July -2025

PROGRESSIVE REPORT

Regional geological mapping for cobalt and associated metals prospecting

BLOCK RS-12V

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BN ENERGY COMPANY LTD
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EXECTIVE SUMMARY

BN company was awarded (264 Km²) Concession for exploration and exploitation of Gold & Associated Metals in Block RS-12V the area located in the Red Sea State ARBAAT, locality.

Prospecting and Exploration activities have been completed in full swing with a dedicated team of National geologists. findings the promising and the general exploration and evaluation in substantial form will continue based on the findings of completed the first phase of exploration. The area of study has been investigated during a field trip generally oriented using Remote Sensing techniques and GIS to study the regional geology, and geochemical survey in large scale Reconnaissance exploration and identify potentiality of gold and association mineral and metals mineralization. detailed exploration to determination different target in concession block from the results of samples collected from surface/subsurface and geological interpretation in the field.

BN mining company has engaged the technical aid of Team of geo consultancy to achievements the complete of field trip for exploration program in the concession area.

According to geological works conducted by the Geologist team, throughout all of the license area, especially by reconnaissance geological trips, geochemical sampling and their respectively interpretation; the geological contours of the license area were verified and redefined.

Structurally the concession area effected by deferent phases of deformations (faulting, brecciating, schistosity, and shearing).

It should be clarified that developed map continuously get updated due to the company keeps conducting detail geological works in different locations of the license area.

The 1st stages of exploration activities in the area have shown that the concession Block RS-12V is a potential for large scale mining project this is evident from the conducive geological environment, geochemical anomalies and the confirmation of the chip samples taken from the anomalous catchments which explain and verify the interpreted geochemical anomalies.

The cobalt and associations minerals on the area of the block is Magmatic Sulfide Deposits which is cobalt are contained in Ni-Cu(-Co-PGE) sulfide deposits hosted in mafic and ultramafic igneous rocks, this deposit type comprises semi-massive to massive sulfides that occur within or near the basal zones of layered intrusive complexes, in discordant magmatic conduits, and within ultramafic intrusions and lava flows. The ages of the deposits, which approximate those of the host intrusions, range from Archean to Tertiary. Nickel is the principal metal commodity, and it is accompanied by subequal proportions of copper in most deposits; cobalt and PGEs are mining byproducts.

Detailed exploration work for the cobalt and associations mates executed in the study represents comprehensive investigations in many different aspects of geology including, structural and tectonic setting and minerals exploration represented in ore chip/channel sampling and measuring and evaluation of the exposed Ore.
Due to the field survey A total number of 26 samples from the cobalt and associated metals including the QC and QA samples were collected from deferent area (fold system) of concession shows potentiality and encouraging ore deposit.
The samples sent to ALS Lab and analyzed for cobalt and other metals as (Co,Cuu,Ni,Rh,Au, Pt,,Pd).
All Samples subjected to the preparation and analysis procedure are recorded result ranging for: Co from (9 to 131ppm), Cu; from 72 up to over 100000 ppm, Ni: from 8 to 116ppm which considered potential result but Au, Pt, and Pd were reflect low potentiality (appendix.2).
Whoever ALL of sample's analysis result resaved for the above-mentioned element are considered acceptable, potential and encouraging result guided to the next exploration phase.
by using the AI, DeepSeek & machine learning with the data of analysis and geological studies the project overview is seem very good and expecting good resource and indicator of NPV, and IRR well come in range of profitable in the scenario of the best choice as (attached presentation) for Cobalt, Nickel and Copper.
With the implementation of required studies and drilling application.
The analysis result is reflecting from the correlation between Au, Co, Cu, and Ni. Strong positive correlation between Co vs. Au Higher Cobalt levels associate with higher gold concentrations, Moderate negative correlation of Ni vs. Cu, Co vs. Cu** and **Au vs. Cu which show Higher Nickel levels associate with lower Copper concentrations and Ni vs. Au Weak positive correlation.

Introduction:

1.1 General

BN ENRGY COMPANY LTD dually registered company by the Government of Sudan represent Ministry of Minerals for exploration and exploitation of cobalt, Nickel, copper, zinc, PGE, Lead, gold and /or silver mineralization in block RS-12V in the Red Sea State. The area of study has been investigated during a field trip generally oriented using Remote Sensing techniques and GIS to study the exploration in regional geology, and geochemical survey to identify potentiality of mention mineralization above and associated metals.

BN company was awarded (264 Km^2) Concession for exploration and exploitation of Gold & Associated Metals in Block RS-12V the area located in the Red Sea State ARBAAT, locality. Prospecting and Exploration activities have been completed in full swing with a dedicated team of national geologists and updated the progress report by Mr. Mohammed Hammad Adam \BN. Technical Manager. The findings thus far are promising and the general exploration and evaluation in substantial form will continue based on the findings and complete of first phase of exploration. The area of study has been investigated during a field trip generally oriented using Remote Sensing techniques and GIS to study the regional geology, and geochemical survey in large scale Reconnaissance exploration and identify potentiality of above mention mineral and associated metals mineralization then detailed exploration to determination different target in concession block from the results of samples collected from surface/subsurface and geological interpretation in the field.

BN mining company has engaged the technical aid of Team of geo consultancy to achievements the complete the field trip of exploration program for concession area.

1.2 Property description and location

Sudan is located along the northeast coast of Africa on the Red Sea, and is bordered to the east by Ethiopia and Eritrea, to the north by Egypt, to the northwest by Libya, to the west by Chad and the Central African Republic, and to the south by South Sudan.

The BN company concession (RS-12V) located in a the area within the Red Sea State east of Sudan, at the area of Arbaat red sea state, approximately 40 km north west of port Sudan and 20 km west of Atbaat market.

From Port Sudan the License area can also be accessed via the Port Sudan road to Arbaat paved asphaltic road and then via unpaved road crossing flat and rocky area, to the block site .

Generally the area is easy accessed from port Sudan to the site throw Agabat Yas road

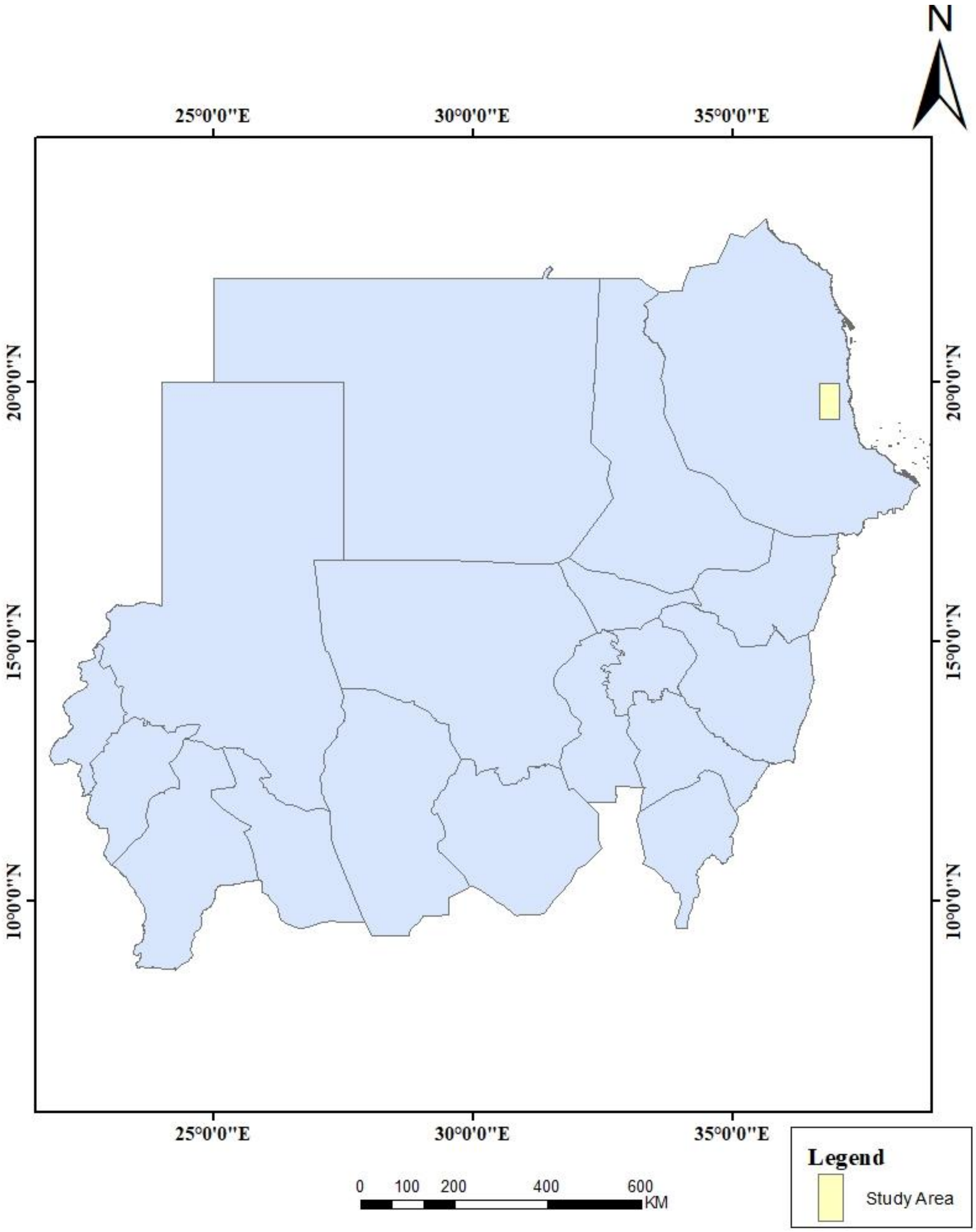


Figure (1): Location map of BN Mining Company.

Table .1 showing the corner coordinate of Block R12V

<table>
<tr><td>Block no</td><td>Corner</td><td colspan="3">Longitude</td><td colspan="3">Latitude</td><td>Area (Km²)</td><td>State</td></tr>
<tr><td rowspan="5">**RS12-V**</td><td>A</td><td>36°</td><td>51'</td><td>36.600"</td><td>19°</td><td>45'</td><td>40.000"</td><td rowspan="5">**264**</td><td rowspan="5">Red Sea</td></tr>
<tr><td>B</td><td>36°</td><td>57'</td><td>21.600"</td><td>19°</td><td>45'</td><td>40.000"</td></tr>
<tr><td>C</td><td>36°</td><td>57'</td><td>21.600"</td><td>19°</td><td>31'</td><td>26.400"</td></tr>
<tr><td>D</td><td>36°</td><td>51'</td><td>36.600"</td><td>19°</td><td>31'</td><td>26.400"</td></tr>
<tr><td colspan="7">**BN ENERGY COMPANY LTD**</td></tr>
</table>

1.3 Climate and Meteorology:

The property is in the desert of Northern Sudan where precipitation is infrequent. The climate is arid to semi-arid with a very hot season from May to September during which the maximum temperatures range from 45°C to 50°C and rainstorms and sandstorms may occur. The coolest period covers the months of December and February with daytime temperatures of 30°C and cool nights ranging from 8°C to 15°C. The dominant winds depend on the season: mainly from the west or northwest during the hot period, and from the north or northeast during the rest of the year. Intermittent rainfall can occur during the period from end of July up to October and the number of rain event averages 3-4. The average rainfall is around 30mm and the highest recording was 80mm.

1.4 Socio-economic features and Population (Local Resources)

The region is mainly inhabited by bija tribes mixed with some Arab tribes e.g. Elrashaida. The inhabitants are mainly rearing of the domestic animals such as camels, goats and sheep. Camels and Donkeys are routinely used for loading water from wells or dams on wadis and for transport purposes. Some inhabitants are practicing seasonal agricultural activities in the wadis, depending on the amount of rainfall. And some others work as labors in big cities.

Ecologically extremely marginal and traditionally very drought-prone with little or no infrastructure.

1.5 Physiography

Site is located Near to Wadi Arbaat north of Port Sudan. Region of the site belongs to the Sudan physiographic region and is the central to southern part of the Nubian Desert.

The region is characterized by many ragged hills (high relief) and relict mountains in the of Khor Arbaat.

Vegetation consists predominantly of sparse thorny shrubs and dry grasses in the valleys. Grasses cover the valleys for several months after heavy rains, serving as grazing grounds for sheep, goats and camels. The group of acacias can occur.

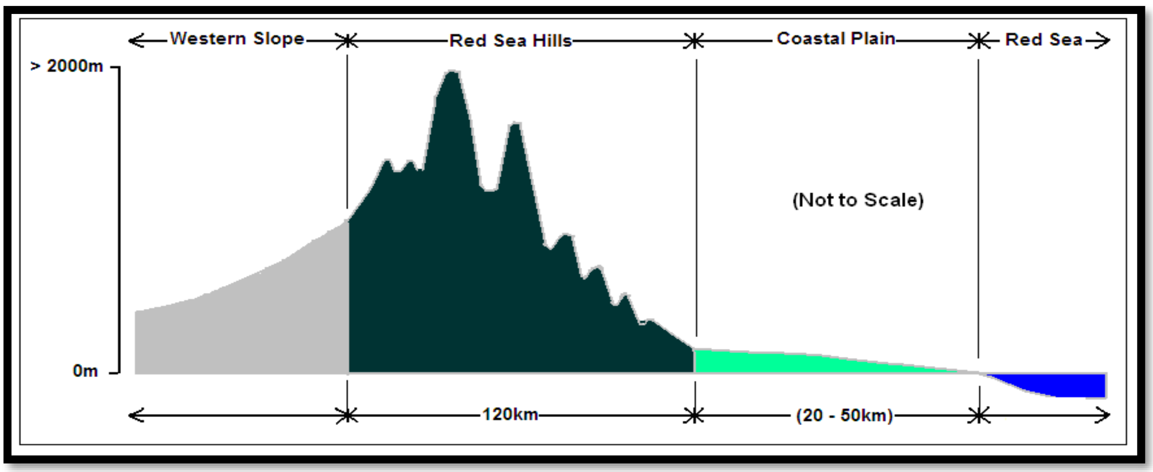


Figure. 2. West-East topographic profile showing the physiographic units

1.6 1. Drainage pattern in concession area:

In the study area the drainage is well developed represented by many stream and khors , this streams are dry for most of the year but carry considerable rain off during the rainy season that starts from late May to October .

The drainage pattern is structurally controlled, and most wadies and khors follow fault plains and major joints. Hand –dug wells along khors and wadies are the main water supply in the investigation area the valleys are usually dry and chocked with windblown sands, so that the derange channels often extended over several kilometers. In Wady Arbaat area the desert relief has highly affected the hydrographic network, which although remarkably dense is in an advanced stage of degradation and the main wadis are filled with sands and silts (Figure.3).

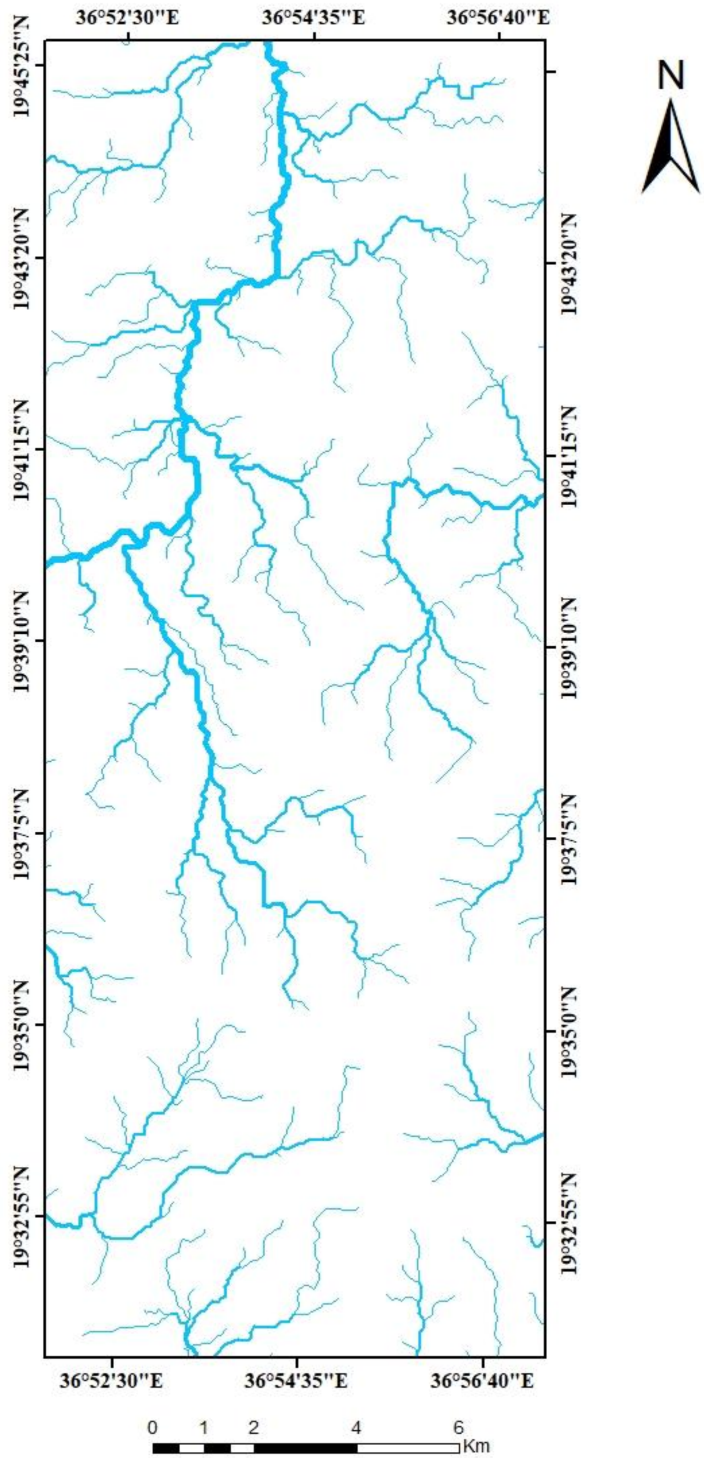


Figure No (3): Drainage map of the concession area.

An Image (1) showing the drainage with water in the area of the concession

1.6 Vegetation Cover

The scarcity of rainfall influences vegetation cover and its distribution. The dominant vegetation cover in the study area is typified by continental semi-desert and acacia desert species as well as other mountain species (Harrison and Jackson, 1958; Barbour, 1961 and Osman, 1996). The plants are of semiarid zone type, manifested by thorny bushes and acacia trees e.g., acacia species like (Kitir and Salam together with Tundob, Arak, mesquite, and Sidir trees. Ushar plants and small yellow-green phretophyte bushes also are found as an indication of the presence of shallow groundwater. The vegetation cover is distributed along seasonal watercourses (wadis) and in areas receiving run-off. The distribution of vegetation cover is highly controlled by watercourses, soil, topography, runoff, and rainfall.

