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Program Support Unit

Egyptian Environmental Policy Program

Mining, Quarrying, Geology & Minerals at Wadi El Gemal-Hamata Protected Areas

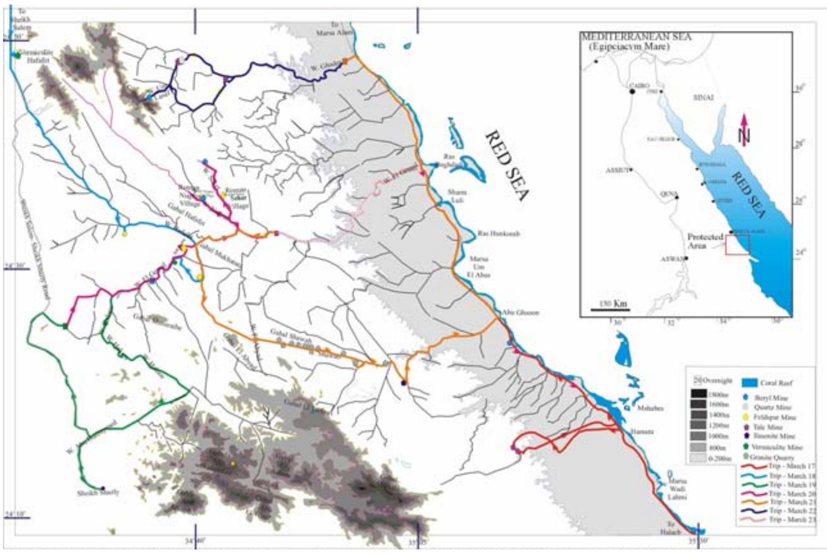

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Table of Contents

Executive Summary

The Red Sea area is known worldwide for its unique coral reefs, marine life and other natural resources. Most of the proposed tourist development areas are located within its coastal zone, with safaris, mining, quarrying and other industrial activities widely distributed in the hinterland mountainous region. Wadi El Gemal – Hamata Protected Area, declared a Protected Area in November 2002, is a valuable watershed area and wildlife habitat, containing unique plants and animals. In addition to its fascinating geologic history, the area is notable for its history of human activity, with a variety of ancient mining settlements of archeological value.

Development activity in the Wadi El Gemal-Hamata Protected Area currently impacts mostly coastal areas, but the environmental pressures could spread to the hinterland mountainous region. Present tourist activities do not appear to have an adverse impact on the terrestrial resources of the area. There is environmental degradation at some parts of the coast, and lesser environmental problems at some other sites in the wadis, but most of these problems are not caused by tourism.

Although the area is included in the list of legally protected areas, it requires more assertive and practical management interventions. The EEAA rangers have started controlling this area, but considerable work is needed to make this more effective and purposeful, starting with a management plan.

The present survey of the coast and land areas provides baseline data for the topography, geomorphology, physical features, geology, and other relevant environmental systems that may be affected, by the execution, and/or the existence of the anticipated development. Anthropogenic activities of the area were also identified. Generally, the pattern of the existing environmental systems was evaluated for envisaging how these systems might be affected by development. Sites which would be capable of supporting tourist, industrial or domestic activities, were identified, and a number of management options were outlined.

Recommendations for consideration in the management plan are summarized below:

- Mining and quarrying activities should be allowed only in areas that have no other important resources, and in areas out of sight of tourism areas. EIA reports much show no unacceptable impacts to critical cultural or natural resources.
- It may be necessary to acquire additional lands as necessary to meet management objectives. In particular, the entire area of Wadi Ghadir is worthy of inclusion in the WGHPA. As it stands, only a part of Wadi Ghadir is within the WGHPA boundaries.
- Developing a guided exploration program covering geologic and human history in the region, organize and limit tourism and damage to the sites.
- Involving native Bedouins in the management of the area.
- Rehabilitation of existing non-historic mining and quarry sites, with the cooperation of the operator and consultancy of a qualified scientists to ensure the area is restored to its approximate natural state to fit the surroundings.
- Travel on existing roads only, and periodic closure of certain roads during heavy rains and floods. Off road travel only with authorization.

1 Introduction

The Wadi El Gemal-Hamata Protected Area (WGHPA) is comprised of coastal areas, islands and hinterland mountainous regions that serve many purposes (fisheries, diving, safari, biodiversity, quarrying, and mining). They are special places, given their close proximity to Marsa Alam airport (110 km south of Marsa Alam International Airport) and the degree to which they are the objects of tourist and industrial demand. The area lies between latitudes 24° 05` and 24° 50` N and longitudes 34° 30` and 35° 30` E (**Fig. 1**). The area is accessible via an asphalt road along the Red Sea coast, and is located about 50 km from Marsa Alam. Traveling south from Marsa Alam, the road passes by the towns of Abu Ghusun and Hamata. WGHPA can also be reached via the asphalt road between the Nile town of Edfu and Marsa Alam, a distance of 220 km., or via Sheikh Salem – Sheikh Shazly road. There are also some desert tracks accessible to light cars like the track in Wadi El Gemal about 60 km from Sheikh Salem –Sheikh Shazly road.

Coastal areas are currently open to tourism while quarries and mining activity can be found throughout the desert area. Along the coast and in the hinterland regions tourism and industrial activities are the principal development options and the primary task will be how to manage them sustainably. Mineral and building material extraction is one of the primary and traditional economic activities in the Eastern Desert of Egypt. These activities can have detrimental impact on the desert environment, both ecologically and aesthetically, if conducted in haphazard or destructive ways. Understanding the geology, landforms and landscape processes of an arid mountainous region, such as that of the WGHPA, is essential for future management.

Under Policy Objective # 12 of the Egyptian Environmental Policy Program (EEPP), the Program Support Unit (PSU) is assisting the Egyptian Environmental Affairs Agency (EEAA) in providing protection to the Egyptian Red Sea coast, Islands, hinterland landscape and Linked Ecosystems of Importance. As part of this assistance, the PSU is providing technical support to prepare a Management Plan for Wadi Gemal - Hamata areas. The PSU has contracted the services of several Egyptian consultants to assist in surveying the area, assess the environmental threats posed by existing uses, in order to prepare a recommended management plan for the area.

The survey team, from March 15 to 23 (2003), investigated the coastal area and hinterland mountainous region via safari vehicles and on foot. The information and recommendations gained from this study will assist the PSU-EEAA staff in identifying conservation management priorities for geological and landscape resources of the newly-declared WGHPA, and to arrive at the most appropriate management action to reduce negative effects of various activities.

