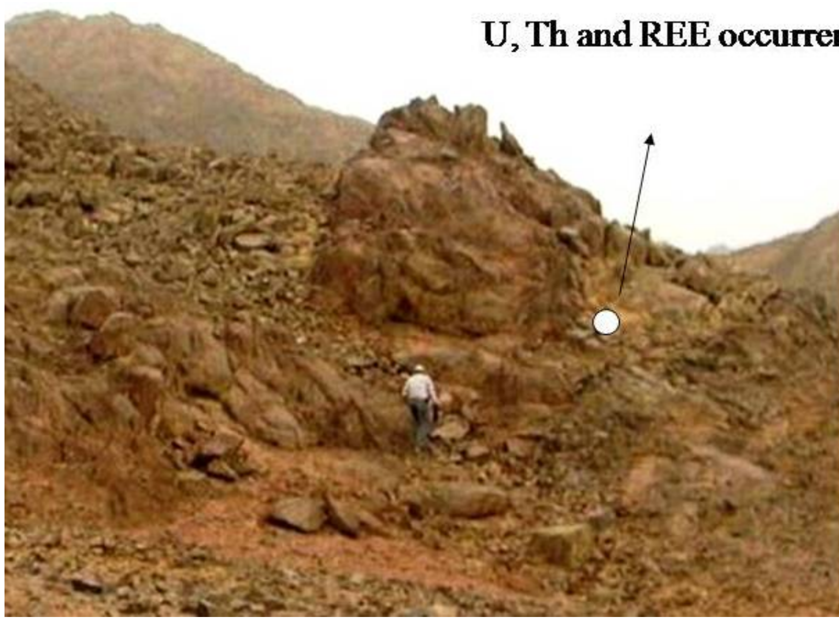

Figure 8. Mineralized uranium (U), thorium (Th) and rare earth (REE) porphyritic trachytic dyke striking N35°W with dip amount 74° to SW looking NW, G. Dara area.

The normal fault zone or shear zone is striking N15°W and the dip is 85° to NE. It is a narrow shear zone and highly crashed and hydrothermally altered and gives 2500 ppm when the radioactivity is measured along this fault zone (Fig.9).

Figure 9. Mineralized normal fault or shear zone striking N15°W and the dip is 85° to NE, Looking N, G. Dara area.

The direction of the maximal resolved shear stress of structurally bound radioactive occurrences is determined using a new technique for resolved shear detection. It is based upon the theory of vector manipulation. This technique is more accessible. It is a graphical method [10]; the three principle stress axes and stress ratio are known by the right dihedron paleostress fault analysis method as shown in figures 10 and 11 [9].

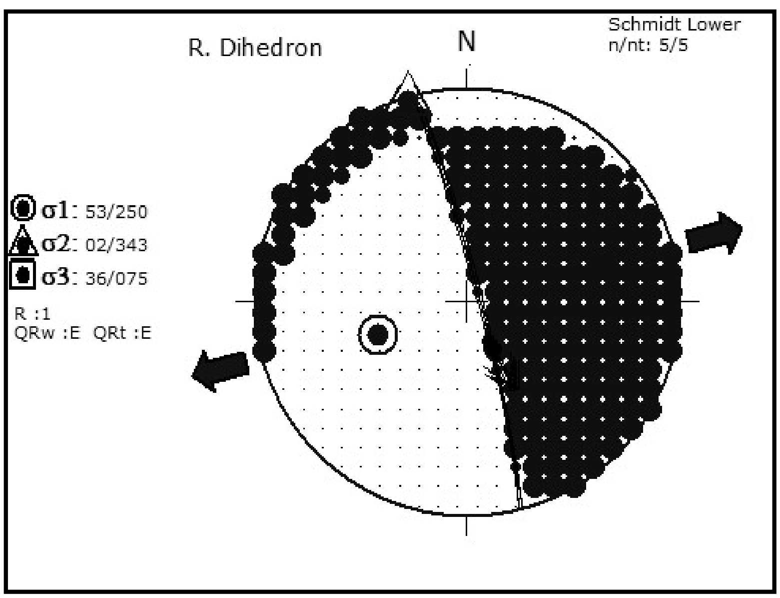

Figure 10. Three principle stress axes for the mineralized shear zone at G. Dara granite.