An image No (2): showing the vegetation cover in the area of the block

1.7 Objective of the study

This study represents general investigations in many different aspects of geology including geological mapping, understudying the structural and tectonic setting and minerals exploration. Hence, the main objective of the study is to evaluate the project area in the above-mentioned aspects of geology and determine the potential targets for more exploration work.

The specific objectives are to carry out the following:

The main objective is to carry out Regional geological survey and exploration of the concession area containing the main geological elements (lithological, structural and mineralization zone), dealing with the geological and potentiality of cobalt, Nickel, copper, zinc, PGE, Lead ,gold and /or silver mineralization, associated minerals, structural setting and related targets occurrences.

This study represents site investigation and potentiality evaluation stage of the geological exploration investigations for the above mention element occurrences specially cobalt ,copper gold and others minerals in the concession area based on the remote sensing studied and field work survey. This investigation is supposed to shed light on the type of mineralization of the cobalt, copper gold and other above mention minrals within the lances'and associated minerals in the concession, potential zones and sectors, which consequently allows the recommendation of appropriate detailed exploration that will follow.

The fieldwork has been conducted in the concession area during march 2025. General geological exploration and chip channel sampling for each exposed and available ore in concession block area.

2- Methods of Investigation

Different methods have been conducted during this study to achieve the objectives stated in the previously. Remote sensing investigations represent the corner stone of this study.In this study GIS- Geo-database technology was developed as an integrated approach to amalgamate the various products of digitally processed remote sensing data, geochemical data, office mapping and field work data all together. Generally, the plan of work was designed to be conducted in four stages which are:

- Stage I: Pre-fieldwork Investigations.
- Stage II: Fieldwork Investigations.
- Stage III: sample Preparations and Laboratory Investigations.
- Stage IV: Office and Laboratorial work.

2. I- Pre field work Investigations:

This stage consists of two parts the first one deal with data collection and literature review for the area of interest and adjacent regions. The other part concerning with remote sensing investigations. The main target here is to prepare base layers and maps, including the geological, structural, drainage and topographic maps later on.

2.1.1. Remote Sensing data:

Remote sensing studies have been utilized in the present investigations using the optical satellite imageries of Landsat 8 OLI instrument

Remote sensing studies aim to reveal the geological, topographical aspects of the area, as well as to decipher the main lineaments and lithological units. Various digital image processing procedures have been attempted in order to the increase the interpretability of the images in a way facilitating the differentiation between the different lithological units. To this end, a package of digital image processing was applied upon the Landsat image, e.g. colour compositing, and decorrelation stretching. High resolution image was prepared for the current detailed investigations at the prospect scale. This image is fused with the panchromatic band in order to produce a relatively higher spatial and spectral resolution data set suitable for the intended task. Hard copy versions of the digitally enhanced satellite images were used in the field as a base map for direct plot of geological boundaries and structural measurement.

These maps were also fed into a computer attached to a hand held GPS which were all used together for navigation to the traverses and waypoints along them. Examples of the prepared images include the creation of a colour composite from Landsat 8 OLI image using the band combination of 752 in RGB, respectively (Figure. 4). This images discriminate the different lithologies to an acceptable degree. The digitally processed data of Landsat imageries paved the way for the geological studies in the Block and reduced both the time span and costs of the field work

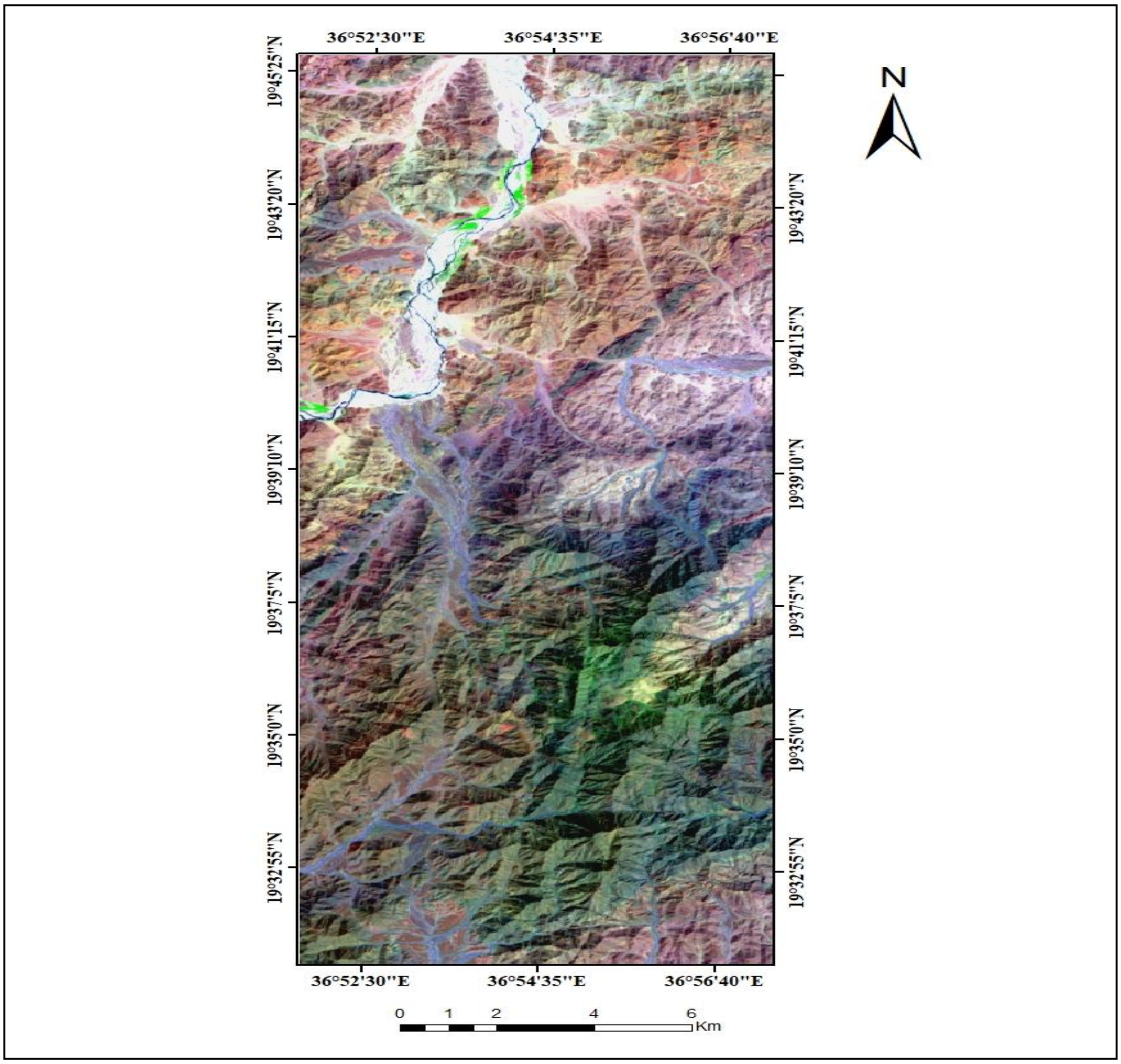


Figure (4): Color composite image obtained using bands 752 in RGB, respectively

Principal Component Analysis (PCA)

Principal component analysis often called PCA, or Karhunen- Loeve analysis. The transformation of the raw data using PCA can result in new principal component images that are more interpretable than the original data (Jensen, 1996). The PCA is used to compress the information content of a number of bands of imagery or to reduce the dimensionality from a number of bands to two or three PCs (Jensen, 1996). It is also used to reduce the redundancy of information in highly correlated image set.

Using the six reflected multispectral bands of Landsat 8 OLI, PCA have been performed over the study area. This procedure has resulted in the production of six principal component images.

Firstly, this analysis was applied to the six Landsat 8 bands (2, 3, 4, 5, 6, and 7).This result allowed to identify which PC contains more useful spectral information from Landsat 8 bands which has much higher contrast than the original bands.

The first three principal components (PC1, PC2 and PC3) were then combined to create a color composite by assigning the first principal component to Red, the second one to Green and the third to Blue filters. The obtained PCA colour composite is displayed in (Fig 5). This image show the hydrothermal alteration in light green color

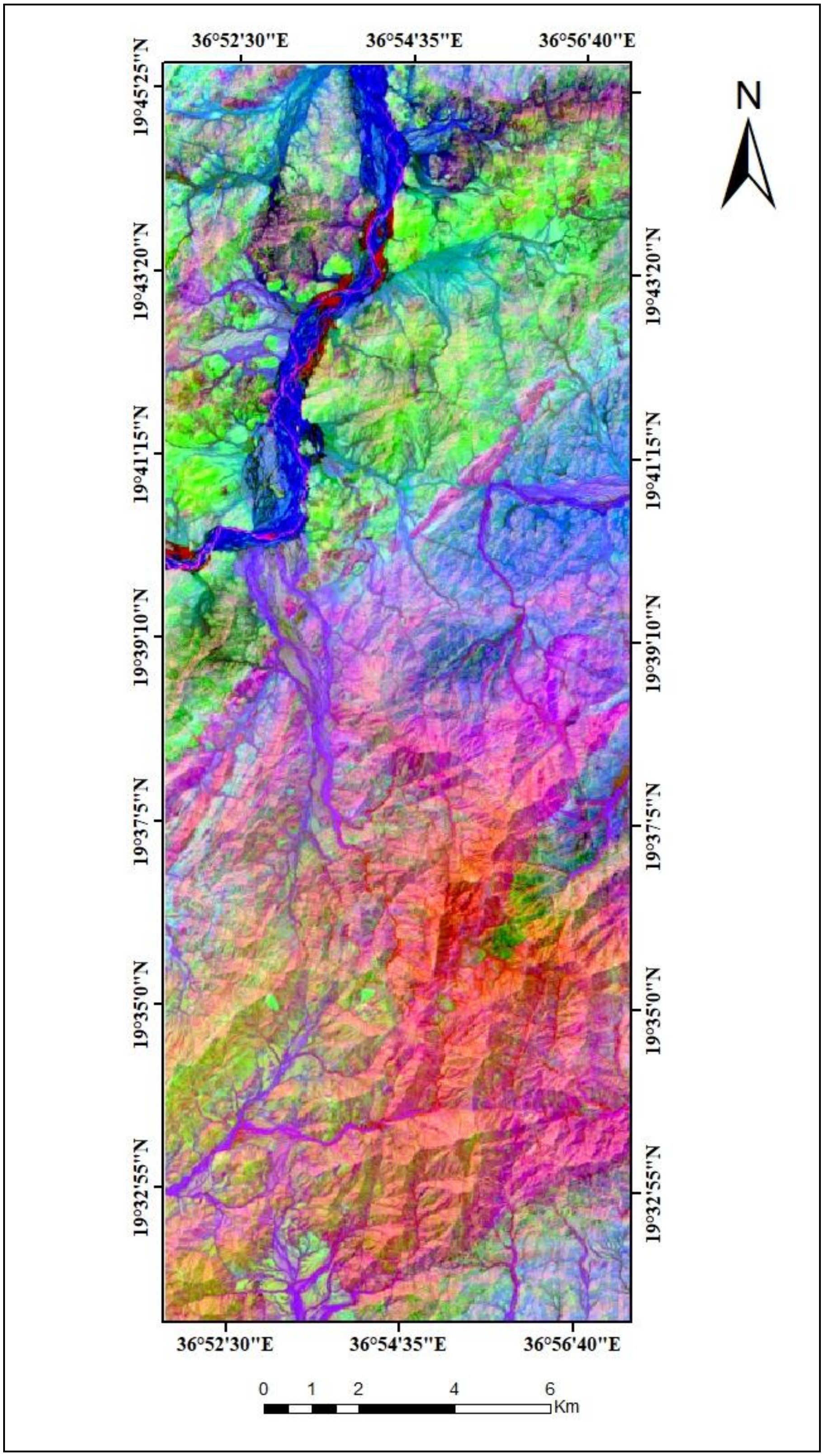


Figure (5): Principal component analysis color composite obtained by assigning PC1, PC2, PC3 to RGB, respectively.

In this study, it was carried out the Crosta technique (Crosta and Moore, 1987), where the Eigenvector statistics output of PCA was analyses in way to identify the PC that contains the spectral information of the target minerals. These selected PC images could then show the targeted minerals by highlighting them as bright or dark pixels, according to the magnitude and sign of the Eigenvector Loadings.

For mapping iron oxides, Landsat 8 bands 2, 4, 5, and 6 were used and for hydroxyl bearing minerals Landsat 8 bands 2, 5, 6, and 7 were used.

An image displaying pixels with anomalous concentration in hydroxyl and iron oxides bearing minerals as brightest pixels was created by merging of hydroxyl bearing image and iron oxide bearing image, by using Crosta technique. This new image was combined with the other two in a RGB composite (Iron oxide bearing image, iron oxide and hydroxyl bearing image, hydroxyl bearing image). A colour image resulted where bright pixels within alteration zones are areas where both iron stained and argilized; bright reddish to dark orange correspond to areas more argillaceous than iron stained; bright cyan to bluish zones are more iron stained than argilized (Figure 6).

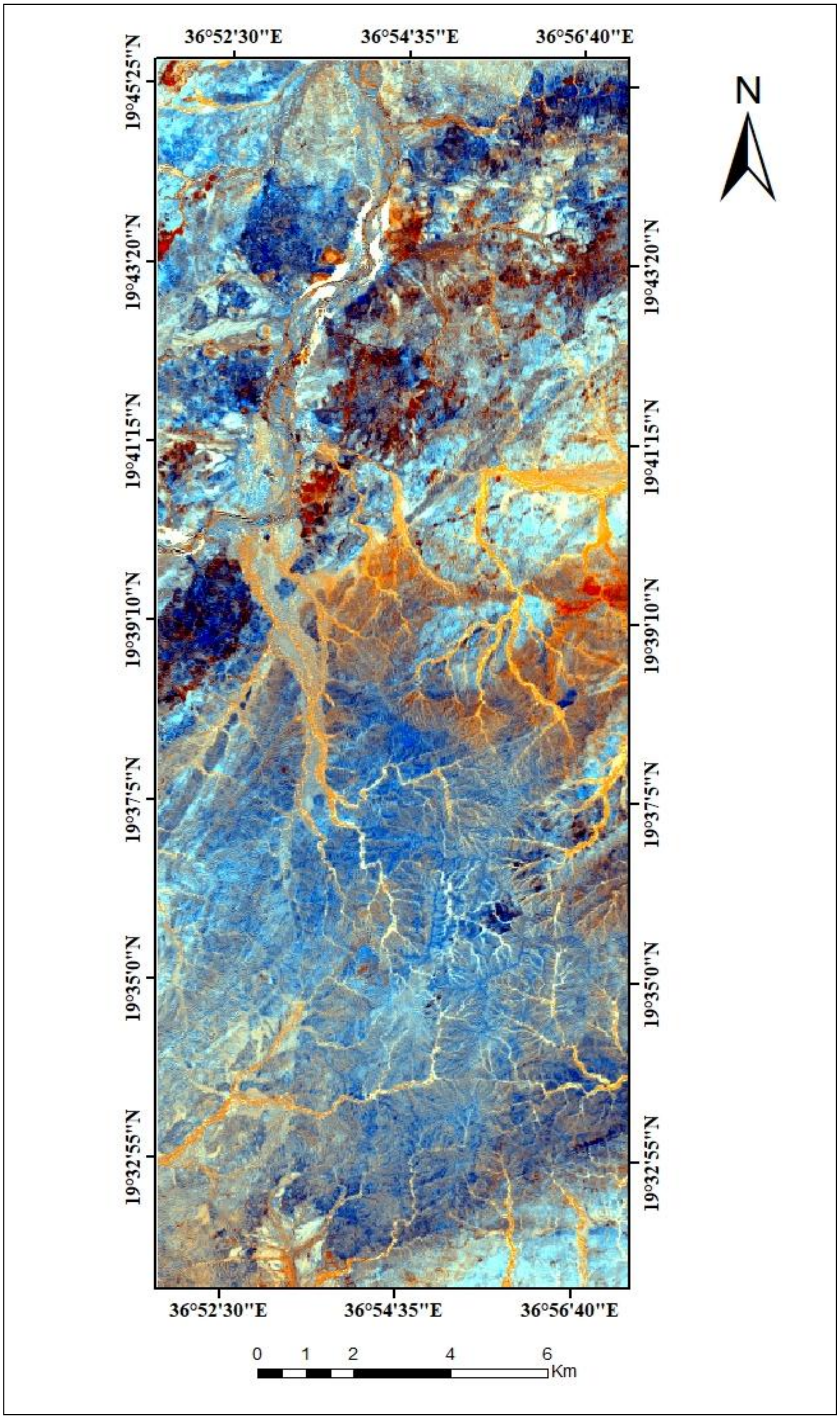


Figure (6) – RGB combination using hydroxyl bearing image, hydroxyl and iron oxide bearing image, and iron oxide bearing image. This composite map the hydrothermal alteration areas.

Band Ratioing

Ratio images are prepared by dividing the DN value in one spectral band by the corresponding DN value in another band for each pixel (Sabins, 2000). It is one of the most commonly used transformations applied to remotely sensed images because certain aspects of the shape of spectral reflectance curves of different earth surface cover types can be brought out by rationing and because the undesired effects on the recorded radiances such as that resulting from the variable illumination caused by variations in topography can be reduced (Mather, 1999).

Ratios images are known for enhancement of spectral contrasts among the bands considered in the rationing and have successfully been used in mapping alteration zones (Segal, 1983; Kenea, 1997).

Different band ratios were tested in this work, in order to enhancing hydrothermally altered rocks and lithological units. The selection of bands are related to the spectral reflectance and position of the absorption bands of the mineral or assemblage of minerals to be mapped.

An image incorporating these band ratios will discriminate altered from unaltered outcrop and highlight areas where concentration of these minerals occurs. An image using Sabin's ratio (4/2, 6/7 and 6/5 as RGB) was produced for lithological mapping and hydrothermal alteration zones (Fig 7). The ratio 4/2 was used for mapping iron oxides as hematite, limonite and jarosite, and has high reflectance in red region. The ratio 6/7 it's used to map clay minerals as kaolinite, illite and montmorillonite. The ratio 6/5 shows high reflectance in presence of ferrous minerals. In this figure the sky blue areas highlights hydrothermal alteration in outcrop rocks.

