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# Reconnaissance Survey of Porphyry type copper- gold mineralization at Wadi Dara occurrence, North Eastern Desert, Egypt

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PORPHYRY type copper- gold mineralization is recorded for the first time in basement rocks of the East African orogeny at Wadi Dara ancient copper occurrence in the north Eastern desert of Egypt. The mineralization is lithologically controlled since it totally related and confined to continental margin island arc granitoids (Andean type) of diorite-granodiorite association. Structurally, the mineralization is confined to composite fractures system oriented in NW- SE developed only within the diorite - granodiorite association. Geochemical reconnaissance survey carried out at Wadi Dara occurrence revealed the presence of a copper mineralization there reflected in swarms of fissures filling associated with copper-bearing alteration zones, copper-bearing host rocks of diorite- granodiorite association and copper-bearing basic dykes. Country rocks which host the copper-bearing mineralized zones and their associated alteration zones revealed a low-grade copper mineralization with an average copper content of 0.28% associated with less significant gold mineralization of an average gold content of 0.25ppm at the Western sector (Area- B). Basic dykes located at the Eastern sub-area of Wadi Dara occurrence (Area- C) revealed significant workable copper mineralization of an average copper content of 1.4 % without any significant gold mineralization. Wadi Dara ancient copper occurrence comprises a workable huge low-grade copper mineralization of a porphyry type style of mineralization associated with a secondary workable gold mineralization. Wadi Dara ancient copper occurrence is highly recommended for further investigations to asses and outline the first recorded porphyry type gold- copper mineralization there.

**Keywords:** Dara, Copper, Gold, Mineralization, Geochemical exploration.

## 1. Introduction

### Previous workings

Copper was exploited in Egypt since the Ancient Egyptians times (5000B.C) mostly from Sinai and partially from the Eastern Desert. At the southwest of Sinai, A low-grade sedimentary copper mineralization spreading over a surface area of about 120 km2 confined to Paleozoic sedimentary rocks, which uncomfortably rest directly on the Precambrian basement rocks at the southwest of Sinai. The general copper content ranges from 0.04 - 0.16% while in the rich mineralized pockets of copper content ranges from 0.05- 1.54%. Copper mineralization is reflected in strata-bound and fissure - bedding planes filling. The mineralization consists of secondary copper minerals including major malachite with minor association of azurite, atacamite, chalcanthite, turquoise and chrysocolla. The copper mineralization was worked out with several ancient mining activities in several localities including Maghara, Gabal Sarabit El Khadim, Wadi Nasib, Abu Thor, Saad El Banat, Um Rinna, Wadi Malha and Wadi khraig dating back to Ancient Egyptian times. In these localities, selective ancient mining activities done only on the rich copper mineralization pockets. The remains of ancient smelting work at Wadi Nasib reflected in immense piles of copper slag show that a considerable amount of ore was treated. The slagheap estimated as amounting to 50,000 - 100,000 tons. At the southeastern part of Sinai, there ancient copper mining activities reflected in numerous heaps of slag and smelting primitive furnaces scattered in El Samra and El Regite areas where copper was produced from malachite–bearing fractures, quartz veins and stockwork confined to Precambrian basement hard rocks which forming the southern triangular part of Sinai. In the Eastern Desert of Egypt, copper was produced from several localities enclosed in the Precambrian basement rocks including, Wadi Dara in the north of the Eastern Desert, El Atwia copper mine

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in the Central Eastern Desert and from Hamash ancient gold-copper mine, Um Samiuki and Abu Swayel in the South Eastern Desert Wadi Dara copper occurrence area was investigated previously by Hume head of one of the branches of Wadi Dara, running down from a semicircle of high dark hills to the east, are low ridges of diorite, in which are old workings (presumed to be Roman) for some ore now exhausted. This was probably copper ore, as chrysocolla of the usual blue-green color. Kochin and Bassyuni (1968) stated that, In the Eastern Desert, copper bearing quartz veins have been reported from the localities of Gebel Dara, El -Atawi, Umm Hagalig, Umm Hamr, Wadi El Gemal, Abu Ghusun, Wadi Hammata and the area to the gold deposit of Sukari and Hammash. Gebel Dara copper occurrence, at the end of the branches of Wadi Dara, there is old working sunk for the copper ore. The ore is represented by chrysocolla associated with granodiorite dyke.

Atalla and Sabet (1983), concluded local geochemical dispersion haloes of copper, chromium, lead and nickel along Wadi Umm Balad and Wadi Dara assigned older ae to the copper mineralization due to the fact that it is only localized to the granodiorites and quartz-diorites of the late Proterozoic. Abdelrahman and Doig (1987) stated that, Wadi Dara copper-mineralized locations are subjected to extensive shearing, that exhibit defined trends, mostly directed NW-SE. Generally, the copper mineralization at Wadi Dara is lith- tectonically controlled. Al Hawary and Shabaan (1994), stated that, copper mineralization at Wadi Dara occurrence is hosted in diorites and granodiorites and the copper old workings are enclosed in alteration zones trending NW-SE enclosed in the fractures system of fault lines or shear zones. Moreover, gold was detected in the granodiorite and altered rocks, as 0.48 g/t, and 0.36 g/t respectively. In the quartz veins, gold reached 2.13 g/t. Omar (2001) stated that, at Wadi Dara ancient copper occurrence, the copper mineralization is confined to granodiorite- tonalite- diorite association which subjected to various alteration processes. Bishady et al., (2001) stated that, the copper mineralization in Wadi Dara occurrence is litho-tectonically controlled. The mineralized rocks are nominated modally as diorite, quartz-diorites, tonalites and granodiorites which subjected to various alteration processes. Bornite is the most common primary copper mineral associated with chalcopyrite, enargite, and pyrite. The secondary mineral association is represented mainly by covellite, chalcocite, stannite, and cuprite. Copper carbonate minerals (malachite & azurite) are concentrated alone the planes of fissures and joints. The geochemical characters of copper mineralized rocks show their obvious close genetic relations through magmatic differentiation processes producing an older diorite phase, followed by granodiorites that finally extruded by dacites. Al-Boghdady et al., (2003) stated that, the copper mineralization in wadi Dara starts with the emplacement of porphyry diorite- granodiorite association relatively rich (notably the diorites) by primary sulphide minerals like pyrite- chalcopyrite-tetrahedrite. The hydrothermal convection system and the fluid- rock interactions led to the oxidation of primary Cu- bearing sulphides (commonly chalcopyrite) into secondary copper minerals, which mostly concentrated in quartz veins and cavities as copper – ore minerals. At the same time sulphides are commonly rich by gold, notably pyrite and pyrrhotite. Its oxidation releases its gold content where easily leached by the hydrothermal solutions to be precipitated with silica in copper- bearing quartz veins. Klemm (2013) stated, the geologic surroundings of mining activities on gold and copper mineralization in Wadi Dara area consist of an intrusive quartz- diorite traversed by NW-SE striking shear zones. Mineralized visible quartz veins display thicknesses vary between 0.5 and 1 m, all strike NW-SE in an almost vertical dip. The mined quartz is milky white, and the center of the vein contains calcite. Among the sulphide minerals, low contents of pyrite and to a lesser extent chalcopyrite could be observed. At 2014, Egyptian Mineral Resources Authority (EMRA) conducted a geological & geochemical reconnaissance survey of copper & gold mineralization at Wadi Dara ancient copper occurrence during the field work season of 2013 – 2014 (EMRA internal Report 2014). In 2025, porphyry copper mineralization is recorded for the first time in wadi Dara ancient copper occurrence, at the north of the Eastern Desert of Egypt. The mineralization is lithologically controlled with the emplacement of felsic intrusions of diorite - granodiorite association and tectonically is confined to composite fractures system oriented in NW- SE and steeply dipping in SW- direction. The copper mineralization is reflected in swarms of fissures filling shallow excavated copper- bearing mineralized zones, copper-bearing alteration zones enclose quartz veins and veinlets, diorite- granodiorite association host rocks and copper-bearing basic dykes (El-Shimi, 2025).

**Methodology**

- All the excavation zones were surveyed by GARMIN GPS device.
- All the collected samples were analyzed for gold and copper content by using Atomic Absorption Analysis (AA) in The Central Laboratories Sector of The Egyptian Mineral Resources Authority, Egypt with detection limits 0.03 and 0.06 ppm for Au and Cu respectively.

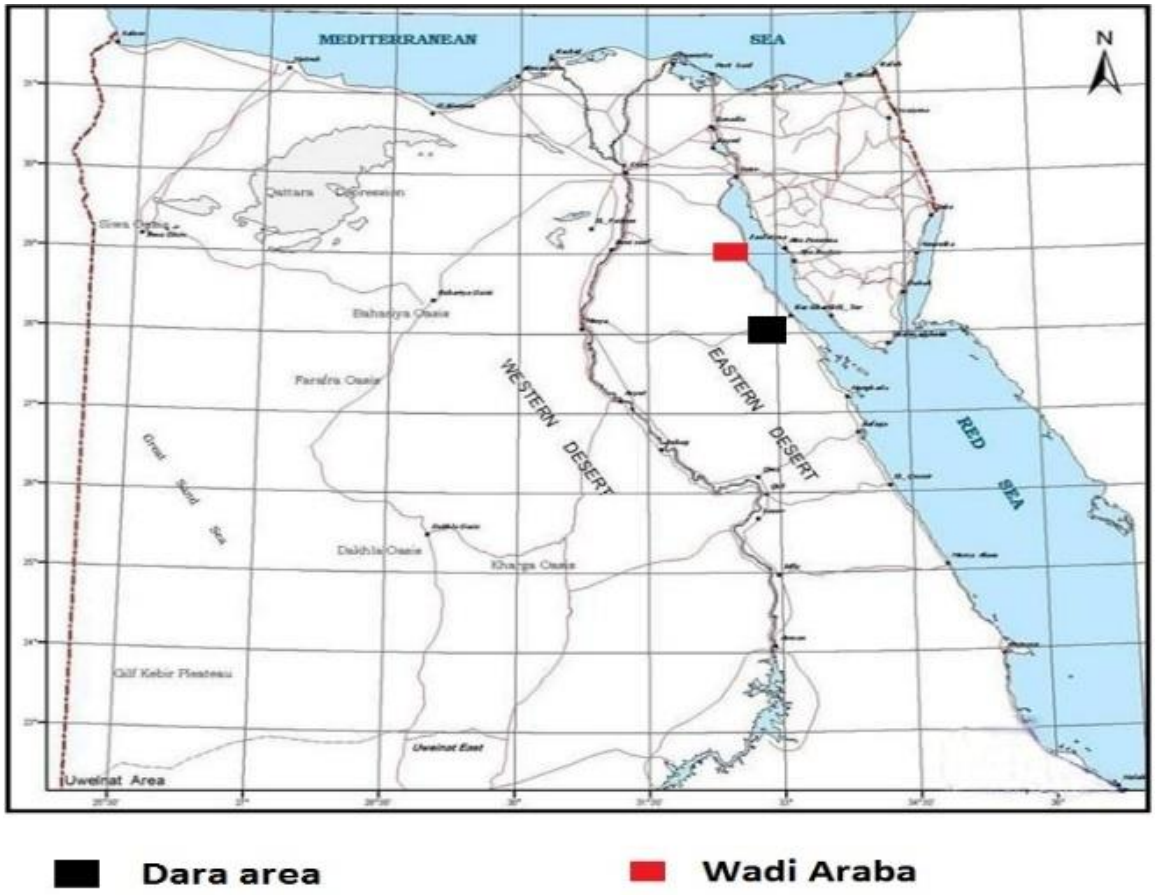


**Fig. 1. Location map of Wadi Dara ancient copper occurrence.**

**2- Location & accessibility:**

Wadi Dara copper occurrence is located at the northeastern part of the Eastern Desert of Egypt, about 90 km to the southwest of Ras Gharib town on the Red Sea coast (fig.1). The area can be reached by 45 km on the asphaltic road south Ras Gharib city and

then directed to the west by a desert track for about 45 km along Wadi Dara (fig.2).

Geographically, Wadi Dara ancient copper occurrence area is outlined with, Lat. 27º ′54 ″00-˚27 ′56 ″40 N & Long.˚32 ′49 ″00-˚32 ′55 ″15 E, Covering an area of 51 km2 (fig.3). Physio- graphically, the area is generally low to moderate relief at central part of and moderate to high relief at south-eastern part of the studied area and dissected by wadi Dara at central area which directed in East –West.