The study was based upon a combination of review of previous literature and fieldwork. The survey covered a large expanse of the Protected Area (**Fig. 1a-d**). The survey work involved an exploration of changes that have occurred throughout the geologic history and focused on the human interaction with this geology over the past centuries. The historic mining, the archeological sites, the current mining activity, and volcanic and structural geology were the central focus of the field work.

By wading along the coast, morphological as well as sedimentological and biological information was collected. Topography, geomorphology and geology of the different landforms in the area are based on the field observations, topographic maps (scale 1:250000, 1:100000 and 1:50000), aerial photographs (scale 1:40000) mosaics (1:50000) and landsat images (1:250000 and 1:50000).

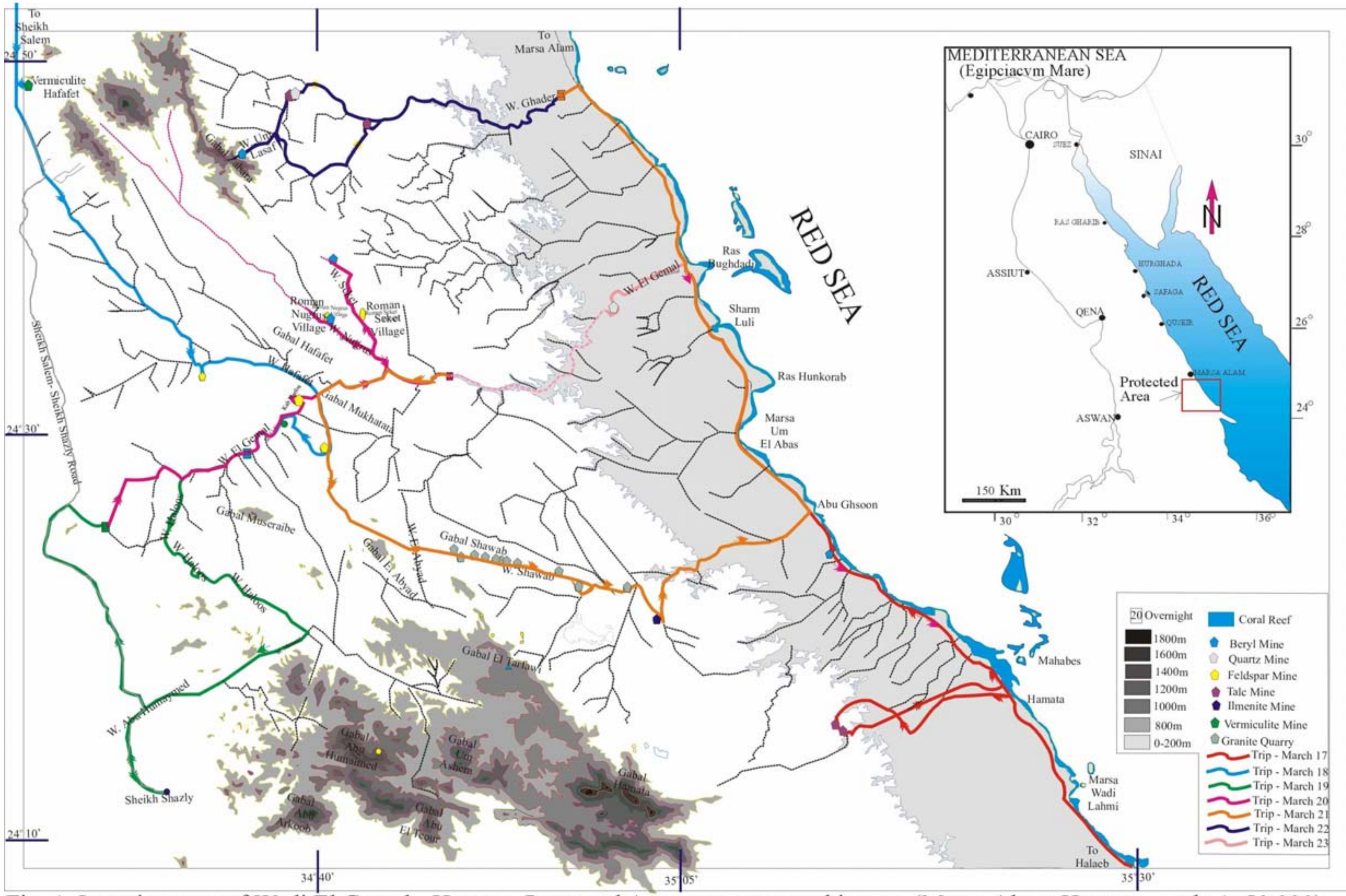

Fig. 1. Location map of Wadi El Gemal - Hamata Protected Area on a topographic map (Marsa Alam, Hamata, scale 1: 50 000).
Note: Days of trip was defined by different colors (March 17 - March 23) and location of visited mines and quarries.