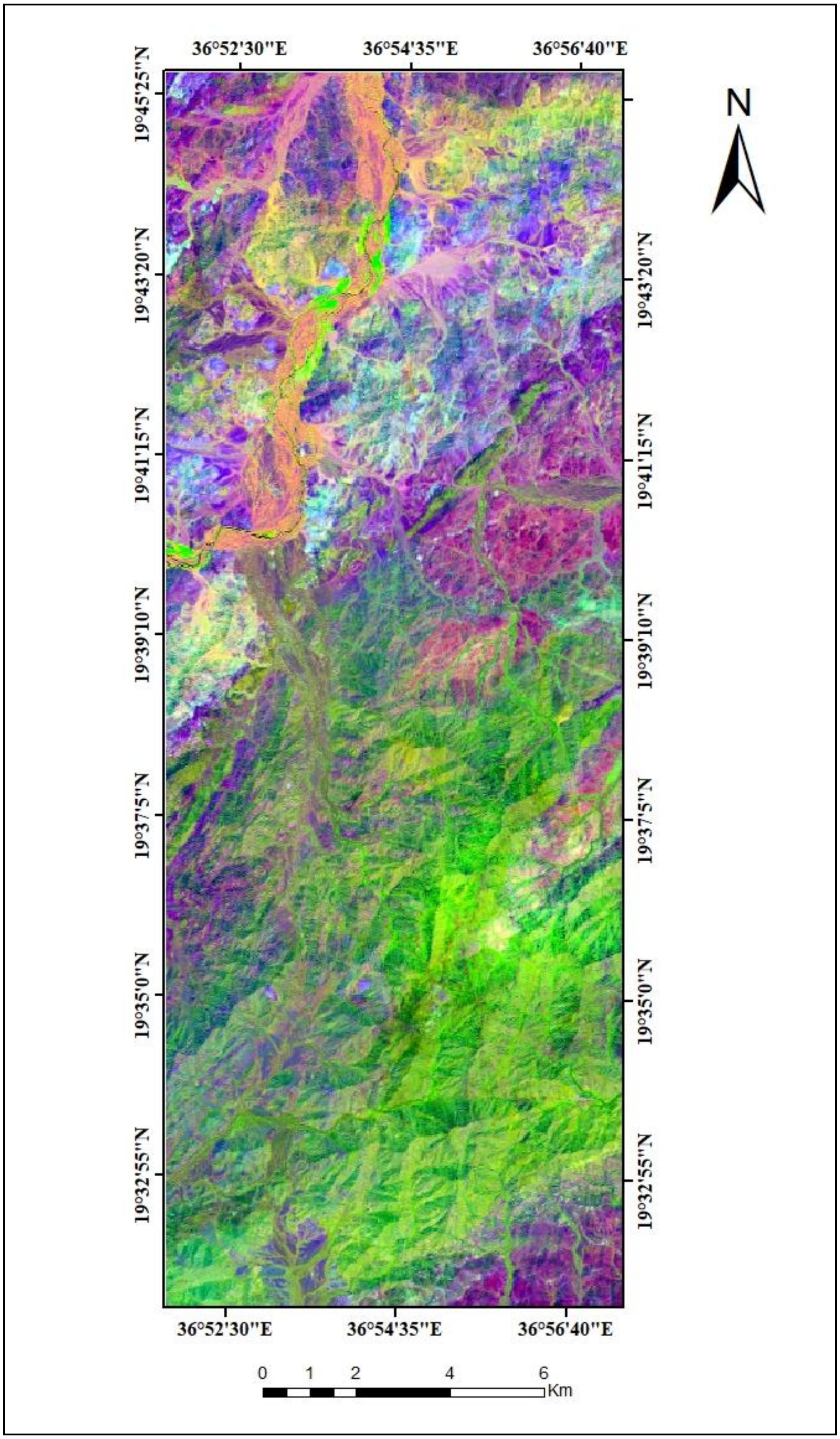


Figure (7): Sabin's ratio image (4/2, 6/7, 6/5). sky green altered rocks.

An additional RGB composite was created with bands (7/5; 5/4; 6/7) in RGB respectively figure (6) that revealed as a good combination for geological purposes. In this image (Figure 8), hydrothermally altered rocks are identified as purple and red.

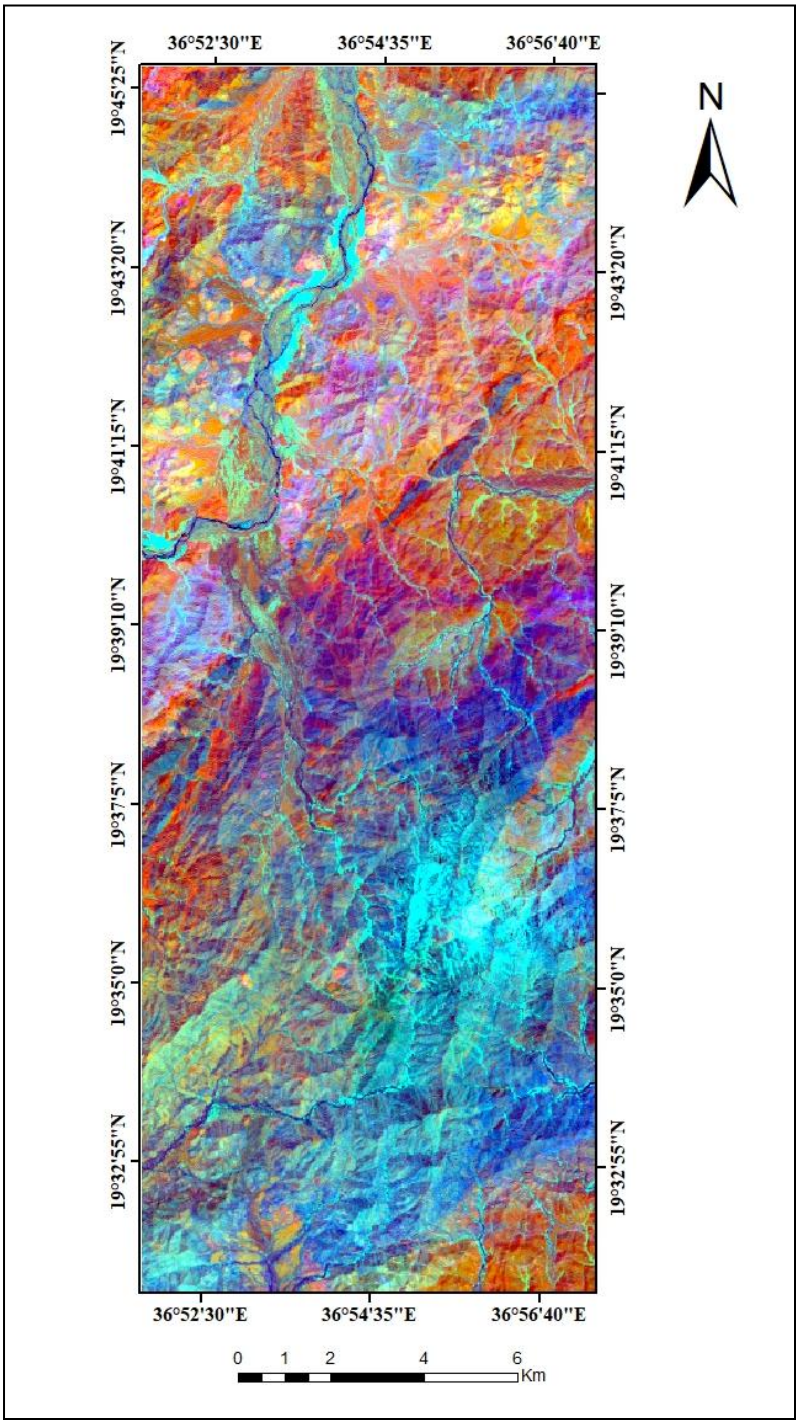


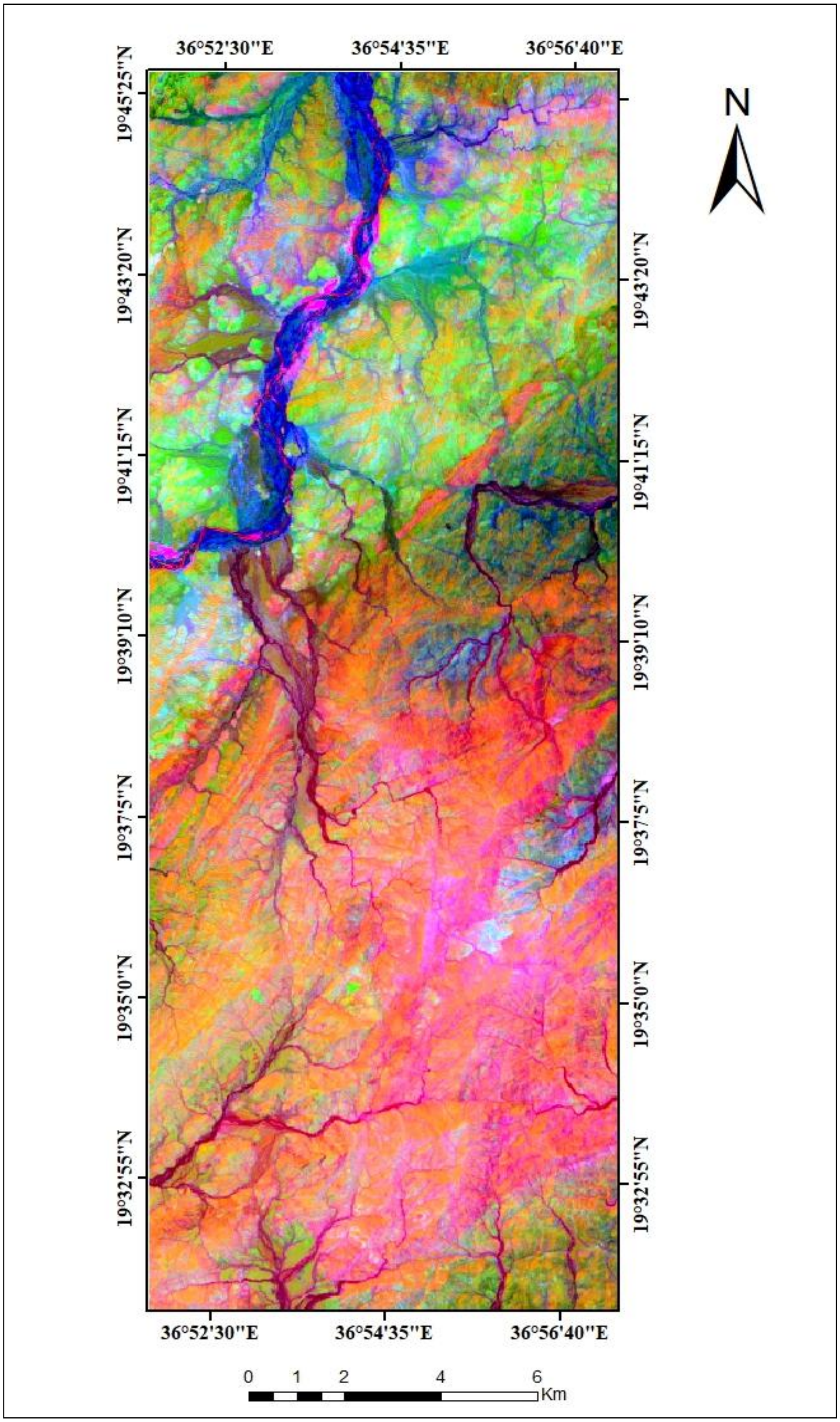
Figure (8): Kaufmann ratio (7/5, 5/4, 6/7). This band ratio combination highlights hydrothermal alteration in red and purple colors.

Minimum Noise Fraction (MNF) Transform

After applying the MNF technique to OLI and ASTER subset data, 7 MNF images of OLI and nine MNF images of ASTER are apparent. A plot of eigenvalues versus MNF band number shows a sharp falloff in eigenvalue magnitude between 1 and 7 for OLI.

Usually the first few MNF bands convey the most information, while subsequent bands increasingly contain noise. The visual inspection of the MNF bands revealed, that a heterogeneous surface composition could also be expected in the study area.

The MNF components of 1, 2 and, 3 are assigned to RGB band combination of Landsat OLI data were assigned to RGB band combination (Figure 8). The results showed that the alteration appear as orange color, the schist as green color in the study area and (Fig 9).



Figure(9): MNF1, MNF2, and MNF3 in RGB of OLI image

3-GEOLOGICAL SETTINGS AND MINERALIZATION

3.1 The Arabian – Nubian Shield

The Arabian Nubian shield (ANS) represents predominantly juvenile continental crust in that it was deformed by differentiation of mantle melts largely without reworking of preexisting continental crust (Stern, 1994). The Sudanese part of the Arabian-Nubian Shield is exposed in the Red Sea Hills of NE Sudan in which the Arbaat area is located.

The ANS represents the northern part of the east African Orogeny, which formed due to collision between east and west Gondwana from this collision the grater Gondwana are formed at the end of Wilson cycle that encompassed most of the Neoproterozoic and defined the pan African orogeny (Stern, 1994).

The Pan-African Orogeny in the Arabian-Nubian Shield is generally considered to span the period 950-550 Ma (Kennedy, 1964; Greenwood, et al. 1976; Kroner, 1984). Rock associations of dismembered arc volcanics and associated intrusive rocks, immature sediments and ophiolites of arc and back arc basin affinities dominate it, which are predominantly in the greenschist facies of metamorphism. Towards the west, they pass into high- grade metamorphic lithologies. This change in metamorphic grade has been interpreted as indicating a pre- Pan- African origin of the high- grade rocks (Vail, 1979; El Nadi, 1984).

The Nubian Shield is composed of a number of terranes (Gerf Terrane, Gabgaba Terrane, Gebeit Terrane, Haya Terrane and Tokar Terrane which are separated by E to NE trending ophiolite-decorated sutures formed during the Pan African Orogeny between 900 –550 Ma ago (Kroner, et al.1987; Fig. (9)

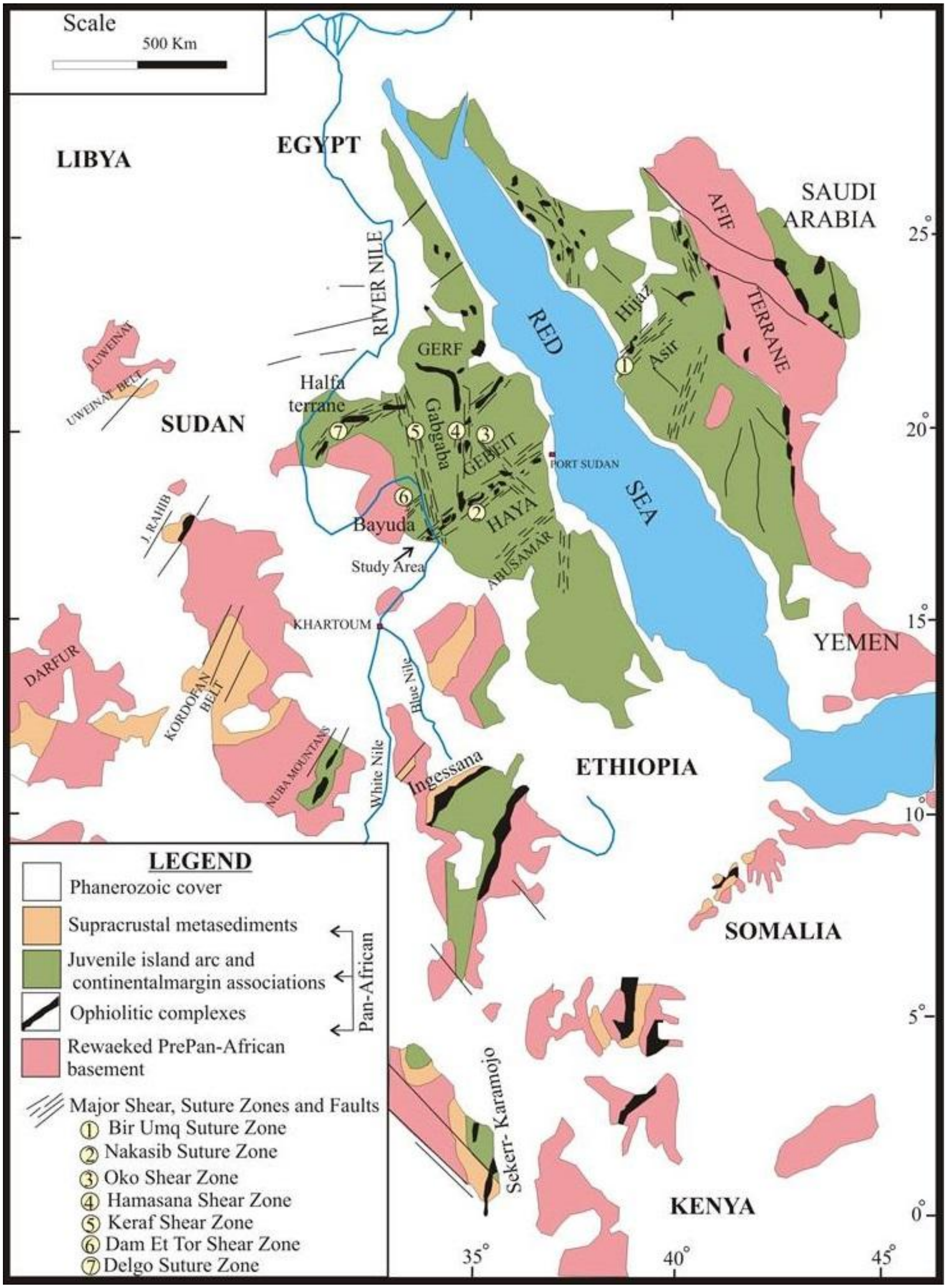


Figure (10): tectonic map shows the Precambrian structures, major shear and suture zone.

3.1.1. Litho-stratigraphic Unit of the Red Sea Hills

The Red Sea Hills region of NE Sudan is a part of the ANS of Proterozoic era. It lies in the central part of the Nubian segment. It extends northwards through the eastern desert of Egypt and Southwards across the Sudan- Eritrean border into the Ethiopian plateau, to the east is bound by the Red Sea coastal plain and the Nubian Desert to the west. Several have described the geology and subdivided The Basement Complex of the Red Sea Hills of NE Sudan geologists. (Gass, 1955) made the first attempt to classify the basement complex in the Red Sea Hills region into sedimentary-volcanic sequences, batholithic granites and younger granites. (Ruxton, 1956) Sub divided the basement complex of the region into three major sedimentary and volcanic subdivisions with four main periods of igneous intrusions. (Vail, 1979) described the basement complex as green schist assemblage. (Abdelsalam, 1993) described the geology of the southern central part of the Red Sea Hills east of long 35˚30˚along the Nakasib Shear Zone (Table 2).