**3- Geologic setting of Wadi Dara ancient copper occurrence:**

Wadi Dara ancient copper occurrence area is geologically covered mainly with Neoproterozoic Pan-African basement rock s comprise diorite (older), granodiorite, Dokhan volcanics and monzogranite (younger) as shown on the following geological map (fig. 4).

Diorite rocks occur as low to moderately hilly masses to the south and south west of investigated area. They are melanocratic, medium- to coarse-grained rocks exhibiting spheroidal weathering, and variably extents of deformation.


**Fig. 2. Location map of Wadi Dara ancient copper occurrence.**

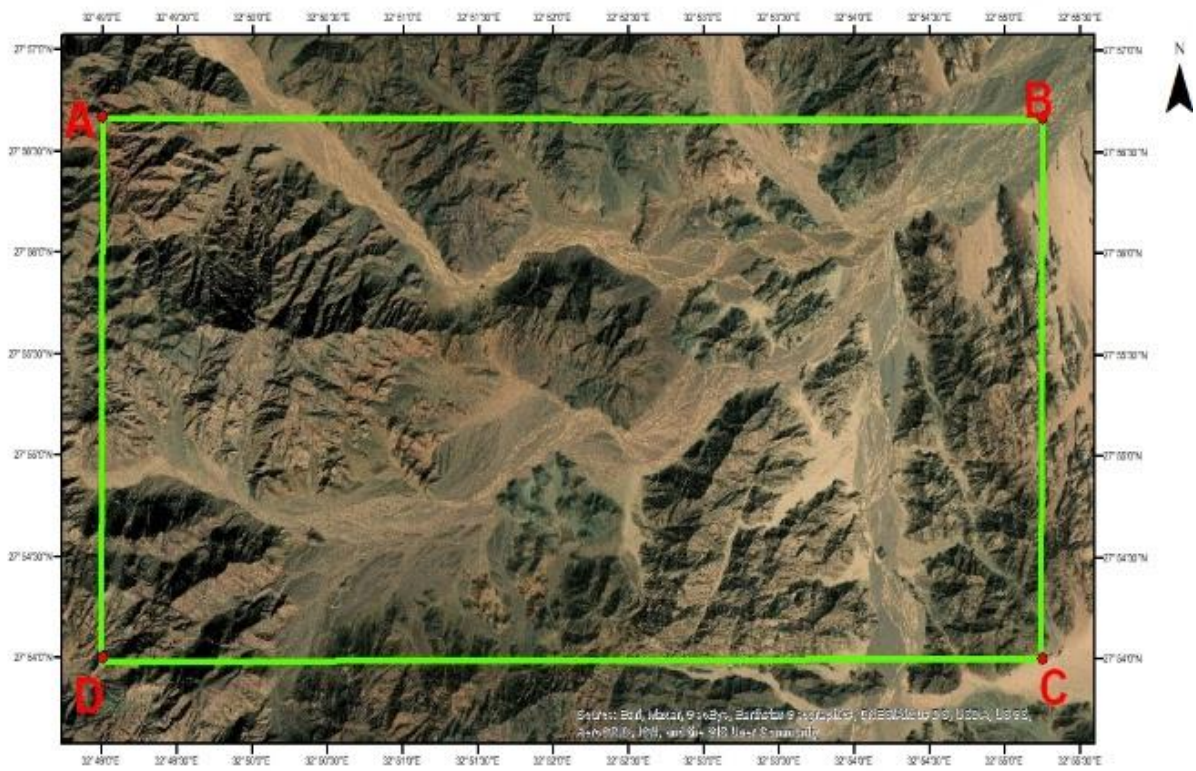


**Fig. 3. Landsat image of Wadi Dara ancient copper occurrence area.**

Diorite rocks are overlain by Dokhan Volcanics, and are intruded by granodiorite with sharp intrusive contacts. Granodiorites crop out mainly at the south western part of the occurrence area and also as few exposures in the central part of the occurrence area forming topographically low-moderate hills with gentle slopes and exhibit variable sized-spheroidal weathering types. Granodiorites are medium- to coarse-grained rocks, and are strongly sheared and foliated along the fault planes and sheared zones. Granodiorites sometimes enclose abundant enclaves of dioritic composition and/or xenoliths of basic and intermediate metavolcanics. Granodiorites are traversed by mafic and alkaline dykes extending in

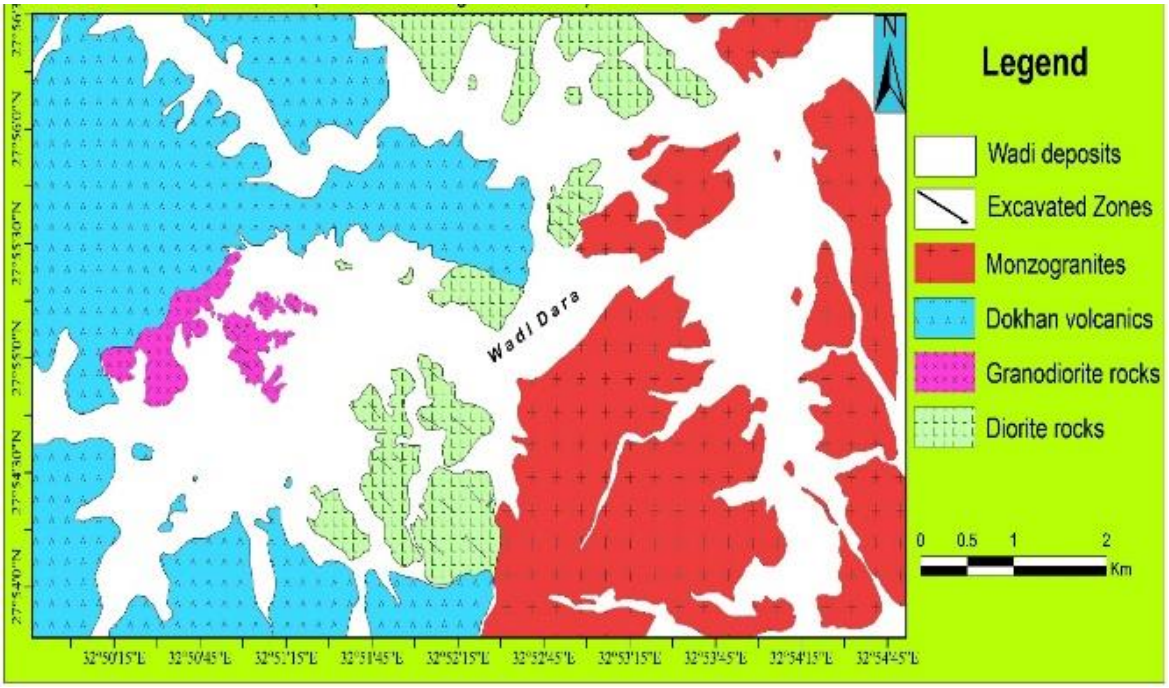


**Fig. 4. Geological map of Wadi Dara copper occurrence area.**

NW-SE trend. Granodiorites are whitish gray, leucocratic, medium- to coarse-grained, massive rocks with very coarse flakes of muscovite. Granodiorites are intruded by biotite-hornblende granite and alkali feldspar granite. Wadi Dara copper occurrence area comprises also unmetamorphosed Dokhan Volcanics which are commonly form high topographically rough mountainous landforms. They are well exposed in the western and southwestern parts of the occurrence forming a NW-SE elongated belt. They constitute a thick succession, which exhibits clear bedding planes. Monzogranites crop out in the northern and central parts of the mapped area at Wadi Dara. Monzogranites are pink medium- to coarse - grained, and are extensively weathered along the joints. These granites intrude the diorite, granodiorite and Dokhan Volcanics, and enclose enclaves and xenoliths of them. They exhibit exfoliation and onion-like weathering type. Felsic dykes are the oldest dykes in the mapped area and are represented by rhyolite and dacite.

Wadi Dara copper mineralization is reflected in swarms of fissures filling shallow excavated copper-bearing mineralized zones associated with copper - bearing alteration zones enclose quartz veins and veinlets, copper-bearing host rocks of diorite-granodiorite association and copper-bearing basic dykes. Geologically, Wadi Dara copper mineralization is completely confined to an association of felsic intrusions of diorite- granodiorite association (fig. 5).

The mineralization is lithologically controlled since it totally confined in diorite - granodiorite association of Andean type continental margin island arc granitoids.

Structurally, Wadi Dara copper mineralization is reflected in copper-bearing mineralized zones and their associated alteration zones are confined in an older composite fractures system trending for more than 2km in NW- SE direction and steeply dipping in SW- direction with an average width of 500 m. The copper-bearing fractures system was developed totally within the island arc granitoids of diorite - granodiorite association of continental margin island arc tectonic setting. The copper mineralized composite fractures system is displaced by several faults trending NE-SW and ENE-WSW major long fault runs along Wadi Dara and extends westward outside the mapped area. The amount of horizontal displacement along this fault reaches more than 200 m. The NE-SW faults are common and cut some NNW-SSE, and NW-SE faults and are displaced by the youngest ENE-WSW faults. That is means, the copper mineralization of Wadi Dara occurrence is lithologically and tectonically controlled.

**4- Reconnaissance survey of Dara copper mineralization:**

In the present work, geological and geochemical reconnaissance survey of copper mineralization at wadi Dara ancient copper occurrence carried out by geologic mapping, samples collection with recording also of all old mining work activities. Excavated copper-bearing mineralized zones were mapped by using GARMIN GPS. Reconnaissance geochemical exploration work

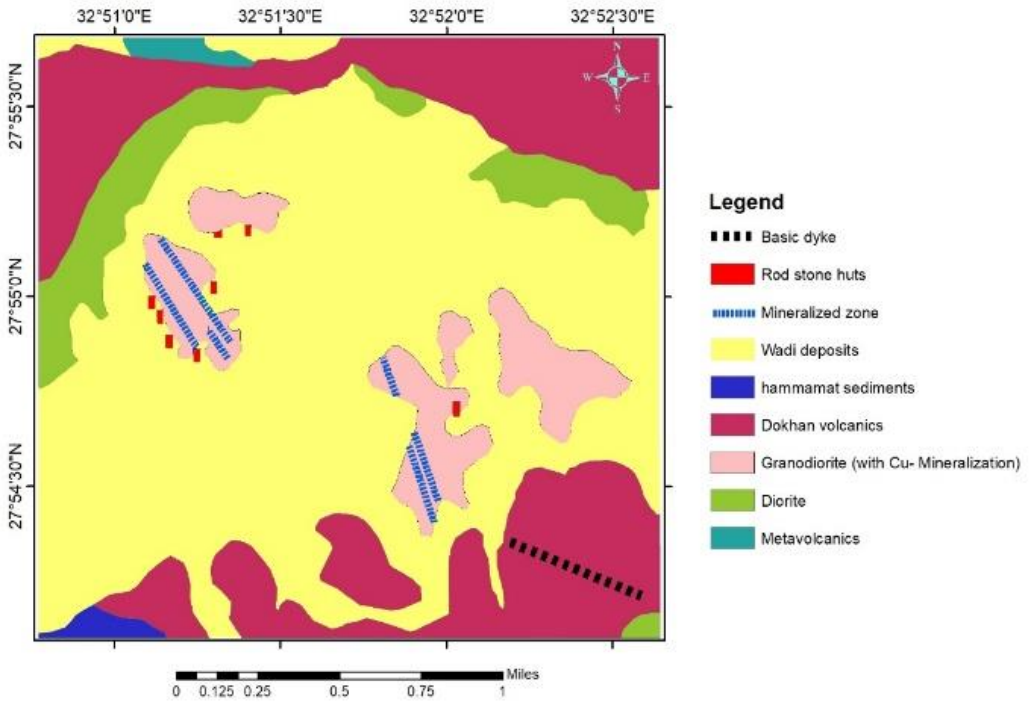


**Fig. 5. Geologic setting of Wadi Dara copper mineralization.**

involves the collection of chips rock samples from remnants of excavated copper-bearing mineralized zones, alteration zones host excavated copper-bearing mineralized zones, country rocks which host both of excavated copper-bearing mineralized zones and it associated alteration zones, basic dykes, quartz and listwaenite veins. During that work about two-hundred twenty-four (224) segments of excavated copper –bearing mineralized zones were recorded and mapped. Geochemical reconnaissance survey of copper mineralization at wadi Dara ancient copper occurrence involved the collection of two hundred and six (206) samples from the above-mentioned rock units located within the ancient copper occurrence area. Collected samples were analyzed by atomic absorption to detect their Cu,Au,Ag,Zn and Pb contents. Generally, Wadi Dara ancient copper occurrence area is subdivided into three sub-area namely, Southern sub-area (Area - A), Western sub-area (Area - B), and Eastern sub-area (Area- C) as shown in figure (6).