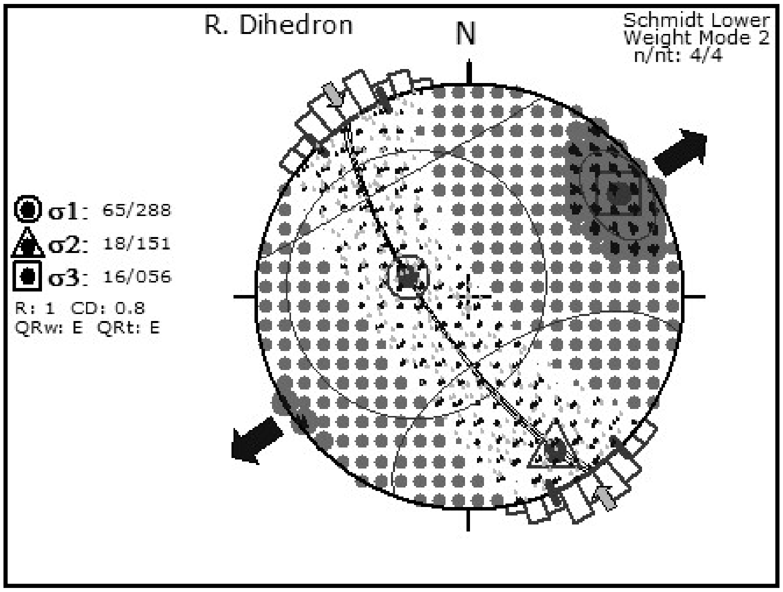

Figure 11. Three principle stress axes for the mineralized trachytic dyke, G. Dara area.

Within the younger granite of G. Dara, the direction of maximum resolved shear stress (τ) plunges 50º on bearing 350º (N-S) for the mineralized normal N15ºW with dips of about 85º to NE fault zone or shear zone (Fig. 12). While the direction of maximum resolved shear stress (τ) plunges 34º on bearing 314º (NW-SE) for the N35°W with dip amount 74° to SW mineralized trachytic dyke (Fig.13).