However, the general description of the rock units has been agreed upon and can be summarized from the oldest are following below respectively.

3.1.1.1 High-grade gneisses (Kashabib Series)

This lithological unit was first described by (Gabert. et al, 1960), who named it “Kashabib Series” after the type locality of J. Kashabib. The early workers have regarded them as remnants of ancient continental basement (Ahmed, 1979). Some authors have described them to wide aureoles around granitoids batholiths (Kroner, et al., 1987a), while others have considered the high-grade rocks as local areas of increased deformation and metamorphism within the green schist assemblage (Embleton, et al. 1983).

El Nadi (1984, 1987) interpreted the Kashabib Series as Shelf metasediments of the Nile Craton. The rocks of this unit occur at Sasa plain west of Mohamed Qol village and southeast of Gebeit Mine. These metasediments show clear foliation. Gneissic structure is not always prominent. They include para- gneisses, Para schist in addition to ortho- amphibolites. Their petrography revealed a wide range of mineral composition of the rocks belonging to the unit. Medium-grained Hornblende represents the dominant mineral. Subdominant minerals include quartz and plagioclases (oligoclase –andesine composition) in addition to orthoclase. These rocks were subjected to metamorphism that ranges from the upper to lower amphibolite facies. The medium- to high-grade rocks of this unit are considered to represent the roots of the arc assemblage (El Nadi, 1984 & 1987)

3.1.1.2. Ophiolite Belts

An idealized fully developed ophiolite, as defined by the Penrose Conference in their lithologies and structures (Anon, 1972) consists of serpentinized, peridotite, tectonite overlain by cumulate mafic-ultra mafic rocks which grade upwards into massive gabbros, often with minor plagio- granites, cut by sheeted dolerite dykes, the latter grade into pillowed basaltic lava, with thin veneer of pelagic sediments comprising cherts, shales and minor lime stones. A major rock assemblage in the RSH comprises tectonically dismembered ophiolite complexes that characterize distinct highly strained major shear zones (Vail, 1983; Embleton, et al. 1983; Hussein, et al. 1984; Kroner et al. 1987; Abdel Rahman, et al. 1990b). Most of the complexes display the full range of the ideal ophiolitic lithologies and internal structure, although often no longer in the original stratigraphic order. Many small occurrences lack the diagnostic features to unequivocally identify them as ophiolitic derivatives. Furthermore, extensive serpentinization has profoundly transformed most of the basal units to talc sericite schists and listovenites. Nevertheless, large relatively intact, almost fully developed complexes form linear belts that mark sutures between previously separated terrains. The best preserved and documented examples are the Sol Hamed complex in the northeast (Fitches et al., 1983), the J. Gerf and W. Allaqi complexes in the north (Kroner, et al. 1987). The Onib and W. Sudi in the northwest (Hussein, et al. 1984), and the Nakasib Ophiolite at the center of the region (Embleton, et al. 1983).

3.1.1.3. Lower Volcano sedimentary Units (Nafirdeib Series)

The most extensive exposure of this unit in the Red Sea Hills occur in the Gebeit terrane the volcanic rocks range in composition from basalt and basaltic-andesite to andesite and Rhyolite which have calc-alkaline affinity (El Nadi, 1989). The metamorphic grade for this lithological unit is a low – to medium grade (greenschist to epidote - amphibolite facies). Kröner, et al. (1987) correlated the whole Gebeit volcanic terrain with the 700- 850 Ma old Hijaz arc of western Arabia as interpreted by Camp (1984). He suggested that Gebeit arc volcanic and the Hijaz arc form a broad NE trending arc complex.

3.1.1.4.Upper Volcanosedimentary Unit (Awat Series)

To designate the volcano - sedimentary sequence unconformably overlying the Nafirdeib series, the upper volcano - sedimentary unit has been previously named Awat series by Ruxton (1956). The volcanic part of this unit is dominantly acidic which includes Rhyolite, rhyodacites and dacites constitute the major lithologies in addition to Ignimbrites and other acidic pyroclastics. The sedimentary part of the upper volcano-sedimentary unit comprises siltstone, greywackes, red conglomerates, Limestones, quartzites and mudstones. The rocks of this unit are less altered, less metamorphosed and less deformed compared to the lower volcanosedimentary unit. The dating the Awat volcanic sequence on the basis of presumed contemporaneous intrusives at 740 Ma (Embleton, et al. 1983). This unit was correlated with the molasses-type sediments of the Hammamat group of eastern Egypt (Ries, et al. 1983) and the J. Balah group in Saudi Arabia (Delfour, 1970). The geochemistry revealed calc-alkaline affinity, indicating that they are subduction related volcanic (El Nadi, 1984).

3.1.1.5 The Syn - to late- orogenic intrusions

They are heterogeneous batholiths of calc-alkaline rocks, which range in composition from gabbros to diorites, granodiorites and Granites. Tonalities and adamellites are less common. The calc- alkaline geochemical affinities characteristically indicate a sub duction related geotectonic environment. An age of 815 - 724 Ma has been assigned for the syn - collisional intrusives by (Klemenic & Pooles 1988). Brown (1980) suggested that the syn - to late-tectonic batholiths of the ANS have been emplaced between 960 - 520 Ma age. Foliation is very characteristic of these rocks, where it is emphasized by the alignment of the phenocrysts of K- feldspars, hornblende and biotite. Rocks of this group are usually chloritized and epidotized. They occur as high rugged mountains but when they suffer from deep weathering they appear as subdued oval sandy plains.

3.1.1.6. The post- orogenic intrusions

The post- orogenic intrusions are characteristically bimodal (gabbro –granite) complexes giving way to alkaline Granites and syenites, with evidence of high level emplacement and the development of ring structures (Neary, et. al. 1976). The emplacement of the post-orogenic plutons is thought to be related to crustal relaxation which accompanied basement uplifting that followed the cessation of the accretion tectonics (Kenea, 1997).

3.1.1.7 Dyke swarms

Represent one of the most striking igneous features exhibited by the Red Sea Hills terrain. They invade the whole older lithostratigrphic units at different times and have different directions. Abu Fatima (1992) classified the dyke swarms into two major groups: older dykes and younger dykes. The older dykes were mostly emplaced at 600 -700 Ma, mainly less than 4 meter thick, and many are related to nearby igneous complexes, while some are likely to be feeders of the volcanic in the area (Babiker and Gudmundsson, 2004). According to Abu Fatima, (1992) the age of the younger dykes is 130 -140Ma, and their thickness may reach 30 m and they commonly form conspicuous ridges. The dyke swarms range in composition from acidic to mafic lithologies including granite, microgranite, Rhyolite, granodiorite, diorite Gabbro and basalt. The major trends are NE, ENE, NNE and NNW. Other common trends are NW, E-W and to a lesser extent N-S.

3.1.1.8 Cenozoic Sediment

This group comprised the siliciclastic and shallow marine, rift-related Cenozoic sediments have been witnessed all along the Sudanese coastal plain, both in drilled boreholes and as surface outcrops. They have a maximum thickness of 4162m as encountered in Durwara II well, 70 km south of Portsudan. They have been divided into: Mukawar Formation, Hamamit Formation, Maghersum Formation, Khor Eit Formation, Abu Imama Formation and Dungunab Formation, in addition to the older gravel (Sestini, 1965). Bunter and Abdel Magid (1989) have recognized the close similarities between the gulf of Sues sediments and those of the Sudanese Littoral zone. They discussed the tectonic and paleogeographic evolution of the Red Sea-Gulf of Suiz graben and divided it into two major tectonic phases; pre-rift and syn-rift and further divided the latter phase into syn-rift pre-salt and syn-rift post-salt phases. These sediments vary from Upper Cretaceous continental sandstone, Eo- Oligo-Miocene shallow marine limestones to thick Miocene evaporites sequences with coarse - to fine - clastic sediments. The older gravels unit (a few to 25m thick), unconformably overlies the Miocene sediments and they represent the different alluvial fan cycles that occurred during the Pliocene-Pleistocene time. The emergent Pleistocene reefs occur as linear terraces, running parallel to the shoreline. Four distinct reef terraces have been identified by Sestini (1965). Their formation was attributed to eustatic changes in sea – level (Whiteman, 1971; Babikir, 1994).

3.1.1.9. Tertiary volcanics and related minor intrusions

The Cenozoic volcanics are widespread in east Africa, especially in Egypt, Ethiopia and east and north central Sudan, (Vail, 1971, 1973; Almond, et al. 1977). Firstly, these volcanics were described them in more detail and related them to Tertiary-Quaternary volcanic activity (Andrew, (1948); Vail (1971); Almond, et al. (1969 & 1977). These volcanics have been reported from various localities within the Red Sea hills terrain (Gass, 1955; Kabish, 1962; Whiteman, 1968; and El Nadi, 1984). Some of them have been related to the Red Sea Rift (Vail, 1978), while others have been considered to be part of the Ethiopian volcanic plateau. The available field radiometric evidence is sparse but sufficient to show that the volcanicity in north and northeastern Sudan began in upper Cretaceous times and continued until the recent (Almond, et. al. 1984). Related dykes and sills are mainly basaltic in composition.

3.1.1.10 Recent Sediments

All the lithology mentioned above are covered by Quaternary to Recent sediments. They occur as a result of the interaction between the Aeolian and fluvial sedimentary processes acting within the Red Sea hills terrain Alluvial fans, wadies deposits and fan-delta deposits represent the products of the fluvial processes. These sediments include gravels, sands, clays, sandy clays and silt.

Table 2. Litho-stratigraphic Units of the Red Sea Hill

	(9) Unconsolidated sedimentary cover (Recent) + Costal sediments	Post pan African Mainly Mesozoic Tertiary < 500 Ma
	(8) Cenozoic volcanics	
Syenite Granite Gabbro	(7) Anorogenic (ring complexes)	
Syenite Granite Gabbro	(6) Post-late orogenic intrusives (batholithic)	Intrusive Pan-African 890-500 Ma
Mainly granites and granodiorites	(5) Early or Syn-orogenic Granitoids	
Greenschist facies	(4) Metavolcano- sedimentary Assemblage Thrust	Pan-African 900-500 Ma
Imbricated in the unit 4	(3) Ophiolitic complexes	
	(2) Amphibolite facies metasediments	Pre-Pan African >1200
	(1) Grey gneisses +granulites	

3.1.2 Structural Framework of Haya Terrane

The Neoproterozoic Arabian –Nubian Shield is characterized by two main types of deformation belts (Abdelsalam and Stern, 1996). The older deformation belts are E- to NE- trending ophiolite-decorated arc – arc sutures formed during collision of intra - oceanic island arc - back arc terranes that occurred between 800 and 700 Ma (Stern, 1994; Abdelsalam and Stern, 1996;). The exception to this is the eastern part of the Arabian Shield where sutures trends NW. The younger deformation belts, which have been referred to as post accretionary structures (Abdelsalam and Stern, 1996), are N- to NW- trending structures and crosscut the arc – arc sutures. These belts were developed in response to shortening of the Arabian – Nubian Shield between the converging fragments of East and West Gondwana. Post-accretionary structures in the Arabian – Nubian Shield consist of (among other structures) N - trending shortening zones in the form of upright folds that developed due to E – W directed shortening at 670 – 610 Ma, and NW- trending sinistral strike-slip faults, that developed at 640 – 560 Ma. Haya Terrane is a segment of the Nubian Shield, which is formed by accretion of island arc, back- arc terranes and continental micro plates during Neoproterozoic (900 -550 Ma) along E- NE - trending ophiolite decorated sutures (Vail, 1985; Kröner, et al. 1987, 1991; Stern, et al. 1990). The Arabian - Nubian Shield suffered several stages of deformation associated with low- grade greenschist metamorphism, and became fully stabilized during the Pan-African tectono - magmatic stage (ca. 550 Ma). Major ductile shearing along strike-slip zones, transcurrent faulting and overriding tectonic forces from the east or southeast are believed to have caused the major NE-trending structures (folds and faults) in the various Red Sea Hills terranes (e.g. Almond and Ahmed, 1987; Almond and Osman, 1992; Stern, et al. 1989; Lescuyer, et al. 1994). Oblique to, and crosscutting these sutures, are younger (c. 640 - 560 Ma) N- NW-trending left-lateral strike-slip shears (AbdelsThe Haya terrane appears to be dominated by complex interaction between a wide spread system of ductile shearing and ENE- to NS-trending folding in addition to NW directed brittle shearing and thrusting it is separated from Gebeit terrane by NE - trending Nakasib - Amur suture (Emblton, et al. 1983; Kröner, et al. 1987; Abu Fatima, 1992; Abdel Rahman, 1993; Abdelsalam, 1994) in the north and from Toker terrane by N-S trending Baraka suture in the south .The N- NNW trending Oko Shear Zone affected the northern part of Haya terrane (Abdelsalam, 1994). The ENE trending Khor Ashat Shear Zone divides Haya terrane itself into southern and northern parts. The northern part of Haya terrane is bounded by the Nakasib ophiolitic belt, which extends from north Portsudan in northern Arbaat area. It may represent the western continuation of the

Bir Umq ophiolitic belt of Saudi Arabia (Embleton, et al. 1983; Johnson, 2004). The Nakasib suture constitutes a well - defined shear and fold belt with sporadically serpentinized and carbonitized ultra-mafic rocks together with volcanics and sedimentary rocks (Kröner, et al. 1987; Abdelsalam, 1994). Original lithologies and primary structures are still intact in spite of pervasive greenschist facies of metamorphism (Abu Fatima, 1992). The Nakasib suture was modified by sinistral strike slip shearing along N to NW trends typified by the Oko shear zone (Almond and Ahmed, 1987; Abdelsalam, 1994). This sinistral movement of the Oko Shear Zone estimated to be about 30 km (Almond and Ahmed, 1987; Abdelsalam, 1994). Almond and Ahmed (1987) suggested a multistage history for the evolution of the Nakasib suture, while Abdelsalam, et al. (1993) suggested that the Nakasib suture evolved through a complete Wilson Cycle orogeny from rifting, through passive margin formation, to closure of the basin and suturing.

The previous regional studies (Guyot, 1983; Abu Fatima, 1992) of the deformational history of Haya Terrane showed that the area is subjected to at least four phases of deformation in the Pan African age.

D1 is characterized by the development of tight to isoclinal folds with an associated closely spaced axial planar cleavage (Sl). D1 is also characterized, by development of thrusts which tectonically stacked imbricate sheets of the Nakasib ophiolites.

D2 is generally coaxial with D1, and is characterized by the development of tight folds in which both bedding planes (SO) and S1-foliation are folded around NE-trending fold axes. However, the orientations of axial surfaces of these folds are modified by D3 folds. Thrusts which developed during D1 deformation continued to be active during D2.

D3 refolded both D1 and D2 structures and fabrics to produce gentle, nearly upright and horizontal, NE-trending antiforms and synforms, D3 is also responsible for the development of NW-verging thrust.

3.2 Geology of the Block RS-12V

The concession Block RS-12V and occupies an area of about 264 km² located in the northern part of the late Proterozoic Pan-African Nubian Shield of NE Sudan which is comprised of juvenile volcano-sedimentary sequences of oceanic island arcs affinities. The area has not been mapped in detailed before. In the present work ETM+ images interpretation of rock units together with the available information has been used to produce the geological map of the area (Fig. 10).

Extensive study of the ETM+ data and its products along with other collateral data (Abdelrahman 1993, Hussein 2004) has been used to establish a litho-stratigraphic sequence for the rock units in Block RS-12V (Table 3) below. The litho-stratigraphic Sequence for the rock Units According to the earlier previous work, the oldest sequence in the area around Block RS-12V is meta-volcano-sedimentary sequence. This sequence was subjected to folding, faulting and green-schist facies of regional metamorphism, Subsequently the sequence was intruded by syn-orogenic granitoids occupying large areas and traversed by frequent dyke swarms. The most recent event in the area is the emplacement of late to post orogenic complexes which were in turn followed by the injection of further dyke swarms. Unconsolidated recent sediments cover some areas in the Block. Unconsolidated Sediments Dykes and Veins Late tectonic granitic complex Syn- Orogenic Granitoids Ophiolitic Mafic-Ultramafic Complexes Low grade Metavolcano-sedimentary Sequence

Geological base maps at scale of 1:100000 have been constructed for the concession Block area The total area has been divided into five major domains for the glod and one main domain for cobalt and copper with assossotion minerals   during a reconnaissance trip. Land sat images band composites (7, 5, 4 and 3, 2, 1) in RGB used in the regional Geological mapping also Hydrothermal and mineral composites of band rationing have been used to generate targets for the alteration zones. A lineament map is also used to identify different trends of structures. Each locality has been documented and marked using GPS (Garmin 62s)