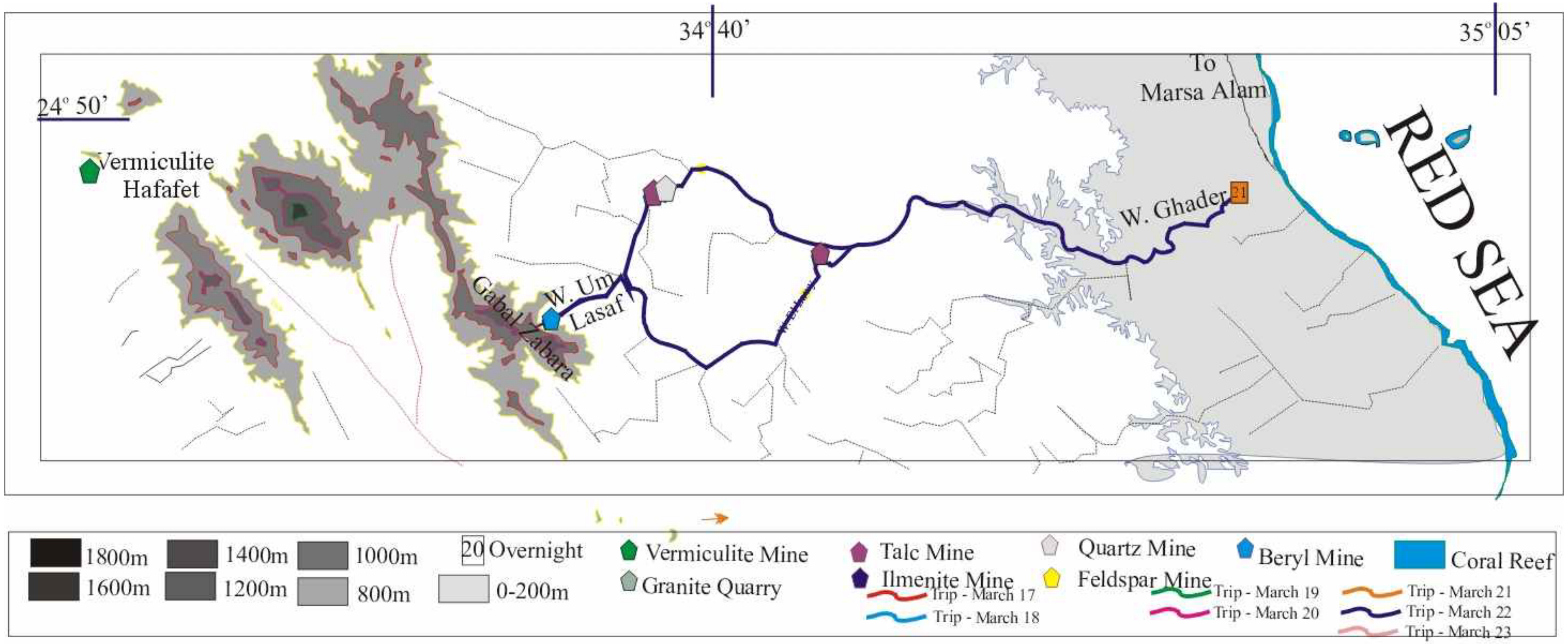

Fig. 1b. Location map of the northern part (Wadi Ghader) of the Protected Area.

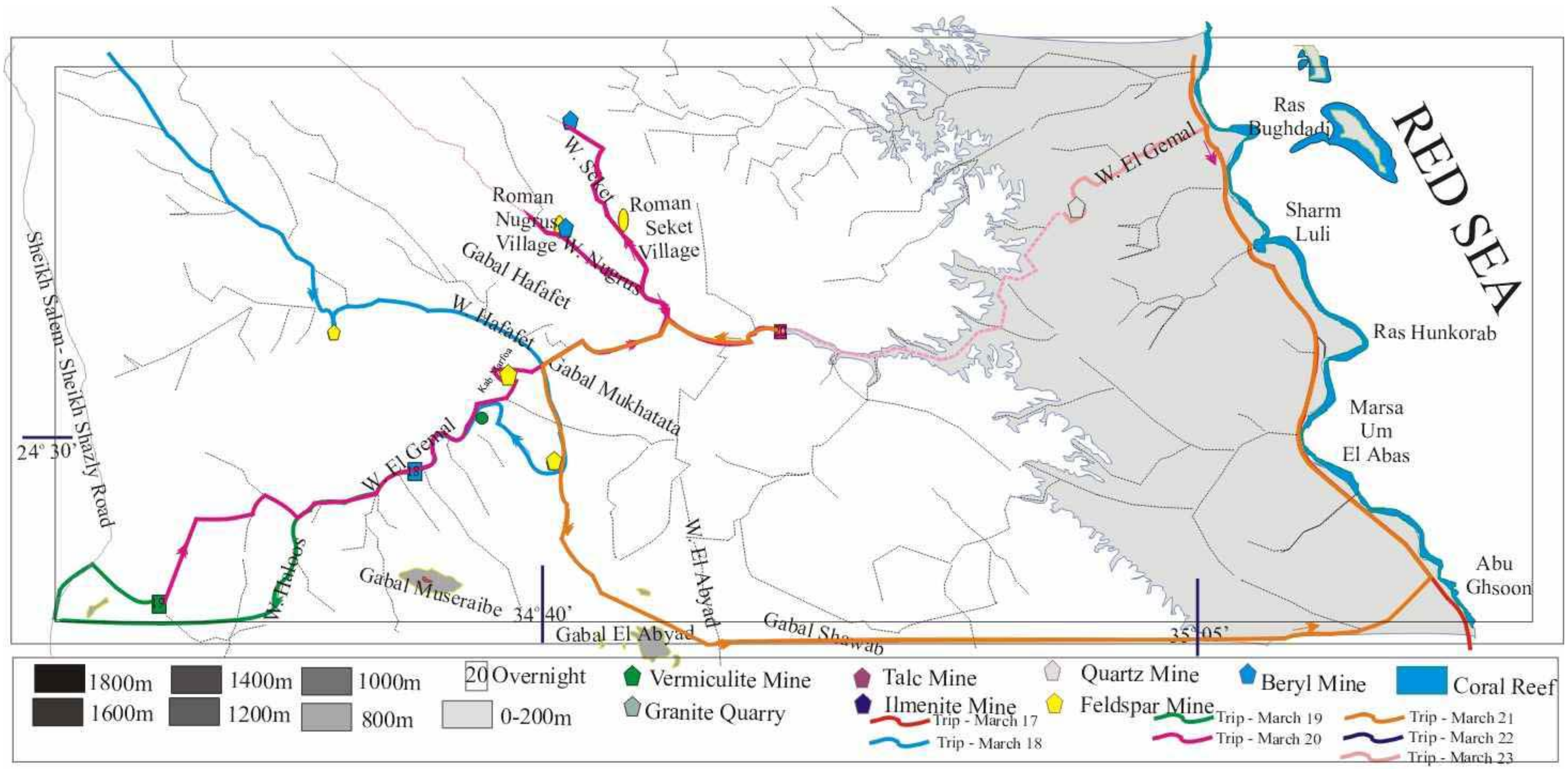

Fig. 1c. Location map of the central part (Wadi El Gemal) of the Protected Area.