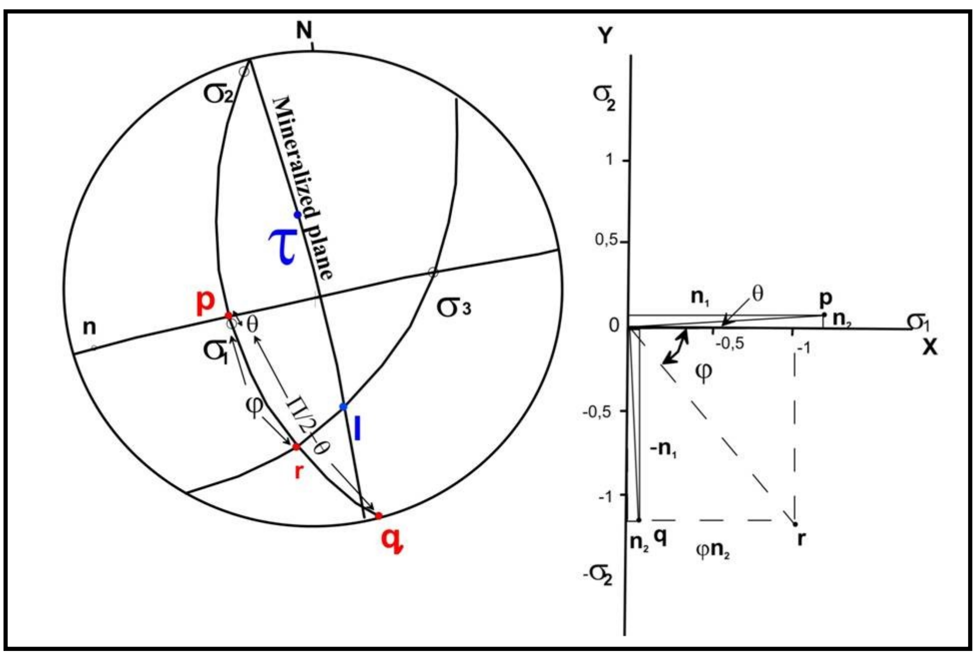

Figure 12. Graphical method to determine the direction of shear (τ) at the mineralized normal N15°W fault zone or shear zone within the younger granite of G. Dara.

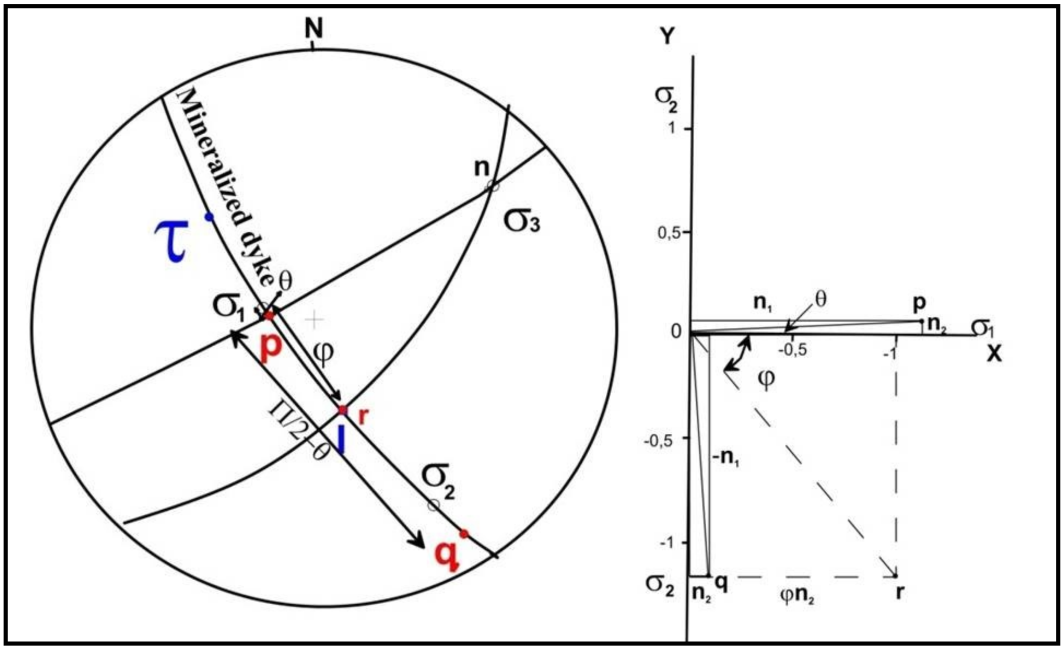

Figure 13. Graphical method to determine the direction of shear (τ) at the mineralized trachytic dyke, G. Dara area.

B. Mineralogy

The mineral constituents of samples in the G. Dara area were analyzed using a binocular stereomicroscope and an Environmental Scanning Electron Microscope (ESEM) attached by an energy dispersive X-ray unite (EDAX) for analysis at the Nuclear Materials Authority (NMA).

The obtained minerals are zircon, columbite, fergusonite and aeschynite minerals that contain uranium, thorium and rare earth elements (REEs), as well as; ilmenorutile, hollandite, hyttsjoite and Rosasite minerals.

Zircon ($ZrSiO_4$)

Zircon is a radionuclide-integrating accessory mineral found commonly in felsic igneous rocks [11-13]. According to ESEM's EDAX analysis, there are two forms of zircon: one that contains both U and Th (Fig.14), and the other that only contains U. (Fig.15).