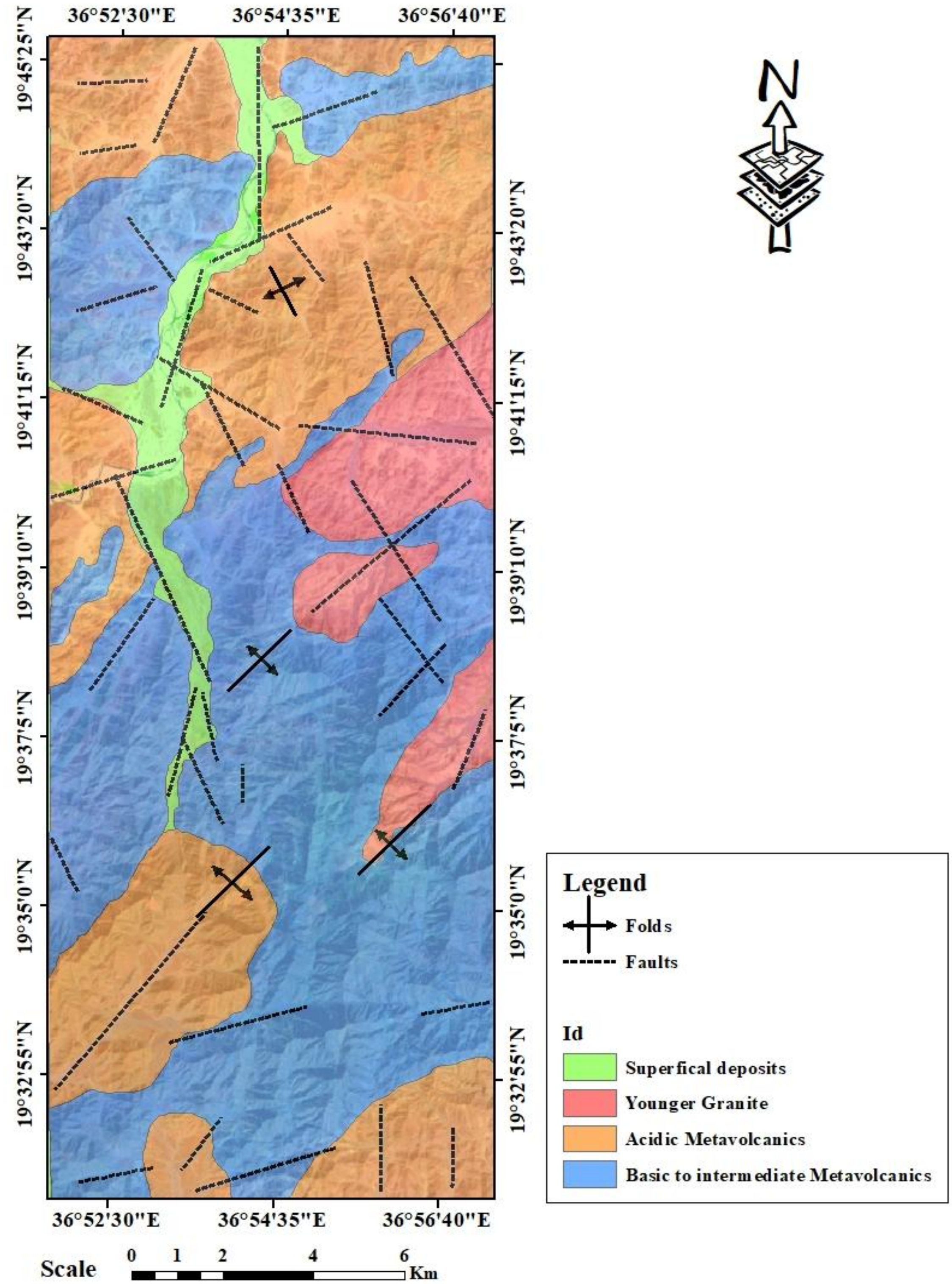


Figure (11) geological map of block RS-12V

Table No (3): below shows Litho-stratigraphic Sequence of Block RS-12V

Unconsolidated Sediments
Dykes and Veins
Younger Granite
Meta volcanic

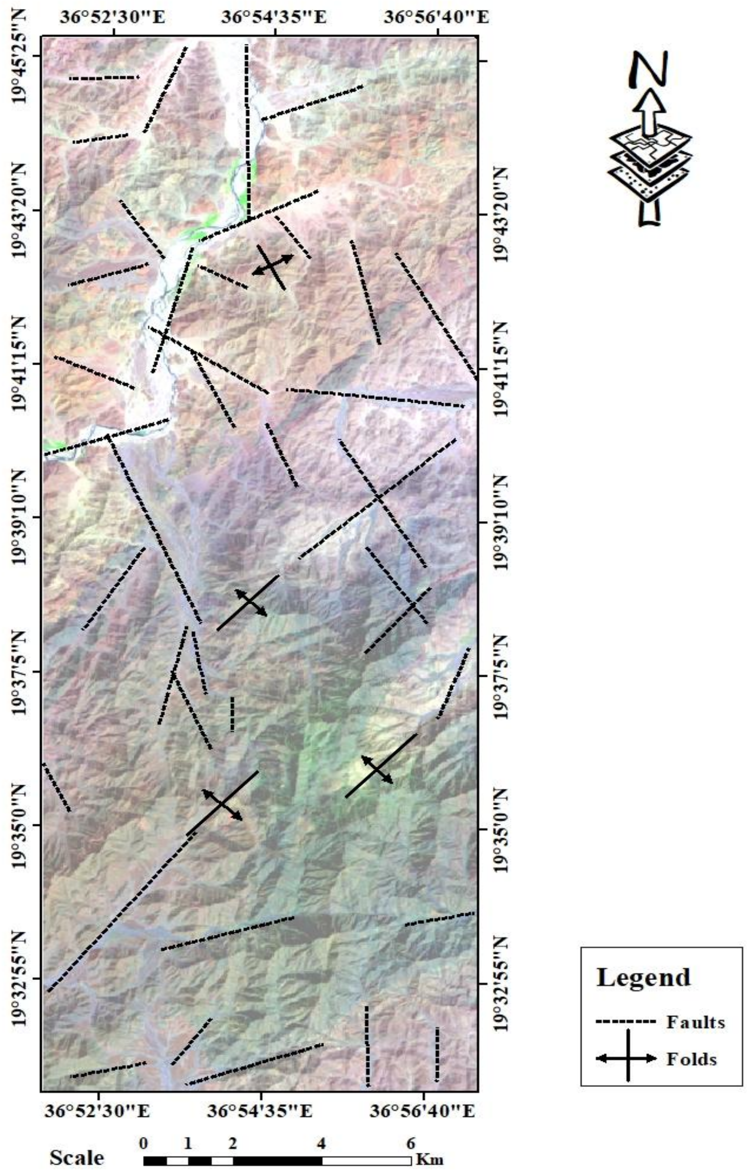


Figure (11) Structural map of block RS-12V

4. Previous exploration activates in area of block RS-12V

Theirs field trip was conducted to the area under investigation on the 1 th of November 2022 to Todanty area and others area surround on behalf of BN Energy CO. Ltd

The field team consisting of geologist/.Hozeifa Ismail khir ALLa. Geologist /Mohammed Bakri. Geologist /Hayder Mahdi have conducted due diligence survey in study area. The objective of survey was to evaluate the Cobalt potentiality of the area study. Therefore team has visited 3 locations. In order to know the geochemical concentration and total of 20 rocks chip samples has collected from the area of investigation.

The study found mineralization in this area is the VMS ore body with iron oxide and malachite (length about 300 meter – width about 50cm to 1 meter) content deferent minerals such as iron (magnetite) copper (malachite) contact with Alteration zone (schist, chlorite schist, diorite) There were a lot of basement rocks along in the area, basically granite, schist, and quartz veins cross the basement. There was a granite mountain in the area.

General trend of NE-SW. and total of 10 Chip samples has been taken from iron oxide with malachite ore body mineralization & Alteration zones of the obvious anomalies were collected by GPS for further mineralization analysis .(see same photo for mineralization ore body) ***Appendix(A)***

An image No (3-1): showing mineralization in the area   of the block

An image No (3-2): showing mineralization in the area   of the block

5. Potentiality of cobalt, copper, and associated metals in Area of (RS-12V)

5.1 introductions:

Cobalt is a silvery gray metal that has diverse uses based on certain key properties, including ferromagnetism, hardness and wear-resistance when alloyed with other metals, low thermal and electrical conductivity, high melting point, multiple valences, and production of intense blue colors when combined with silica. Cobalt is used mostly in cathodes in rechargeable batteries and in superalloys for turbine engines in jet aircraft. Annual global cobalt consumption was approximately 75,000 metric tons in 2011; China, Japan, and the United States (in order of consumption amount) were the top three cobaltconsuming countries. In 2011, approximately 109,000 metric tons of recoverable cobalt was produced in ores, concentrates, and intermediate products from cobalt, copper, nickel, platinumgroup-element (PGE), and zinc operations. The Democratic Republic of the Congo (Congo [Kinshasa]) was the principal source of mined cobalt globally (55 percent). The United States produced a negligible amount of by product cobalt as an intermediate product from a PGE mining and refining operation in southeastern Montana; no U.S. production was from mines in which cobalt was the principal commodity. China was the leading refiner of cobalt, and much of its production came from cobalt ores, concentrates, and partially refined materials imported from Congo (Kinshasa). The mineralogy of cobalt deposits is diverse and includes both primary (hypogene) and secondary (supergene) phases. Principal terrestrial (land-based) deposit types, which represent most of world's cobalt mine production, include primary magmatic Ni-Cu(-Co-PGE) sulfides, primary and secondary stratiform sediment-hosted Cu-Co sulfides and oxides, and secondary Ni-Co laterites.

The total terrestrial cobalt resource (reserves plus other resources) plus past production, where available, is calculated to be 25.5 million metric tons. Additional resources of cobalt are known to occur on the modern sea floor in aerially extensive deposits of Fe-Mn(-Ni-Cu-Co-Mo) nodules and Fe-Mn(-Co-Mo-rareearth-element) crusts. Legal, economic, and technological barriers have prevented exploitation of these cobalt resources, which lie at water depths of as great as 6,000 meters, although advances in technology may soon allow production of these resources to be economically viable. Environmental issues related to cobalt mining concern mainly the elevated cobalt contents in soils and waters. Although at low levels cobalt is essential to human health (it is the central atom in the critical nutrient vitamin B12), overexposure to high levels of cobalt may cause lung and heart dysfunction, as well as dermatitis. The ecological impacts of cobalt vary widely and can be severe for some species of fish and plants, depending on various environmental factors. Introduction Cobalt Uses, Demand, and Availability of Supply Cobalt is a technologically important metal that has many diverse uses, including in batteries, superalloys, and cemented carbides and diamond tools (fig. 12).

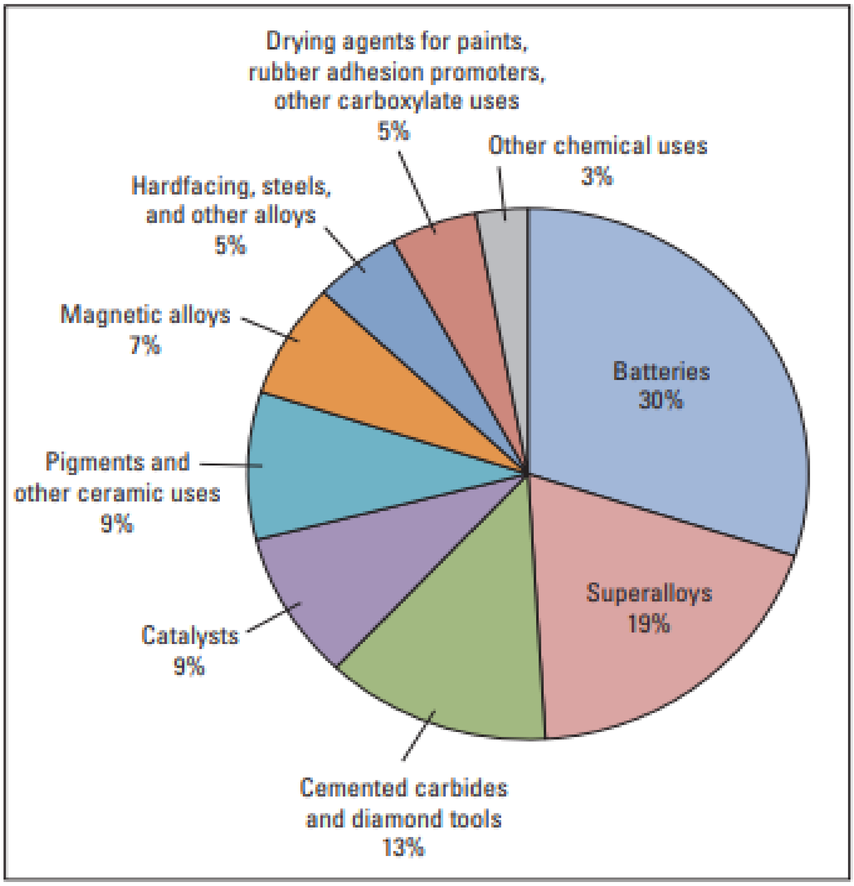
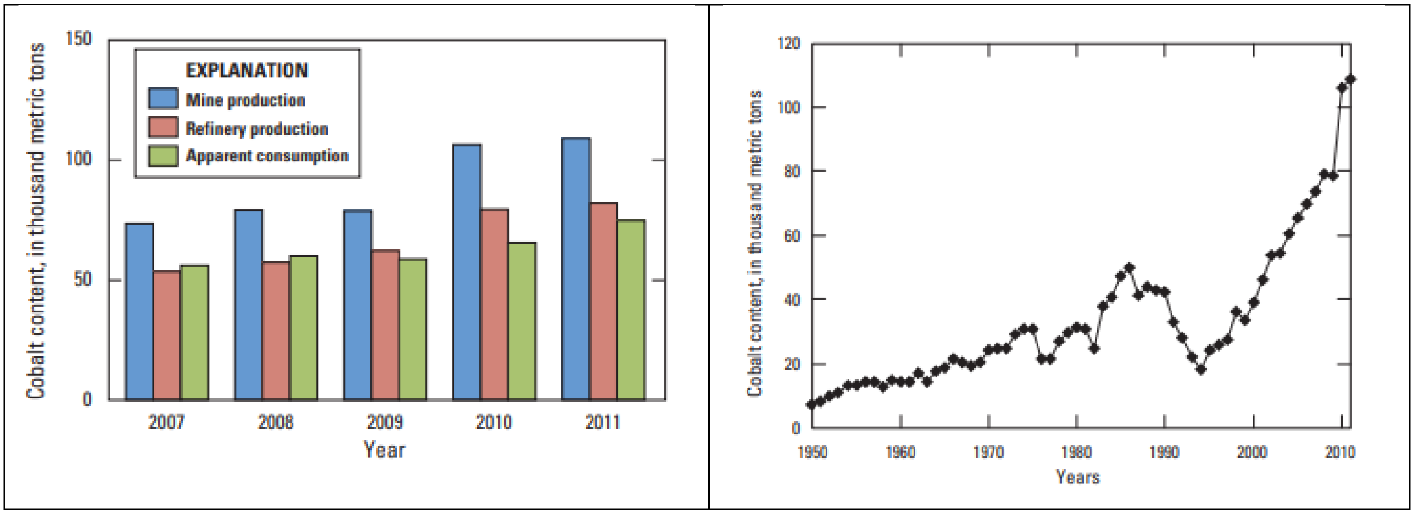


Fig (12) Pie chart showing major end uses of cobalt as a percentage of consumption worldwide in 2011. Data are from the Cobalt Development Institute (2012).

Globally, the leading use is in the manufacture of cathode materials for rechargeable batteries, primarily lithium-ion, nickel-cadmium, and nickel-metal-hydride batteries, which are used in consumer electronics, electric and hybrid-electric vehicles, energy storage units, and power tools. Superalloys are alloys developed for high-temperature service where relatively high mechanical stress is encountered and where surface stability is frequently required. The principal use for superalloys is in parts for turbine engines for jet aircraft and terrestrial energy generation. Cemented carbides, which are composite materials made of cobalt and tungsten carbide, are used as cutting tools and wear-resistant components by the metalworking, mining, oil and gas drilling, and construction industries. Diamond tools are similar to cemented carbides in that cobalt is the matrix that binds the wear-resistant particles together. Cobalt is used to make permanent and soft magnetic alloys. Cobaltbearing steels include high-speed steels for cutting tools and maraging steels, which are characterized by their great strength, toughness, and workability. Other cobalt-bearing alloys are characterized by their resistance to corrosion and (or) wear or by their particular thermal expansion properties. Additional chemical applications for cobalt include animal feed additives; bonding agents in steel-belted radial tires; catalysts for chemical, petroleum, and other industries; drying agents for paint; glass decolorizers; ground coat frits for porcelain enamels; humidity indicators; magnetic recording media; pigments; and vitamin B12.

.In 2011, the United States produced a negligible amount of byproduct cobalt as an intermediate product from Stillwater Mining Co.'s PGE mining and refining operation in southeastern Montana. Since then, minor amounts of byproduct cobalt in nickel concentrate have been produced from Lundin Mining Corp.'s underground Eagle Mine, which is a highgrade magmatic Ni-Cu(-Co-PGE) sulfide orebody located northwest of Marquette, Michigan, where mining began in 2014. No U.S. production was from mines in which cobalt was the principal commodity. Other projects in the feasibility and development stages include Formation Metals Inc.'s underground cobalt mine to be constructed in a strata-bound Co-Cu-Au deposit in the Blackbird district (part of the Idaho cobalt belt) in Lemhi County and PolyMet Mining Corp.'s open pit mine to be constructed in the NorthMet Cu-Ni-CoPGE deposit in the Duluth Complex, which is a large mafic intrusive complex in northeastern Minnesota. Cobalt would be produced as a byproduct from the NorthMet project. China was the leading refiner of cobalt in 2011, with much of its production coming from cobalt ores, concentrates, and partially refined materials imported from Congo (Kinshasa). Other significant sources of refined cobalt were Australia, Belgium, Canada, Congo (Kinshasa), Finland, Norway, and Zambia. Refined cobalt from Belgium and Finland was wholly or mainly produced from imported material, respectively



Fig(13)chart and Graph showing world cobalt mine and refinery production and apparent consumption world

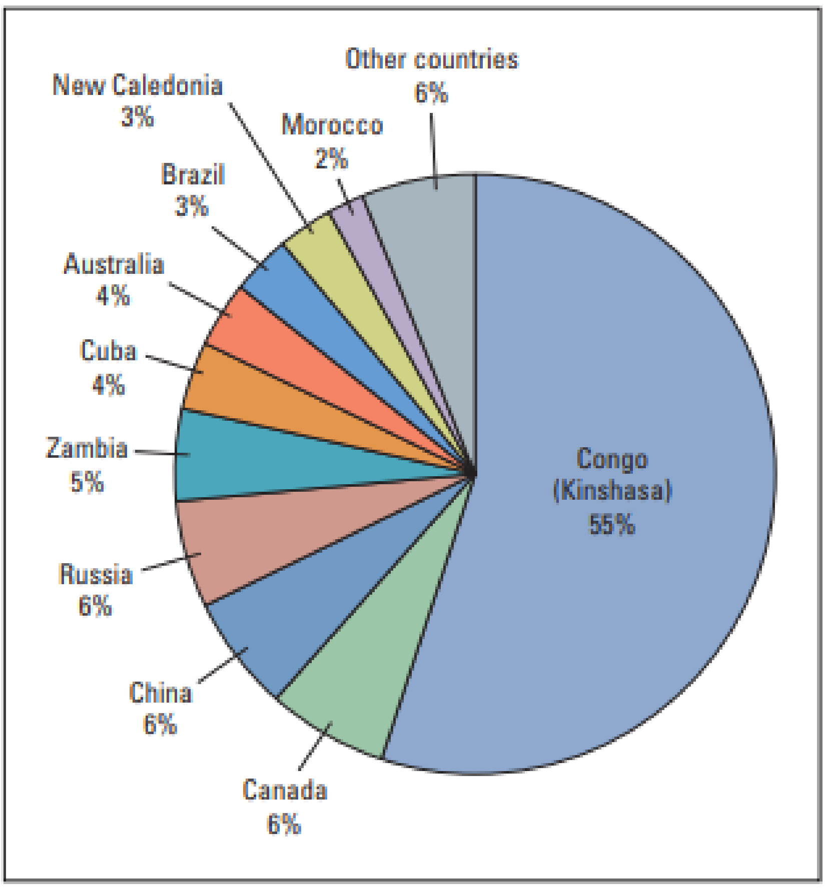


Fig (14) Pie chart showing percentage of world cobalt mine production in 2011, by country. The sources of production are cobalt, copper, nickel, platinum-group-element, and zinc operations. Data are from Shedd (2013a). Congo (Kinshasa) is a short-form name for Democratic Republic of the Congo.

