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Geology, Morphotectonics And Geophysical Interpretation Of Wadi Garara Graben, East Aswan Egypt, Using Landsat Images

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Abstract: In the southern Eastern Desert of Egypt, A NW- SE oriented structural graben extends from north of Aswan to the Red Sea coast with a length of about 400 km and an average width of 30 km. The area has significant potential for development as it may be provided with water from surface and subsurface sources and is the site of prospection for petroleum. The present paper is an attempt to understand the structural evolution and genetic development of the geomorphologic features of the area and constructing presently a new geomorphological map at a scale 1: 250 000 using Landsat ETM images and field checks. Available geological maps and the produced geomorphological map are digitized by using the ARC-GIS software. The same program is also used to produce a 3D DEM for surface and subsurface features. Based on new interpretations of aeromagnetic and radiometric data, the subsurface features of the basement cover were illustrated on a 3D map. Geological-geomorphological profiles have been constructed in different directions in the area to identify present and ancient geomorphologic features. The place and shape of subsurface deep seated NW-SE trending faults have been determined. The faults, which generated the graben have downthrows in the order of 900 m to 5800 m. The surface and subsurface observations delineate the dominant downthrow of about 3750 m. Three E-W subsurface faults have been detected under Nubia sandstone, one of them, displaying a downthrow of about 845 m, cuts through the basement rocks.

Key wrods:

INTRODUCTION

Garara structural graben is the most pronounced Phanerozoic rocks inlier in the Precambrian rocks exposures of Egypt. May workers referred to Garara graben as the biggest one of the NW structural grabens bordered by deep-seated faults of Red Sea trend in Eastern Desert of Egypt in North East African Shield, eg. Shurrmann (1974). It extends in the South Eastern Desert from Kom Ombo (40 km north of Aswan) to the Red Sea in the SE coast, with a length of about 400 km and an average width of 30 km. The area lies between latitudes 23° 00'and 25° 00'N and longitudes 33° 00' and 34° 30' E (Fig.1). Figure 2 illustrates the locations discussed in text, the names written from topographic maps.

This area was not geomorpholgically mapped before, in spite of the fact that a good knowledge of the geomorphology and terrain charactristics of a region is very important for efficient planing. This paper deals with how the tectonics, lithilogy and geomorphic processes integrated to sculpted the landscape of the Garara graben, the structural evolution and genesis of the landscape geomorpholgy of this sector through the investigation of the endogenetic and exogenetic geomorpholgical processes during geological time, as well as subsurface geophysical interpretations.

Geological Setting:

The investigated area is a part of the Pan African Arabian-Nubian Shield that was discussed by many workers. Proterozoic igneous and metamorphic and Phanerozoic rocks are exposed within a geological map of the area illustrated in Figure 3 from Conoco Coral map (1987). The field observations in South Eastern Desert demonstrate that the volcano sedimentary-ophiolite-plutonic-sequenceis is tectonically controlled showing a three-tier succession based on normal or formal nape stacking (De Wall *et al*, 2001). The basement rocks in the south Eastern Desert include iscland arc metasediments and metavolcanics over an oceanic crusts subjected to major orogeny, causing thrusting and mixing of the ophiolitic melange. Gneisses are the oldest Precambrian rocks in the study area, outcropped southwest Wadi Garara and in the eastern part of the study area as highly fractured weathered hills. They are composed of leucocratic and melanocratic medium to high grade metamorphic rocks of gneiss, granite gneiss, schist and amphibolite. Stern (1994) postulated ophiolite occurrences around Wadi el Kharite in the investigated area. Ophiolite group includes serpentinites and their varied derivatives occur as allochthonous masses of various sizes down to small clastics in typical elongated masses of mélanges. High relief small bodies of serpentinites are scattered around the Nubia Formations.

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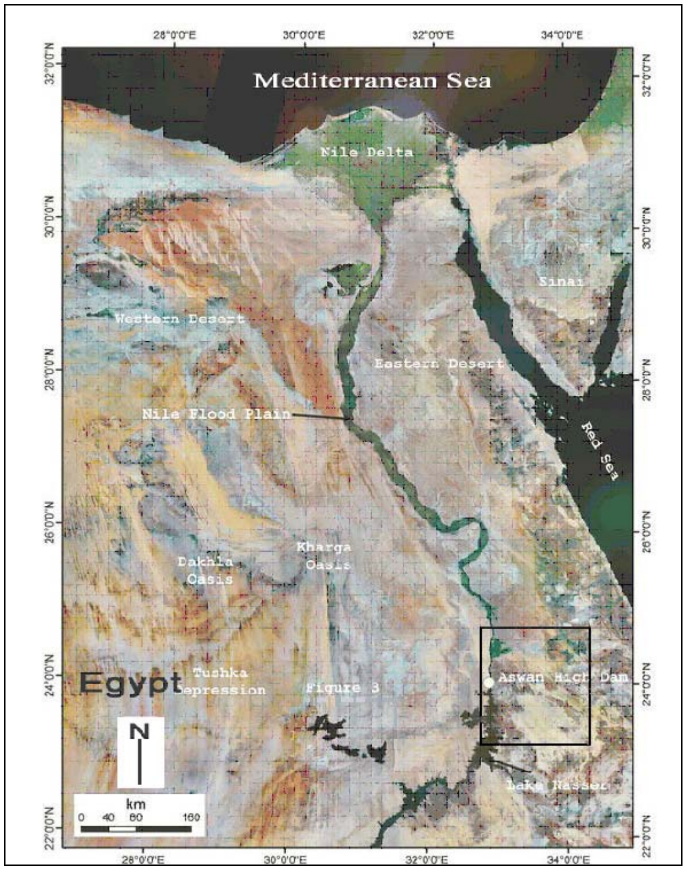

Fig. 1: location map, the study area marked by frame

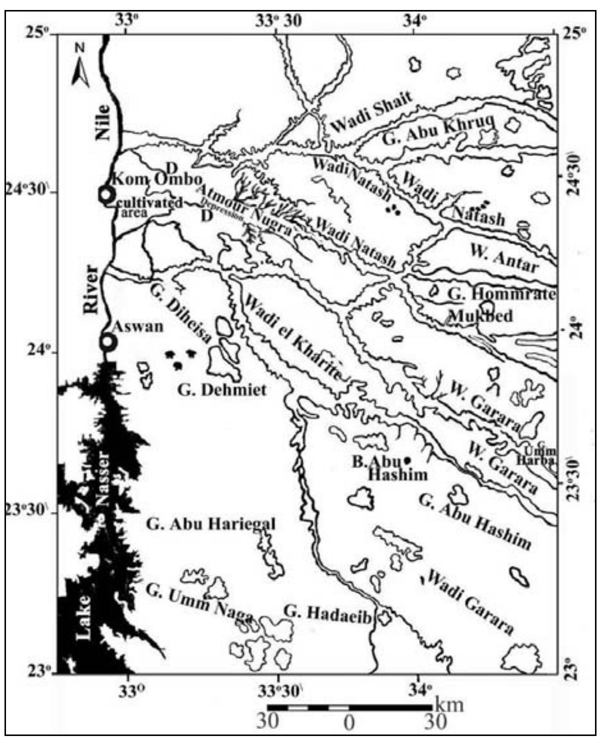

Fig. 2: The localitions discussed in the text (G- Gabal, W- Wadi, B- Bir and D- depression)