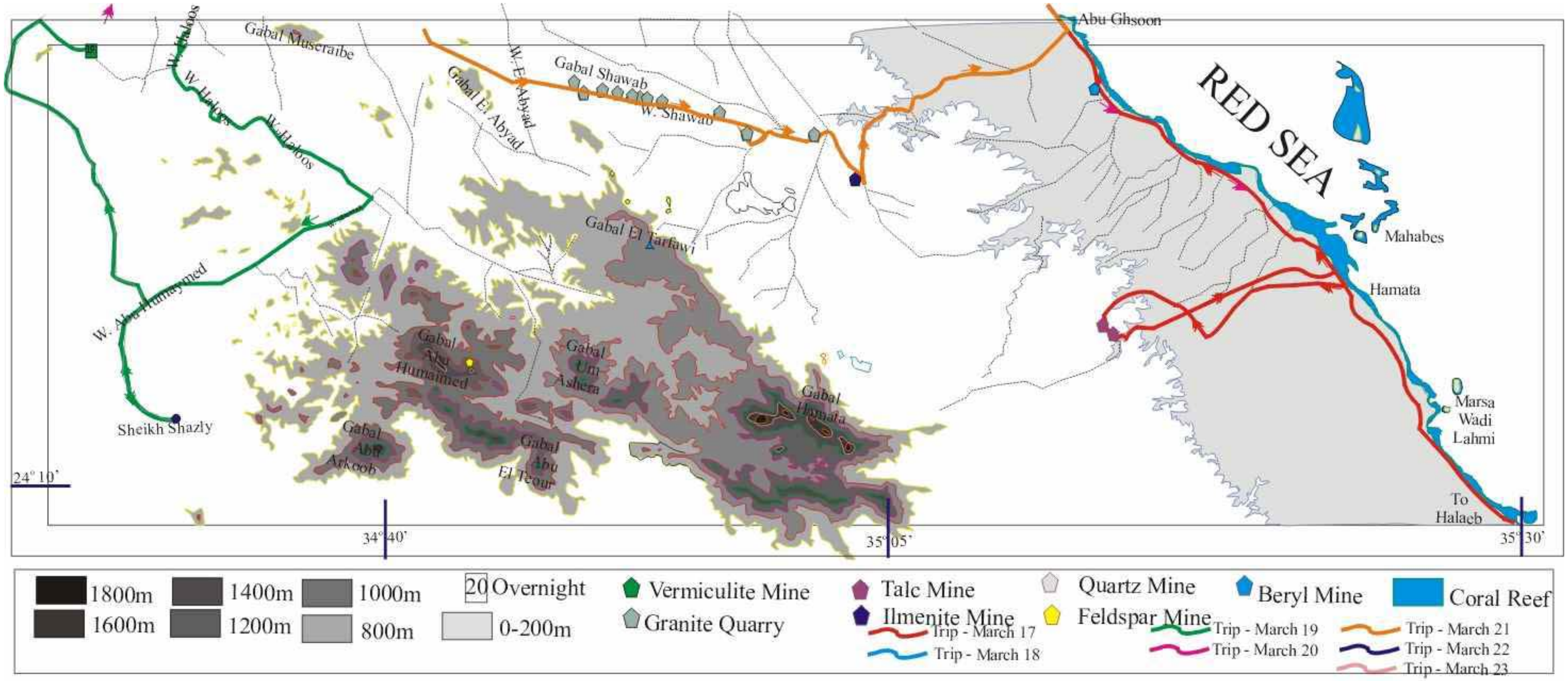

Fig. 1d. Location map of the southern part f the Protected Area.

2 Climate and Oceanography

The area is characterized by an arid climate and dominated by hot, rainless summer and mild winter. The average annual precipitation rate is about 17.4 mm (meteorological stations of Ras Banas). Most of this precipitation occurs as heavy showers with short duration results in flash floods during the winter season between October and February. The maximum amount of perception recorded in one day was 64 mm (24 November 1966). The monthly mean temperature varies between 24-38^{o}C during summer and 12-26^{o}C during winter. The relative humidity varies between 28% in summer and 57% in winter. The average evapotranspiration varies between 8.7mm/day in winter and 28 mm/day in summer. According to these climatic parameters, the area from Marsa Alam to Ras Banas (Mansour et al, 2003) receives an average rainfall quantity equal to 98.78 million cubic meters/year (**Table 1**). However, a considerable amount is lost to evaporation. The amount of water surplus reaches up to 80% of the total rainfall amount (Ghodeif, 1995). Therefore, a huge amount of rainwater can be percolated and replenish the groundwater storage if the runoff is controlled.

All year round, winds from NW to NE predominate, only in rare cases wind in a southerly direction occurs. (**Fig. 2**). The velocity usually ranges between 66.07 km/h and with an average of 22.04km/h in summer and between .096 km/h and 62.93km/h with an average of 19.26km/h in winter (Meteorological station, Institute of Oceanography and Fisheries, Red Sea branch). In general, wind velocity is distinctly higher during the daytime, a phenomenon that can be explained by the higher temperature differences between the stronger heated landmass and seawater during the day.

The water level changes periodically as a result of thermally driven winds, blowing landward in daytime. The chimney effect, especially of NW winds blowing sediments from the coasts results in southward transport of sand and its eventual dumping into the sea. NW winds carry oil spill and litter into the coastal areas and islands (**Fig. 3**). Winds also create a mainly NE-SW oriented wave motion. This leads to higher waves in exposed areas, and drives longshore currents. This current by northerly wind in summer drives surface water southward. The reverse in winter pushes water into the Red Sea from the Gulf of Aden. Waves and currents redistribute terrigenous debris carried into the sea either via wadis or NW winds on the tidal flat, and most likely also sweep some of the fine terrigenous sediments from the submarine slopes into the deeps (Mansour, 1995). The marine area around the islands and along the coast is subjected to the wave action, and therefore some areas are considered erosion zones **(Fig. 4)**. Erosion should be taken into consideration for any construction plans in the coastal areas. Because of nearly permanent air- and water- turbulence, a complete mixing of the water column occurs and no stratification is developed inside the water body. This is reflected also by the values of temperature and salinity, which show no significant differences between surface and bottom waters (Piller and Pervesler, 1989).

Tide: Summaries by Morcos (1970) and Edwards and Head (1987) describe the now well known oscillatory condition, whereby the central part at 20-21°N has almost no daily difference in tidal height, and the northern and southern ends have daily ranges increasing with distance from the central region (approximately 0.6m in the north and up to 0.9m in the south). These are spring tide ranges, and greater than the average. A seasonal tide in the Red Sea is in winter over 0.5m higher than in summer. The tide is semidiurnal, peaking every 12h with a mean tidal range of about 0.65m and about 0.95m at the islands.

In July-August, 1998, most oceanographic parameters were measured in areas from Hurghada to Marsa Alam along the Red Sea coast of Egypt (Mansour et al. 2000) (**Table 2**).