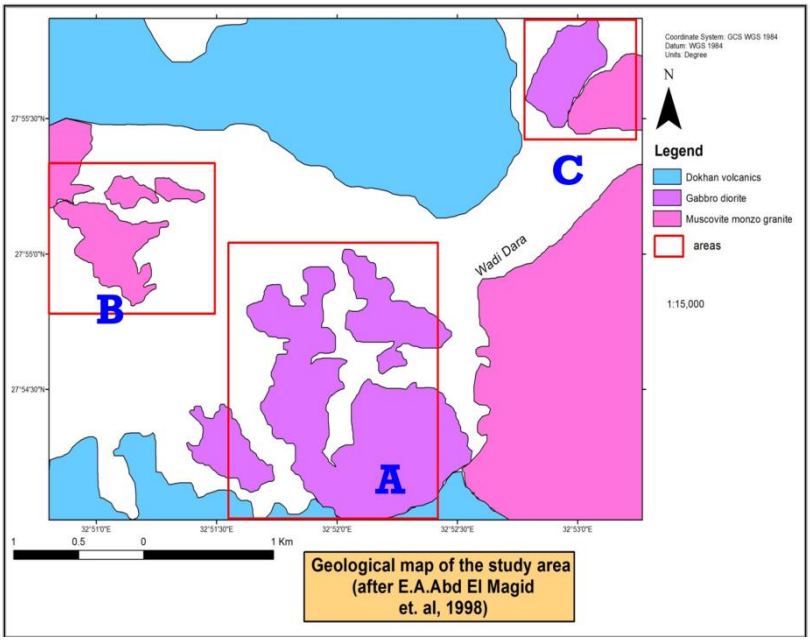


**Fig. 6. Distribution of the three sub-areas which form Wadi Dara ancient copper occurrence.**

**4.1- Copper mineralization at the southern sector (Area - A) of Dara occurrence:**

About eighty-two segments (82) old workings of surfaces inclined excavated zones of depths up to 4m depth were recorded at southern subarea of Dara occurrence (Area- A). The occurrence area at such site comprises also several of dump heaps, rod stone huts and milling stone (fig.7 & 8).

**Fig. 7. Rod stone huts at southern subarea (Area-A) of Dara occurrence.**

**Fig. 8. Milling stone at Southern sub (Area-A) of Dara occurrence.**

Geochemical reconnaissance survey carried on the southern sector of Wadi Dara copper occurrence (Area -A) including sampling and analyses of thirty-three (33) samples from excavated mineralized zones, thirty- four (34) samples from alteration zones which host excavated mineralized zones. Alteration zones sampling includes one (1) sample from quartz vein, and one (1) sample from listwaenite vein. Collected samples were subjected to atomic absorption analyses to detect their copper and gold contents. Generally, sixty- seven collected samples (67) from southern sector (Area -A) of Wadi Dara ancient copper occurrence display a promising copper mineralization of copper contents range from 5 ppm to 65000 ppm (6.5 %) with an average content of (0.92%). The recorded copper mineralization there is associated with a promising gold mineralization of gold contents range from< 0.01 ppm (ND) to 28.8 ppm with an average of 1.49 ppm. The recorded copper

mineralization at the southern sector (Area - A) is distributed as followings:

**4.1.1 Copper mineralization of excavated mineralized zones:**

The southern sector of Dara occurrence (Area - A) comprises more than eighty-two (82) segments of shallow excavated mineralized zones (Fig. 9) enveloped in alteration zones host quartz veins and veinlets. Excavated mineralized zones mapped by GARMIN GPS. These zones are hosted in diorite rocks. Excavated mineralized zones extend along their strike in NW-SE for distances range from 36 m – 428 m with width ranges from 0.3 to1m and dip to SW with ranges from 60-85 (fig. 10).

**Fig. 9. Excavated mineralized zone at Southern (Area-A) of Dara occurrence.**


**Fig. 10. Excavated copper-bearing mineralized zone (blue arrow) and alteration zone extend along two sides (yellow arrows).**

At the surface the excavated mineralized zones display a copper mineralization reflected mainly in malachite and azurite. Excavated mineralized zones were stopped out vertically at shallow depth range from 1-4m in ancient times along fractures and joints in diorites host rocks. Remnants of excavated mineralized zones display a workable copper- gold mineralization of copper contents range from 52 ppm to 65000 ppm (6.5%) with an average content of (1.56%) associated with gold mineralization of gold contents range from< 0.01ppm to 24 ppm with an average content of 1.79 ppm Au (33 sample).

**4.1.2 Copper mineralization of alteration zones:**

Excavated mineralized zones at the southern sub -area (Area- A), are enclosed in alteration zones extend along the both sides of the excavated zones with width range from 5-10 m. and extending about 430 m in the NW-SW direction. Alteration zones are superimposed on highly fractured country rocks, and characterized with an alteration pattern comprises an association of iron oxides, kaolin, sericite, silicification and carbonization with the formation of copper-bearing minerals of malachite and azurite. Alteration zones enclosed the excavated mineralized zones comprise many of discontinues highly furrginated reddish brown quartz veins & veinlets trending in NW-SW with thickness range from 5 to 40 cm and comprise also many of hard listwaenite vein& veinlet of reddish-brown color, associated with calcite crystals trending in NW-SE for about 30 m with an average thickness of 1.3 m. Fracture planes of alteration zones are stained with copper minerals especially malachite (Fig.11).

During geochemical reconnaissance survey, thirty – four samples (34 sample) were collected from alteration zones which host the excavated mineralized zones at the southern sub-area (Area- A) (fig. 12) and analyzed by atomic absorption analyses to detect their copper and gold contents. Analyzed sampled display a low-grade copper mineralization of copper contents ranges from 5 ppm – 21416 ppm (2.14%Cu) with an average content of 3278 ppm (0. 32 %). The recorded copper mineralization is associated with a low-grade gold mineralization of gold contents range from< 0.01ppm----2.46 ppm with an average content of 0.36 ppm Au. The only one collected sample from quartz vein there, displayed anomalous copper content of (0.18%) with the highest recorded gold content in the area of 28.8 ppm. Listwaenite vein displays copper content of 376 ppm with 0.009 ppm gold content. About (48.3%) of alteration zones analyzed samples (15 samples) display copper contents range from 650 ppm (0.065 %) to 21416 ppm (2.14%) with an average copper content of 0.63 %. The recorded copper mineralization is associated with a gold mineralization of gold contents range from< 0.01ppm--- 1.08ppm with an average of 0.22 ppm. The rest 51.7 % of analyzed samples (16 samples) revealed poorly mineralized copper alteration zones of copper contents range from 5 ppm to 417 ppm with an average of 0.0095%. Poorly mineralized copper alteration zones are associated with more or less significant gold mineralization of gold contents range from <0.01ppm---2.46ppm Au with an average of 0.5

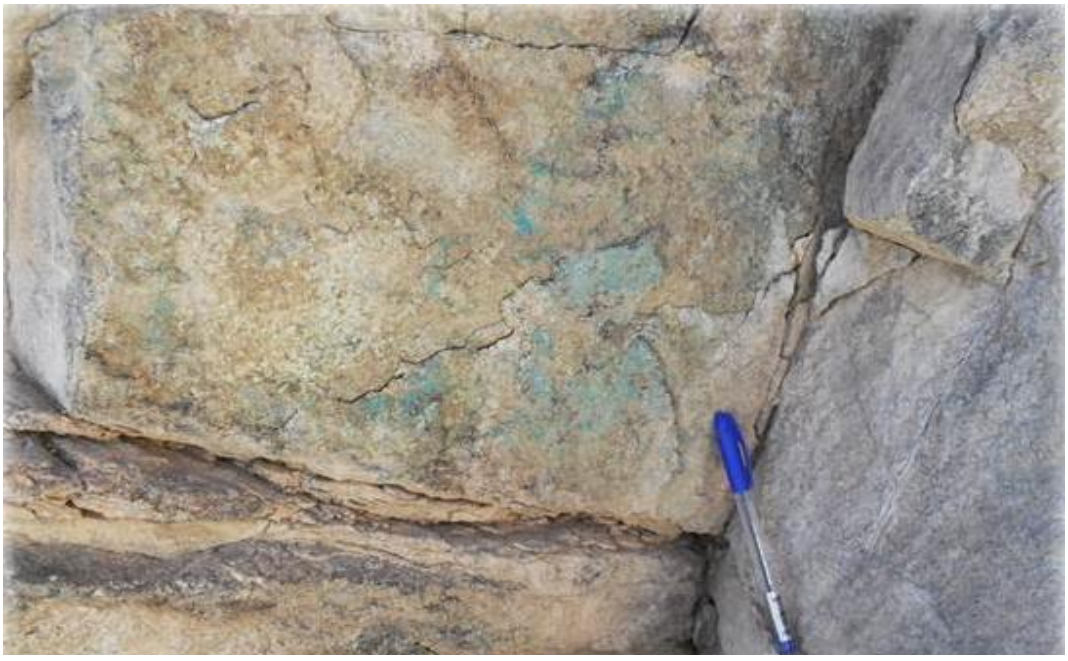

**Fig. 11. Fracture surfaces of alteration zone stained with malachite at Southern subarea (Area-A) of Dara occurrence.**

**Fig. 12. Alteration zones at the southern sub-area (Area- A) of Dara occurrence.**

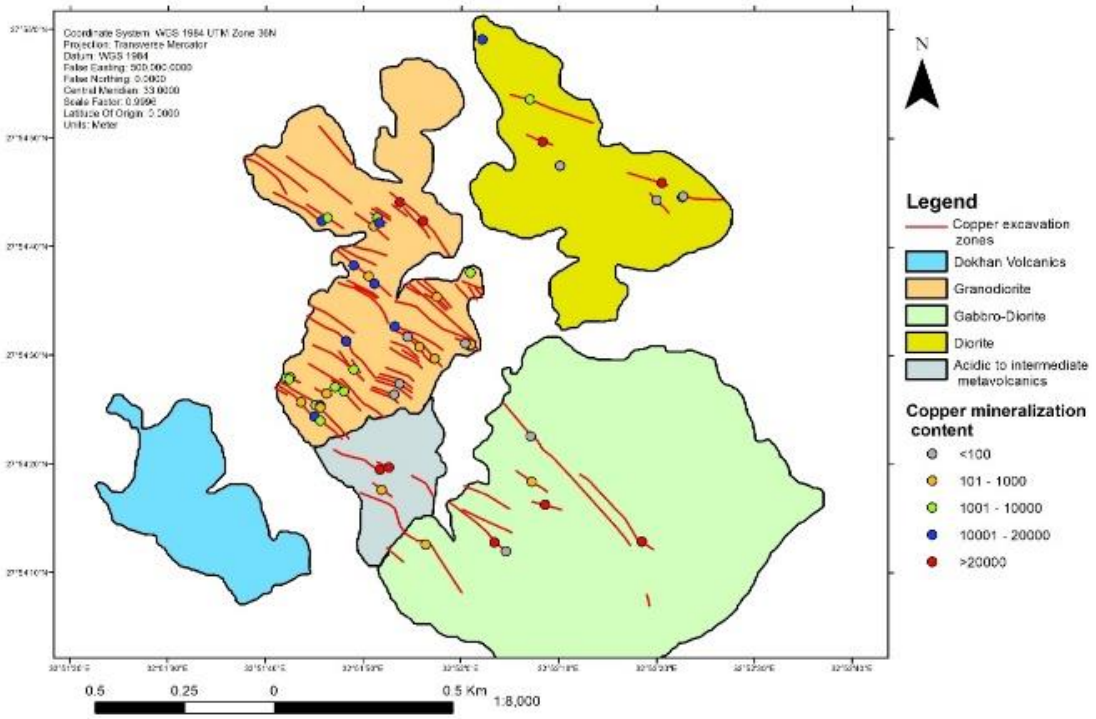


**Fig. 13. Distribution of copper in southern sub-area (Area- A) of Dara occurrence.**

ppm Au. That is means, an inverse relationship between gold and copper contents in the alteration zones which enclosed the copper-bearing mineralized zone in such investigated subarea of Wadi Dara ancient copper occurrence (fig. 13 & 14).