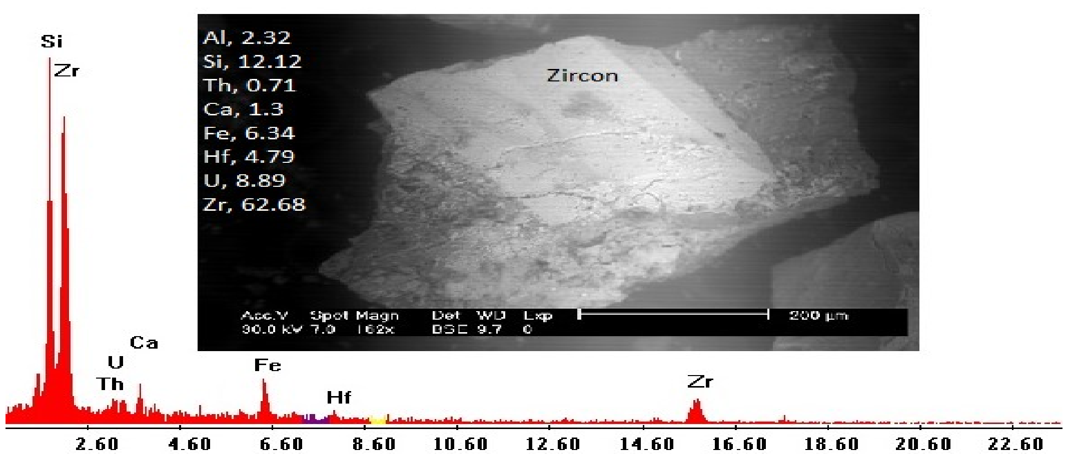

Figure14. Back-scattered electron image and EDAX chart of zircon mineral, G. Dara area.

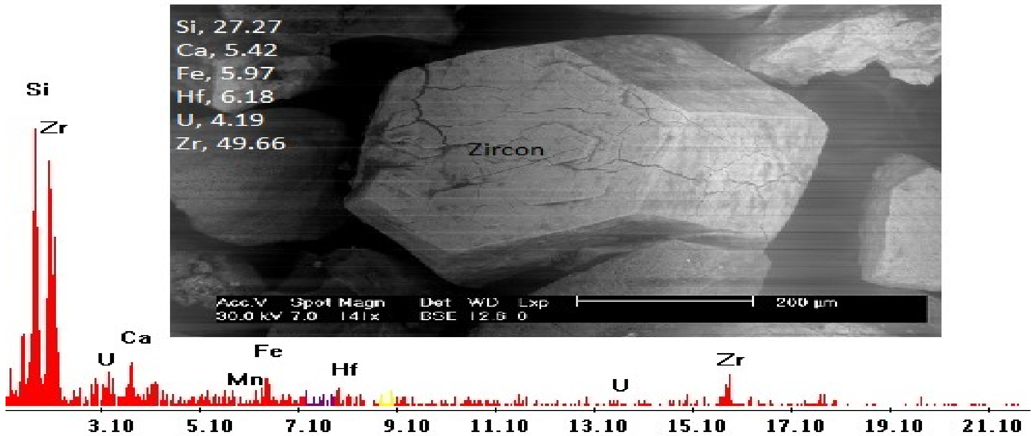

Figure15. Back-scattered electron image and EDAX chart of zircon mineral, G. Dara area.

Columbite (Fe,Mn)Nb_2O_6

Columbite composites from tantalite (Ta), and niobite (Nb), iron (Fe), and manganese (Mn). The columbite highly Nb carries radioactive thorium (Th) elements with a minor amount equal to 3.65 wt. % (Fig. 16); Gabal El mueilha granites are also contained columbite with radioactive elements [14]. it is associated with ilmenorutile (Ti, Nb, Fe,)O5 that composites of (Ti), (Nb), (Fe) and some calcium (Ca), silica (Si), aluminum (Al), potassium (K) and a few sodium (Na). It is considered as a source for (Ti).