They are altered to talc carbonate rocks and magnesite veinlets frequently observed in the outer serpentinites. Metasediments covers vast of the area have considerable thickness and include metamudstone, greywacke and conglomerate. They are frequently metamorphosed up to the chlorite and biotite zones and certainly older than the calc-alkaline intrusive rocks. They strike mainly in NW-SE direction, and are folded along NE and NW trending axes. Metavolcanic rocks are present in the southern and eastern parts of the mapped area of medium topograpy composed of meta-basalt-andesites overlain by rhyolite and rhyolite-tuffs; they have schistose texture in green-schist grade. Older granitoid rocks described elsewhere as "Shaitian granites" occurs as composite pluton of batholithic dimensions in Wadi Shait (its type locality). Shaitian granite composed of trondhjemite, tonalite, granodiorite of medium grain size in equigranular texture. It contains abundant xenoliths and rafts of other rocks in various stages of digestion. Hashad and El Reedy (1979) determined the age of the Shaitian granites at Wadi Shait as 876 Ma. High relief younger granitic pluton composed of laccolithic dimensions with pink and red colors intruded the adjacent rocks in the eastern part of the area. Ring complexes named Abu Khruq ring composed mainly of syenites, trachyte and nepheline – syenites is occurred. It is affected by post Nubian faulting which causes local blockling in a series of Cretaceous-Tertiary sediments, volcanism of minor extrusions is associated with these faulting. The young volcanics extrusions inside and around Wadi Natash are distributed in the NE direction according to structural control of Phanerozoic age. They formed cone-shape and plugs in black color and named by some workers as Natash volcanics. The albitised volcanic varities and trachytic basalt volcanic are very abundant in Wadi Natash .i.e. the alkali and sodium reach magma are extruded in different ages along NW trend around the graben. The basement rocks described above are traversed by many dyke systems in different composition from basic to acidic and different ages. The older granitoid rocks are most influenced unit by the dyke extrusion forming hard peaks of the exfoliated older granitoid weathered blocks in Wadi Shait and Wadi Natash. The Phanerozoic sedimentary cover is unconformably overlying the Precambrian basement (Fig.3). It is composed mainly of sandstones, siltstones, and shales, represented by the Abu Aggag-, Timsah, Umm Brammily and Quseir Formations (Fm) of Upper Cretaceous age according to Conoco Coral geological map (1987). Abu Aggag Fm streched in NW-SE lagre belt of horizontal beds covering the western part of the Garara graben forming Gabal Abu Hashim and surroundibg, it bourdered in the west by structural contact with metasediments. It composed of fluvial deposits with cross-bedded sandstones, ripple-laminated sandstone, lenticular sand bodies and channel fills and locally paleosols. Timsah Fm outcropped in NW-SE belt inside the Garara graben and easterly bordered by metasediments with structural contact and wide wadis that formed after major faults (Wadi Garara and Wadi el Kharite) and bordered in the west by Abu Aggag Fm with NW-SE faults .Timsah Fm, composed of fluviatile near-shore marine and locally eolian sanstone, with interbedded channel and soil deposits. Umm Brammily Fm overlies unconformably Abu Aggag Fm northwestern part of the graben covering broad area south and east Atmour Nugra depression. Umm Brammily Fm composed of fluviatile sandstone, becoming more marine towards the north. Quseir Fm covers a wide area north of Atmour Nugra depression. Its elevation varies from 280m north of Atmour Nugra depression and reach up to 425m in the northern part of the study area. Quseir Fm composed of littoral varicolourd shale, siltstone, and flagy sandstone containing mixed marine and fresh-watwer gastropods. Thin rock beds most probably Tertiary overlie the Nubia with little or no angular unconformity but the marked difference in rock type indicates a considerable change in environment. The chalk, marl and calc-arenite sequence in east Kom Ombo is indicative of shallow open seas rather than the estuarine littoral environment of the Nubia. Quaternary deposits are represented by surficial accumulations wadi deposits of clay, sands, gravels and rock fragments as well as sand sheets cover the low lands.

Methodology:

Surface mapping using Landsat TM and ETM image mosaics (Fig.4) of 1:250 000 of principal components (PC), bands 2,4,7 were used to prepare a new geomorphological map. A digital Elevation Model (DEM) was displayed by using Landsat ETM images, topographic maps and ARC-MAP Program (Fig.5). Geological and geomorphological profiles along different orientations were prepared to clarify the present and ancient (paleo-) geomorphology of the area. The geological and geophysical airborne data were also digitized and processed by the ARC-MAP Program to be included in a GIS. The same program was also used to construct a 3D picture of the surface of the area by drawing a processed image on the Digital Elevation Model (DEM) of the study area..