**4.2 Copper mineralization at Western sector (Area – B) of Dara occurrence:**Geochemical reconnaissance survey carried on the Western sector of Wadi Dara copper occurrence (Area – B) involved the collection of hundred nineteen (119) hard rock samples from excavated mineralized zones

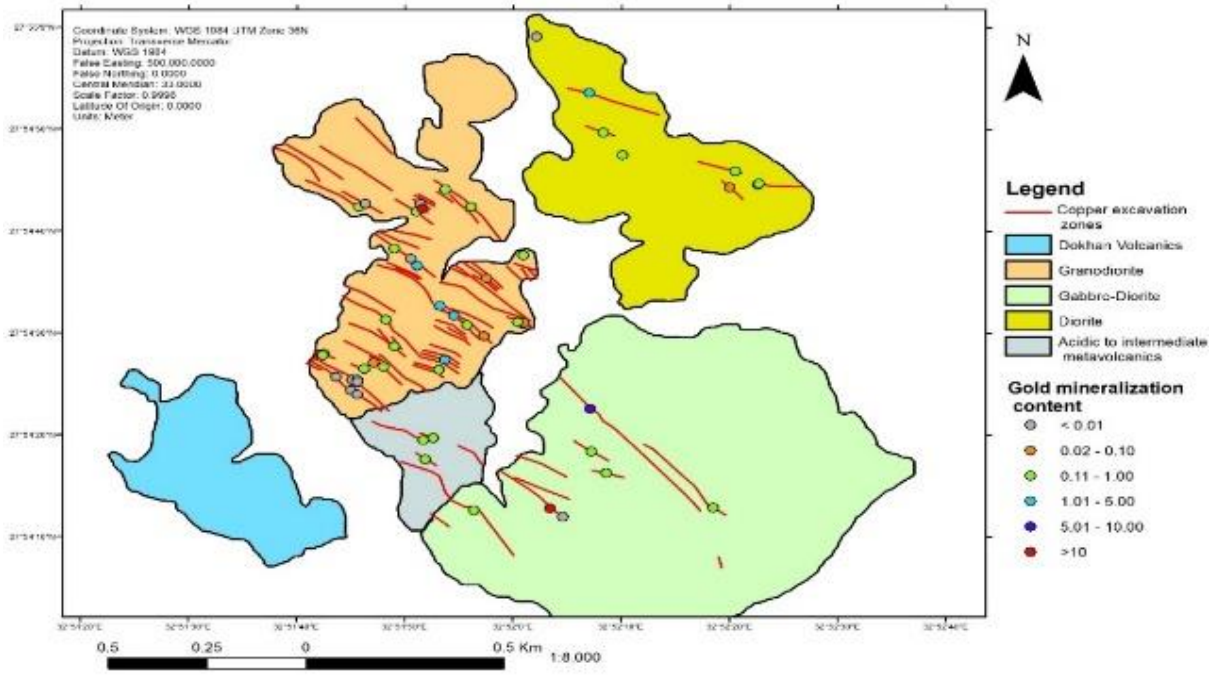


**Fig. 14. Distribution of gold in southern sub-area (Area- A) of Dara occurrence.**

(13 samples), alteration zones which host excavated mineralized zones (80 samples), country rocks which host mineralized zones and alteration zones (24 samples) and basic dykes (2 samples).

Collected samples were analyzed by atomic absorption analyses to detect their copper and gold contents. Generally, the different rock varieties of analyzed samples (117samples) except the samples of basic dykes displayed copper mineralization of copper contents range from 80 ppm to 28300 ppm (2.83%) with an average (0.55%). Recorded copper mineralization is associated with gold mineralization of gold contents range from <0.01 to 15.63 ppm with an average gold content of 0.64ppm. The distribution of recorded copper mineralization recorded at the western sector (Area - B) of Dara copper occurrence is shown as followings:

**4.2.1 Copper mineralization of excavated mineralized zones:**

Geological reconnaissance survey carried on the Western sector of Wadi Dara copper occurrence (Area

– B) led to recognize mineralized composite fractures system extending for more than 1km in NW-SE and dip to SW with widths reaches to more than 500m. Mineralized composite fractures system comprises swarms of partially excavated mineralized zones associated with alteration zones with quartz veinlets and basic dykes of visible copper minerals of malachite and azurite .During geological reconnaissance survey carried on the Western sector of Wadi Dara copper occurrence (Area – B), one hundred - thirty (130) segments of excavated mineralized zones extending in NW-SE direction with lengths range from 20-180m with thickness range from 0.5 to1m were recorded and mapped there. Excavated mineralized zones are discontinuous and separated from each other's with alteration zones and both of them are hosted in granodiorite country rock. Eexcavated mineralized zones were stopped out at shallow depths range from 1-5m at ancient times (fig.15).

During geochemical reconnaissance survey carried out at the western sector (Area- B), thirteen (13) samples collected from the remnants of excavated mineralized zones and analyzed by atomic absorption to detect their copper and gold contents (fig. 16 & 17). Collected samples revealed workable copper mineralization of copper contents range from (0.25%) to (1.27%) with an average of 0.73 % associated with promising workable gold mineralization of gold contents range from 0.01ppm---12.68 ppm with an average of 1.74 ppm.


**Fig. 15. General surface view of excavated mineralized zone at western sector (Area - B).**

**Fig. 16. Excavated mineralized zones at western subarea (Area - B).**

**Fig. 17. Remnants of excavated mineralized zone at western sector (Area - B).**

**4.2.2 Copper mineralization of alteration zones:**

Excavated mineralized zones at the western sector (Area- B) of Dara copper occurrence are associated with alteration zones extending along the both sides of the excavated mineralized zones in NW-SW direction with lengths range from about 20 ---180m and width ranges from 4-8 m. Alteration zones display fractured appearance of surfaces coated and stained with copper minerals especially malachite. Alteration zones display the presence of quartz veinlets, micaceous iron mineral (speculirite), sulphides altered into red iron oxides and the formation of malachite (hydrated copper carbonate mineral) as a result of hydration and carbonatization of sulphide –bearing copper minerals (fig.18). Quartz veins -veinlets in alteration zones extend in discontinues shape along copper-bearing mineralized zones in NW-SW with thickness range from 5 to 15 cm. Alteration zones which host excavated mineralized zones at the western sector of Dara copper occurrence (Area-B) (fig. 19) revealed workable copper mineralization of copper contents range from 285 ppm to 28800 ppm (2.88%) with an average of (0.6%). The recorded copper mineralization in alteration zones is associated with a gold mineralization of gold contents range from < 0.01ppm to 15.63 ppm with an average of 0.64 ppm (80 samples).

**4.2.3 Copper mineralization of the country rocks:**

Twenty-four (24) samples were collected from the country rocks which host both of the excavated mineralized zones and their associated alteration zones at the Western sector (Area – B) of Dara copper occurrence area. Collected samples revealed copper mineralization of copper contents range from 80 ppm ---9950 ppm with an average of (0.28%). The recorded copper mineralization is not associated with any significant gold mineralization since the gold contents of the analyzed samples range < 0.01 to 0.64ppm with an average of 0.068. That is means, the country rocks which enclosed both of excavated mineralized zones and their associated alteration zones at the Western part of Dara copper occurrence area displays a low-grade copper mineralization of an average copper content of 0.28% (fig. 20 & 21).

**Fig. 18. Alteration zone at western subarea (Area - B) of Dara copper occurrence.**

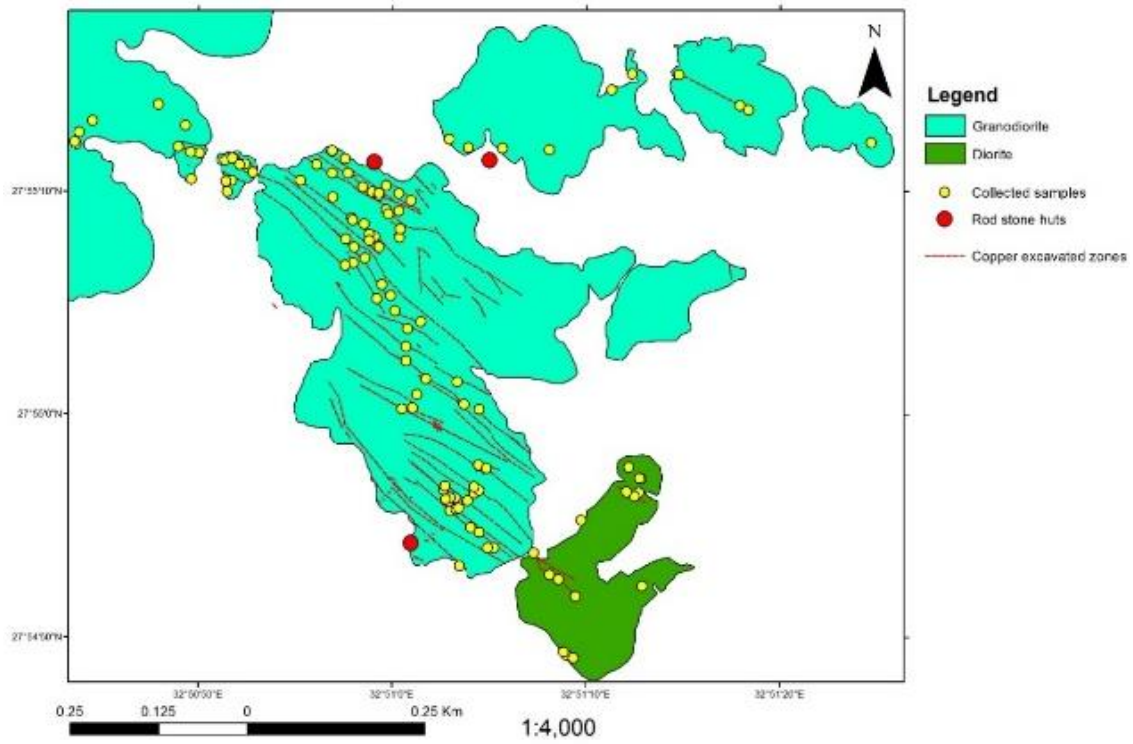


**Fig. 19. Geologic and sample location map of the western sector (Area-B).**

**4.2.4 Copper mineralization of basic dykes at (Area – B)**

Two samples collected from basic dykes of dark color with thickness about 0.8m trending in NE-SW for about 120m, perpendicularly cutting mineralized zones at the western sector (Area- B). Collected samples revealed anomalous copper content of 2484ppm (0.24%) with 0.08ppm gold content in one sample and 270 ppm copper content with nil gold content in the other sample.

**4.3 Copper mineralization at Eastern sector (Area -C) of Dara occurrence**

During geochemical reconnaissance survey carried out at the Eastern sector (Area- C) of Dara copper occurrence area, twenty (20) hard rock samples were collected from the remnants of excavated