5.2. Geology and Geochemistry study

Cobalt is ferromagnetic, and it retains this property at the highest temperature of any metal. Although pure cobalt is not found in nature, cobalt-bearing minerals and compounds are numerous and widespread.

Among common rock types, the highest average cobalt content occurs in ultramafic igneous rocks, such as dunite and serpentinite, which contain, high percentage (ppm) cobalt, and the mafic igneous rocks such as basalt contain, on medium ppm cobalt. shale as well as granite and related felsic igneous rocks can contains very low cobalt.

The mineralogy of cobalt deposits is diverse and includes both primary (hypogene) and secondary (supergene) phases. In primary deposits, most cobalt is recovered from sulfide minerals, such as carrollite ($Cu(Co,Ni)_2S_4$), pentlandite ($(Fe,Ni,Co)_9S_8$), linnaeite (Co_3S_4), and siegenite ($(Co,Ni)_3S_4$); arsenide minerals, such as skutterudite ($(Co,Fe,Ni)As_{2-3}$) and safflorite ($(Co,Fe)As_2$); and sulfarsenide minerals, including cobaltite (CoAsS) and glaucodot ((Co,Fe)AsS). Cobaltiferous pyrite and pyrrhotite—$(Fe,Co)S_2$ and $(Fe,Co)_{1-x}S$, respectively— are mined in some deposits. Among secondary cobalt-rich phases, which form during surficial weathering, one of the most important historically was erythrite ($Co_3(AsO_4)_2 \cdot 8H_2O$), which is a bright pink mineral also known as “cobalt bloom.” In modern mining of secondary cobalt-rich deposits, the principal economic phases, in addition to erythrite, are heterogenite (CoO (OH)) and asbolane ($(Ni,Co)_{2-x}Mn(O,OH)_4 \cdot nH_2O$), plus local heazlewoodite ($(Ni,Co)_3S_2$), together with cobaltiferous oxyhydroxides, including goethite ($Fe^{3+}O(OH)$), limonite ($FeO(OH) \cdot nH_2O$), and lithiophorite ($AlMnO_2(OH)_2$). With respect to the cobaltiferous oxyhydroxides, it is unclear from studies to date whether the contained cobalt is present in the crystal structure or adsorbed onto surfaces

5.3 Principal Deposit Types

Cobalt deposits of economic or potential economic importance are diverse in terms of their geologic setting, age, morphology, mineralogy, geochemistry, origin, and gradetonnage relations (for example, Crockett and others, 1987; Smith, 2001; British Geological Survey, 2009). The principal deposit types that account for most of the world’s cobalt mine production are stratiform sediment-hosted Cu-Co deposits, Ni-Co laterite deposits, and magmatic Ni-Cu(-Co-PGE) sulfide deposits.

5.3.1 Stratiform Sediment-Hosted Cu-Co Deposits

Most of the world's cobalt is produced as a byproduct of copper mining in sediment-hosted Cu-Co deposits that form strata-bound and commonly stratiform zones within siliciclastic or carbonate strata (Hitzman and others, 2005). Important ore hosts in some deposits are giant breccias that originated by the dissolution of former salt beds. Globally, the deposits contain chalcopyrite, pyrite, and carrollite, plus minor amounts of bornite and chalcocite, in gangue material composed mainly of potassium feldspar, muscovite, biotite, albite, quartz, and carbonate. The ages of the mineralization are principally Neoproterozoic and Permian, but some important deposits are Mesoproterozoic. Although current genetic models differ in some respects, the consensus opinion is that metalliferous saline hydrothermal fluids were introduced at low to moderate temperatures during diagenesis and the early stages of deformation and metamorphism (see Zientek and others, 2013).

5.3.2 Ni-Co Laterite Deposits

Laterites are red regoliths that develop in humid tropical climates during the weathering of diverse types of bedrock. Those that developed on ultramafic bedrock may contain important Ni-Co deposits (Freyssinet and others, 2005; Butt and Cluzel, 2013). Ni-Co laterites locally contain abundant scandium and, rarely, elevated concentrations of PGEs. Ni-Co laterite deposits consist of the following layers, from top to bottom: overburden, limonite, saprolite, and weathered ultramafic source rocks. Ore zones of laterite deposits range in thickness from about 10 meters (m) to as much as 40 m in some cases, and generally contain more than 1 percent nickel and less than 0.15 percent cobalt. Limonite developed overultramafic rocks tends to have higher cobalt grades, whereas saprolite has higher nickel grades. Metal accumulation involves supergene processes and several key variables, including primary bedrock lithology, climate history, topography, and structural preparation (that is, the fracture or joint density of bedrock). Ages of the deposits typically are mid-Tertiary to Holocene; some fossil Ni-Co laterites are known. Major ore constituents include the following: (a) nickeliferous serpentine (garnierite), talc, and chlorite; (b) nickel- or cobalt-bearing clays (for example, nontronite, and montmorillonite); (c) erythrite, heterogenite, asbolane, heazlewoodite, and millerite; and (d) goethite, limonite, and lithiophorite. The gangue (non-ore) material may include various amounts of quartz, amorphous silica, clays, and serpentine.

5.3.3 Magmatic Ni-Cu(-Co-PGE) Sulfide Deposits

Large resources (including reserves) of cobalt are contained in Ni-Cu(-Co-PGE) sulfide deposits hosted in mafic and ultramafic igneous rocks (Naldrett, 2004; Eckstrand and Hulbert, 2007). This deposit type comprises semimassive to massive sulfides that occur within or near the basal zones of layered intrusive complexes, in discordant magmatic conduits, and within ultramafic intrusions and lava flows. The ages of the deposits, which approximate those of the host intrusions, range from Archean to Tertiary. Nickel is the principal metal commodity, and it is accompanied by subequal proportions of copper in most deposits; cobalt and PGEs are mining byproducts. Cobalt resides mainly in cobaltiferous pentlandite and, to a lesser extent, in linnaeite. The gangue minerals consist mostly of primary magmatic minerals, such as olivine, pyroxene, and plagioclase. Mineralizing processes involve magmatic segregation of sulfides and, in some deposits, hydrothermal mobilization into post-magmatic structures. Deposits of this type that currently feature significant byproduct production of cobalt include Voisey's Bay in Newfoundland and Labrador, Canada (Naldrett and Li, 2007); the Sudbury district in Ontario, Canada (Ames and Farrow, 2007); and the Norilsk-Talnakh district in Siberia, Russia (Naldrett and others, 1996). Other Deposit Type

5.3.4 Black-Shale-Hosted Ni-Cu-Zn-Co Deposits

Black shales are well known for containing elevated contents of many metals of economic interest, including Cu, Mo, Ni, Zn, Co, Cd, Ag, Au, Se, Cr, V, U, and PGEs (for example, Desborough and Poole, 1983; Coveney, 2003). Metals concentrated in black shales may reside in pyrite; organic matter; aluminosilicate minerals, such as illite; and locally in sphalerite and chalcopyrite. Some deposits contain very high contents of molybdenum, nickel, zinc, and (or) vanadium within primary sedimentary beds or laminae. In other deposits, high contents of cobalt formed by hydrothermal leaching, mobilization, and concentration into sulfide minerals during deformation and regional metamorphism. One of the few black-shale-hosted deposits from which byproduct cobalt is recovered is the giant Talvivaara orebody in central Finland, which is being mined for nickel, zinc, and copper (Loukola-Ruskeeniemi and Lahtinen, 2013).

5.3.5 Fe-Cu-Co Skarn and Replacement Deposits

Pluton-related skarn and replacement deposits form by the introduction of hydrothermal fluids into chemically reactive rocks, mainly carbonate (limestone and dolostone), and by metasomatic processes that introduce metals and other components into the precursor strata. These deposits occur proximal or distal to intrusive bodies and contain a diverse suite of metals (Megaw, 1998; Meinert and others, 2005). Sulfide minerals may include pyrite, pyrrhotite, chalcopyrite, sphalerite, and galena, together with abundant magnetite in some deposits. Cobaltiferous deposits generally contain mainly copper residing in chalcopyrite; cobalt occurs in cobaltite or cobalt-rich pyrite. In replacement deposits, which commonly are located distal from pluton contacts, gangue minerals typically include quartz or carbonate. The gangue minerals of skarn deposits, which occur near plutons, are generally different and include garnet, pyroxene, amphibole, epidote, olivine, plagioclase, and (or) scapolite. The Cornwall and the Morgantown (Grace Mine) Fe-Cu-Co deposits, which are two of only a few large cobaltiferous skarn deposits in the world, are located in southeastern Pennsylvania (Lapham, 1968) but are no longer operating. Another large deposit of this type, although it lacks significant amounts of iron, is Ruby Creek in northwestern Alaska (Bernstein and Cox, 1986). The Mount Elliott Cu-Au(-Co-Ni) skarn deposit in Queensland, Australia, differs in that it contains a significant amount of gold (Wang and Williams, 2001)

5.4 Structural Frame Work of Concession Area:

5.4.1 General

Structural geology is the study of the architecture of the earth's crust; it is resulted from deformation (Merland, 1972). The term deformation is used in different ways by different people and under different circumstances. It define as the process whereby physical changes are produced in the material as a result of the action of applied forces, this change may be consist of a change in shape or volume, or both together. On the other hand, Force is the product of amass and its acceleration, it is a vector quantity, and thus possesses both amount of direction (Park, 1997). It depends on magnitude and direction of action. Stress is a pair of equal and position forces acting on unite area of a body, it is the force applied over a given area of the rock mass. The magnitude of stress depends on the magnitude of force and on the surface area over which it acting (Park, op. cit.), thus:

$$Stress = Force/Area.$$

It can be divide into three types are given below:

- *Compressional stress, which tends to squeeze the rock.*
- *Tensional stress, which tends to pull a rock apart.*

- *Shear stress, which results from parallel forces that act on different parts of the rock body in opposite directions.*

Confined pressure, Temperature, Solutions, competency of rocks and time are factors control of rocks behavior under stress. Strain is the geometrical expression of the amount of deformation caused by the actions of stress on a body (Park, op. cit.). It is the change in the shape or size of a rock in response to stress. Strain is expressed as dilation (volume change) or distortion (shape change) or as a combination of these processes.

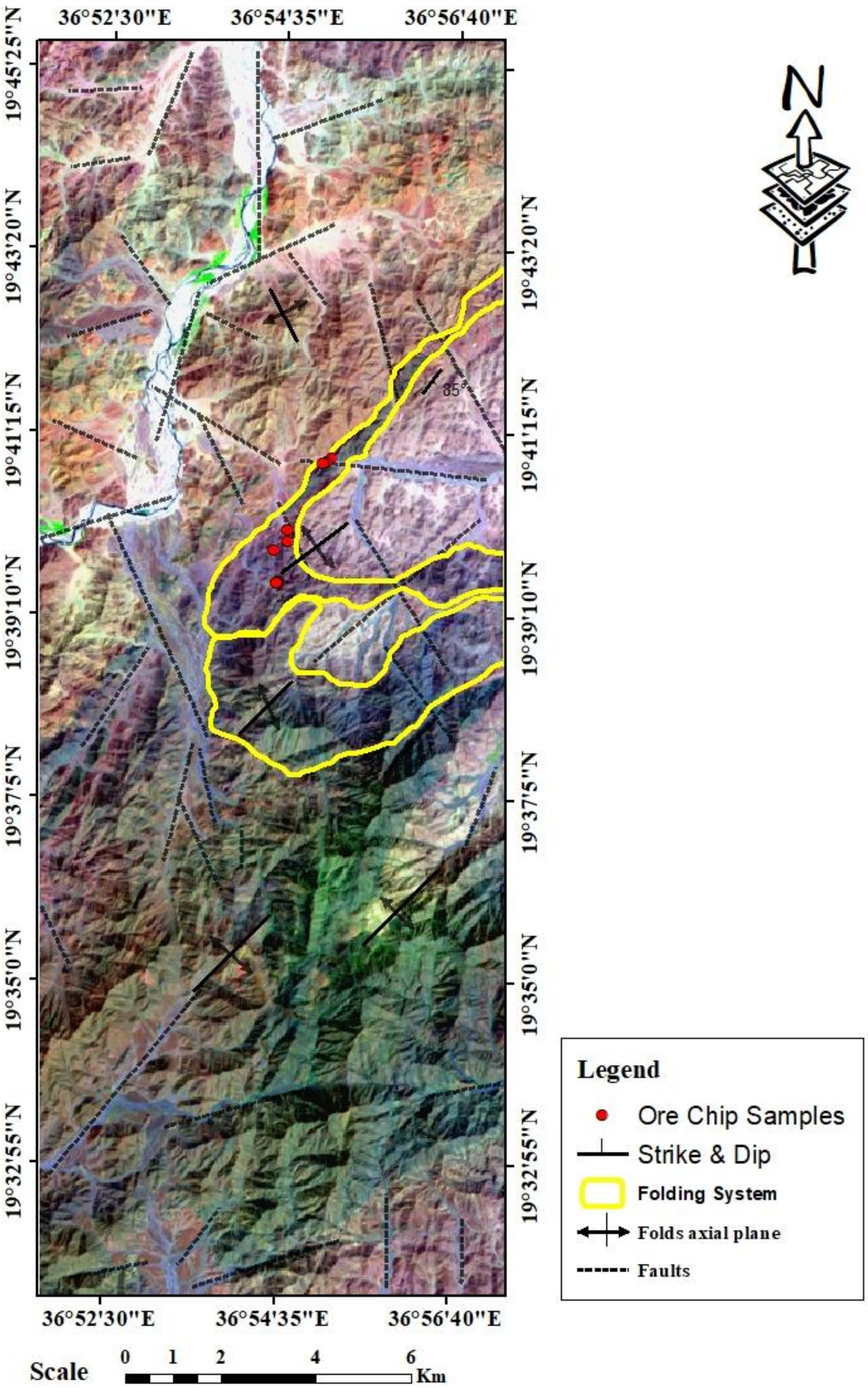
The structural analysis is done based on the tectonic and geological history of the concession area in addition to the interpretation of the remotely sensed data and the field confirmation. displays the suture zones in the Nubian Shield that are mainly trending in NE-SW direction, such as Nakaseab and Onib-Sol Hamid sutures. The Hamissana and Oko shear zones are extending in N-S trend. Accordingly the Stress- Strain analysis was applied to differentiate the potential open fractures (Extensional, Tensional & Release fractures) from the closed shear fractures in the study area

. The results show that the extensional fractures trending NW-SE trend that coincide with the course of Wadi ease. The course of Wadi ease running parallel to the direction of the release fractures NW-SE direction.

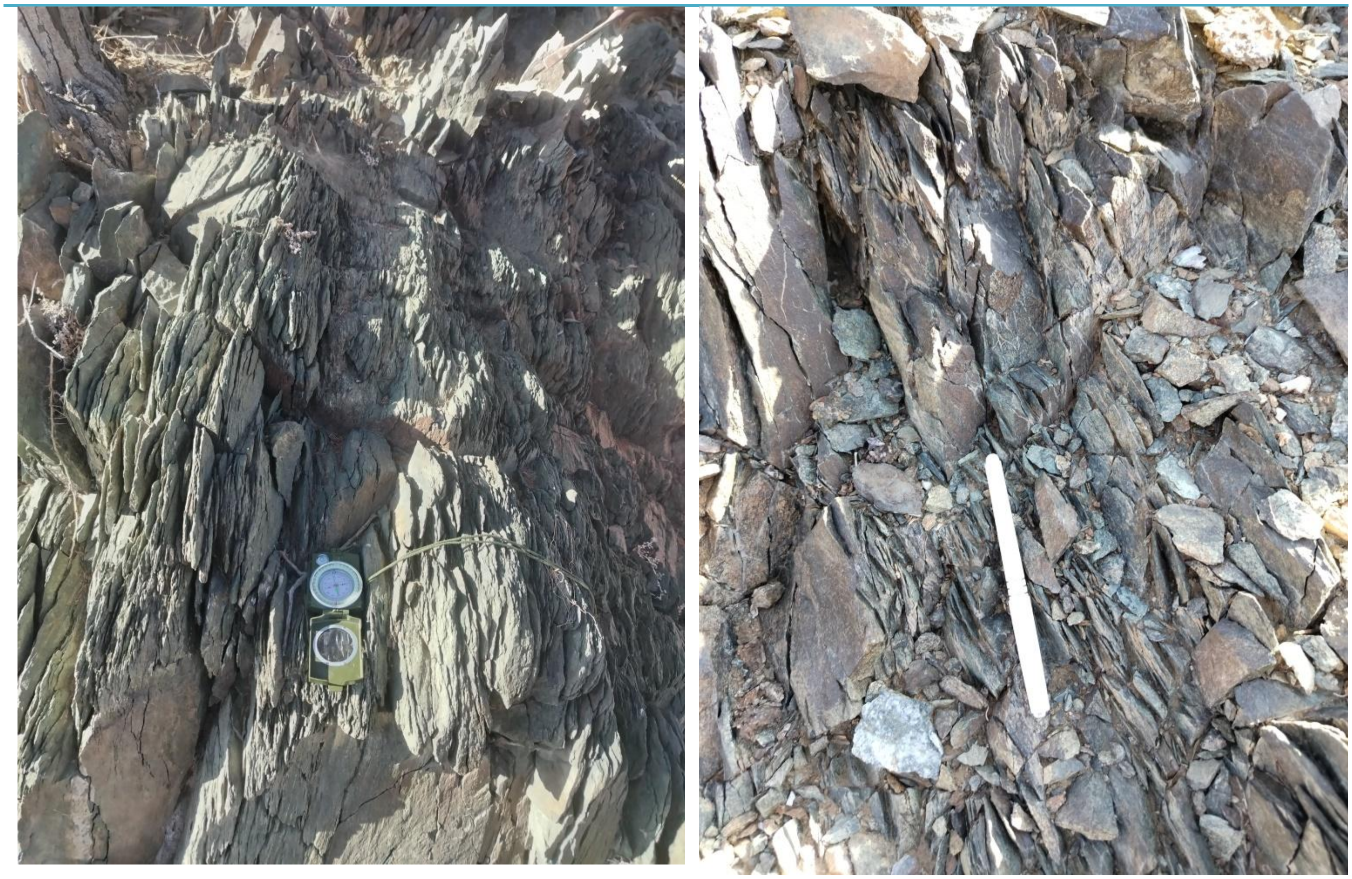
Many structural processes span thousands to millions of years. Most structural data describe the final product of some deformation history, ductile deformation occurs when rocks flow under the influence of stress. The opposite, discontinuous deformation or brittle deformation, occurs when rocks break or fractured. Field observations of deformed rocks and their structures represent the most direct and important source to understand the natural deformation. The structural analysis depend some of base (Geometric analysis and Dynamic analysis). The analysis of the geometry of structures is referred to as geometric analysis. This includes the shape, geographic orientation, size and geometric relation between the main (first order) structure and related smaller-scale (second order) structures. The geometrical analysis is very useful to represent orientation data. Stereographic projection is used to interpret both the orientation and geometry of a structure. Both strain and kinematics expressions are a result of the accumulation and release of stress. The interplay between stress and kinematics is called dynamics. Dynamic analysis thus explores the connection between stress and the structures or strains that can be observed in the crust.