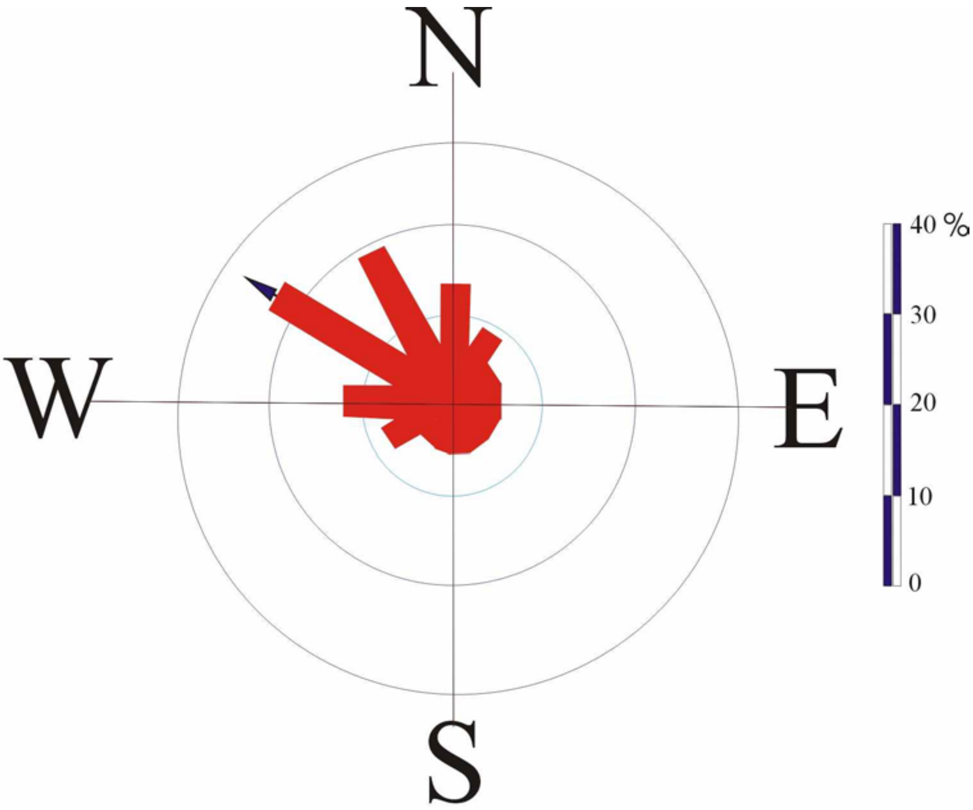

Fig. 2. Yearly mean wind rose diagram.

Table 1: Estimated Rainfall Quantities of South Marsa Alam Basins (Mansour et al. 2003).

#	**Basin name**	**Area (Km^2)**	**Annual Rainfall ($10^6 m^3$/year)**	**Max. Rainfall/ day ($10m^3$)**	**Max. Runoff/ day ($10m^3$)**	**Min. Runoff/ day ($10m^3$)**
1	Wadi Samadi	63.26	1.1	4.05	2.66	0.24
2	Wadi Umm Tundeba	67.07	1.17	4.29	2.82	0.25
3	Wadi Ambaut	90.47	1.57	5.79	3.8	0.34
4	Wadi Nakari	48.34	0.84	3.09	2.03	0.18
5	Wadi Ghadir	554.24	9.64	35.47	23.28	2.08
6	W. Khalilat El Bahri	13.28	0.23	0.85	0.56	0.05
7	Wadi Khalilate El Qibli	11.52	0.2	0.74	0.48	0.04
8	Wadi Sharm Faquri	73.05	1.27	4.68	3.07	0.27
9	Wadi Erier	261.32	4.55	16.72	10.98	0.98
10	Wadi El Gemal	1476.7	25.7	94.51	62.02	5.54
11	Wadi Umm Abbas	337.97	5.9	21.63	14.19	1.27
12	Wadi Abu Ghusun	495.29	8.62	31.7	20.8	1.86
13	Wadi Ranga	309.63	5.39	19.82	13	1.16
14	Wadi Qulan	57.33	1	3.67	2.41	0.21
15	Wadi Raadi	156.77	2.73	10.03	6.58	0.59
16	Wadi Umm Rimarim	48.83	0.85	3.13	2.05	0.18
17	Wadi Khashir	464.01	8.07	29.7	19.49	1.74
18	Wadi Lahmi	967.08	16.83	61.89	40.62	3.63
19	Wadi Umm Gazal	16.42	0.29	1.05	0.69	0.06
20	Wadi Kirah El.Hertawi	37.21	0.65	2.38	1.56	0.14
21	Wadi Staiya	39.06	0.68	2.5	1.64	0.15
22	Wadi Sharm Luli	60.15	1.08	3.85	2.53	0.023
23	Wadi Umm Dahise	24.12	0.42	1.54	1.01	0.09
Total			98.78	363.08	238.27	21.073

Table 2: Oceanographic Parameters Measured in July-August, 1998, at Different Locations on the Red Sea Coast of Egypt (Mansour et al. 2000).

Location	Do (mg/l)	S (‰)	pH	Eh (mv)	Temp (°C)	TDS (g/l)	Spec (ms/am)
Hurghada	5.44	40.3	8.65	333	27.8	38.1	59.69
Safaga	4.3	39.79	8.55	433	27	36.45	57.3
Quseir	4.4	40.4	8.5	389	28.3	38.2	59.3
Marsa Alam	4.22	39.91	8.71	336	27.35	37.91	59.24

Do = dissolved oxygen, S = salinity, Eh = oxidation-reduction potential, TDS = total dissolved salts, Spec = specific conductivity