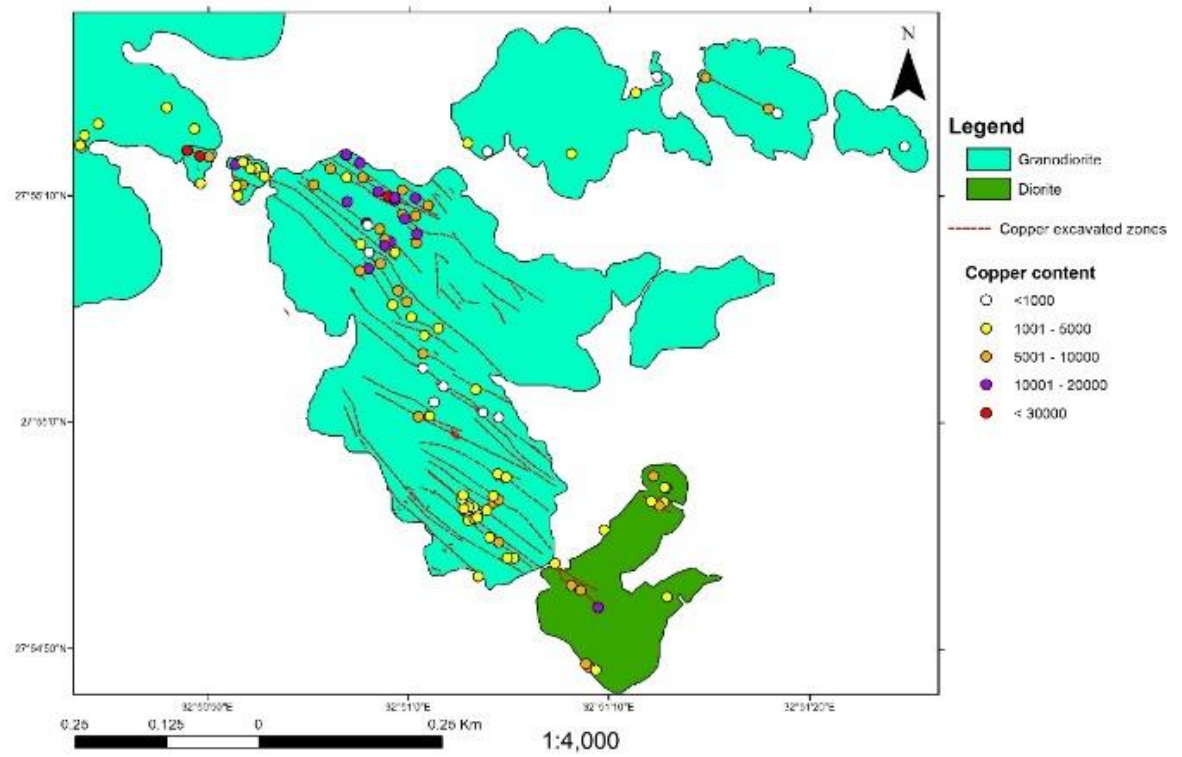


**Fig. 20. Distribution of copper in Western sector (Area- B) of Dara copper occurrence.**

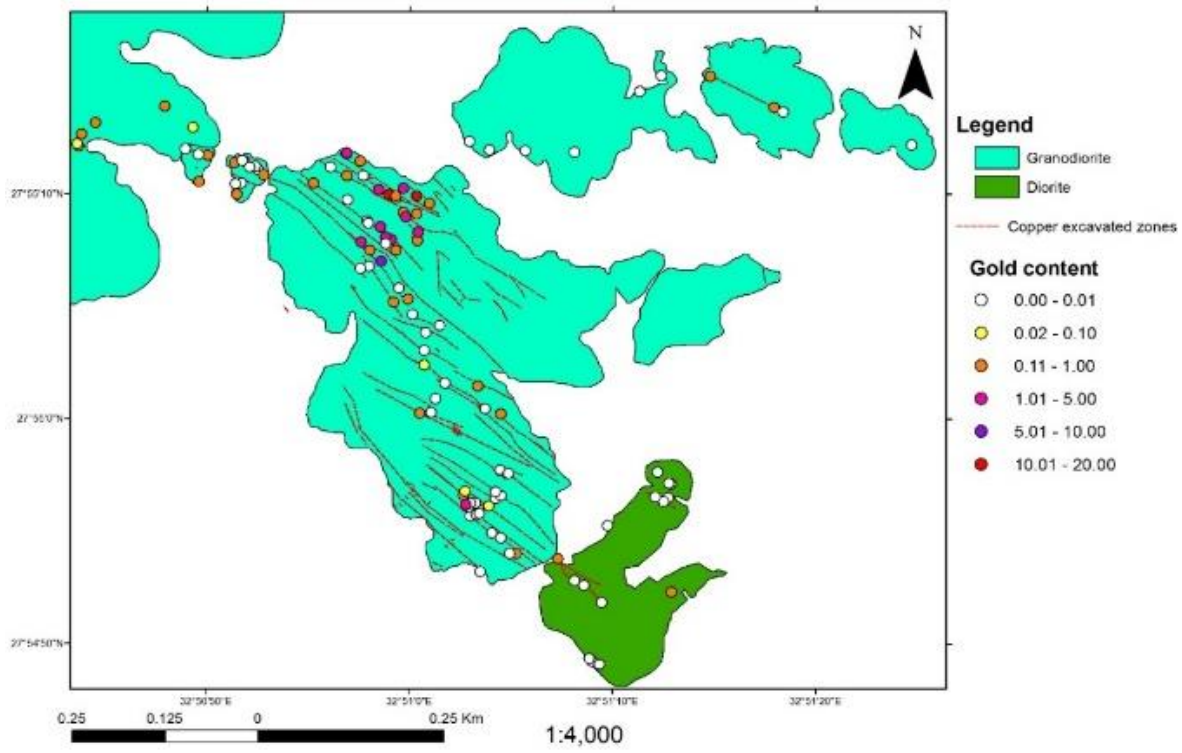


**Fig. 21. Distribution of gold in Western sector (Area- B) of Dara copper occurrence.**

mineralized zones, alteration zones and basic dykes. Collected samples analyzed by atomic absorption to detect their

copper and gold contents. Generally, collected samples revealed copper mineralization of copper contents range from 101 ppm to 34000 ppm (3.4%) with an average copper content of 10998 ppm ((1.09%). The recorded copper mineralization is associated with gold mineralization of gold contents range from 0.47ppm to 16.12 ppm with an average

of 5.07 ppm in five (5) out of the twenty (20) analyzed samples. The recorded copper mineralization at the Eastern sector (Area- C) of Dara copper occurrence is confined to the excavated mineralized zones, alteration zones and basic dykes as followings:

**4.3.1 Copper mineralization of excavated mineralized zones:**

At the Eastern sector (Area – C) of Dara copper occurrence, twelve (12) excavated copper-bearing mineralized zones were recorded and mapped by GARMIN GPS (fig. 22). Excavated mineralized zones are enclosed in diorite and granodiorite country rocks and mostly trending in NW-SE and dip to SW with degree from 70-85. Excavated mineralized zones extend along their strike for distances range from 10-160 m with thickness ranges from 0.5 to1m. During the geochemical reconnaissance survey, five (5) samples were collected from excavated mineralized zones and analyzed by atomic absorption to detect their copper and gold contents.

Collected samples display pronounced copper mineralization of copper contents range from (1.22%) to (3.40%) with an average copper content of 2.46% associated with gold mineralization of gold contents range from 0 to 5.45 ppm with an average content of 1.74 ppm Au. That is means, excavated mineralized zones display significant copper mineralization of 2.46% an average copper content associated with a significant gold mineralization of an average gold content of 1.74 ppm.

**4.3.2 Copper mineralization of Alteration zones:**

At the Eastern sector (Area – C) of Dara copper occurrence, excavated mineralized zones are associated with alteration zones extending along their both sides in NW-SW direction for about 160 m with width range from 4-8 m. Alteration zones display intensive shearing with an association of iron oxides, kaolin, sericite, quartz veinlets and malachite. Alteration zones (9 samples) display a low-grade copper mineralization of copper contents range from 101 ppm to 7300 ppm with an average copper content of (0.268 %). The recorded copper mineralization is not associated with gold mineralization since only one (1) sample out of nine (9) samples revealed 16.12 ppm gold content.

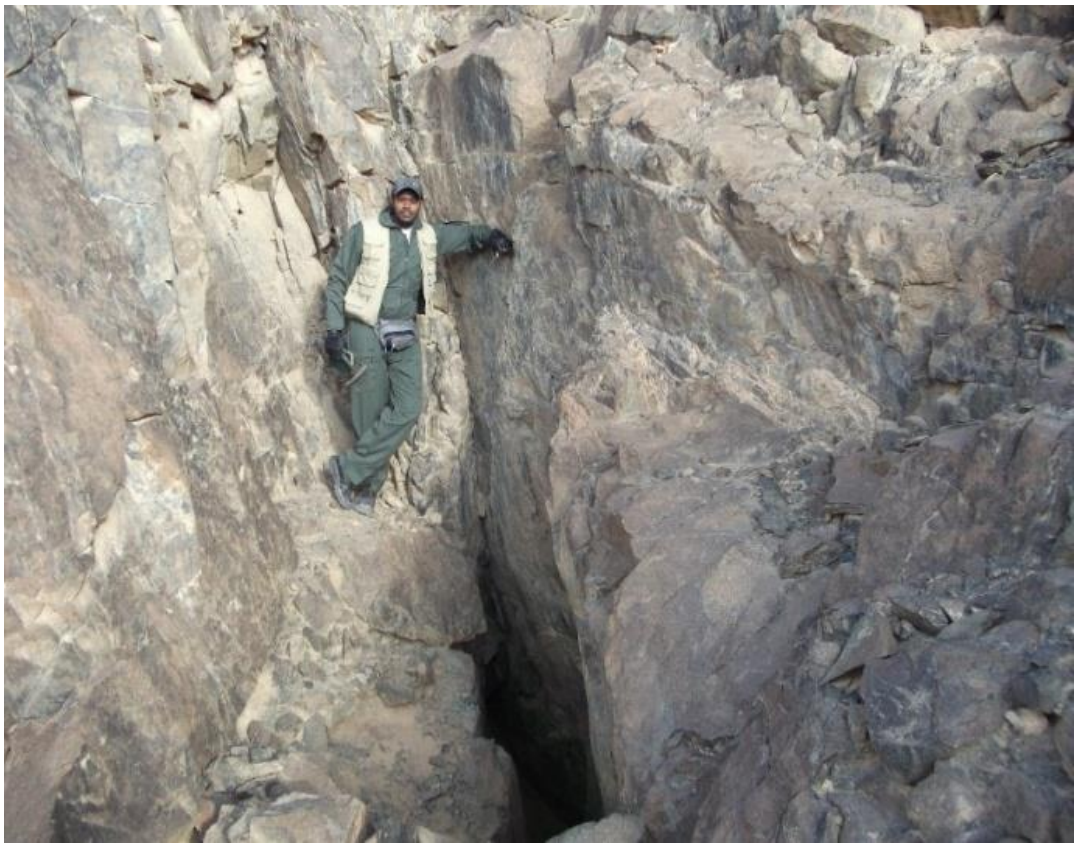

**Fig. 22. Excavated mineralized zone at Eastern subarea (Area – C).**

**4.3.3 Copper mineralization of basic dykes:**

At the Eastern sector (Area – C) of Dara occurrence, dark basic dykes trending in NE-SW for about 60m with thickness range from 0.6 -1m, cutting excavated mineralized zones is recorded there. Six (6) samples collected from basic dykes revealed pronounced anomalous copper contents range from 362 --- 21400 ppm with an average content of 14177ppm (1.4%.). That is means, basic dykes located at the Eastern sector (Area – C) of Dara occurrence display significant and workable copper mineralization of an average copper content of 1.4% /t. without any of gold mineralization (fig. 23 & 24).

