

# Research on altered granites



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Visible yellow radial U- minerals (up to 1 % U )was recorded coating the fractures in the sheared granites, border on the two sides by milky quartz veins, which play as septa for U- minerals migration. From the mineralogical point of view, the sheared granite rich in; a) uranium (meta-autunite, kasolite and phurcalite) , b) thorium (uranothorite) and c) base metals (wolframite, columbite, fergusonite and Plumbopyrochlore minerals) in addition to zircon, allanite, rutile, fluorite, fluoro-apatite, phlogopite and iron oxide minerals (hematite, ilmenite, goethite and magnetite )(Table. 1). Meta-autunite occurs as lemon-yellow to greenish yellow, subhedral crystals formed as dehydration pseudomorphs after autunite (Fig, 6a) and usually associated with kasolite. Phurcalite occurs as light brown subhedral to anhedral crystals of calcium uranium phosphate (Fig, 6b) and usually associated with iron oxides.

The altered granites are enriched in most major oxides ( $\text{Fe}_2\text{O}_3$ ,  $\text{TiO}_2$ , , Mn, Mg, CaO and  $\text{P}_2\text{O}_5$  ,) except  $\text{SiO}_2$  and  $\text{Na}_2\text{O}$  than fresh granites (Fig. 7) manifesting ferrugination, calcification , desilicification and illitization . Also the fresh granites are depleted in most trace elements (Ni, Cr, Sr, Zr, Y, Ga, Zn, Pb, and Cu) except Nb than altered ones. Based on major element data, the main characteristic features of the studied altered granites are higher in Fe/Mg ratio (15 av.), lower in  $\text{SiO}_2$ (av. 52. 8 %)and  $\text{Na}_2\text{O} / \text{K}_2\text{O}$  ( av. 0. 16) than fresh granites Table 2 ) .

Fig. 6: Photomicrographs showing; a) meta-autunite crystal surrounded by phurcalite mineral in altered granites. C. N., X= 40 and b) phurcalite mineral associated with iron oxide in altered granites. C. N., X= 40.

Table (1): Shows the result of minerals occurrences in the study area.

Minerals group	Rock types	Minerals
Uranium minerals	Altered granite	Meta-autunite, Phurcalite and Kasolite
Thorium minerals		Uranothorite
	Altered granite	Wolframite
Base Metals	Black Jasper	Cassiterite, Wolframite, Zincite, Ni-chromite and Cr-spinel
	Red Jasper	Ni-Chromite and Cr-spinel
	Milky quartz	Galena, Pyrite, pyrrhotite and Sphalerite
Copper	Milky	covellite,

	quartz	bornite
	Red Jasper	crysocolla
Minerals		
	Black Jasper	Atacamite, Paratacamite, and cuprite
	Black Jasper and Milky quartz	Gold and Nickel
		Plumbopyrochl
Nb-Ta minerals	Altered granites	ore, Columbite and Fergusonite
REEs- Bearing Minerals	Alkali feldspar granites	Zircon, Fluorite
	syenograni tes	Zircon, allanite
	Altered granites	Zircon, Allanite, Rutile and Fluorite