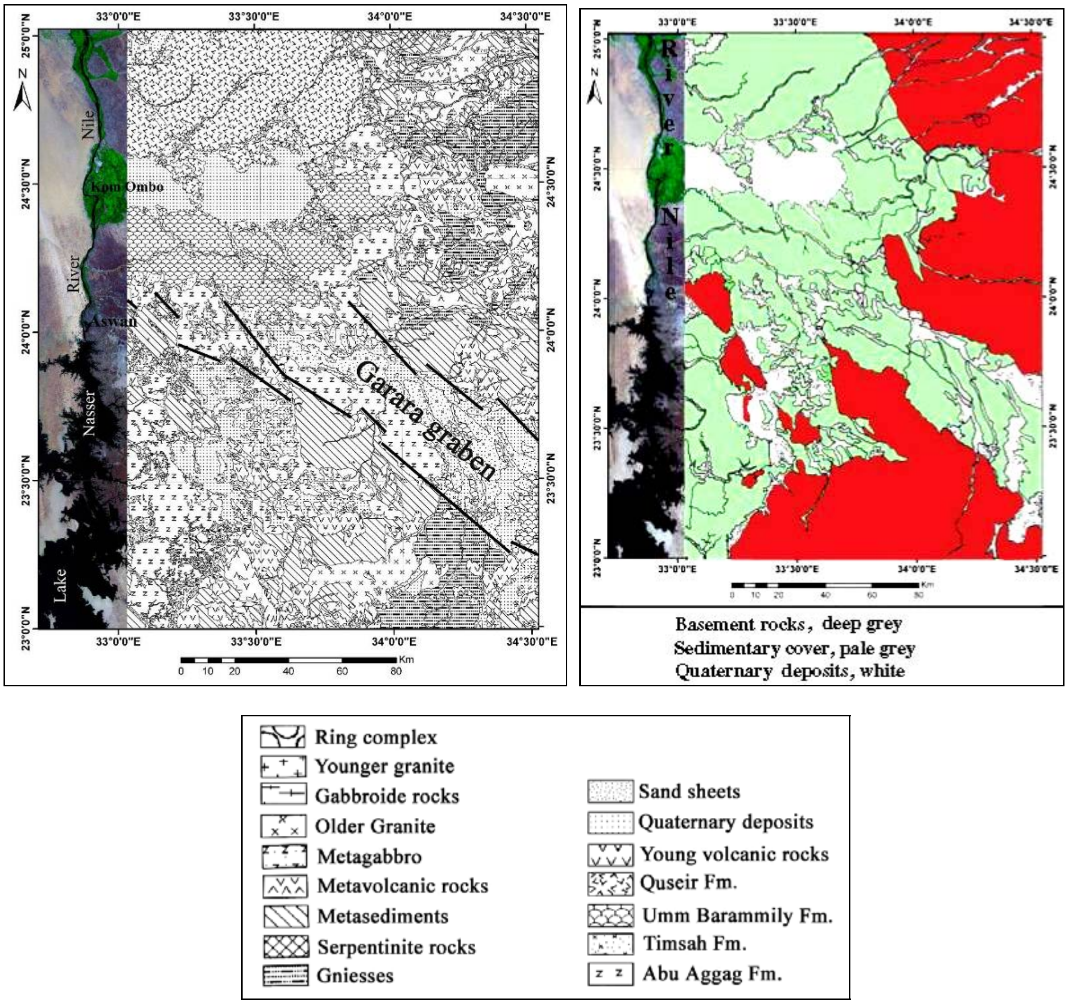

Fig. 3: Geological map of Wadi Garara area from Conoco (1987).

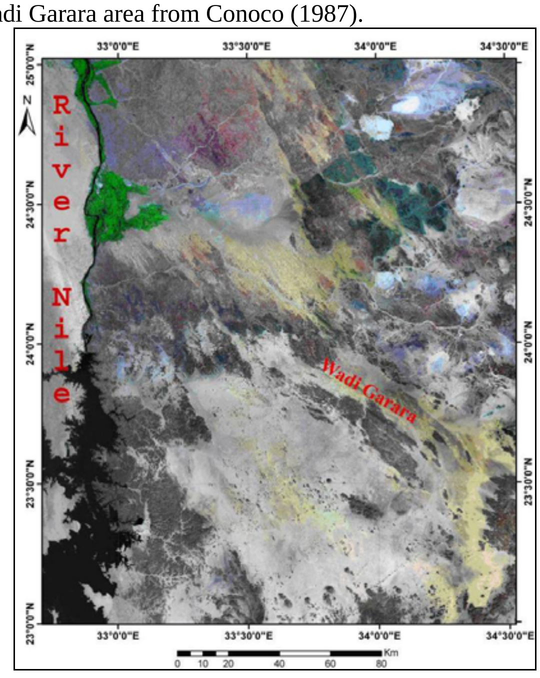

Fig. 4: TM images for the study area.

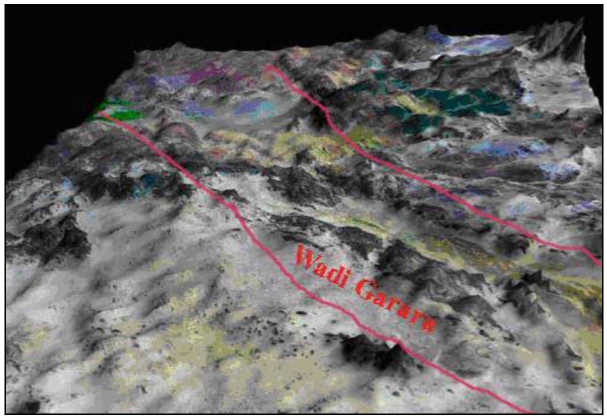

Fig. 5: A digital Elevation Model, (3D) prepared from Landsat TM images of the Wadi Garara area

Geomorphology:

The Landsat images used for geomorphologic mapping provide good discrimination between different physiographic features as follows; mountains and hills constituted by metasediments, metavolcanics, or gneisses. Older (syn – tectonic) granitoid rocks are exposed as isolated hills with medium reflectance of electromagnetic radiations on Landsat ETM images. Faulted denudational mountains and hills are mainly constituted by serpentinites, gabbro, and diorite. Weathered and dissected batholiths and lacoliths from serpentinite, gabbro and diorite rocks, exhibits high and medium topographic relief and dark grey and green colours (in false color). A new drainage network and physiography map was drawn from Landsat TM image mosaics (Fig.7).

Geomorphological Units:

A new geomorphological map has been drawn at a scale of 1:250 000 using Landsat TM images and field check (Fig.8). This work use the genetic geomorphologic classification together with the endogentic-processes, based on structure and lithology, to define the main geomorphologic units, and use the morphologic shape classification together with the exogenitic processes to the geomorphologic sub-units postulated by El Gammal (1999) and El Gammal et.al (2003). The geomorphologic units in the mapped area are shown in Figure 8. The following gives a brief description of the most dominant units in the area:

Structural Landforms:

Faulted Mountains And Hills:

Faulted denudational mountains and hills are mainly constituted by serpentinites, gabbro, and diorite. They are weathered , fractured and exhibit high and medium topographic relief and dark grey and green colours in the field . Some hills are highly weathered, and exhibit low relief. ellipsoidal gabbro hills are slightly dissected and their lineaments on TM Images display a specific rectangular drainage pattern. They show smooth weathered surfaces in the eastern part of the study area.

Bedded Mountains And Hills:

Metasediments and metavolcanics with some exposures of gneisses constitute eroded mountains and hills. They are variegated, banded and folded on TM images. The weathering products of the hills accumulate as pencil-shaped masses of dilluvial fragment on their foot slopes. The rocks exposed in these hills are highly weathered, dissected and tilted– tectonically. Metavolcanic rocks are more resistant to weathering and develop higher reliefs than the metasedimentary rocks. Some hills constitute hogbacks.

Dissected batholiths and Lacoliths:

Older granitoid batholiths are weathered and dissected and now form the present denudational structural landforms with onion-shape and tors landforms. They are located in Wadi Shait with low topographic relief and grey colour.

Younger granites plutonic rocks are located in eastern and southern parts of the area. They have ellipsoidal- and rounded-shapes with high topographic relief and red colour. They are hard plutons and slightly weathered. Some of them show parallel and vertical drainage patterns. There are small magals on the red granites surface. Circular and ellipsoid masses from intrusive gabbro in laccolithic dimensions with high relief and steep slopes are located in the northeastern part of the area and traced by faults and fractures cutting this oval-shape. These masses have peaks forming water divide lines and formed parallel drainage patterns with deep drainage channels.

Ring Complexes:

The main ring complexes in Egypt are present in the study area. Gabal Abu Khruq is slightly dissected, eroded and has moderate to high relief syenite, alkali granites and trachytes. The rings were intruded at fault intersections. The main fault trends are : NE-SW, E-W, N-S and NW-SE. Others of considerable size occur; Gabal Umm Naga 644 m and Gabal Abu Hariegal 604 m in southern part of the mapped area. Other ring complexes in Wadi el Kharit (500-510 m) formed as a result of Cretaceous tectonic movements. They are slightly dissected hard rocks and located in zones where major ESE -WNW and ENE -WSW faults intersect the NNW-SSE faults of the Nubia border. They are arranged similar to the Wadi Natash lava plugs. dissected plateau extendeds at the north of Atmour Nugra with heights ranging from 265 to 400 m with general gentle slope (about 4°) towards the west to the Nile Valley.