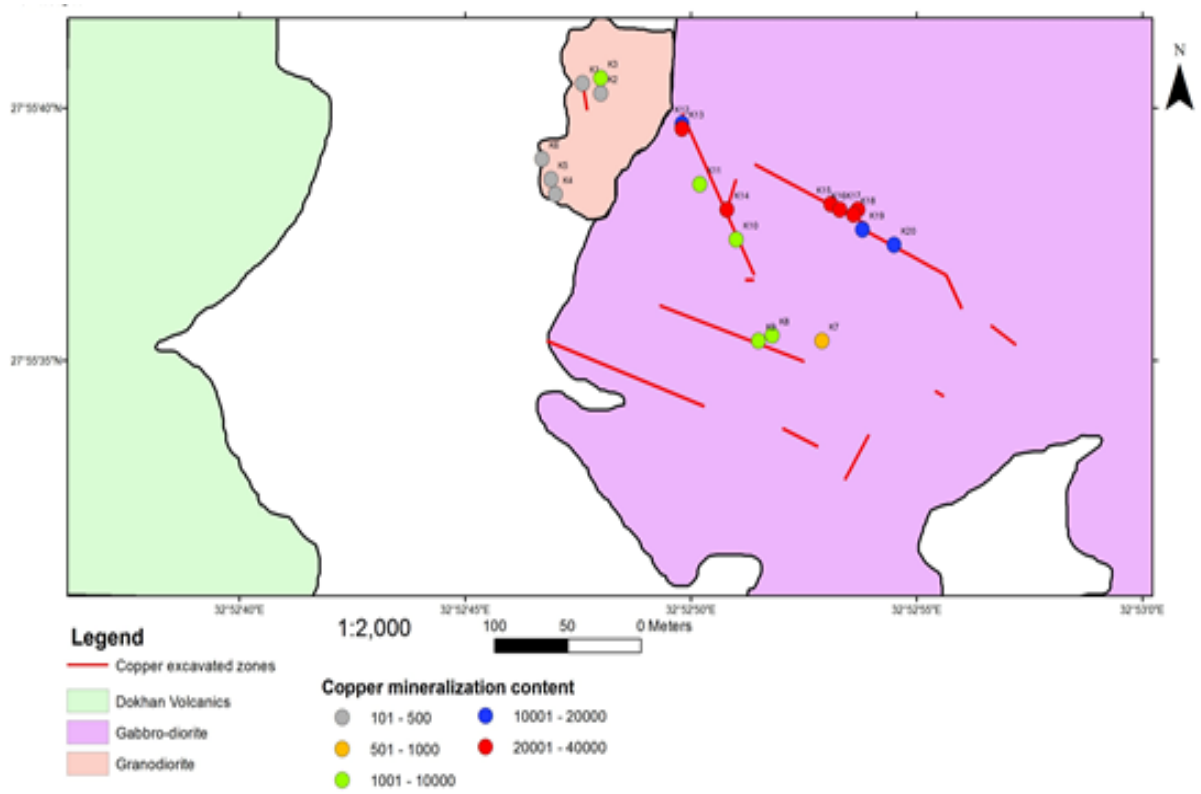


**Fig. 23. Distribution of copper at the Eastern sector (Area – C) of Dara occurrence.**

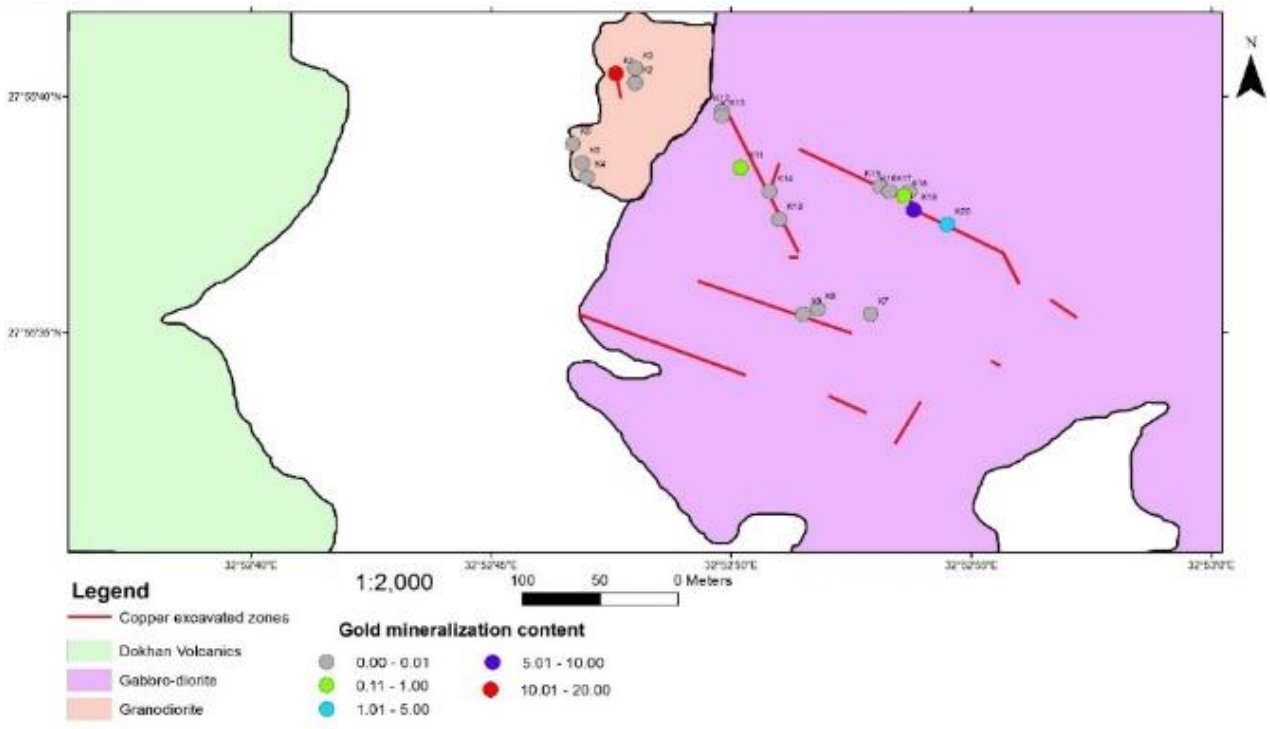


**Fig. 24. Distribution of gold at the Eastern sector (Area – C) of Dara occurrence.**

**5 Profiling:**

Two profiles were done at Wadi Dara ancient copper occurrence at the Sothern sector (Area- A) and the western sector (Area- B), to demonstrate the intensity of excavated mineralized zones, their dip direction and dip amount. Geographic locations of such profiles are shown on the Landsat image of Wadi Dara copper occurrence area(fig.25).

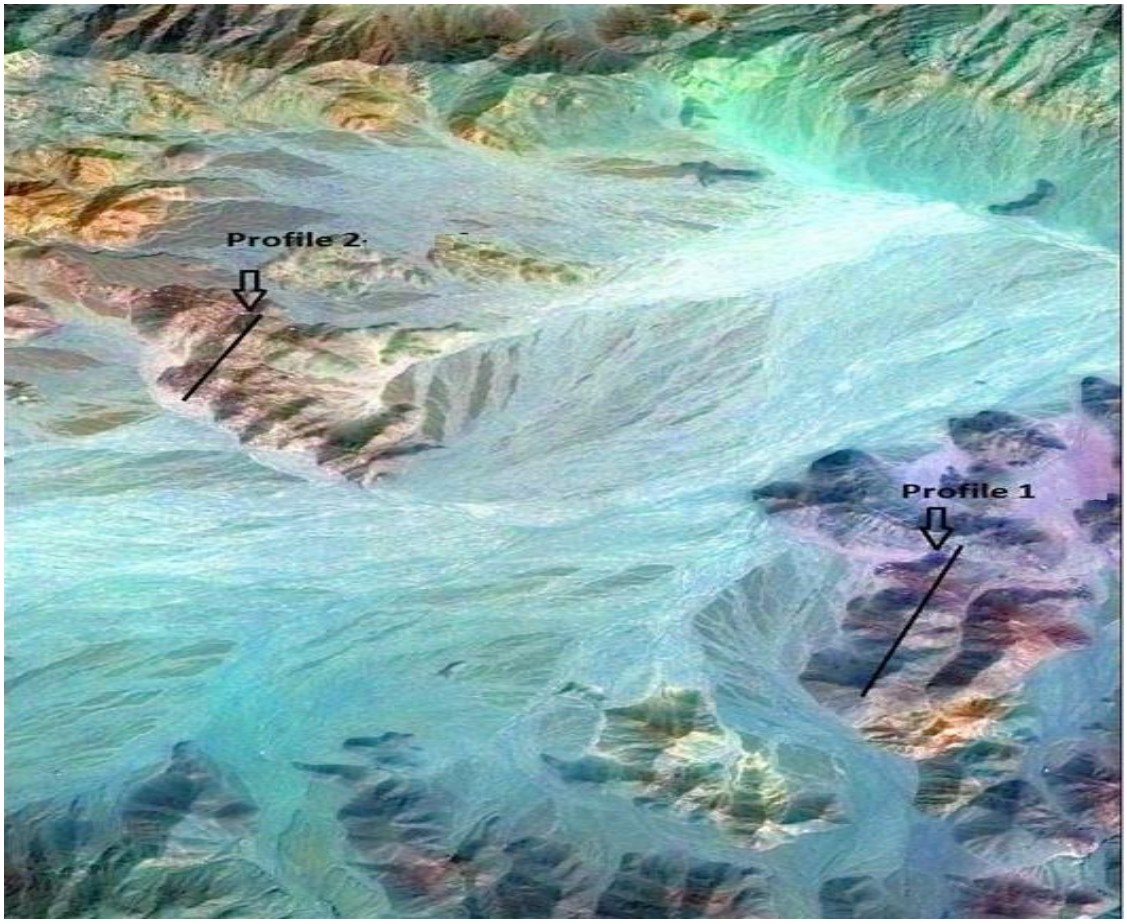


**Fig. 25. Locations of two conducted profiles at Wadi Dara occurrence mine.**

**Profile No.1:**

was done at southern sub- area (Area- A) with length about 850m and trend NE-SW, perpendicular to the trend of excavated mineralized zones there. The profile cutting 20 mineralized zones, dip 60°-82° to SW direction (Fig.26).

**Profile No.2:**

was done at Western sub- area (Area- B) with length about 720m and trend NE-SW, perpendicular to trend of excavated mineralized zones. The profile cutting 23 mineralized zones which dip with 65°-82° to SW direction (fig. 27).

**6 Summary:**

Wadi Dara ancient copper occurrence is located at the northern part of the Eastern desert of Egypt,). Wadi Dara ancient copper occurrence displays extensive shallow excavated copper -bearing mineralized zones spreading over three isolated hills nominated here as the southern sector (Area-A), the Western sector (Area- B), and the Eastern sector (Area- C). At the southern sector (Area- A), more than eighty-two (82) segments of shallow excavated copper-bearing mineralized zones enveloped in alteration zones host quartz and listwaenite veins & veinlets were recorded there (fig. 28). Copper-bearing mineralized zones and their associated alteration zones are extending along their strike in NW-SE for distances range from 36-428 m with widths range from 0.3 to1m enclosed in diorite and granodiorite country rocks. Copper mineralization is reflected there in copper-bearing minerals mainly of malachite ($CuCO_3 \bullet Cu(OH)_2$) and azurite ($2CuCO_3 \cdot Cu(OH)_2$) confined to shallow excavated copper-bearing mineralized zones and their associated alteration zones which stopped out at shallow depths range from 1-4m in ancient times. At the Western sector of Wadi Dara ancient copper occurrence (Area- B), it was recorded the presence of one hundred - thirty (130) segments of shallow excavated copper-bearing mineralized zones rocks extending in NW-SE along their strike for