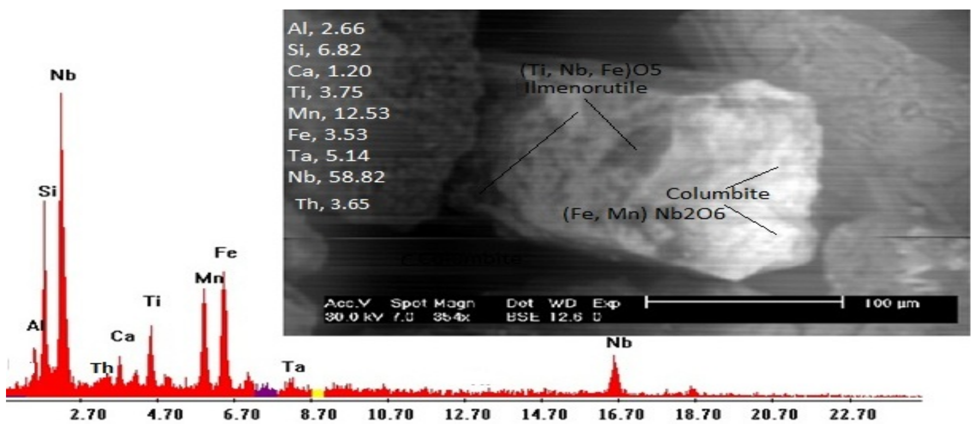

Figure 16. Back-scattered electron image and EDAX chart of columbite and ilmenorutile minerals, G. Dara area.

Fergusonite (Y, REE) NbO_4

Fergusonite (Fig.17) is a mineral with a general chemical formula of (Y, REE) NbO_4. Yttrium is usually dominant (Y= 16.39 wt.%) and tantalum (Ta= 2.11wt.%) substitutes for some of niobium (Nb= 39.88 wt.%); As a result, the mineral is known as fergusonite-beta- (Y) and other (REE) elements are present with minor content such as cerium (Ce= 1.76 wt.%) , neodymium(Nd= 0.96 wt.%) and carrying high content of both radioactive elements uranium (U=7.50 wt.%) and thorium (Th= 8.08 wt.%).Fergusonite is exclusively encountered in alkali feldspar granite of Gabal El-Ineigi [15].

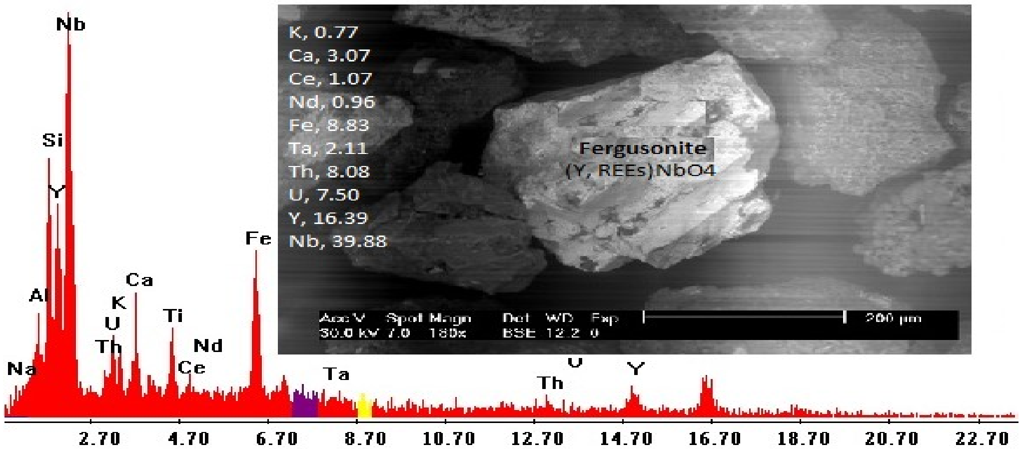

Figure 17. Back-scattered electron image and EDAX chart of fergusonite mineral, G. Dara area.