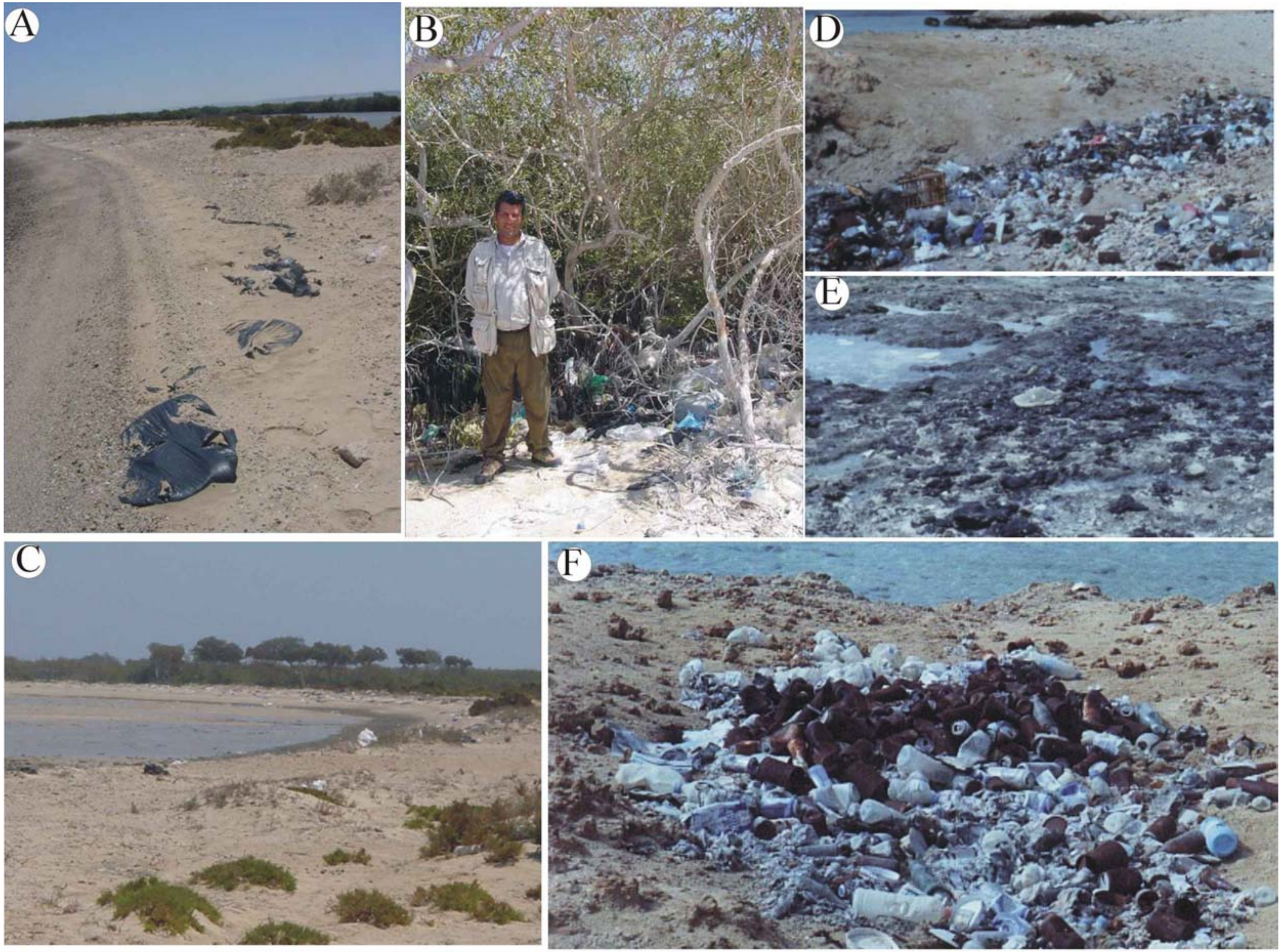

Fig. 3. Garbage and oil pollution of coastal areas (A, B, C) and Wadi El Gemal Island (D, E, F), abundant in the NW and NE sides, even in the mangrove swamps (B).

Fig. 4. Erosion of coastal areas (Delta Wadi El Gemal, upper pictures) and Wadi El Gemal Island (lower pictures), abundant in the NW and NE sides.

3 Topography and Geology

The area is comprised essentially of high and rugged mountainous, built up of a series of mountain ranges, more or less coherently trending parallel to the coast and interrupted by number of detached masses and peak (**Fig. 1**). The high peaks are concentrated in the southwest corner where they rise to elevations up to 1975m (Gebel Hamata). The river Nile – Red Sea water divide of the area runs over the high peak of the Red Sea Mountains with an average elevation of 650m.

The moderate relief occurs in the southeast and northwest, surrounding the high mountainous zone. The most important hills and mountains (**Fig. 1**) are as follows:

G. Hafafit (1341m)

G. Nugrus (1505m)

G. Zabara (1360m)

G. Ghadir (864m)

G. Sukari (630m)

G. Ghyweil (1062m)

G. Skeit (796m)

G. Sabahia (694m)

G. Lawi (615m)

G. Raady (556m)

G. Leweiwi (663m)

G. Umm Kabu (644m)

G. Abu Hade (663m)

G. Khariga (927m)

G. Umm Harba (718m)

G. Umm Regeba (568m)

G. Umm Maghar (851m)

G. Museraibe (1021m)

G. Abu Etl (643m)

G. Umm Sueh (748m)

G. Shawab (762m)

G. Kab El Ahmer (604m)

G. Umm Abbas (660m)

G. Mahali (612m)

G. Tarafawi (1361m)

G. Sertote (1368m)

G. Mureir (612m)

G. Sarobi (468m)

G. Hamata (1975m)

G. Qulan (376m)

G. Umm Leham (999m)

G. Khashir (1562m)

G. Ras El Khorate (1658m)

G. Ejat (1596m)

G. Mikibit (1412m)

G. Zitit (898m)

G. Mukhatata (570m)

G. Abu Jurdi (1096m)

G. Umm Junud (880 m)

G. Umm Mayat (976m

The area is dissected by large number of wadis that initiate from the mountainous terrain and run towards the Red Sea following the general estwardly slope. Slope gradient is mostly steep in the upper reaches of drainage ways and tends to be gentle to the east. The wadis are mostly oriented E-W, W N W – E N E, NNW and N E (Ahmed, 2001). The main wadis are considered important as they serve as a network of roads in the area and as the main arteries for underground water. Most wadis are accessible by car. The main wadis, with their tributaries and branches from north to south are as follows:

- Wadi Ghadir: Wadi Ghuel, Wadi Fagas, Wadi Umm Ud, Wadi Sabahia, Wadi Zabara (Wadi Atabi, Wadi Umm Abid, Wadi Umm Dafiri, Wadi Umm Lasaf)) and Wadi Allawi (Wadi Lewewi).
- Wadi Khalilate El Bahri.
- Wadi Khalilate El Qibli.
- Wadi Sharm Faquri.

- Wadi Erier: Wadi Rimarim
- Wadi El Gemal: Wadi Hulus (Wadi Abiad El Hulus, Wadi Mahali, Wadi Tarfawi, Wadi Umm Semiuki, Wadi Marasan, Wadi Abu Gerifat, and Wadi Abu Etl), Wadi Umm Suerab El Gemal, Wadi Durunkat, Wadi Haffafit (Wadi Abu Had, Wadi Hefeifit), Wadi Nugrus (Wadi El Nom, Wadi Abu Rasheid, Wadi Abu Sada and Wadi Skeit), Wadi Mukhatatat, Wadi Umm Sueh, Wadi Umm Heran, Wadi Nasbia, Wadi Abiad (Wadi Umm Seyal), Wadi Umm Kabu, Wadi Ghazal.
- Wadi Umm Abbas: Wadi El Anz.
- Wadi Abu Ghusun: Wadi Dabaka, Wadi Abu Ghalga, Kab El Ahmer, Wadi Shawab, Wadi Romit, Wadi Abu Ashush, Wadi Hakkara and Wadi Dibag.
- Wadi Ranga, Wadi Sarobi, Wadi Dendikan, Wadi Rusas, Wadi Umm Seiral, Wadi Hamata, Wadi Seleim and Wadi Hilefifi, Wadi Masturra.
- Wadi Qulan, Wadi Saneiyat.
- Wadi Raadi, Wadi Qulan El Atshan.
- Wadi Umm Rimarim.

The islands located in front of Wadi El Gemal – Hamata area are low land rocky islands with fossilized coral and carbonate rocks. The entire region around the islands is a shallow water area with rugged bottom morphology. The islands area is surrounded by well-developed fringing coral reefs consisting of shallow reef bordered by a sloping sandy bed. Beyond the shallow reef-flats and intertidal areas the reef slope drops away and is replaced by sand, sand with seagrass, or sand with coral patches.