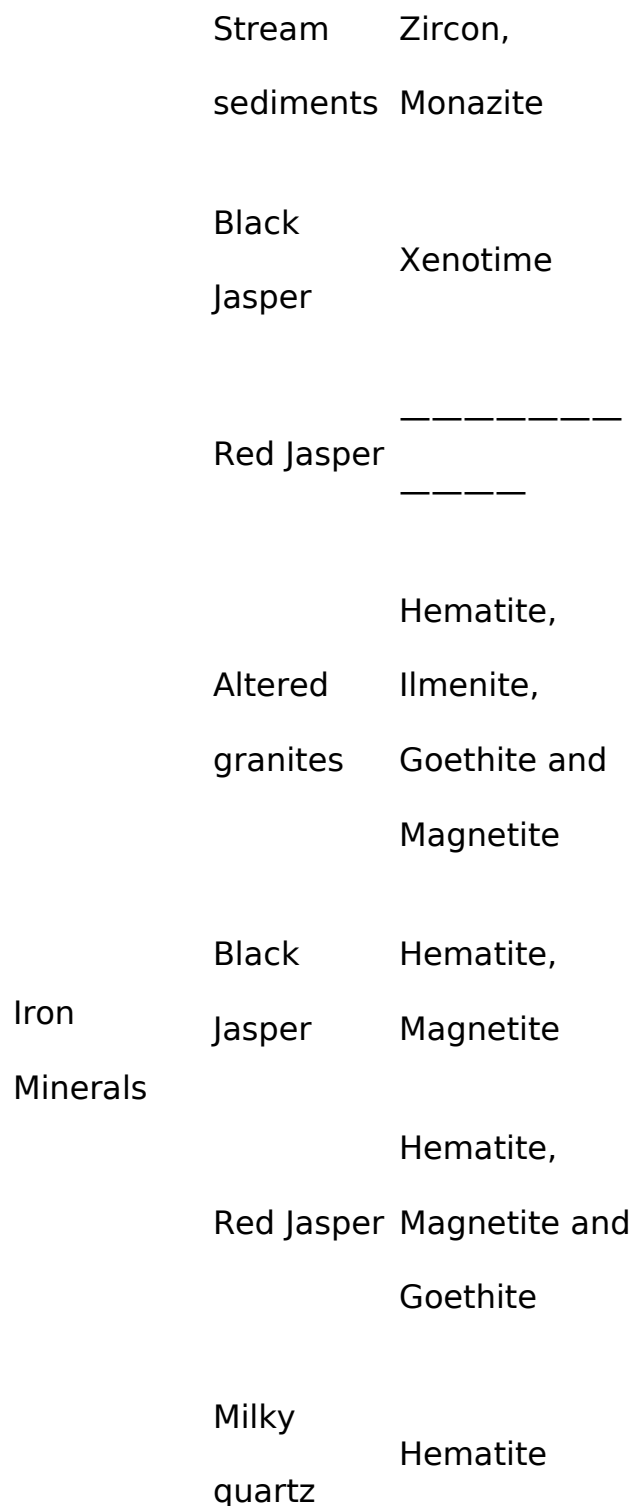


Fig.( 7 ) The enrichment and depletion of major oxides and trace elements of altered granites to the fresh granites samples.

Fig.( 8 ) Bar- diagram showing the trace elements distribution of red and black jasper.

The content of HFSE in both fresh and altered granites (Nb (36-10 ppm), Zr (316- 759 ppm), Y(69- 220 ppm) , U (8-ppm) respectively as well as low Rb/Sr ratio (1. 04-0. 45) and K/ Rb ratio (0. 03-0. 04) (Table 2) suggest that the fresh granites are primarily derived from felsic source . On the other side, these criteria in the altered granites are critical for uranium exploration . The black jasper more richer than red one in Ni (av. 1004 - 81ppm), Cr(av. 8575 -853ppm), Zn (av. 144 -80 ppm), Cu(av. 1106- 35 ppm), Co(av. 371-0. 0 ppm), Au(1. 04 -0. 5 ppm) and U(40- 8800ppm)respectively (Table 2, Fig. 8 ).

The latest event invades the WNW-ESE shear zone was the intrusion of silica and jasper veins with different magnitude. The excess of released quartz can migrate as colloidal silica to precipitate later in the tension fractures as jasperoid vein at upper structural levels under low temperature condition . Silicification along the main shear zone has a noticeable amount of liberated secondary silica occurs as fine crystals associated with the large primary quartz crystals and characterized by the existence of three generations of silica veins differ in color, mineralization and age.

1) The milky quartz veins are the first phase (the youngest one), mainly barren, running WNW and dipping 70°/ SSW direction, highly brecciated (2-5 Km in length, 0. 25-3 m in width)and common only at the southern border of the shear zone.

2) The red jasper veins (second phase) have E-W , WNW, NW and NE trends (Fig. 5), dipping 50-75°/N or S , 45°/ SSW, SW and SE direction respectively. They fractured, fragmented, discontinuous, brecciated,(7km in length, 0. 30-

3 m in width) and rich in Cr, Ni, Sn, Zn and Cu- mineralization (Fig. 6) (some parts of red jasper are rich by vugs (physical tap) that are filled by mineralization. These veins exhibit combinations of more than one style; orbicular and brecciated. Brecciated red jasper (Plate 4. a) can vary from soft swirls of color to dramatically fragmented shades of rich brown, brick red and cream colors. Deeply integrated colors come from organic materials and iron oxides imbedded in the stones.

Ore microscopic investigation reveals that; quartz crystals occur as anhedral cryptocrystalline associated and stained by iron oxide. Sometimes cryptocrystalline crystals of amorphous silica form banding. Iron oxide occurs as black crystalline minerals and staining of quartz.