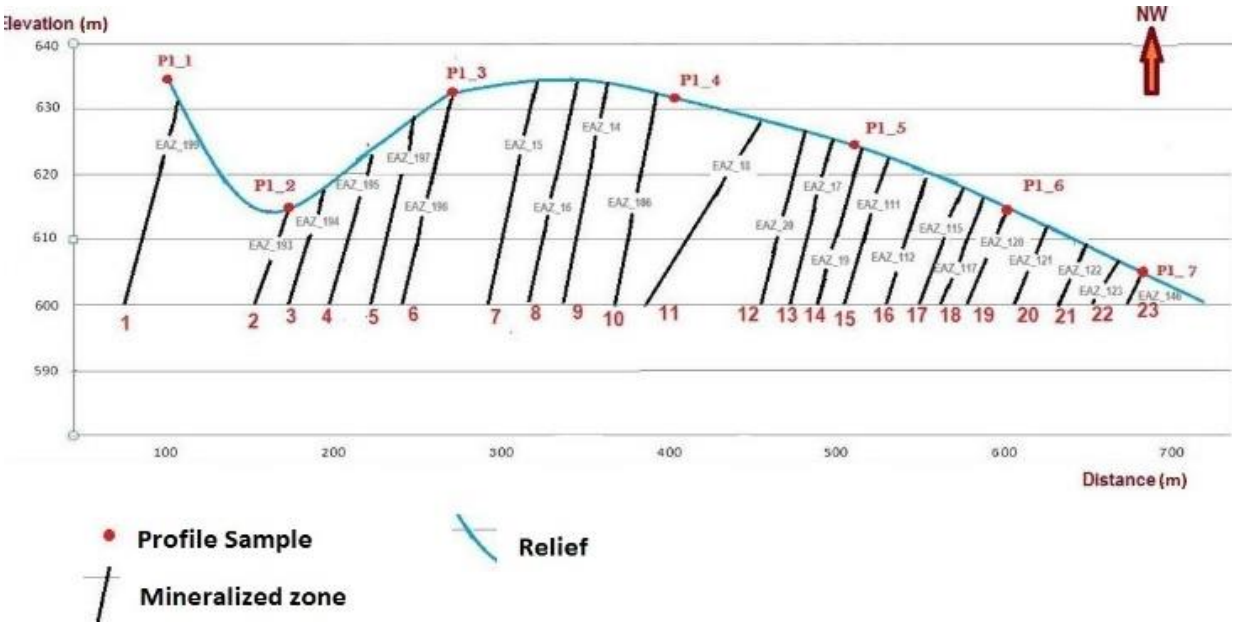


**Fig. 26. Profile No.1 at the Southern sub-area (Area- A) of Dara occurrence mine.**

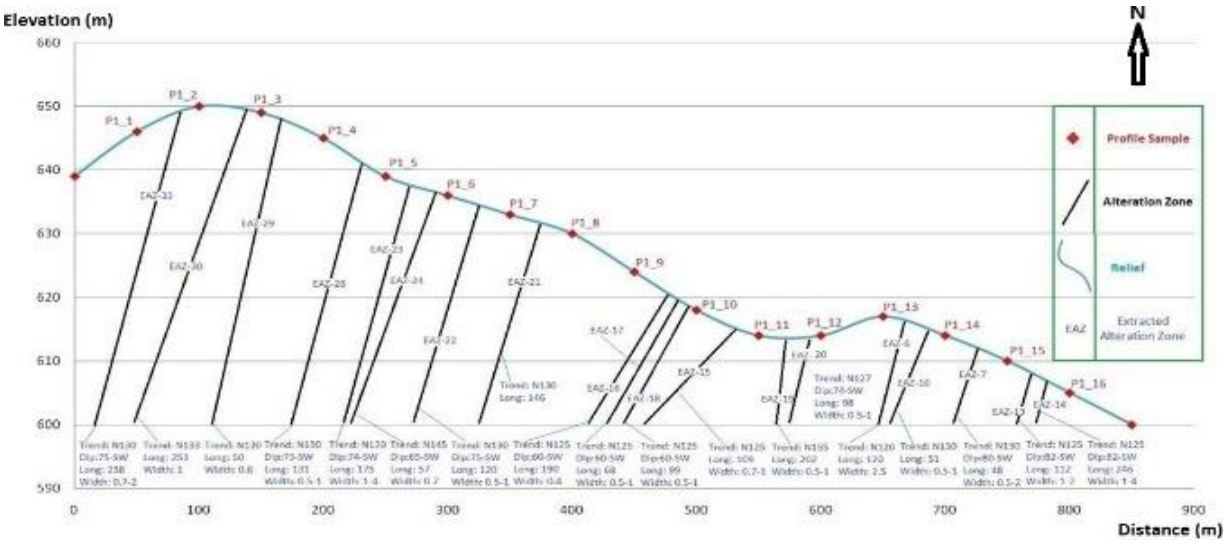


**Fig. 27. Profile No.2 at Western sub area of Dara occurrence mine.**

enclosed in diorite and granodiorite country rocks extending in NW-SE direction with lengths range from 20-180m with widths range from 0.5 to 1m. At Wadi Dara ancient copper occurrence, the copper mineralization reflected in excavated copper-bearing mineralized zones and their associated alteration zones are confined to tensional composite fractures system extending for more than 3km in NW-SE and dip to SW with width reaches up to more. The Eastern sector of Wadi Dara ancient copper occurrence (Area-C), displays less extensive localization of excavated copper-bearing mineralized zones of twelve (12) ones enclosed in diorite and granodiorite country rocks extending in NW-SE direction with distances range from 10-160m with thickness ranges from 0.5 to1m.

Geochemical reconnaissance survey carried out on Wadi Dara ancient copper occurrence including collection and analyses of 206 hard rock samples from the three sectors constitute of such occurrence revealed the presence of copper mineralization as followings:

A- At the southern sector of Wadi Dara copper occurrence (Area- A), collected samples from excavated mineralized zones (33 sample) and associated alteration zones (34 sample) are totally revealed a promising copper- gold mineralization of

**Fig. 28. Field photograph for the southern sector of Wadi Dara ancient copper occurrence (Area- A) shows the extensive shallow excavated copper-gold-bearing mineralized zones masked with white aeolian sands.**

copper contents range from 5 ppm to 65000 ppm (6.5 %) with an average copper content of 9279 ppm (0.92%). The recorded copper mineralization is associated with a promising gold mineralization of gold contents range from< 0.01 ppm (ND) to 28.8 ppm with an average of 1.49 ppm. The recorded copper mineralization there is confined to excavated mineralized zones and alteration zones which host it. Excavated mineralized zones display a workable promising copper gold mineralization of copper content ranges from 52 ppm to 65000 ppm (6.5%) with an average content of (1.56%) associated with gold mineralization of gold contents range from< 0.01ppm to 24 ppm with an average content of 1.79 ppm Au (33 samples). Alteration zones which host the excavated copper-bearing mineralized zones display a low-grade copper-gold mineralization of copper contents range from 5 ppm -- 21416ppm (2.14%) with an average copper content of 3278 ppm (0. 32 %) associated with a low-grade gold mineralization of gold contents range from< 0.01ppm to 2.46 ppm with an average content of 0.36 ppm (34 samples). The only one collected sample from quartz vein there, displayed anomalous copper content of (0.18%) with highest recorded gold content in the area of 28.8 ppm. Listwaenite vein displayed less significant copper and gold contents.

B- At the Western sector of Wadi Dara copper occurrence (Area -B), geochemical reconnaissance survey carried out there involved the collection and analyses of (119) hard rock samples from excavated mineralized zones (13 samples), alteration zones which host excavated mineralized zones (80 samples), country rocks which host both of mineralized zones and alteration zones (24 samples) and basic dykes (2 samples). Analyzed samples (117 sample) of the different rock varieties except the two samples of basic dykes displayed copper-gold mineralization of copper contents range from 80 ppm to 28300 ppm (2.83%) with an average (0.55%,) associated with gold mineralization of gold contents range from <0.01 to 15.63 ppm with an average gold content of 0.64ppm. The recorded copper mineralization there is confined to excavated mineralized zones, alteration zones, country rocks which host both of the excavated mineralized zones and their associated alteration zones and basic dykes. Excavated mineralized zones revealed copper- gold mineralization of copper contents ranges from (0.25%) to (1.27%) with an average of 0.73 % associated with gold mineralization of gold contents range from 0.01ppm---12.68 ppm with an average of 1.74 ppm (13 samples). Alteration zones which host the excavated copper – bearing mineralized zones at the western sector (Area-B)

revealed copper- gold mineralization of copper contents range from 285 ppm to 28800 ppm (2.88%) with an average of (0.6%). The recorded copper mineralization in alteration zones is associated with a gold mineralization of gold contents range from < 0.01ppm to 15.63 ppm with an average of 0.64 ppm (80 samples). Country rocks which host both of the excavated mineralized zones and their associated alteration zones at the Western sector of Dara copper occurrence (Area – B), revealed copper mineralization of copper contents range from 80 ppm to 9950 ppm with an average of (0.28%). The recorded copper mineralization is not associated with any significant gold mineralization since the gold contents of the analyzed samples range < 0.01 to 0.64ppm with an average of 0.068 ppm ((24 sample). The two collected samples from basic dykes located at western sector (Area- B) revealed anomalous copper content of 2484ppm (0.24%) with 0.08ppm gold content in one sample and 270 ppm copper content with nil gold content in the other sample.

C- At the Eastern sector of Wadi Dara copper occurrence (Area - C), twenty (20) hard rock samples collected from the remnants of excavated mineralized zones, alteration zones and basic dykes during the geochemical reconnaissance survey carried out there revealed generally, copper-gold mineralization of copper contents range from 101 ppm to 34000 ppm (3.4%) with an average copper content of 10998 ppm ((1.09%). The recorded copper mineralization is associated with gold mineralization of gold contents range from 0.47ppm to 16.12 ppm with an average of 5.07 ppm in five (5) out of the twenty (20) analyzed samples. The recorded copper mineralization is confined to the excavated mineralized zones, alteration zones and basic dykes. Excavated mineralized zones display copper- gold mineralization of copper contents ranges from (1.22%) to (3.40%) with an average copper content of 2.46% associated with gold mineralization of gold contents range from 0 to 5.45 ppm with an average of 1.74 ppm Au (5 samples). Alteration zones located there, display a low-grade copper mineralization of copper contents range from 101 ppm to 7300 ppm with an average copper content of (0.268 %) associated with gold content of 16.12 ppm in only one out of nine (9) samples. Basic dykes located at the Eastern sector of Dara occurrence (Area– C), revealed pronounced workable copper mineralization of copper contents range from 362 --- 21400 ppm with an average content of 14177ppm (1.4%.) without any of gold mineralization.

Mineralogically, Wadi Dara copper mineralization is made up of Bornite (Cus-Cus.Fes) as the most common primary mineral associated with chalcopyrite. ($CuFeS_2$) while the secondary copper minerals are represented mainly with Covellite (CuS), Chalcocite ($Cu_2S$) and cuprite ($Cu_2O$). Dara copper mineralization comprises also hydrated copper carbonate minerals reflecting in Malachite (CuCo3. Cu $(OH)_2$ and Azurite ($CuCo_3$.Cu $(OH)_2$.

**7 Discussion**

Wadi Dara ancient copper occurrence area constitutes a part of the northern Eastern desert of Egypt which in turn is a part of the Nubian Shield which consists of deformed and metamorphosed Neoproterozoic crust (1000–542 Ma) evolved entirely during the East African orogeny event (late -Proterozoic). The arc accretion model is accepted here as the basic model for explaining the crustal evolution of the Arabian-Nubian shield. This cratonization model suggest that during the Upper Precambrian the area evolved from intra - oceanic island systems by repeated plutonism and volcanism and eventually arc accretion to truly continental character. Arc- arc accretion was accompanied by regional scale compressions stress which had resulted in the thrusting of ophiolitic mélange, thickening of the crust and creation of subduction zone associated with the emplacement of syn-tectonic granitoids and their equivalent volcanics and finally the emplacement of late-tectonics younger granites intruding the accreted terrains. According to the present work, Wadi Dara copper mineralization is completely confined to felsic intrusions of an association of diorite-granodiorite developed in association with the crustal evolution of Andean type continental margin island arc as an arc granitoids which emplaced during the subduction of oceanic crust under the continental crust of an oceanic island arc during the basins closure of East African orogeny. Abdelrahman and Doig (1987) stated that, at Wadi Dara copper occurrence, the diorite-tonalite rocks yielded a proposed age of 881±58 Ma and 650±16 Ma for the extrusive dacite and the copper-mineralized locations are subjected to extensive shearing, that exhibit defined trends, mostly directed NW-SE. Generally, the copper mineralization at Wadi Dara is lith- tectonically controlled. Structurally, Wadi Dara copper mineralization reflects fissures filling style of

mineralization evolved only within arc granitoids of granodiorite- diorite association of Andean type (continental margin island) tectonic setting. Wadi Dara copper mineralization is confined to an older composite fractures system striking roughly in NW-SE direction for more than 3km in NW- SE direction with an average width of 500, and steeply dipping to SW direction. The copper mineralized composite fractures system is displaced by several faults trending NE-SW and ENE-WSW which reflected as a major long fault runs along Wadi Dara. The mineralized composite fractures belt is also dissected by NE-SW faults which are displaced by the youngest ENE-WSW faults.

Mineralized composite fractures system had been developed only and totally in diorite-granodiorite association (Andean type continental margin island arc granitoids). That is means, the copper mineralization of Wadi Dara occurrence is lithologically and tectonically controlled and genetically connected and related to magmatic processes which formed the Andean type continental margin island arc granitoids of granodiorite- diorite association. In the light of plate-tectonic theory the gold and copper mineralization in the Eastern desert of Egypt are considered to be genetically connected to subduction related calc-alkaline magmatic activity which comprises calc-alkaline granites, subvolcanic granite porphyries, felsites, and Dokhan volcanics (EL Gaby, 1988). Gold mineralization in the Eastern Desert of Egypt was interpreted to be developed in association with Andean type (continental margin environment) calc-alkaline felsic volcanics and their magmatic batholiths and hence it genetically related to Dokhan volcanics and their plutonic equivalent (Hussein 1990). That is means, the copper mineralization of Wadi Dara occurrence is lithologically and tectonically controlled and is genetically connected and related to magmatic processes which formed the granodiorite- diorite felsic intrusions association of Andean type (continental margin island arc granitoids. Therefore, Wadi Dara copper mineralization is reflected in porphyry type copper- gold- mineralization developed in association of excavated mineralized zones, their associated alteration zones and their hosting country rocks.

At the Western sector of Wadi Dara copper occurrence (Area- B), the country rocks felsic intrusions of granodiorite- diorite association which host the excavated copper- gold mineralized zones and their associated alteration zones revealed copper mineralization of a pronounced anomalous copper contents range from 80 ppm ---9950 ppm with an average of (0.28%). The recorded copper mineralization is not associated with any significant gold mineralization since the gold contents of the analyzed samples range < 0.01 to 0.64ppm with an average of 0.068. That is means, the country rocks which enclosed both of excavated mineralized zones and their associated alteration zones displays a low-grade copper mineralization of an average copper content of 0.28% which is clearly exceeds 50 times of the crustal abundance of the copper in the felsic intrusions (60 ppm) which strongly support that we are dealing with a syngenetic porphyry type copper-gold mineralization at Wadi Dara occurrence.