3.1 Geomorphology

The area is divided into three major geomorphic units. The Red Sea high mountains, the coastal hilly area and lower mountains, the coastal plain and the Red Sea coast. The coastal plain in the area comprises different morphotectonic features. They are rift shoulder, fault scarp, alluvial fans, inselbrge, piedmont plain and raised beaches.

The elongated massive block of ultramafic rocks forms the highest mountainous in the area and the watershed that separates the Nile basins from the Red Sea basins. The coastal hilly area and the lower mountains form conspicuous topographical features between the coast and the main Red Sea hills. The isolated ranges and prolongation of the main igneous mass within the coastal plain helped in protecting the sedimentary rocks (especially gypsum deposits) by breaking the general erosion processes. The granitoid rocks are strongly weathered forming low to moderate country. On the other hand, the gabbroic rocks are more resistant to weathering and hence form relatively higher hills.

The coastal plain is a low topographic feature of a variable breadth ranging between 0.6km in the north (Wadi Ghadir) to more than 12 km in the south at Hamata. The wadis (ex. Wadi El Gemal 60 km long) that drain the Red Sea rugged mountains dissect it. Flash floods and temporary systems along a great number of parallel valleys running towards the Red Sea cover the surface. Sedimentary systems from the piedmont to the Red Sea coast comprise alluvial fans, wadis and littoral (reef) terraces. Modern fringing coral reef (50-100m wide) is extended along the coast. Coral reefs disappeared at the mouths of some wadis as a result of sediment (sand and pebbles) accumulation during floods. However, marsas occur in these areas.

Several terrace steps represent alluvial fans, sometimes occurring as single features flanking the sides of the wadis, but are occasional found arranged in vertical successions forming flights along the sides of the wadi channels. They were recorded along the coast of the Red Sea and the Gulf of Suez and Aqaba and were considered to be closely related to the Plio- Pleistocene peripheral uplift of the hinterland areas (Sellwood and Netherwood, 1984).

The qualitative and quantitative geomorphic analyses of the drainage basins in the area may give the possible surface water potentialities in the hydrographic basins. The area is dissected by numerous parallel pronounced wadis that initiate in the mountainous region and run towards the Red Sea, following a general eastwardly slope. Through geologic history, those wadis have formed geological structures downstream on the Red Sea. These structures, called embayments, receive the total amount of surface runoff from the land. Embayments shape the coastline and affect the health of the marine life.

3.2 Geology and Structural Deformations

The Eastern Desert consists of high and rugged mountains parallel to, and at a relatively short distance from the coast. The Red Sea Mountains do not form a continuous range, but rather a series of mountain groups, more or less coherently disposed in linear direction approximating that of the coast, with some detached masses and peaks. The highest peak of the area is that of Gebel Hamata,, which reaches a height of 1975 m. The Red Sea as a geologic province is of special importance. The Red Sea Mountains represent most of the Egyptian rocks from youngest to oldest.

From the geological map (**Fig. 5**) of the region (after the geological survey of Egypt, 1977 and CONOCO, 1987) and my findings in the field trip, the exposed basement rocks include, from oldest to youngest, the following mapable units:

1-Gneiss and migmatite

2-Metasediments

3-Metavolcanics

4-Serpentinites

5-Metagabbro diorite complex

6-Older granitoids

7-Hammamat group

8-Gabbros

9-Younger granitoids.

Dyke swarms of different types and colors are widely distributed in these rocks. Colored dykes in black metavolcanics form fascinating pictures in some areas. These pictures become more beautiful when Acacia or Palanite trees occur in the area (ex. the eastern side of Gabal Hafafet, Lat: 24^{o} 33’ 39”, long: 34^{o} 47’ 15”- **Fig. 6A**), the entrance of Wadi Ghader, Lat: 24° 47' 15", Long: 34° 56' 04", **Fig. 6B, C, D**). The basement rocks are rich with geologic structures such as faults (ex. At Wadi Nugrus, **Fig. 6E, F**) and folds (ex. Folds around the temple at Wadi Sekeit (**Fig. 6G, H**). These structures are fascinating for interested peoples. Landscape of these rocks also forms fascinating pictures (ex. at the entrance of Wadi Seket, **Fig. 6I**) . Shear zones are the most important structural features in the area. They open out to the north to form a flower structure (**Fig. 7**). El Ramly et al (1993) made a structural map of the Hafafite area and recorded eleven phases of deformations. Details of these tectonic events have been discussed by Kroner et al (1987). Faults of Cretaceous age in the area trend NW-SE. The minor folding in this area is complex varying from recumbent to up right.

The Neogene and Quaternary sediments occupy the eastern flank of the basement rocks. From Wadi Ghadir to Wadi El Gemal, the piedmont gives good examples of the relative positions of sedimentary formation along the coast where the Precambrian basement, faulted by clysmic and possibly Aqaba-oriented faults, locally comes within a few kilometers or less of the Red Sea. Above the basement, Miocene evaporites and Pliocene continental and marine beds forming a belt of coastal hills overlie transgressive Miocene dolomites. In the Wadis, late Pliocene to recent sediments include clastic and marine deposits. In the area between Wadi El Gemal and Wadi Renga, the Abu Ghusun formation overlies basement rocks and unconformably underlies the Renga Formation. Subsequent faulting caused relative lowering of sea level and the Abu Dabbab evaporates at the foot of the main middle Miocene carbonates of Umm Mahra formation.

Uplift of the rift periphery led to the deposition of the Pliocene sediments in areas nearer to the present Red Sea. In the area between Wadi Renga and Wadi Raadi, a relatively narrow coastal plain lies between the basement range and the Red Sea coast. Lower Miocene (Renga Formation) crops out immediately to the east of the basement range. This unit is overlain unconformably by carbonates of the Umm Mahara formation which, in turn are bounded to the east by the Miocene, Abu Dabbab evaporates belt to the south of Wadi Raadi. Down to Wadi Lahmi, a relatively wide (12Km) tectonic depression formed a relatively deep embayment in the basement, bounded by N120-140 and N50-60 fault. Upper Miocene silisiclastics were deposited at the foot of the basement. In the eastern parts, a dominantly carbonate (Shagra formation) forms the latest marine Pliocene sediments. Pleistocene siliciclastics (Samadi formation) constitute most of the outcrops within the forementioned structural embayment where they extend southwards to Wadi Umm Ghazal.

Alluvial fans of different width (N–S) and length (E–W) are represented by several terraces steps, sometimes occurring as single features flanking the sides of the Wadis but in occasions arranged in the vertical successions forming flights along the sides of the present Wadi channels. These fans are composed mainly of sand and gravel.