Cuestas and Mesas:

More than 25 000 km in the mapped area are present as cuestas with dip angle 7º-15º in different directions (Fig. 7). Cuestas represent the main landforms of sedimentary rock, fill of the Garara graben of Nubia Formations, composed mainly of sandstone interbedded with some clay, mud and marl. Some cuestas are capped with iron oxides.. They are covered by clay and mud beds of Tertiary age southward and eastward of Wadi Nugra and in the southwestern part of the area (Fig 7).

Volcanic landforms:

Volcanic landforms, cone-shape, plugs and dome-shape with medium to low topographic relief showing radial drainage patterns. occur in an area extending NW – SE between Wadi Shait and Wadi Antar, it is called Natash volcanic . Numerous exposures of basalt are met with in the area of Wadi Natash. The cones and sheets of volcanic rocks are very abundant around Wadi Natash and are arranged along NW trend around the graben Cretaceous volcanics extruded periodically in Abu Khruq and Umm Naga ring complexes.

Fluvial Landforms:

Fluvial landforms are present in low relief localities of the area. They are mostly of Quaternary age and divided here into depositional and erosional.

Depositional Fluvial Landforms:

Alluvial fans:

There are alluvial fans present in the northern part of the area with more than 25 metres thick deposits of different grain sizes and rock fragments derived from drainage basins, most probably during Pleistocene age.They are sloping in northeast direction. Two major accumulated fans are present in the central part of the mapped area. and lie on the foot slope of a steep fault scarp of Nubia Formations. They are large and accumulated from gravels, boulders, sand and rock fragments. They are widspread in NW direction and highly dissected. These fans are formed by gravity and wind actions together with fluvial processes.

Erosional Fluvial Landforms:

Depressions:

Atmour Nugra-Kom Ombo depressions (Fig. 2) have generally flat surfaces stretching in an east- west direction for 70 km to a detached hill near the eastern scarp. The depression is about 100 m below the encompassing scarps and its floor is covered by thin Quaternary sediments with relics of older rocks. A big mesa of Nubia sandstones separates between Atmour Nugra and Kom Ombo depression, this mesa rises 100 m above the east and west plains assuming the same elevation of the scarps around the depression. The Kom Ombo depression is less flat than the Atmour Nugra (Fig.2). Atmour Nugra-Kom Ombo depressions are structurally controlled by subsurface and surface faults, indicating by local faultscarp and affected by cycles of fluvial erosion causing scarp-retreat and subordinately by aolian erosion giving the recent planation surface. It is covered by thin Quaternary sediments with relics of older rocks.

Rugged land:

Rugged land lies in the eastern part of the investigated area, and is denoted by highly ruggded, hilly terrain which is filled in-between by sands. Older granites and metasediments occupy wide areas. They are highly weathered with corridors in different directions. Sand sheets cover areas between isolated granitic hills. Several volcanic cones and plugs are scattered in these lands. This unit formed after exogenetic processes.

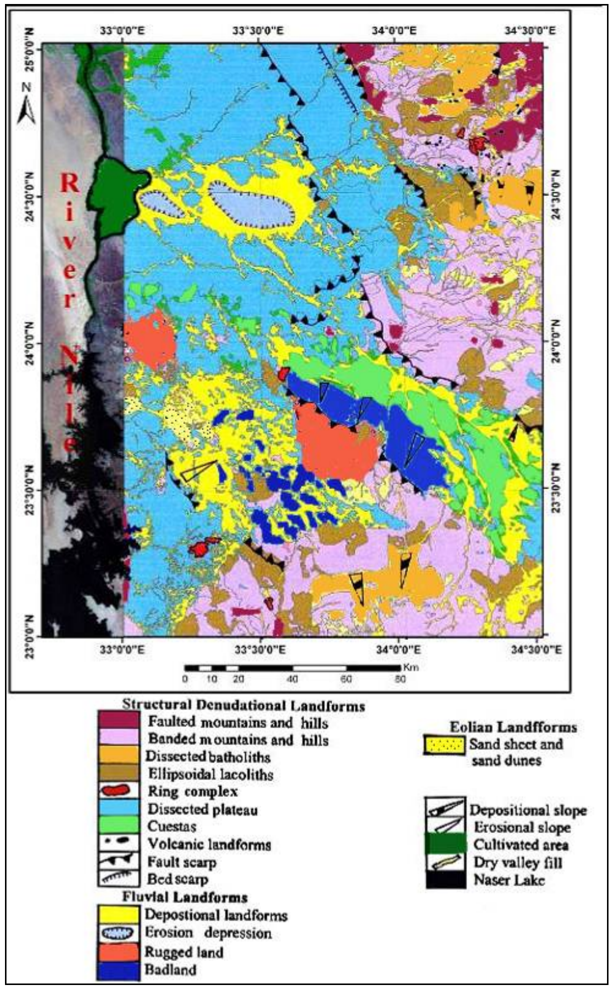

Fig. 7: Geomorphological map of Wadi Garara area

Badland:

In the western edge of Wadi Garara and inside the graben, there are badlands in the sedimentary exposures due to high weathering and high drainage density in some sedimentary beds. They exhibit steep slopes and overlie beds of rock fall and rock sliding. This unit formed by exogenetic processes in thick sedimentary succession.

Aeolian Landforms:

Three geological-geomorphological profiles were prepared nearly perpendicular to the graben direction (Fig.8). Their locations are plotted on Figure 6 Profile, elucidates that there is a northern downthrow of EW fault, which coincides with the present side (wall) of Wadi Natash and nearly coincide with the subsurface magnetic airborn interpretations. Therefore, there is downthrow after the graben development, and there are later other downthrows more recent than the Atmour Nugra depression. In locality of profile no.2, (Fig. 6) the airborne magnetic interpretations suggest that the granitic rocks appear in the subsurface bigger than on the surface geologic maps. Profile no.3 elucidates that extensive fluvial weathering processes affected on the metasediments and Nubia sandstones forming rugged land that followed by aeolian deposition processes fillling the rock grooves with sands and covering the lower lands with sand shhets.