At Wadi Dara ancient copper occurrence, the copper mineralization is litho-tectonically controlled and confined to granodiorite- tonalite-diorite association which subjected to various alteration processes. The mineralization is reflected in secondary copper carbonate minerals (malachite & azurite) which are concentrated along the planes of fissures and joints. The dominance of bornite, chalcopyrite, and other recorded copper-bearing sulfides can declare an original chalcopyrite rich domain. Iron oxides minerals are represented by magnetite, hematite, goethite and ilmenite. Magnetite is extensively martitized. Wadi Dara copper mineralized rocks are affected by hydrothermal solutions or meteoric waters, which led to phyllic multi-stages alteration processes (alteration processes mostly in granodiorites overprinting earlier K- metasomatism, whereas propylitic processes prevail in diorites. Generally, in these multi-stages' alteration processes (phyllic and propylitic overprinting earlier potassic alteration processes), prevail hydrothermal solutions with low salinities and low pH values, at temperature ranges from 200° to 350° C. The enrichment- depletion diagrams show obvious copper enrichment through these alteration processes, which is associated with some chalcophile and siderophile elements. Geochemical investigations of copper mineralized rocks declare that, these rocks have calc-alkaline affinity, following compressional trend. Geochemical characters show their obvious genetic relations through magmatic differentiation processes, producing an older diorite phase, followed by

granodiorite, that finally extruded by dacites (Oma ,2001). At Wadi Dara copper occurrence, the mineralized rocks are nominated modally as diorite, quartz-diorites, tonalites and granodiorites which subjected to various alteration processes. The mineralized copper rocks display an opaque minerals association are mainly the copper -bearing minerals. Bornite is the most common primary copper mineral associated with chalcopyrite, enargite, and pyrite. The secondary mineral association is represented mainly by covellite, chalcocite, stannite, and cuprite. The geochemical characters of copper mineralized rocks show their obvious close Genetic relations through magmatic differentiation processes producing an older diorite phase, followed by granodiorites that finally extruded by dacites.

Wadi Dara copper-bearing rocks are affected by hydrothermal solutions and / or meteoric waters which led to induced phyllic alteration processes mostly in granodiorites overprinting earlier K-metasomatism whereas propylitic alteration processes prevail in diorites. Chlorite geothermometry indicates that two main hydrothermal stages leading to the copper mineralization process in wadi Dara area. The first one occurred at about 443° C and confined to diorite and granodiorite rocks, while the second one happened at 283° C and confined to dacites. The second hydrothermal stage is also responsible for the formation of the mineralized quartz veins. The magmatic minerals like magnetite, zircon, apatite and other have some copper content which confirm the copper magmatic origin of copper mineralization at wadi Dara area. Generally, the source of copper mineralization and its mineralizing fluids(brine$H_2O$) at wadi Dara is the diorite – granodiorite magma itself. The mineralization occurred at two stages, the first is magmatic and exhibited by the formation disseminated copper ores like chalcopyrite in diorite – granodiorite rocks at 443° C or more and depth of 3.2 km at least. The second stage which represents the magmatic / meteoric fluids effect can be noticed by deposition of gold- bearing quartz veins at 170- 334° C. The copper mineralization of Dara area is considered the end result of magmatic / meteoric fluid – rock interactions. Mineralogically Wadi Dara copper occurrence comprises paragenetic mineral assemblages of pyrite- chalcopyrite- tetrahedrite-bornite assemblage, is of primary magmatic origin as confirmed by fluid inclusions investigation. This mineral assemblage is considered the source of the copper ores in the area. Chalcocite- iron oxides assemblage, secondary pyrite and chalcopyrite-covellite-sphalerite assemblage, malachite-azurite chrysocolla-goethite- calcite assemblage, Au-Ag-Cu- bearing quartz veins minerals assemblage is considered the end result of the hydrothermal activity system in wadi Dara area. The silica rich solutions of magmatic / meteoric origin have leached gold -silver, copper and iron oxides from the sulphide minerals and precipitated them in the open fractures system as mineralized quartz veins. Gold and silver are commonly associated with secondary pyrite, while copper is mostly represented by secondary chalcopyrite, covellite, malachite and rarely native copper, iron oxides are commonly hematite and goethite (Bishady et al., 2001). Wadi Dara copper mineralization is fundamentally a porphyry copper type which modified locally to produce a mineralized quartz vein of higher grade. An amount of copper mineralization and attendant hydrothermal alteration took place with the diorite- granodiorite and dacites. Each intrusion appears to have produced its own hydrothermal fluids to form their related deposits. From the distribution of alteration zones pattern associated with each pluton, the restricted development of sericitic alteration is taken to indicate the predominance of magmatic fluids rather than meteoric in the hydrothermal system at this stage. The positive relationship between the development of potassic zone and the $K_2O$ content of the granodiorite further suggests a close magmatic control of the hydrothermal fluids. In general conclusions, the source of copper mineralization and its mineralizing fluids(brines) is the diorite- granodiorite magma. The mineralization occurred at two stages. The first stage is the formation of disseminated syngenetic primary copper minerals like chalcopyrite and other in diorite- granodiorite at P-T conditions of 443° C or more and depth of 3.2 km. The second stage is the formation of Cu- bearing quartz veins (secondary copper ore like covellite and others), at a temperature range from 170° -334° C and a pressure of 208- 0.95 kb. The first stage was completely magmatic, while the second stage was formed as a result of mixed magmatic and convective recycled meteoric fluids Al-Boghdady et al., (2003). Gamma-ray spectrometry is considered as an effective and applicable tool for exploration of hydrothermal copper mineralization that possess

associating slight uranium enrichment at Wadi Dara copper occurrence (Mahdy, et al.,2007).

Porphyry Cu systems host some of the most widely distributed mineralization types at convergent plate boundaries, including porphyry deposits centered on intrusions; skarn, carbonate-replacement, and sediment-hosted Au deposits in increasingly peripheral locations; and superjacent high- and intermediate-sulfidation epithermal deposits. The systems commonly define linear belts, some many hundreds of kilometers long, as well as occurring less commonly in apparent isolation. The systems are closely related to underlying composite plutons, at paleodepths of 5 to 15 km, which represent the supply chambers for the magmas and fluids that formed the vertically elongate (>3 km) stocks or dike swarms and associated mineralization. The plutons may erupt volcanic rocks, but generally prior to initiation of the systems. Commonly, several discrete stocks are emplaced in and above the pluton roof zones, resulting in either clusters or structurally controlled alignments of porphyry Cu systems. The rheology and composition of the host rocks may strongly influence the size, grade, and type of mineralization generated in porphyry Cu systems. Individual systems have life spans of ~100,000 to several million years, whereas deposit clusters or alignments as well as entire belts may remain active for 10 m.y. or longer. The alteration and mineralization in porphyry Cu systems, occupying many cubic kilometers of rock, are zoned outward from the stocks or dike swarms, which typically comprise several generations of intermediate to felsic porphyry intrusions. Porphyry Cu ± Au ± Mo deposits are centered on the intrusions, whereas carbonate wall rocks commonly host proximal Cu-Au skarns, less common distal Zn-Pb and/or Au skarns, and, beyond the skarn front, carbonate-replacement Cu and/or Zn-Pb. The alteration-mineralization in the porphyry Cu deposits is zoned upward from barren, early sodic-calcic through potentially ore-grade potassic, chlorite-sericite, and sericitic, to advanced argillic, the last of these constituting the lithocaps, which may attain >1 km in thickness if unaffected by significant erosion. Low sulfidation-state chalcopyrite ± bornite assemblages are characteristic of potassic zones, whereas higher sulfidation-state sulfides are generated progressively upward in concert with temperature decline and the concomitant greater degrees of hydrolytic alteration, culminating in pyrite ± enargite ± covellite in the shallow parts of the lithocaps. The porphyry Cu mineralization occurs in a distinctive sequence of quartz-bearing veinlets as well as in disseminated form in the altered rock between them. Magmatic-hydrothermal breccias may form during porphyry intrusion, with some of them containing high-grade mineralization because of their intrinsic permeability. In contrast, most phreatomagmatic breccias, constituting maar-diatreme systems, are poorly mineralized at both the porphyry Cu and lithocap levels, mainly because many of them formed late in the evolution of systems.

Porphyry Cu systems are initiated by injection of oxidized magma saturated with S- and metal-rich, aqueous fluids from cupolas on the tops of the subjacent parental plutons. The sequence of alteration-mineralization events charted above is principally a consequence of progressive rock and fluid cooling, from >700° to <250°C, caused by solidification of the underlying parental plutons and downward propagation of the lithostatic-hydrostatic transition. Once the plutonic magmas stagnate, the high-temperature, generally two-phase hyper-saline liquid and vapor responsible for the potassic alteration and contained mineralization at depth and early overlying advanced argillic alteration, respectively, gives way, at <350°C, to a single-phase, low- to moderate-salinity liquid that causes the sericite-chlorite and sericitic alteration and associated mineralization. This same liquid also causes mineralization of the peripheral parts of systems, including the overlying lithocaps. The progressive thermal decline of the systems combined with synmineral paleosurface degradation results in the characteristic overprinting (telescoping) and partial to total reconstitution of older by younger alteration-mineralization types. Meteoric water is not required for formation of this alteration-mineralization sequence although its late ingress is commonplace.

Many features of porphyry Cu systems at all scales need to be considered during planning and execution of base and precious metal exploration programs in magmatic arc settings. At the regional and district scales, the occurrence of many deposits in belts, within which clusters and alignments are prominent, is a powerful exploration concept once one or more systems are known. At the deposit scale, particularly in the porphyry Cu environment, early-formed features commonly, but by no means always, give rise to the best ore-bodies. Late-stage

alteration overprints may cause partial depletion or complete removal of Cu and Au, but metal concentration may also result. Recognition of single ore deposit types, whether economic or not, in porphyry Cu systems may be directly employed in combination with alteration and metal zoning concepts to search for other related deposit types, although not all those permitted by the model are likely to be present in most systems. Erosion level is a cogent control on the deposit types that may be preserved and, by the same token, on those that may be anticipated at depth. The most distal deposit types at all levels of the systems tend to be visually the subtlest, which may result in their being missed due to overshadowing by more prominent alteration-mineralization. Porphyry copper deposits are typically mined by open-pit methods.

## 8 Conclusion

Geological and geochemical reconnaissance survey carried out on Wadi Dara ancient copper occurrence, revealed the presence of a porphyry type copper- gold mineralization for the first time in the basement rocks of the Eastern desert of Egypt. Porphyry copper- gold mineralization is reflected in swarms of shallow excavated copper-gold mineralized zones and their associated alteration zones; the country rocks which host excavated mineralized zones and their associated alteration zones and basic dykes as followings:

- Excavated copper- gold – bearing mineralized zones at the three sectors forming Wadi Dara occurrence display a promising workable copper-gold mineralization of 1.56 % an average copper content associated with gold mineralization of 1.79 ppm an average gold content at the Southern sector of Wadi Dara occurrence (Area-A) , workable copper- gold mineralization of 0.73 % an average copper content associated with gold mineralization of 1.74 ppm an average gold content at the Western sector of Wadi Dara ancient occurrence (Area-B) and a promising workable copper- gold mineralization of 2.4% an average copper content associated with gold mineralization of 1.74 ppm an average gold content at the Eastern sector of Wadi Dara ancient occurrence (Area- C).
- Alteration zones which enclosed the above-mentioned excavated copper- bearing mineralized zones display a low-grade workable copper- gold mineralization of an average copper content of 0.32 % associated with gold mineralization of an average gold content of 0.36 ppm at the southern sector of Wadi Dara ancient copper occurrence (Area-A), a workable copper- gold mineralization of an average copper content of 0.6 % associated with gold mineralization of an average gold content of 0.64 ppm at the western sector of Wadi Dara ancient copper occurrence (Area-B), and a low grade copper mineralization of an average copper contents 0.26 % without any gold mineralization at the eastern sector of Wadi Dara ancient copper (Area- C).
- Country rocks which host the copper-bearing mineralized zones and their associated alteration zones at Western subarea of Dara copper occurrence (Area- B) revealed copper mineralization of an average copper content of 2835 (0.28%) associated) with less significant gold mineralization of an average gold content of 0.25ppm Au in 6 out of 24 samples.
- Basic dykes located at the Eastern sub-area (Area- C) of Wadi Dara ancient occurrence revealed significant workable copper mineralization of an average copper content of 1.4 % without any significant gold mineralization (6 samples).

Wadi Dara ancient copper occurrence comprises a workable huge low-grade copper mineralization of a porphyry type style of mineralization associated with a secondary workable gold mineralization. Wadi Dara ancient copper occurrence is highly recommended for further investigations to asses and outline the first recorded gold- copper mineralization there.

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