3) The black jasper (oldest one) is represented by 1.8 km in length, 0.5-10 m in width, trending N45°W, dipping 50°-65° /SW (Figs. 5), and rich in Cr, Ni, Cu and Au mineralization, Fig. 7). They are concentrated only in the eastern part of G. Um Bakra shear zone and less abundant in length than milky and red veins. The black jasper are vuggy than milky and red silica veins and these vugs filled by calcite minerals. The apical parts of the veins are intensely weathered, oxidized, brecciated fragments (Plate. 4b) and decomposed to forming gossans.

Petrographically, quartz occurs as cryptocrystalline and polycrystalline forming spherulitic texture and associated with iron oxide. Iron oxide associated with quartz and sometimes forming network or needle (Plate . 4c). Cr- spinel with blood red color was observed and having darker boundaries with quartz (Plate. 4d). Ore microscopic study reveals the

presence of gold, chromite and magnetite minerals. Fire assay for gold content give 1. 04 g/ton . Chromite occurs as anhedral crystal associated with magnetite (Plate. 4e). Chromite existed in different forms; zoned veinlet or disseminated specks (Plate. 4 f&g). Black minerals filling fracture and associated with quartz (Plate. 4h) .

Fig. (6): showing different types of copper minerals in red and black jasper , a) atacamite mineral, b) paratacamite mineral, c) cuprite mineral and d) chrysocolla mineral .

Fig. (7): Photograph showing copper minerals from black jasper of the study area.

### Alterations

Two phases of hydrothermal alterations; acid and alkaline were distinguished in the shear zone resulting in Kaolinization and ferrugination processes as illustrated below:

Kaolinization indicates that the rocks were affected by acidic solution with low temperature varying from 200 to 250 °C (Helgeston 1974).

Kaolinitization process causes an increase in alumina (18. 2%) at the expense of the other major oxides (Table2). Kaolinization affects sheared granites in the shear zone are characterized by the formation of clay minerals and adsorbed secondary U- minerals( meta-autunite, Kasolite and Phurcalite) (Table1).

Acidic alteration of biotite produces illite+quartz , while magnesium, iron, oxygen, and fluorine are dissolved in hydrothermal fluids (Pirajno, 1992).

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These solution caused the alteration of the feldspars and micas to clay minerals (Fig. 8) are produced by an acidic fluid and it liberates silica and  $K^+$  according to Pirajno,(1992). Similarly, the anorthite component of plagioclase is transformed to (clay minerals) (Hemley and Jones, 1964; Pirajno1992) and frees  $Ca^{2+}$  ions transported also by the hydrothermal solution. The free  $Al^{+3}$  increase the alumina in the clay mineral. This kind of alteration by acid solution is responsible for transported and redeposited uranium and base metals mineralization in WNW-ESE shear zone which acts as a good trap.

carbonitization: The common presence of calcite manifesting carbonitization process along the shear zone (Fig. 8). Also both of ultramafic -mafic rocks and intrusive gabbros are rich by carbonate minerals.

Ferrugination causes increase in total  $Fe_2O_3$  content ( $FeO_t = 4.7\%$  to  $32.7\%$ ) at the expense of other oxides. The strong alkaline solution may precipitate  $Fe^{+3}$  and  $U^{+6}$  within the shear zones in the form of iron oxy-hydroxides rich in uranium (Cuney, et al., 1984). Sheared granite samples stained by Fe - oxides adsorb U minerals at the main shear zone.

Ferrugination is represented mainly by hematite and goethite minerals (table1, Fig. 9). Oxygen may combine with iron to produce hematite forming hematitic alteration.

Plate 4: Photomicrographs showing; a) brecciated red jasper vein, C. N., X= 40., b ) brecciated black jasper vein with vugs, c) black silica vein showing hematitization in quartz, iron oxide occurs as needles in quartz. C. N., X= 40, d) blood red, Cr spinel having darker boundaries in BJV (PPL), X= 20., e) chromite (cr) in rim and magnetite (mag) in core in BJV. X = 40, f) veinlet of  
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chromite and groundmass of magnetite in BJV. X= 40, g) disseminated specks of chromite in BJV. X= 40, h) red jasper vein showing iron oxide present as black crystalline minerals and staining of quartz. C. N., X= 20

fluoritization : Fluorite was emplaced through the fractures and fissures in altered granite along the shear zone. The released  $3\text{Ca}^{2+}$  and  $6\text{F}^{\wedge}$  during illitization of the anorthite and biotite may combine together forming fluorite which is observed within the shear zone associate with U- minerals.