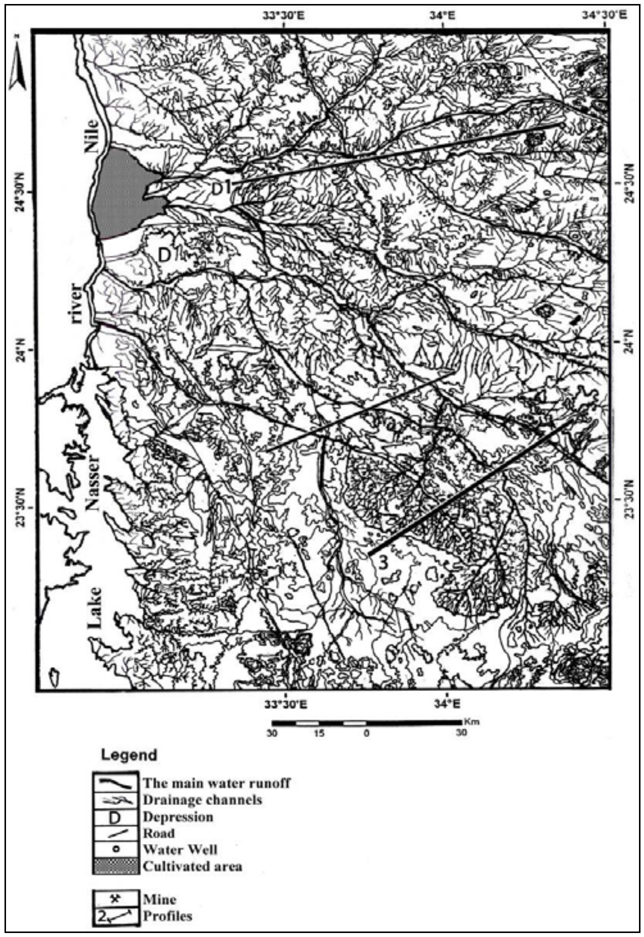

Fig. 6: Drainage network of Wadi Garara area prepared from Landsat TM images

Structure:

In the interior of the African–Nulian Shield, steep vertical movements are accepted and they are for the Precambrian rocks and Phanerozoic rocks. These faults are regenerated often with quite steep the graben borders are intersecting uplift in Miocene age. In connection with the variations and oscillations in the vertical pattern of faulted areas on the plunges of old massifs, (Schurrmann1974). The orientation of the Late-Paleozoic to Mesozoic large–scale undulations indicates that the reason for the SE-NW compression in the rotation tendency of Africa strting in Carboniferous and culminating in Tertiary of Africa separated from Asia (Schurrmann1974). The ancient platforms of the East Africa have existed as continental blocks since mid-Archean time nearly 3000 million year ago (m.y.). Their basement consolidated during late–Proterozoic(1600 m.y.), a sedimentary cover of the ancient platform began to accumulate. The basement of young platform began to form with fold-belts much later, in mid-Proterozoic time. Some of these young platform attained stability at the beginning of Paleozoic, others at the end of Paleozoic while some margins of platform in the studied area attained stability at Cretaceous age. Schurrmann (1974 postulated two structural stages can be recognized in the history of the young platform in north east Africa: The first stage involves the formation of the depressions, some of them very long and deep, seated faults cutting the basement. On all platforms, some of these depressions are disturbed by folds and contain volcanic series and small igneous intrusions. Being of epi-Hercynian age, they are generally filled with Triassic and Jurassic series. Often thick, containing such volcanics such as andesite, basalt, and related tuff. Unlike the aulacogens of ancient platforms, scientists have suggested calling these depressions taphrogenes. The second stage in the young platforms is characterized by generation of gentle uplifts, similar to shields, and by extensive and long-developing depressions looking loke syneclises and pericratonic down-warps of ancient platforms. The depressions were initiated in the Jurassic and then developed during the Cretaceous, Paleogene, and Neogene; some of them are subsiding at present. Paul Morgan (1990) suggested main faults directions as tectonic events that have directly or indirectly affected the geology of Egypt and he classified these events chronolgically and stated that the northeast-southwest faults pattern has not been explicitly recognized in Egypt, but a parallel of northwest-south faults system is predicted this coincide with the present study in Garara area forming the graben.

Structural data are obtained from Landsat images, the interpreted structural elements from geophysical aeromagnetic survey and faults from Sigaev map (1959) are plotted also in Figure 9 that have enabled analysis of the major structural elements in the investigated area. Geomorphologically, NW-SE, NE-SW, WNW-ESE and NNE – SSW structural sets traversed the rock units in the area through major tectonic movements that can be summarized as follows:-

1. Precambrian to Rephian (pre-Nubia) structures on the Basement rocks.
2. -Cretaceous (Nubi structures)
3. -Tertiary (Post-Nubia structure)

Precambrian-Rephian (pre-Nibia) structure:

Paul Morgan (1990) stated that during the Precambrian proto-crust for Nile craton and there is reworking and stabilization of Nile craton followed by Pan African island arc accretion. In the study area, the Precambrian-Rephian faults trending WNW-ESE, NW-SE and NE -SW with displacement throughout the basement rocks In southern part of Eastern Desert of Egypt, there is a series of strong fractures trending NNE from the wadi Allaqi (south of the study area) west north west wards can be seen, although much diminished, in the extreme NE of the area. The zone in which these faults could be expected to cross the Nubian "tongue" in the basement rocks, has few faults of similar trend and these are minor effect. The NNE faulting appears to be of pre-Nubian age. In the west of Wadi Hodein (eastof the study area) area a considerable element of shear is present in the NNE - SSW faults. This is not reflected in the distribution of the Nubian over the basement the shear element is therefore of pre-Nubian origin.

Major NW -SE deep-seated faults (Red Sea direction) formed the Garara graben (Fig. 9). Series of fractures trending NE-SW and NNE forming wadis in the NE part of the area and these major faults not cut the Nubian sandstones. NE-SW and E -W faults cut the older granite and NE - SW faults cut the younger granite. Dyke swarms before Nubian formation are locally very intense, as in the south eastern border of the area. Three dyke trends are present: - NNE - SSW, NNW -SSE, and ENE - WSW. Many of them continue into the major fault zones, yet none of the major swarms cut the Nubian in which only isolated dykes occur in the eastern part of the mapped area.

Nubia Structure:

The Nubia sandstone within this area deposited in an aqueous environment varying from littoral to estuarine. This is indicated by cross bedding exclusively of aqueous origin, well-rounded conglomerates, clayey sandstone, ripple marks and spotted ferruginous sandstone, The proximity of the source of detritus is indicated by large local thickness of very coarse deposits with torrential cross bedding,. The persistence of the Nubia sandstone and the occurrence of dykes reflect continued uplift of the source of detritus.

The Nubia Formation is an essentially horizontal formation but there are dipping beds in different directions due to faulting and folding inside the Garara graben. The eastern and western margins of basement rocks (bordering Garara graben) are generally irregular due to complex rectilinear fault patterns before and after the graben formed.

Main folding movement affected the Nubia Formation as NW- SE folding followed a series of superimposed, secondary folds trending NE -SW were although more open in style and less continuous then in development folds, these probably have an important effect on the regional distribution of rock types in the area. In Wadi el Kharite area, a series of isolated first folds in the schists show sharp flexures around NE-SW trending second fold axes of similar trend deformed the first folds more sharply into an irregular isoclinal pattern. It seems clear that the first fold complex was asymmetric with an overall dip of the axial surface to the NE, a steeply dipping near-vertical northern limb and a more gently southern limb. Steeply plunging folds trending N-S appears in the gniesses and migmatite belt of the east part of the area.