Aeschynite $(Y,Ce,Ca,Fe,Th)(Ti,Nb)_2(O,OH)_6$.

Aeschynite (Fig.18) is a rare earth mineral of yttrium (Y), calcium (Ca), cerium (Ce), iron (Fe), thorium (Th), titanium (Ti), niobium (Nb), oxygen (O_2), and hydrogen (H_2). It has a general formula: $(REE,Y,Th,U,Ca)(Ti,Nb,Ta)_2O_6$. The Aeschynite contains high niobium (Nb= 20.3 wt. %) caring high content of both uranium (U=10.73 wt. %) and thorium (Th= 13.78 wt. %) and it is usually found associated with fergusonite mineral [16].

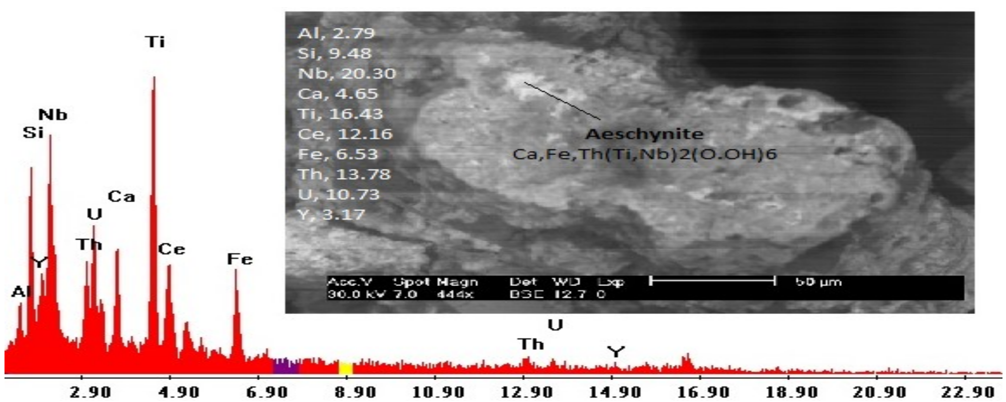

Figure 18. Back-scattered electron image and EDAX chart of aeschynite mineral, G. Dara area.

Rosasite $(Cu,Zn)_2(CO_3)(OH)_2$

Rosasite is a carbonate mineral (Fig. 19). It is a copper and zinc carbonate hydroxide with a ratio of 3 (copper) to 2 (zinc) that occurs in the secondary oxidation zone of copper-zinc deposits [17]. It's normally contained in globular aggregates and has minor potential as a zinc and copper mineral.

Hollandite $Ba\ (Mn)\ OBaMnFe_2O_{16}$

Hollandite mineral (Fig.20) is oxide has a formula $(Ba_{0.8}Pb_{0.2}Na_{0.1}Mn^{4+6}.1Fe^{3+1}.3Mn_{2+0.5}Al_{0.2}Si_{0.1}O_{16})$, it contains a great amount of barium (Ba) and manganese (Mn); so that it considered as a source for (Ba) elements and as a primary mineral of manganese ores [18]. It is detected associated with also rich (Mn) HyttsjÖite (Fig.20) mineral .it is chemical formula is $Ba_2\ Ca_5\ Mn_2\ Fe_2\ Pb_{18}\ Si_{30}\ [H_2O]_6$. It occurs sparingly in Mn-rich skarn with other minerals such as andradite, hedyphane, rhodonite and melanotekite at its type locality [19].