Folds and foliation are result of ductile deformation. Folds are bending in the rocks forming the earth’s crust. Not all folds are of tectonic nature, rather it can be also formed when non uniform forces are applied across the layering, bending process such as a variable vertical subsidence of crustal layers, deferential shearing in shear zones or by the sliding of rock masses. A folded layer shows variations in curvature which are used to define important features of the fold. As any other rock deforming structures, folds exist in a wide range from microscopic scale to hundreds of kilometers wide. The attitude of folds (their orientation in space) is characterized by the attitude of both their axial surface and their fold axis. The fold axis corresponds to the fold hinge line, the line that links points of maximum curvature on a folded surface. The axial surface is defined as the surface containing all the hinge lines on successive folded surfaces.

The folds are classify to deferent type based on the direction of closer, attitude of axial surface, size of inter-limb angle and shape of profile, folds usually come in groups or systems. Folds can form in many different ways by means of different mechanisms. In the project area, ductile deformations (folds) were found in macro- and meso-scopic forms under different type represent different deformation. In geological map image, many folds are observed, the SW trending fold is the mean folding direction the SW and SSW folding directions are also shown in map Fig (15).



Fig(15) map showing the fold system in the area of the block



An image (4) showing the shared mafic ultramafic rock in the fold limb

6. Geochemical survey:

The cobalt and assossotion minerals on the area of the block is Magmatic Sulfide Deposits which is cobalt are contained in Ni-Cu(-Co-PGE) sulfide deposits hosted in mafic and ultramafic igneous rocks, This deposit type comprises semi-massive to massive sulfides that occur within or near the basal zones of layered intrusive complexes, in discordant magmatic conduits, and within ultramafic intrusions and lava flows. The ages of the deposits, which approximate those of the host intrusions, range from Archean to Tertiary. Nickel is the principal metal commodity, and it is accompanied by subequal proportions of copper in most deposits; cobalt and PGEs are mining byproducts.

The field trip focus in geological and structural mapping to understand the structural farm work and the rock unite that include the cobalt cooper zinc and PEG

the prospect target located at the central part of the block, the prospect block covers an area of 6 km^2, the area is underlined by folded mafic ultra-mafic rock unit

The mafic ultra mafic fold system in the area of the concession specially the closure of the fold it's the most potential prospecting area for the above mention minerals and assossotion

A total of 26 chip /channel samples including the QCQA samples has been taken from the area the determine the potentiality of the area.

An image (5) showing the hand specimen samples of cobalt from the target area

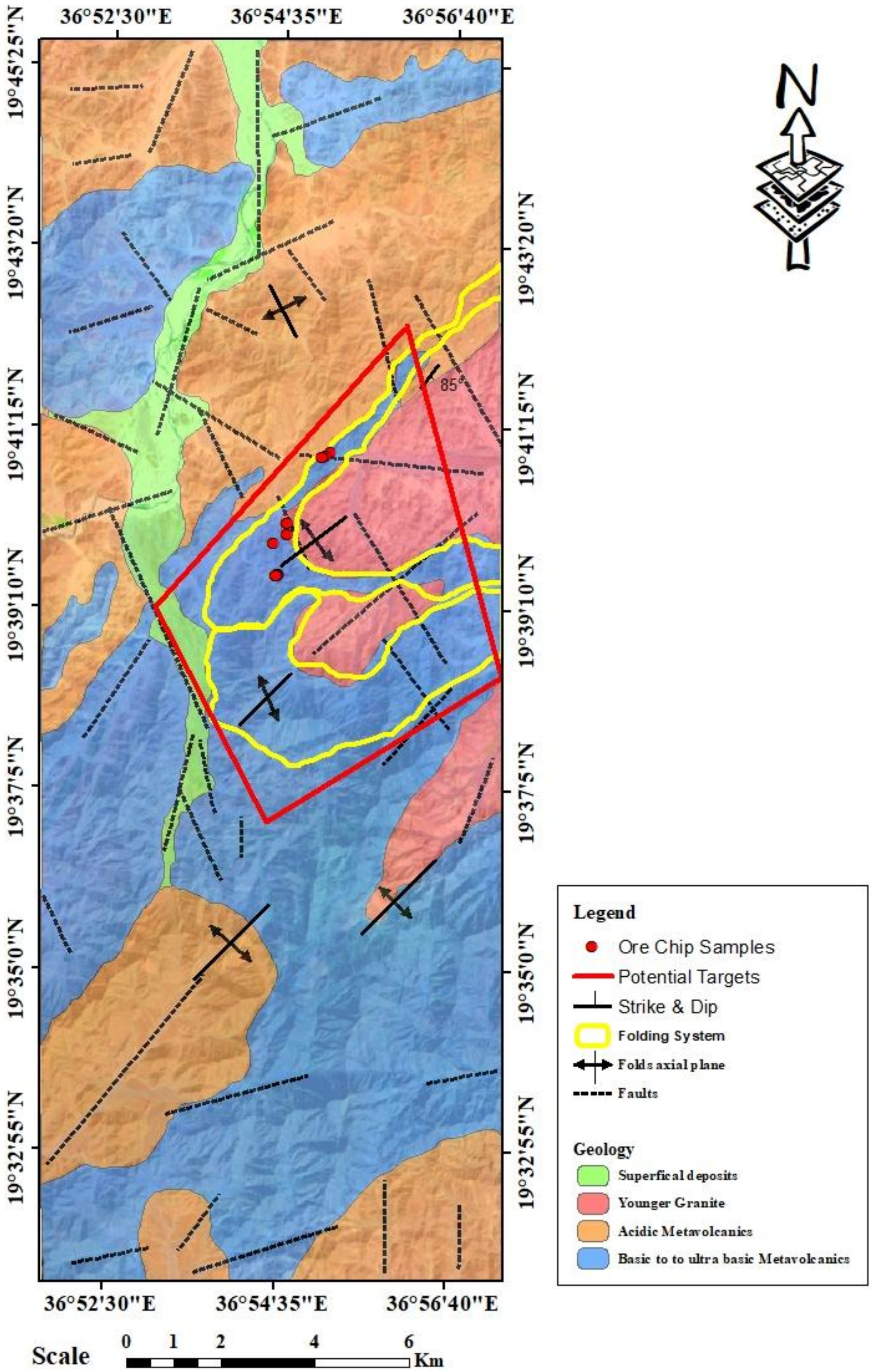


Fig (16) map showing the target area with in the mafic ultra-mafic closure fold and the samples locations

An image (6) showing the hand specimen samples of cobalt from the target area

An image (7) showing the samples collected from the outside dump from the target area

7. Quality Control and Quality Assurance (QC-QA)

QAQC procedures are applied to check the accuracy and precision of the sampling and analytical processes and ensure no contamination or smearing is taking place.

Check samples (standards, blanks, duplicates, and triplicate) will be introduced into the samples collected at a rate of 10% of the total samples submitted and the same protocols' will be fallow with cross check of 10% from the total samples .

Quality Control (QC)

The assembly of all planned and systematic action necessary to prove adequate confidence in checked samples that are included in each assay run to ensure that the analytical test has been accomplished to acceptable levels.

Quality Assurance (QA)

The operation technic and activities that are used to satisfy the quality requirement to ensure that the final assay data is within defined acceptable limits

Standard Deviation (SD)

Average squared deviation of values from the mean, SD is the statistical measure of the precision in a series of repetitive measurements. This statistical measure of spread or range (dispersion) of the sample, values are measured in the same units as the data and are the square root of the variance.

Quality control protocols will be applied in all the sample sent to the laboratory, across check analysis of (10%) of the sample's patches will also be done in the international laboratory (ALS).

7.1 Standards

Two CRM samples Medium and high pulp samples- GEOSTATS- will be used by different grade in cobalt and above mention association

7.2 Duplicates

The duplicates samples from the field collected chip and crushed samples showing the comparison between the results the two duplicate samples will be insert

7.3 Blank

The blank samples is used in the submitted batch and the samples taken from the local pure cementing break ..

7.4 Cross check

A total of (10) samples from the total of collected samples will be sent to the arbiter lab to be analyzed for cobalt and associated metals determination.

The cross-check samples will select to cover all the rock unit and to identify the differences in mineralization zones occurring in the exploration target area.

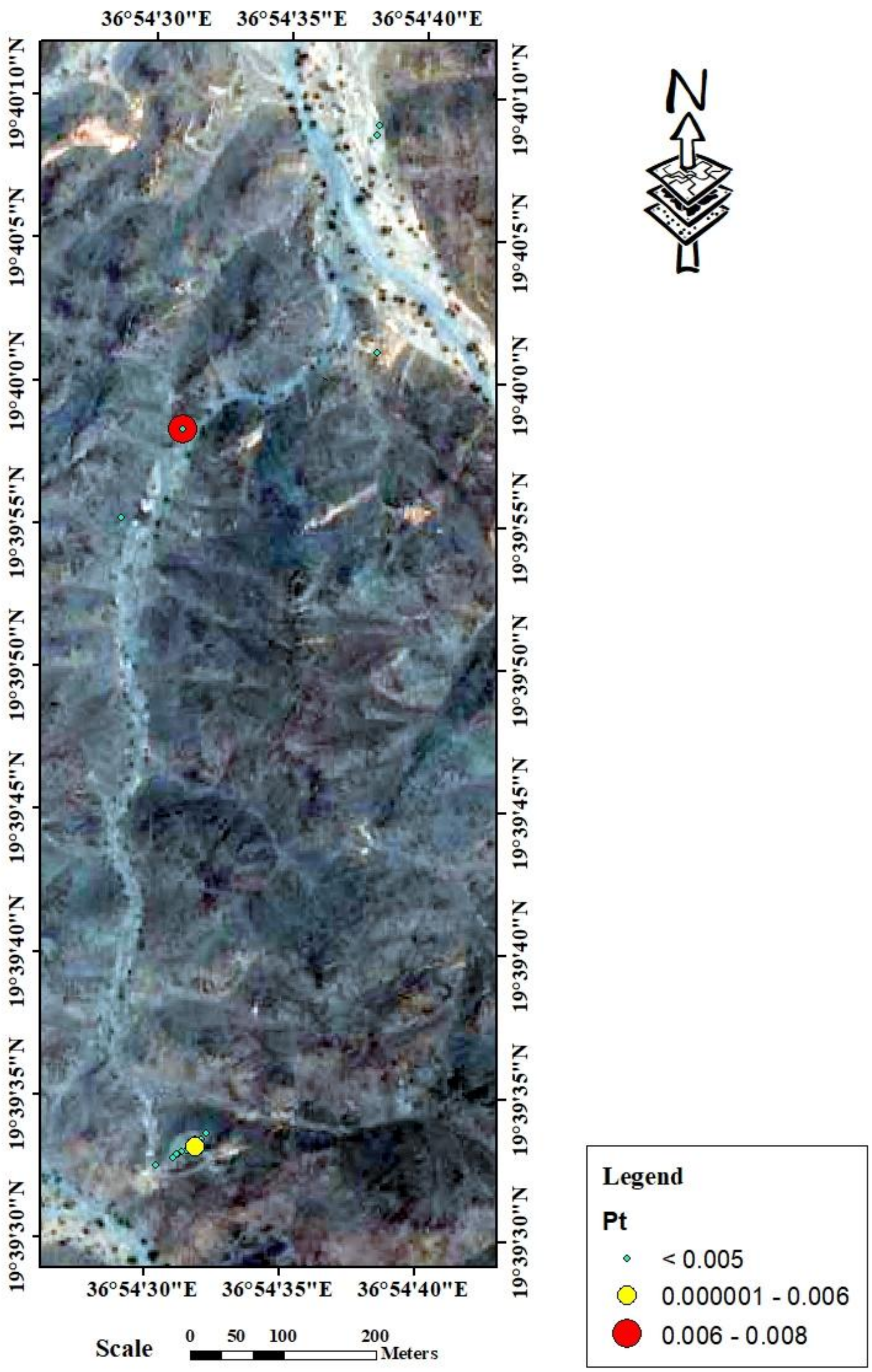


Fig (17) map showing the target area of the sample's locations and Pt Assay.

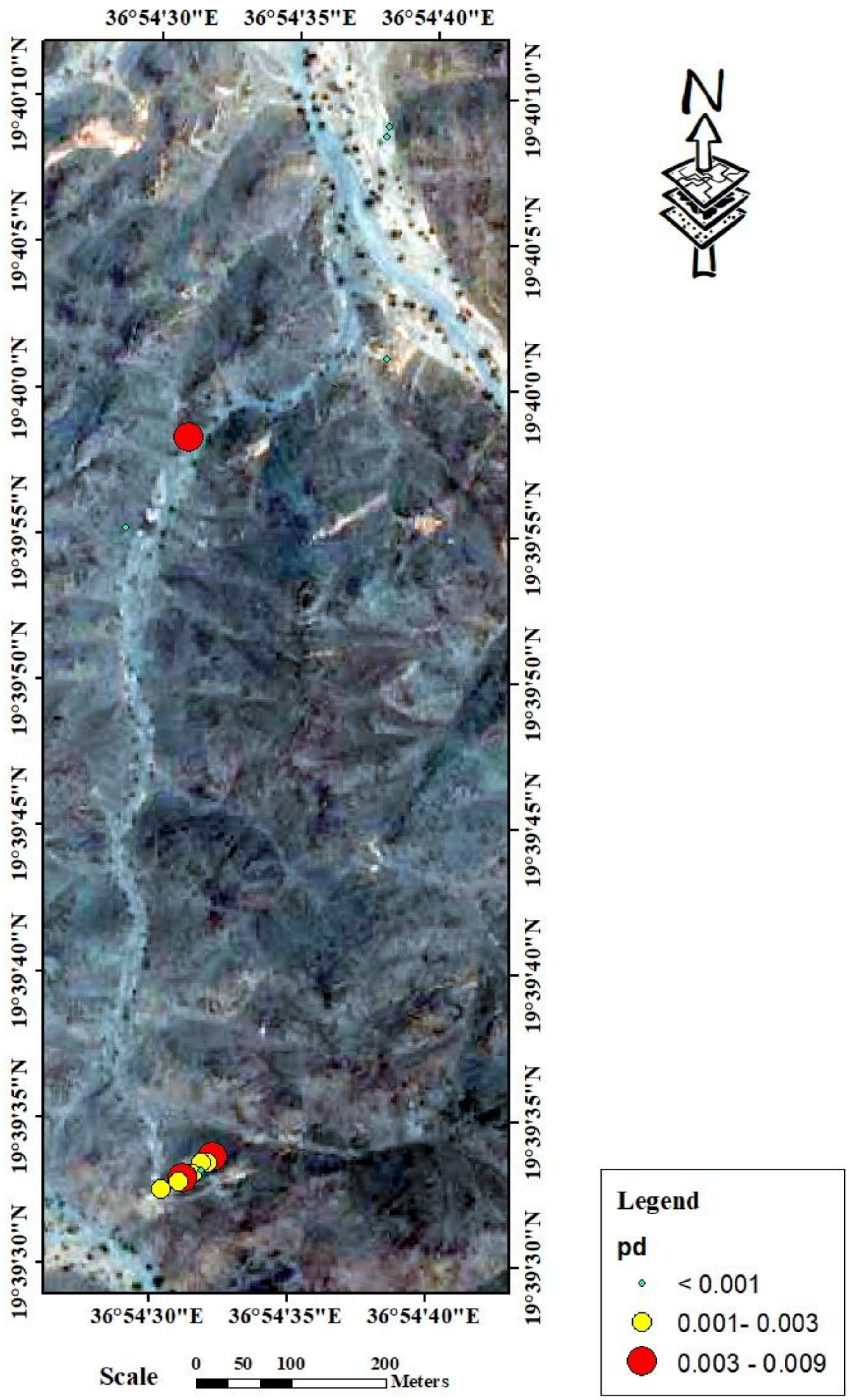


Fig (18) map showing the target area of the sample's locations and Pd Assay.