Post Nubia structure:

Two major NW–SE faults affected the Nubia sanstones with about 60m WS downthrow extending in the northern border of the graben forming a post Nubia structural regeneration phase in the graben development. Tertiary volcanics arranged in NW direction indicate deep seated structures in Tertiary age along the Red Sea coast. Rift faulting then took place, along NNW-SSE fault zones that were established during the Precambrian. These are associated with plugs and domes aligned on the ENE-WSW trending faults, the lava’s decrease rapidly in amount both laterally and upward. Some are rich in ore minerals especially hematite and it is suggested that contemporaneous erosion of these gave rise to the sedimentary iron ores within the Nubian.

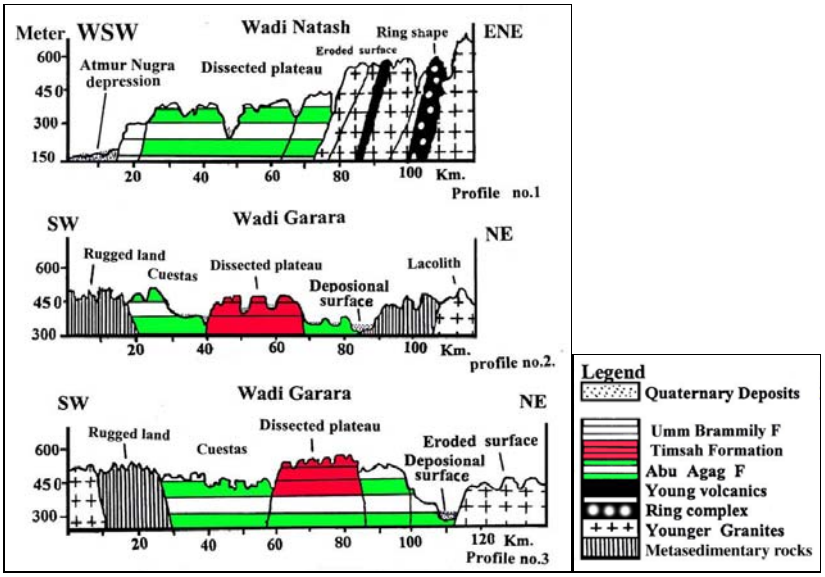

Fig. 8: Geolgical-geomorphological profiles at Wadi Garara area prepared from topographic and geologic maps, their locations marked on Fig. 6.

Geophysical Interpretation:

Geophysical values data are taken from airborne gamma-ray spectrometer and magnetometer surveys of the Eastern Desert, carried out by Aero Service Division, Western Geophysical Company of America for Egyptian General Corporation (1985). The values of both reflected aeromagnetic and radiometric rays for measured points are taken from this report. These values dtermined by the magnetic and radiometric response reflected on the surface of the basement rocks to refere to the distance from the basement rocks to the airborn. Few points have simple interpretation and not linked to each others. Using ARC MAP Program we calculated and addapted these measured values to the sea level and plotted and prepared an Isopach map (Fig.10) to establish the surface of the the basement rocks under the Panerozoic sedimentary cover. In the fowllowing, a brief summary of new interpretations on the aeromagnetic and radiometric values and calculations is given.

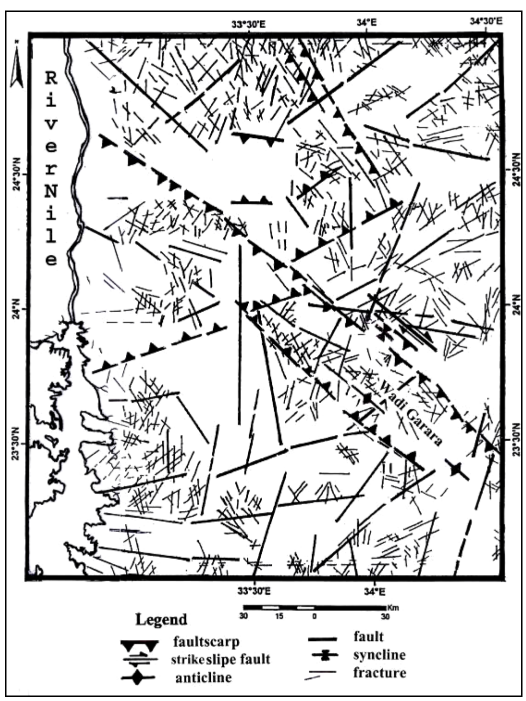

Fig. 9: Structural features in the study area collected from Landsat images interpretation, aero magnetic survey and from Sigaev (1959)

Aeromganetic Interpretations:

At Wadi Shait, there is a very strong magnetic response in serpentinite rocks (rom Service Division, Western Geophysical Company of America for Egyptian General Corporation (1985). This suggest a body larger than that presently in the geological map. Under Wadi Shait's Nubia sandstones, the depth of basement rocks is calculated between 300 and 1000 meters below sea level (m.b.s.l.). While at the southeastern part of Wadi Shait, the depth reachs up to 2000 m.b.s.l., Under the southern part of Wadi Shait, the basement depth reachs up to 3750 m.b.s.l. in a large basin of 3000 m.b.s.l., due to northwest down at a NE- SW major fault. Under Wadi Natash, the values suggest that the deepest basement subsurface magnetic response is at 4700 m.b.s.l. depth. This indicate a deep basin below the east end of Wadi Natash. This means that basement rocks exhibit a high magnetic response of true depth of the basement surface or there is a deep magnetic source. To the south of Wadi Natash there is a very broad gradient depth 3100 m.b.s.l. for the basement surface. In the south of Wadi Natash the basement levels flattens at a depth of 1000-1500 m.b.s.l., i.e. there is a northern downthrow in this area, this downthrow can be calculated and result about 3100- (1000+ 1500 / 2) = 1845 m.b.s.l. To the south, the depths ranging from 2100 to 2700 m.b.s.l. inside the Garara graben. In the western-south of Wadi Natash and near Aswan, the basement rocks are generally very shallow near its exposures it is range from 300 to 500 m.b.s.l. In the contact area between the basement rocks and Nubia sandstones, there is a high magnetic response potentiality indicate large mineralised magnetic body. In the northern part of Wadi el Kharite, there are flatened area with depth 1000 m.b.s.l. with the exeption of few minor strctures which are present due to the second downthrow to the north of the E-W fault at Wadi el Kharite. Several depths at the south are calculated at 3300 and 3400 m.b.s.l. The depth of the basement magnetic response (subsurface depth) ranging from 300 to 700 m.b.s.l. east Aswan 800 m.b.s.l. this indicates the presence of fault steps and accordingly several structural movements.

At Wadi el Kharite area, there are lineaments and individual basins in the subsurface. Shallow basement rocks are interpreted from magnetic data which vary between 300 and 400 m.b.s.l. These individual basins are more shallow in the east in this area. A fault inE-W direction at depth 300 m.b.s.l. in Nubia sandstone is suggested by magnetic data in the western part of Wadi el Kharite.

Under Wadi el Kharite in depths for faults rich with radometric anomalies in granite rocks my be due to subsurface minerlised fissures filling in the granites

There are three faults (structural disturbance) are ranging from E-W to NE-SW with downthrow to the north (Fig.9).