### Acknowledgements

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### Discussion& Conclusion

1-To form a hydrothermal deposit in Um Bakra- Um Samra WNW-ESE shear zone requires: (1) a magma source of fluid, (2) dissolved metals in the magmatic fluids, , (3) heat source and activate tectonic, causes the migration of fluid and (4) Presence of channel ways, layering and physical cavities, to precipitates the metals or minerals.

2-G. Um Samra -G. Um Bakra shear zone strikes N-80° and dipping 45° /SSW and ranges from 30 to 500 m in thickness and extends 10 km in length. The host rock (syenogranites)is highly altered, fine -grained, ferruginous , reddish pink and grayish pink to grayish in color. Two opposite N-S strike-slip faults and NNE and NNW strike-slip faults dextral and sinistral sense of movement(good channel ways) forming grabben and horst structures

respectively (6 km in length, 30 m in width, dipping 10°-20° towards E or W) cut the shear zone.

3-Three generations of silica veins differ in color, mineralization and age are common. The first phase (youngest), is barren milky quartz veins, running WNW and dipping 70°/SSW direction, highly brecciated (2-5 Km in length, 0.25-3 m in width. The red jasper(second phase) has N 60°-76° W trend, dipping 45°/SSW direction, fractured, fragmented, discontinuous, brecciated, (7km in length, 0.30-3 m in width) and rich in Cr, Ni, Sn, Zn and Cu- mineralization). The third phase (oldest one) is represented by black jasper (1.8 km in length, 0.5-10 m in width, trends N75W, dipping 50°-65°/SSW and rich in Cr, Ni, and Au mineralization).

4-The black jasper more richer than red one in Ni (av. 1004 -81ppm), Cr(av. 8575 -853ppm), Zn (av. 144 -80 ppm), Cu(av. 1106- 35 ppm), Co(av. 371-0.0 ppm), Au(1.4 -0.5 ppm) and U(av, ..... ppm)respectively (Table ).

5-The presence of clay mineral (dickite:  $\text{Al}_2\text{Si}_2\text{O}_5(\text{OH})_4$ ) in quartz and jasper veins indicates a temperature environment higher than 200°C. The mixing of volatile fluids with meteoric water and fluid- wall rock interaction result in changes in pH and oxygen activity and deposition of base metals.

6- Precipitation of hematite in shear zone and red jasper veins probably decreased the pH of the solution and rising acidic fluids. The sudden change in the pH and temperature of the fluids will lead to destabilization of base metal complexes favouring their deposition (Alexandrov et al., 1985).

7-The cooling of the hydrothermal solution decreases the solubility of the metals. Cooling can take place when hot magmatic fluids enter cooler wall rocks or when two fluids mix. Similar reactions can take place between hydrothermal solutions and wall rock; a solution containing dissolved sulfide might contact a rock containing magnetite, to convert the magnetite to pyrite by a process called sulfidation. Or, a solution containing Cu might react with a rock containing pyrite to form Cu sulfides.

8- The base metals mineralization are accumulated in the residual melt of the late fractionated alkali feldspar granites (Bright, 1974) especially upward in the magmatic system (Smith, 1979). During the emplacement of the basic and intermediate dikes (olivine basalt, andesite and dolerite dikes) which accompanied with high temperature and  $\text{CO}_2$ , the base metals (galena, pyrite, sphalerite and cassiterite) were precipitated from saline and reduced fluids as sulfides due to cooling, fluid mixing and wall rock reaction.

9-The banded texture in jasper veins is common in epithermal base metals, indicating of boiling event and rapid deposition (Hedenquist et al., 1995). Most epithermal deposits consist of numerous separate, largely vertical veins that form a conjugate set, sometimes reflecting regional tectonic stress. Low-temperature hydrothermal solutions ( $<300^\circ\text{C}$ ) can transport Cr, Ni, As, Ga, U, Co, and Au metals, and deposits them into the epithermal brecciated veins. The high concentrations of Cr, Ni, Ga, Zn, Cu, Co, As and Au in the jasper veins can be attributed to the ore fluids enriched in these components. We assume their ultimate source to be the ultramafic and mafic rocks in the study area.

10- The non-sulfide ore deposits are classified into two major types; supergene and hypogene deposits (Hitzman et. al., 2003). (a) Supergene deposits form primarily from the oxidation of sulfide-bearing deposits and are formed principally zinc carbonate or silicates, and (b) hypogene deposits consist dominantly of zinc silicates and oxides, and they commonly result from mixing of a reduced, Zn-rich, with an oxidized, sulfur-poor fluid. Um Bakra-Um Samra shear zone containing zinc oxides (hypogene deposits).