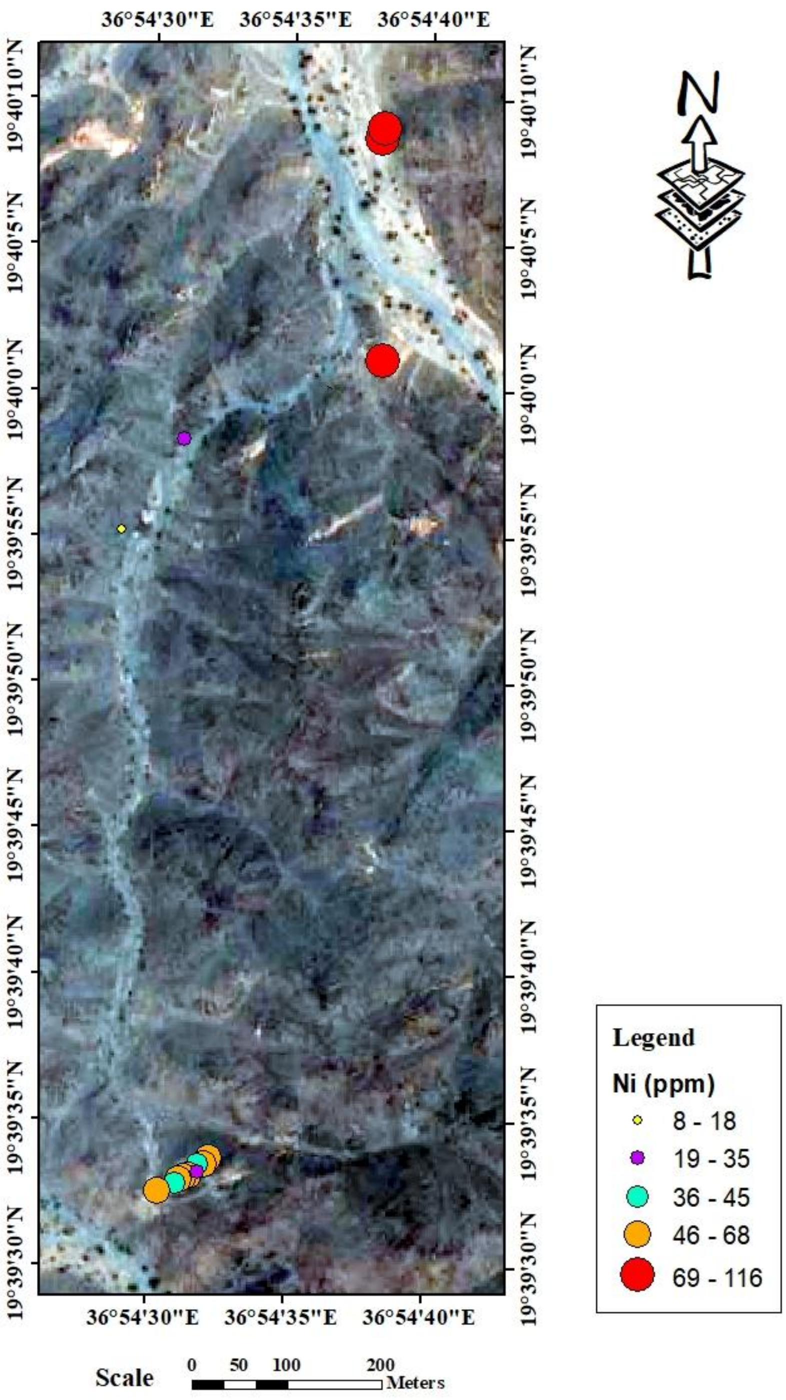


Fig (19) map showing the target area of the sample's locations and Ni Assay.

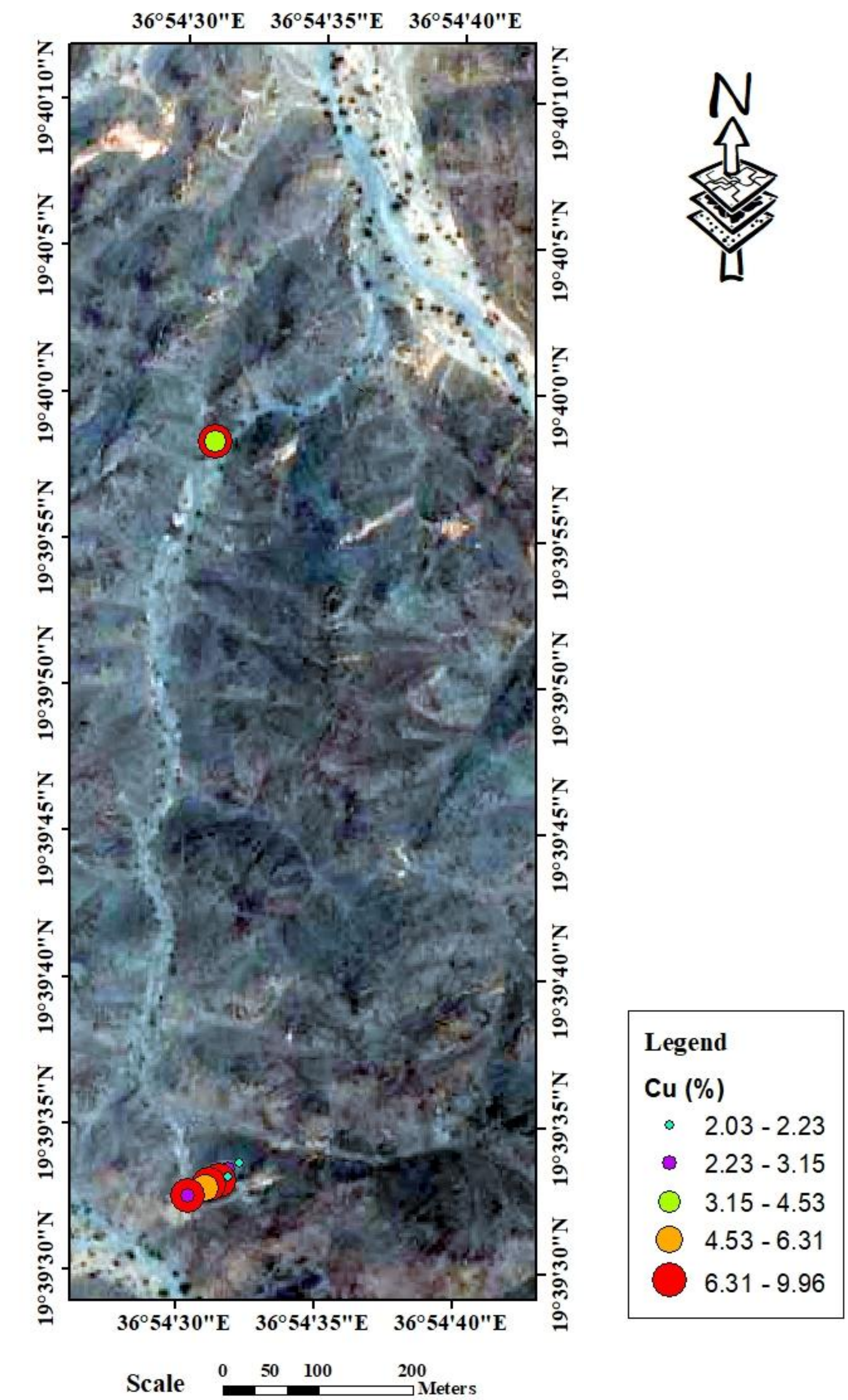


Fig (20) map showing the target area of the sample's locations and Cu Assay.

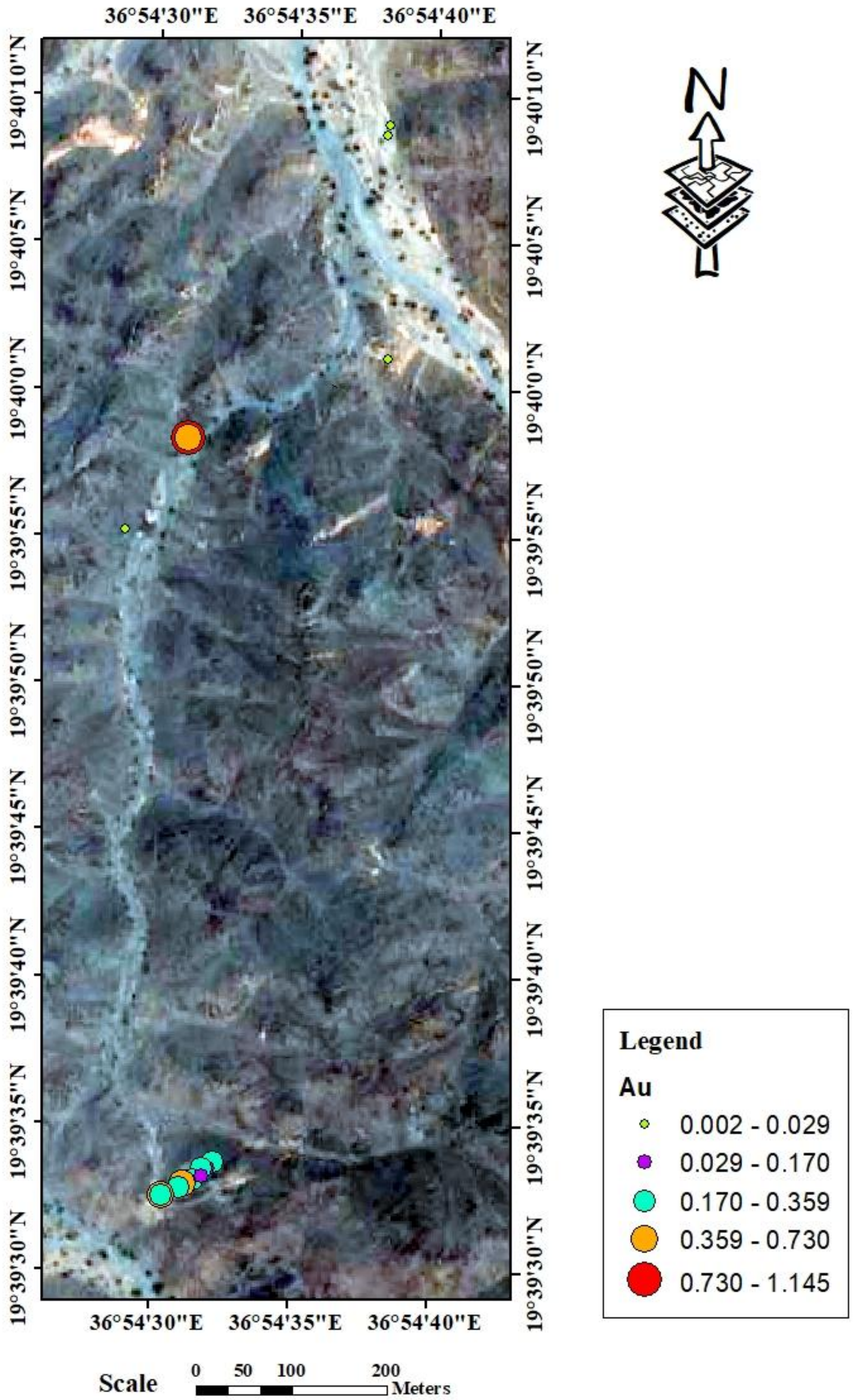


Fig (21) map showing the target area of the sample's locations and Au Assay.

8.Result discussions

The cobalt and associations minerals on the area of the block is Magmatic Sulfide Deposits which is cobalt are contained in Ni-Cu(-Co-PGE) sulfide deposits hosted in mafic and ultramafic igneous rocks, this deposit type comprises semi-massive to massive sulfides that occur within or near the basal zones of layered intrusive complexes, in discordant magmatic conduits, and within ultramafic intrusions and lava flows.

The ages of the deposits, which approximate those of the host intrusions, range from Archean to Tertiary. Nickel is the principal metal commodity, and it is accompanied by subequal proportions of copper in most deposits; cobalt and PGEs are mining byproducts.

Detailed exploration work for the cobalt and associations mates executed in the study represents comprehensive investigations in many different aspects of geology including, structural and tectonic setting and minerals exploration represented in ore chip/channel sampling and measuring and evaluation of the exposed Ore.

The total number of 26 samples that had been collected from cobalt and associated metals deposit; including the QC and QA samples were sent to ALS Lab (from deferent area of fold system) of concession area shows very encouraging ore

The samples were sent to ALS Lab prepared and analyzed for above mention metals resaved under the certificate code (AL25159601).

All crushed Samples of the Magmatic deposits' types are prepared as (crushed backup 2to 3kg weight) were send to ALS lab through the samples sending protocols by requirement of for cobalt and associated elements (Co, Cu, Ni, ppm Cu%, Rh, Au, Pt, Pd ppm).

The ALS procedures highly slandered and perfect system of the samples protocols. the preparation of samples crushed QC test for the fine crushing; 70%<2mm and split samples riffle splitter pulverized 1000g to 85%<75um.

The analysis procedure is under codes of samples analysis; ore Grade Elements -four Acid (ICP-AES), ore grade Cu four Acid (ICP-MS), Rh;30g FA ICP-MS (ICP AES), Pt, Pd, Au50g FA ICP (ICO AES):34 element four Acid ICP-AES.

8.1 The samples Analysis results

The samples that subjected to the preparation and analysis procedure above are recorded result ranging for: Co from (9 to 131ppm), Cu; from 72 up to over 100000 ppm, Ni: from 8 to 116ppm which considered potential result but Au, Pt, and Pd were reflect low potentiality (appendix.2).
Whoever the result that resaved for the above-mentioned element are considered acceptable, potential and encouraging result guided to the next exploration phases.

81.1 Correlation between Au,Co,Ni,Cu.

Based on the provided data from Sheet1(apendix2), the Pearson correlation matrix for Au (Gold), Co (Cobalt - assumed to be Column A), Ni (Nickel), and Cu (Copper) is as follows. Note that ">10000" values in the Cu column were converted to 10000 for analysis:

Table (4) Correlation Matrix (Pearson).

	Co	**Ni**	**Cu**	**Au**
Co	**1**	**0.101**	**-0.148**	**0.58**
Ni	**0.101**	**1**	**-0.345**	**0.181**
Cu	**-0.148**	**-0.345**	**1**	**-0.138**
u	**0.58**	**0.181**	**-0.138**	**1**

Key Observations:

1. **Co vs. Au**:

Strong positive correlation (`r = 0.580`).

→ Higher Cobalt levels associate with higher Gold concentrations.

2. **Ni vs. Cu**:

Moderate negative correlation (`r = -0.345`).

→ Higher Nickel levels associate with lower Copper concentrations.

3. **Co vs. Cu** and **Au vs. Cu**:

Weak negative correlations (`r = -0.148` and `r = -0.138`), indicating minimal linear relationships.

4. **Ni vs. Au**:

Weak positive correlation (`r = 0.181`), suggesting limited association.

Notes:

- **Data Cleaning**: Cu values like ">10000" were treated as `10000` (lower-bound approximation). This may slightly bias correlations.

- **Method**: Pearson correlation assumes linear relationships. For non-linear patterns, consider rank-based methods (e.g., Spearman).

9. Summary and Conclusions

BN ENRGY COMPANY LTD dually registered company by the Government of Sudan represent Ministry of Minerals for exploration and exploitation of cobalt and associated minerals in block RS-12V in the Red Sea State. The area of study has been investigated during a field trip generally oriented using Remote Sensing techniques and GIS to study the exploration in regional geology integrated with field observation, and geochemical survey to identify potentiality of cobalt and associated metals mineralization

BN company was awarded (264 Km^2) Concession for exploration and exploitation of cobalt & Associated Metals in Block area the area located in the Red Sea State wadi Arbaat locality.

The company has engaged the services to complete the exploration and block evaluation with professionals who have Excellent experience in the business and implementation of mining operations.

The license area Block (RS-12V) according to the Geological Research Authority of the Republic of Sudan (GRAS) is located in largely underlain by Upper Proterozoic volcano-sedimentary-ophiolitic-granitoid greenschist assemblage intruded by Proterozoic orogenic granitoid batholiths and syn-late tectonic granitoid and gabbroic bodies. These Proterozoic structures are mainly covered by quaternary desert sediments,

According to geological works conducted by the Geologist team, throughout all of the license area, especially by reconnaissance geological trips, geochemical sampling and their respectively interpretation; the geological contours of the license area were verified and redefined.

Structurally the concession area effected by deferent phases of deformations (faulting, brecciating, schistosity, and shearing).

It should be clarified that developed map continuously get updated due to the company keeps conducting detail geological works in different locations of the license area.

The 1st stages of exploration activities in the area have shown that the concession Block RS-12V is a potential for large scale mining project this is evident from the conducive geological environment, geochemical anomalies and the confirmation of the chip samples taken from the anomalous catchments which explain and verify the interpreted geochemical anomalies.

The cobalt and associations minerals on the area of the block is Magmatic Sulfide Deposits which is cobalt are contained in Ni-Cu(-Co-PGE) sulfide deposits hosted in mafic and ultramafic igneous rocks, this deposit type comprises semi-massive to massive sulfides that occur within or near the basal zones of layered intrusive complexes, in discordant magmatic conduits, and within ultramafic intrusions and lava flows. The ages of the deposits, which approximate those of the host intrusions, range from Archean to Tertiary. Nickel is the principal metal commodity, and it is accompanied by subequal proportions of copper in most deposits; cobalt and PGEs are mining byproducts.

Detailed exploration work for the cobalt and associations mates executed in the study represents comprehensive investigations in many different aspects of geology including, structural and tectonic setting and minerals exploration represented in ore chip/channel sampling and measuring and evaluation of the exposed Ore.

Due to the field survey A total number of 26 samples from the cobalt and associated metals including the QC and QA samples were collected from deferent area (fold system) of concession shows potentiality and encouraging ore deposit.

The samples sent to ALS Lab and analyzed for cobalt and other metals as (Co, Cu, Ni, Rh, Au, Pt, Pd).

All Samples subjected to the preparation and analysis procedure are recorded result ranging for: Co from (9 to 131ppm), Cu; from 72 up to over 100000 ppm, Ni: from 8 to 116ppm which considered potential result but Au, Pt, and Pd were reflect low potentiality (appendix.2).

Whoever ALL of sample's analysis result resaved for the above-mentioned element are considered acceptable, potential and encouraging result guided to the next exploration phase.

The analysis result is reflecting from the correlation between Au, Co, Cu, and Ni. Strong positive correlation between Co vs. Au Higher Cobalt levels associate with higher gold concentrations, Moderate negative correlation of Ni vs. Cu, Co vs. Cu** and **Au vs. Cu which show Higher Nickel levels associate with lower Copper concentrations and Ni vs. Au Weak positive correlation.

by using the AI, DeepSeek & machine learning with the data analysis, correlation and geological studies the project overview is seem very good and expecting good resource and indicator of NPV, and IRR well come in range of profitable in the scenario of the best choice as (attached presentation) for Cobalt, Nickel and Copper.

With the implementation of required studies (Example; Geophysics) and drilling application.

10.ATTACHEMENTS

Samples description and coordinates

note	discription	samples ID	y	X
highly sheard rock within the fold limb	basic ultrabasic rock	RS-01	2177718	281884
highly sherd host rock 0f mafic ultra mafic rock	strick 20 /dip=85E	RS-02	2177648	281778
highly sherd host rock 0f mafic ultra mafic rock	strick 20 /dip=85E	RS-03	2177617	281726
highly sheard rock within the fold limb		RS-04	2177628	281710
Donite Rock		RS-05	2176208	280952
ultramafic rock with in the fold system		RS-06	2176218	280955
within the fold clusher system		RS-07	2175973	280952
		RS-08		
		RS-09		
		RS-10		
		RS-11		
		RS-12		
		RS-13		
		RS-14		
out site dump of more than 20 truck with high malchite		RS-15	2175796	280677
		RS-16	2175133	280769
		RS-17	2175127	280764
		RS-18	2175127	280757
		RS-19	2175115	280748
		RS-20	2175113	280742
		RS-21	2175110	280738
		RS-22	2175110	280737
		RS-23	2175107	280733
tracing of exposed excavation ore vien with malchite		RS-24	2175098	280714
		RS-25	2175098	280714