It is noteworthy that the shallower subsurface depth is 300 m.b.s.l. of the basement magnetic response near the contact between basement rocks and Nubia sandstones and at the northern part of the present area under Wadi Shait's Nubia sandstones, the depth of basement rocks is calculated between 300 and 1000 m.b.s.l..Under Atmour Nugra, the depth of basement rocks is calculated about 700 m.b.s.l.. and near east Aswan, it is 500 m.b.s.l.

Radiometric Interpretations:

Under Wadi Natash, the Potassium radiometric anomalies have been interpreted in younger granites and in adjacent Nubia sandstones, this due to the presences of potach feldspars or may due to mineralised anomaly.

Gabal Diheisa granites exposures exihibts of strong radiometyric responses and can be a good target for further mineral explorations.

Radiometric data indicate an anomaly at the northern part of Wadi Natash Nubia sandstones. There is an radiometric anomaly over Nubia sandstones under Wadi Natash and under Wadi el Kharite. It may indicate an unmapped exposure of granites or radioactive mineralised zone in the unconformity zone (paleosl beds) between basement rocks and sedimentary rocks.

Radiometric data indicate that the granitoid rocks which intruded in metasediments and metavolcanics are larger than that present in the geologic map. This due to the emanations of radioactive minerals into the surounding metamorphic rocks from granites, and my due to contact metamorphism. Radiometric data indicate that dykes cause a zone of radiometric potential in the surrounding sedimentary rocks may due to contact metamorphism.

Disscusion:

Geomorphological Indications:

Geomorphological features refelect the genesis of the present landscape of the east Aswan sector as follows;

- In Atmour Nugra depression, the Quaternary surface height is 110-120 m a.s.l. It represents the lowest part in the considered area. This depression is a deep basin and indicates a repettion of fault movement, and erosion cycles.

- The slopes and dip directions of the cuesta landforms in Wadi el Kharite, indicate that the sedimentary rocks in the graben have NW folded post Cretaceous (most probably during the Miocene tectonics)due to load pressers of Nubia Formations.
- Volcanic landforms in Wadi Natash include different cone shapes such as: plug, domes and shield.
- Young Volcanics are present at Wadi Natash, Wadi Shait, Wadi el-Kharite and Wadi Antar. Most of these volcanic exposures are arranged along major structural trends.
- Most ring complexes indicate NW and NE trends, surrounded and/or cut the Nubia Formations. Natach volcanics and ring complexes e.g. Abu Khruq 875 m in the northern part of the area and Gabal Umm Naga 800 m, and Gabal Abu Hariegal in southern part of the area, other two ring complexes at the graben cut the Nubia Formations. represent a hot spot swells are typically several hundred kilometers across and rise mor above the surround Mesozoic sedimentary thickness reach up to 1.2 km.
- The Nubia sandstone plateau around the Atmour Nugra depression have topographic elevation ranging about 400m, while the elevation of the adjacent basement rocks ranging about 750m. Topographic features elucidates that a post Nubia structural regeneration phase tookplaced in the graben history. It can be calculate the surface downthrow of the basement rocks in the graben is equal to 750 m. Where the depth of the basement surface under Nubia sandstones in the graben is around 3000 m from aeromganetic interpretations plus 750 m caculated from the surface topography, so the downthrow equal to 300 (from subsurface data) + 750 (from surface data) = 3750 m.

Geological History:

Two stages can be recognized in the geological history of the depressions in the basement platform in North East Africa: The first stage involves the formation of the depressions, some of them very long and deep, seated faults cutting the basement. Some of these depressions are disturbed by folds and contain volcanic series and small igneous intrusions. Often thick, containing such volcanics as andesite, basalt, and related tuff.

Hashad and El Reeddy (1979) concluded that the distribution pattems of the trace elements indicate a typical “within plate” nonorogenic setting for Wadi Natash volcanic. They are characterized by milicy alkalic and exclusively sodic nature. “Hashad and El Reeddy (op. cit.) suggest three phases of igneous activity which are tentatively assigned the following ages:-

1-The 230±20 m.y. Phase: massifs of Zargat Naan, (Zargat Naan lies north of the mapped area) and other Paleozoic rocks.

2-The 140±15 m.y. Phase: massfis of some ring complexes are Early Cretaceous.

3-The 90 T± 20 m.y. phase, during which the Wadi Natash alkalic volcanics were erupted followed by intrusion of Abu Khruq ring (Late Cretaceous) extend to Wadi Natash volcanic activity to 70 m.y. It is believed that a tholeiitic basic melt crystallized through a limited fractionation process, injected in the continental crust. A second pulse gave a felsic injection which assimilated most of the pre-existing basic rocks, giving rise to the microdiorites, microsyenites then finally the aplites.

A study of stratigraphic section of the sandstones sequence in South Eastern Desert of Egypt leads to some understanding of the epeirogenic history of Egypt. Klitzsch (1984) consider the Late Caledonian positive element oriented approximately NW, this trend corresponds with the Gulf of Suez trend. Issawi and Jux (1982) suggested that the sedimentation environment at Gabal Abraq (adjacent to the eastern border of the study area) is the oldest sedimentary rocks in the Eastern Desert, showing evidence of being deposited under shallow marine and coastal margin incursion. The present of plant ramain indicate Carboniferous age of them. Abu Ballas Formation, show evidence of being deposited in braided fluvial system invaded by shallow marine in Jurassic age. Nubia Formation was deposited under fluvial to shallow marine conditions in Confucian age. Tarif sandstone member was deposited under fluviatile to braided channel deposits and assigned a Confucian -Santonian age. In Kom Ombo area, the Jurassic-Nabian tectonic stage is conformable with the bottom of the Upper Cretaceous. In Komb Ombo area, there is an unconformity between these tectonic stages (Issawi and Jux op.cit.). Jux, and Issawi (1983), described Paleozoic section of about 150 m. thickness in Gabal Umm Besilli adjacent to the eastern border of the study area. They suggested that these sedimentry rocks are continental and marine sedimentation environments. Seleim and Said (1992 and 1993) belived that the Paleozoic sedimentary rocks in Wadi Garara about 150 m underlain the Cretaceous formations. They found a paleosol with iron concretions on top of the Paleozoic rocks unit, bellow the Taref member of Nubia sandstones (Cretaceous). Conoco Coral geological map 1987 draw the Nubia sandstone in east Aswan and Wadi Garara as Cretaceous age (Abu Aggag Formation(F) ,Timsah F, Umm Bramil F. Magdy,et,al. (1995) suggested that the Nubia sandstone in Gabal Abraq (east of the area) are Cretaceous age, and composed mainly of sandstones, siltstones, and shales, represented by Abu Simbel Formation of Late Jurassic to Early Cretaceous age, theAbu Ballas Formation of Aptian age and the Sabaya Formation of Aptian to Cenomanian age.