11-Pyrite presents in two generations, disseminated and along fractures. The occurrence of covellite, bornite and magnetite are related to the oxidation product of disseminated pyrite, whereas the second type of pyrite transformed into pyrrhotite.

12-The chloritization process is the last phase of alteration in the shear zone, where fluids became rich in Mg/Fe most probably due to the decomposition of ferromagnesian minerals from the basic and intermediate dikes.

Fig.( 8) : Showing Kaolinization map for Um Bakra -Um Samra area.

Fig.( 9) showing ferrugination map for Um Bakra -Um Samra area.

Table (

2 ) chemical analysis of major oxides and trace elements of Um Samra-Um Bakra area.

Trace elements (ppm)

	Altered	Red	Black	
Fresh				
h				
	Range	0.0-55	0-18095	314-0-409 1501
Ni	Average	10	2322	81 1004
	Range	233-485	113-2409	294-2689 3490-12898
Cr	Average	296	798	853 8575
	Range	83-210	0-392	0.0-1161 0.0
Rb	Average	147.	128	289 0.0
	Range	17-507	73-58	8-127 0-17
Sr	Average	142	278	74 7
Zr	Range	89-	196-	0-466 0.0

	659	1873			
Y	Average	316	759	238	0.0
	Range	16-102	84-512	0-79	0-142
Nb	Average	69	220	38	77
	Range	14-56	0-62	0-35	0.0
Ga	Average	36	10	11	0.0
	Range	22-45	0-151	0-59	0.0
Zn	Average	32	73	24	0.0
	Range	16-145	0-2409	32-169	56-281
Pb	Range	0-52	0-684	0-173	0.0

	Average	16	157	45	0.0
	Range	0-32	0-210	0-80	431-2045
Cu	Average	4	26	35	1107
	Range	0.0	0.0	0.0	0-558
Co	Average	0.0	0.0	0.0	371
	Range	0.0	0.0	0-127	0.0
Mo	Average	0.0	0.0	25	0.0
	Range	0.0	0.0	0-2098	0.0
As	Average	0.0	0.0	419	0.0
U	Range	0.0	0-	0.0	0.0

7640



Average  
0.0 1749 0.0 0.0  
e

Major oxides %

Fresh Altered Red Black

	69.			72.
	22-	23.	70.	93-
Range	75.	14-72.	3-92.	91.
SiO2	33	09	53	27

Average  
72.9 52.8 84.2 82.7  
e

	0.		0.	
Range	01-0.	0.28-	01-0.	0.0
TiO2	29	2.46	22	

Average  
0.2 1.08 0.2 0.0  
e

	12.	10.		0.
Range	35-	37-18.		69-
Al2O3	15.4	02		14.
				85

Average 13.7 12.7 6.8 0.8  
e

	0.	1.	4. 46-
	2. 10-		
Fe2O	Range 08-2.	39-4.	22.
	91	97	54

3

Averag	1. 9	19. 8	3. 4	13. 4
e				

	0-0.	0-0.	0.	0. 01-
	08	75	01-0.	0. 04
MnO			03	

Averag	0. 03	0. 1	0. 03	0. 03
e				

	0.	0.	0. 19-
	13-0.	0. 24-	29-1.
MgO	65	7. 23	0. 60
		75	

Averag	0. 31	1. 32	0.	0.
e			806	442

	0.	0.	0. 01-
	45-2.	1. 26-	31-0.
CaO	55	4. 4	1. 74
		76	

Averag	1. 1	2. 6	0. 6	0. 5
e				

Na2O	Range 3.	0. 12-	0.	0. 05-
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	15-4.	3. 34	05-2.	0. 12
	34		2	
	Averag	3. 7	0. 8	0. 6
	e			0. 08
	Range	4-6.	1. 84-	0. 1-
		70	7. 78	6. 96
K20				0. 04-
	Averag	5	5	3
	e			0. 06
	Range	0.	0. 01-	0.
		020.	1. 23	07-0.
P205		16		48
	Averag	0. 08	0. 39	0.
	e			224
	Range	0.	0. 8-2.	0.
		04-0.	80	032
L. O.		85		
I.				
	Averag	0. 31	1. 43	
	e			
Total	Range	99.	93.	99.
		73-	22-99.	36-
		99. 9	91	99.
				99.

92 01

Average 98.  
 100 98.42 99.7  
 e 288

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