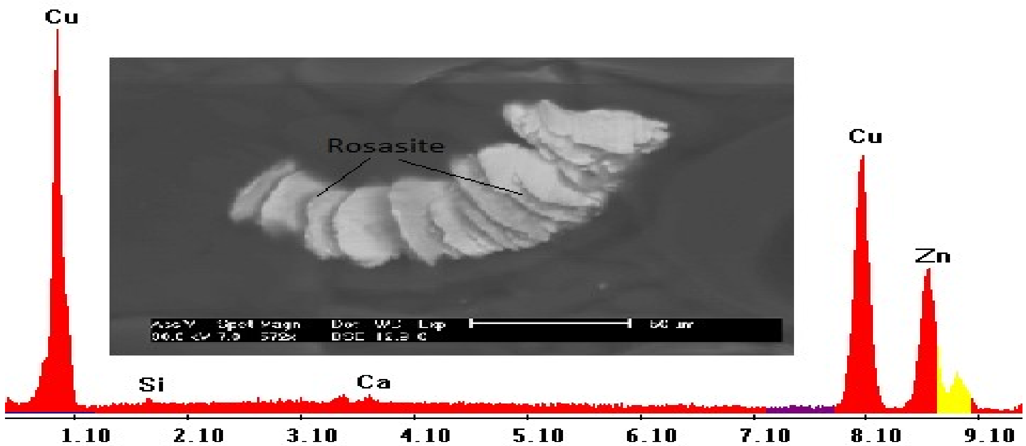

Figure19. Back-scattered electron image and EDAX chart of rosasite mineral, G. Dara area.

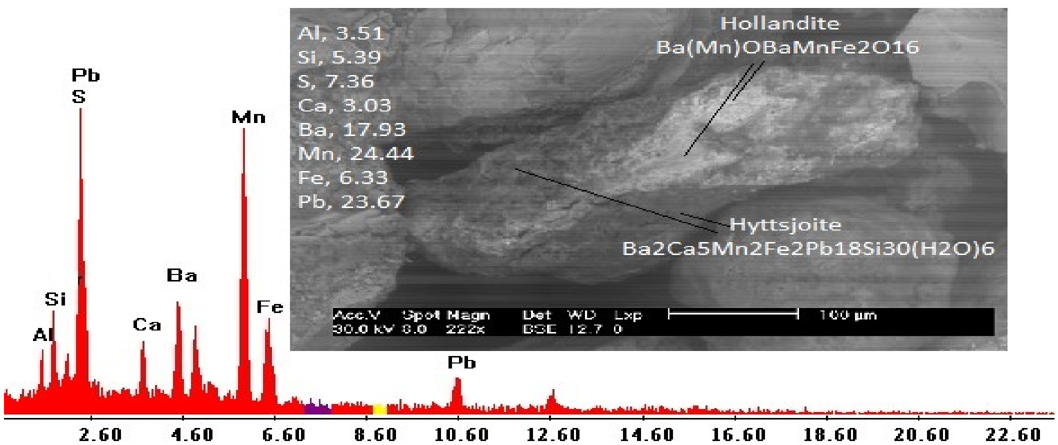

Figure 20. Back-scattered electron image and EDAX chart of hollandite and hyttsjoite minerals, G. Dara area.

V. CONCLUSION

The alkali feldspar granites G. Dara and G. Um Swassi are homogeneous, and a radiometric survey conducted during field measurements revealed structurally bound radioactive occurrences in the G. Dara area. It is recorded along trachytic dyke traverse and runs parallel to NW-SE faults and fracture trends and along shear zone is striking N15°W and the dip is 85° to NE at the younger granite of G. Dara area.

A new technique for resolved shear identification is used to determine the direction of the maximum resolved shear stress of structurally bound radioactive occurrences. it is revealed that the direction of maximum resolved shear stress (τ) plunges 50º on bearing 350º (N-S) for the shear zone while, at the mineralized trachytic dyke, the direction of maximum resolved shear stress (τ) plunges 34º on bearing 314º (NW-SE).

G. Dara area is mineralogically studied for the mineral constituents of the samples. The obtained minerals are zircon, columbite, fergusonite and aeschynite minerals that contain uranium, thorium and rare earth elements (REEs), as well as; ilmenorutile, hollandite, hyttsjoite and Rosasite minerals.

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VII. DECLARATION OF INTERESTS

The authors have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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