Subsurface Geophysical Events:

It is noteworthy that the shallower subsurface depth is 300 m.b.s.l. of the basement magnetic response near the contact between basement rocks and Nubia sandstones and at the northern part of the present area under Wadi

Shait's Nubia sandstones, the depth of basement rocks is between 300 and 1000 m.b.s.l. Under Atmour Nugra, the depth of basement rocks is about 700 m.b.s.l and near east Aswan, it is 500 m.b.s.l.. Under the southern part of Wadi Shait, the basement depth reachs up to 3750 m.b.s.l. in a large basin with range depth of about 3000 m.b.s.l., Under Wadi Natash, the values suggested that the deepest basement subsurface magnetic responses are 4700 m.b.s.l. This indicate a deep basin below the west end of Wadi Natash i.e. it is the deepest basement blook in South Eastern Desert. This meens that either the basement rocks exhibit a high magnetic response of true depth of the basement surface or there is a deep magnetic source and any way, the deepest subsurface basement blooks lies between Wadi Shait and Wadi Natash and it is the maximum downthrow at intersections of the major NE and NW faults. It is noteworthy that this geophysical subsurfaces interpretation coincide with the surfaces geomorphologicl profiles and features as well as explain the present depression shape of Atmour Nugra and presense of the badland due to high erosion processes. The Potassium radiometric anomalies have been interpreted in younger granites and in adjasent Nubia sandstones under Wadi Natash and at Gabal Diheisa granites exposures exihibts of strong radiometyric responses and can be a good target for further mineral explorations. Radiometric data indicate presence anomaly at the unconformity zone (paleosl beds) between basement and sedimentary rocks due to uplift movement and erosion processes. Radiometric data indicate that the granitoid rocks are more larger than that present in the geologic map and indicate presence of imanations of radioactive minerals from granites to the surounding metamorphic rocks due to cntact metamorphism. These data indicate that dykes cause a zone of radiometric potential in the surrounding sedimentary rocks

The Nubia sandstones surface elevations in range is about 400m at the border of graben , while the adjacent basement rocks elevations in range is about 750m , i.e. the surface downthrough is apparently at least is equal to 750m. The surface measurments on the sides of the graben deliniate 750 m graben’s downthrow and the aeromagnetic survey interpretations give a subsurface downthrow 3000m, in major parts, so, the actual graben downthrow is equal to 3000 + 750 = 3750m.

Mineralization known in the present area includes gold, copper, tin, tungsten, lead, zinc, nickle, chromium, iron, radioactive minerals, alumina, carbonatites and titanium. Other economic resources include, talc, barites, asbestos, graphite, marble and various ornamental and building stones.

The Nubia iron ores, are exploited east of Asswan. Further exploration might first take form of visual Landsat reconnaissance, seeking concentrations of red sands. In Wadi Shait and Wadi Garara ironstone bands occur in some sand regions as cap rock or laminated within the succession. The Wadi Natash lavas may be the primary source of the iron. Oxidation of surface flows could provide an abundance of iron-rich dust to pass into solution, or be swept into the Nile basin and redeposited under lacustrine or fluvio-marine conditions.

The alkaline stocks and ring complexes are at special interest for alumina and carbonatite mineralization. Abu Kruq syenite and Gabal Umm Naga are considered as source of alumina. Other ring complexes in the Garara graben and Gabal Hadaeib may possess carbonatites, which sometimes yield niobium and various rare earth minerals.

The unconformity surface between the basement and sedimentary rocks is a suitable environment for radioactive mineral deposits. The basal conglomerates and paleosols in the study area may have radioactive minerals.

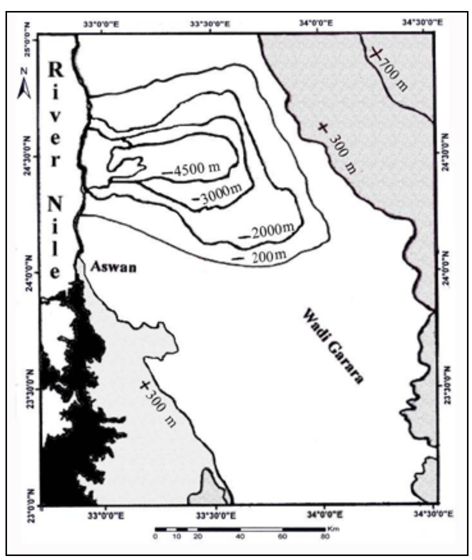

Fig. 10: Isopach map for the surface of basement rocks in the study are

Conclusion:

The established main geomorphological units in the area are: structural landforms (faulted- and bedded-mountains and hills,volcanics, dissected plateau and cuestas), Fluvial, (depositional- and erosional –landforms), and aeolian landforms.

The topographic features elucidate that a post Nubia structural regeneration phase took place in the graben development.i.e the calculated surface downthrow is equal to 750m. The aeromganetic interpretations show that the surface of the basement rocks under the Nubia sandstones is around 3000m plus 750m caculated from the surface, so the actual downthrow equal to 3750m.

The geomorphological studies, structures and geological history together with the aeromganetic interpretations can delineated that the Garara graben had firstly bounded by deep seated NW-SE faults in Precambrian in continental platform forming continental blocks. An extensive erosion cycle took placed and followed by a thick downthrow took placed at the Createaceous. Also crustal uplift motion took placed around the graben due to thermal activity in hot mantle. Hot spots swells of volcanic activity in Natash alkali volcanic series ,alkali ring complexes in upper and in the end of Createaceous and dykes are alkali magmatic eruptions characterised by high sodium content due to deep seated faults. The ruptures which formed due to uplift movement of the basement rocks followed by erosion cycle and did not loose their activity during the Paleozoic and Mesozoic. The downthrow regenetated during Tertiary age.

The detected shallower depth resulted from basement magnetic response at subsurface lies 200 meters bellow sea level near the contact between basement rocks and Nubia sandstones. This suggest that there are steps of parallel faulted movement in multi-temporal ages and nera east Aswan.

In the east northern part of the graben, there are two major NW–SE faults affected in the Nubia sandstones with about 60m WS surface downthrow forming a post Nubia structural regeneration.

Volcanic landforms in Wadi Natash elucidate that the volcanic activity happened in long period which allow to this wide magmatic differentiation.

Atmour Nugra depression formed by NE-SW deep seated faulting movement took placed post-Cretaceous in the northern part of the graben and affected on the sedimentary rocks forming a new depression inside the graben with about 1000m downthrow and known as Atmour Nugra. Then in the Cenozoic, a vertical movment took plcaced and erosion cycles durated until the Quaternary and followed by a thin Quaternary deposits.

Under Wadi Natash, the values suggested that the deepest basement subsurface magnetic responses are 4700 m.b.s.l. This indicate a deep basin below the east end of Wadi Natash i.e. it is the deepest basement blook in South Eastern Desert. This means that either the basement rocks exhibit a high magnetic response of true depth of the basement surface or there is a deep magnetic source and any way, the deepest subsurface basement blooks lies between Wadi Shait and Wadi Natash and it is the maximum downthrow at intersections of the major NE and NW faults. It is noteworthy that this geophysical subsurfaces interpretation coincide with the surfaces geomorphologicl profiles and features as well as explain the present depression shape of Atmour Nugra and presense of the badland due to high erosion processes.

Gabal Diheisa granites exposures exihibts of strong radiometyric responses and can be a good target for further mineral explorations. Radiometric data indicate presence anomaly at the unconformity zone (paleosol beds) between basement and sedimentary rocks.

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