Geometrically, the modern extension of coastal plain is very similar to its Pleistocene counterpart. A few facies similar to the older Pleistocene facies are nearly restricted to extreme shallow water defined by their dominant biota, morphology and sediment type. As elsewhere along the Red Sea, the fringing reef is the seaward extension of the coastal plain (Einsele et al., 1967; Mergner and Schuhmacher, 1974).

The image map landsat (**Fig. 7**) shows a disrupted mountainous chain of basement rocks of moderate elevation except for a number of conspicuous peaks such as Gabal Hamata (1975m) and Gabal Abu Hamamid (1745m). Relatively low Miocene and Pliocene sedimentary succession (white to light gray) flank the basement exposure on the east. Drainage is well developed and mainly deeply incised wadis are structurally controlled. The coastal plain is evidently fault modified. The eastern edge of the basement is fault controlled in places and unconformity demarcated in others. The basement (dark brown to bright Reddish brown) consists dominantly of older granites, metavolcanics and gneisses. Dyke swarms are discernible. A few islands located opposite to the coast are covered by low-lying Quaternary coastal deposits (white) and are being fringed by coral reefs (blue). Fractions and faults are dominantly oriented NW to NNW, NE to NNE and WNW to E.

Structural analysis of the basement complex in the area reveals four main deformation phases made the tectonic framework of the area (Abdel Aziz, 1999). The oldest phase was represented by NW-trending folds and NE-dipping low-angle thrust faults. The folds are upright gentle synclines and anticlines of varying dimensions plunging gently in the, SE direction. The folds and the thrusts had been formed by compressive stress acting from the NE direction. The pattern of orientation of the quartz c-axes within the foliation indicates orthorhombic symmetry.

The second phase is represented by NW - SE left lateral strike-slip faults, which may belong to the so-called Najd Fault System. The paleostress analysis of these faults using slip lineations data indicates that they had been formed by a horizontal triaxial compressive stress acting from ESE – WNW direction. Strain analysis of stretched pebbles collected from shear zones belong to this trend has revealed that most of the analyzed pebbles are of oblate and prolate types. The maximum stretching direction of the pebbles is the NW - SE. The crystallographic preferred orientation of the quartz c-axes confirmed the left lateral sense of the faults.

The third phase of deformation is represented by E -W left lateral strike-slip faults with small vertical component. The paleostress analysis using the slip lineations data indicates that the faults had been formed by a 20 plunging compressive stress acting in ENE - WSW direction. Fry analysis of deformed grains indicates that the strain ellipse is oriented in the E-W direction.

The fourth phase of deformation is represented by NNW – SSE right lateral strike-slip faults. The paleostress analysis using the slip lineation data indicates that the faults had been formed by a horizontal compressive stress acting in NNE - SSW direction.

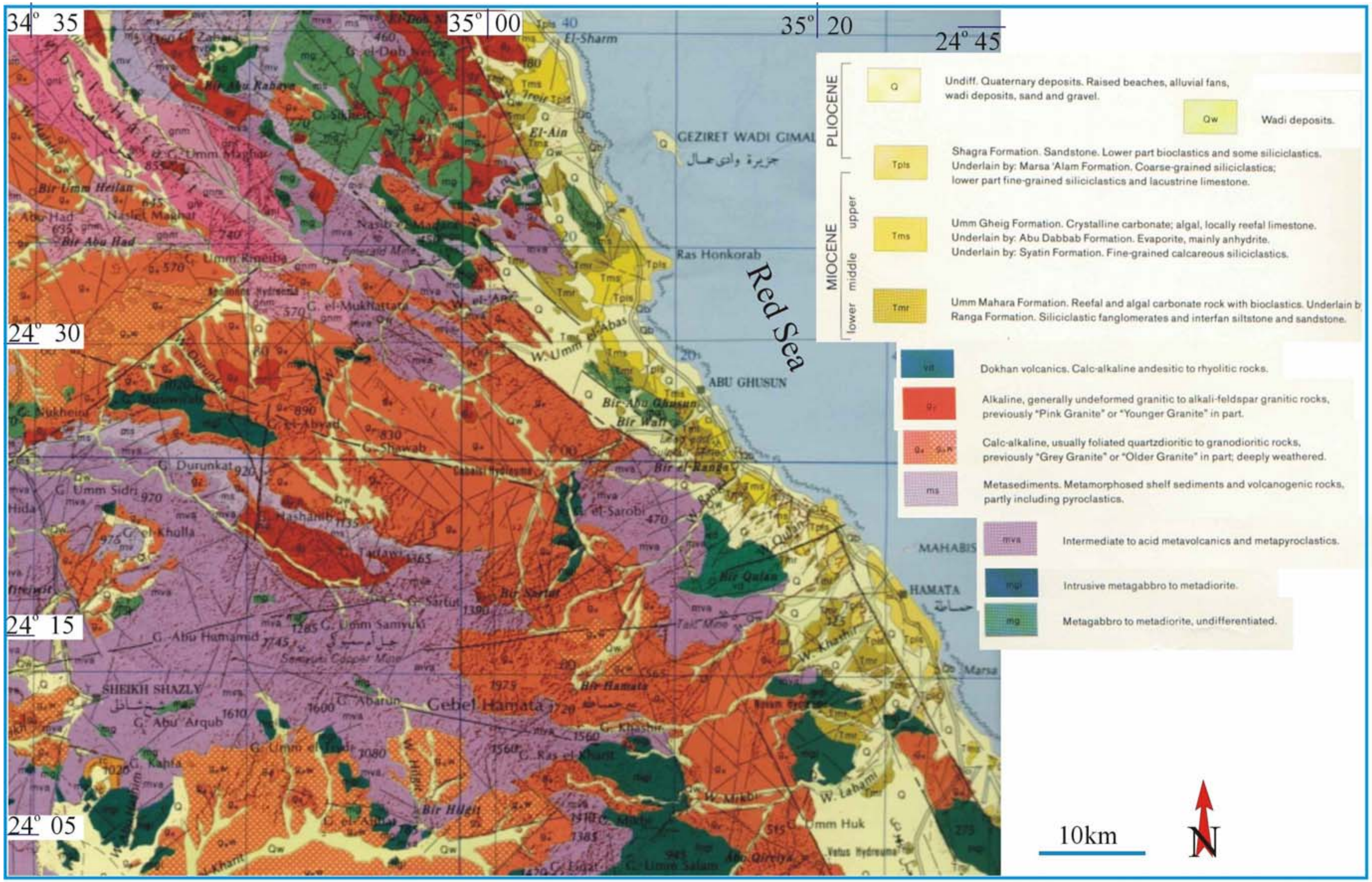

Fig. 5. Geological map of Wadi El Gemal-Hamata area (CONOCO, 1987-Sheet NG36SE Gebel Hamata, 1:500 000)

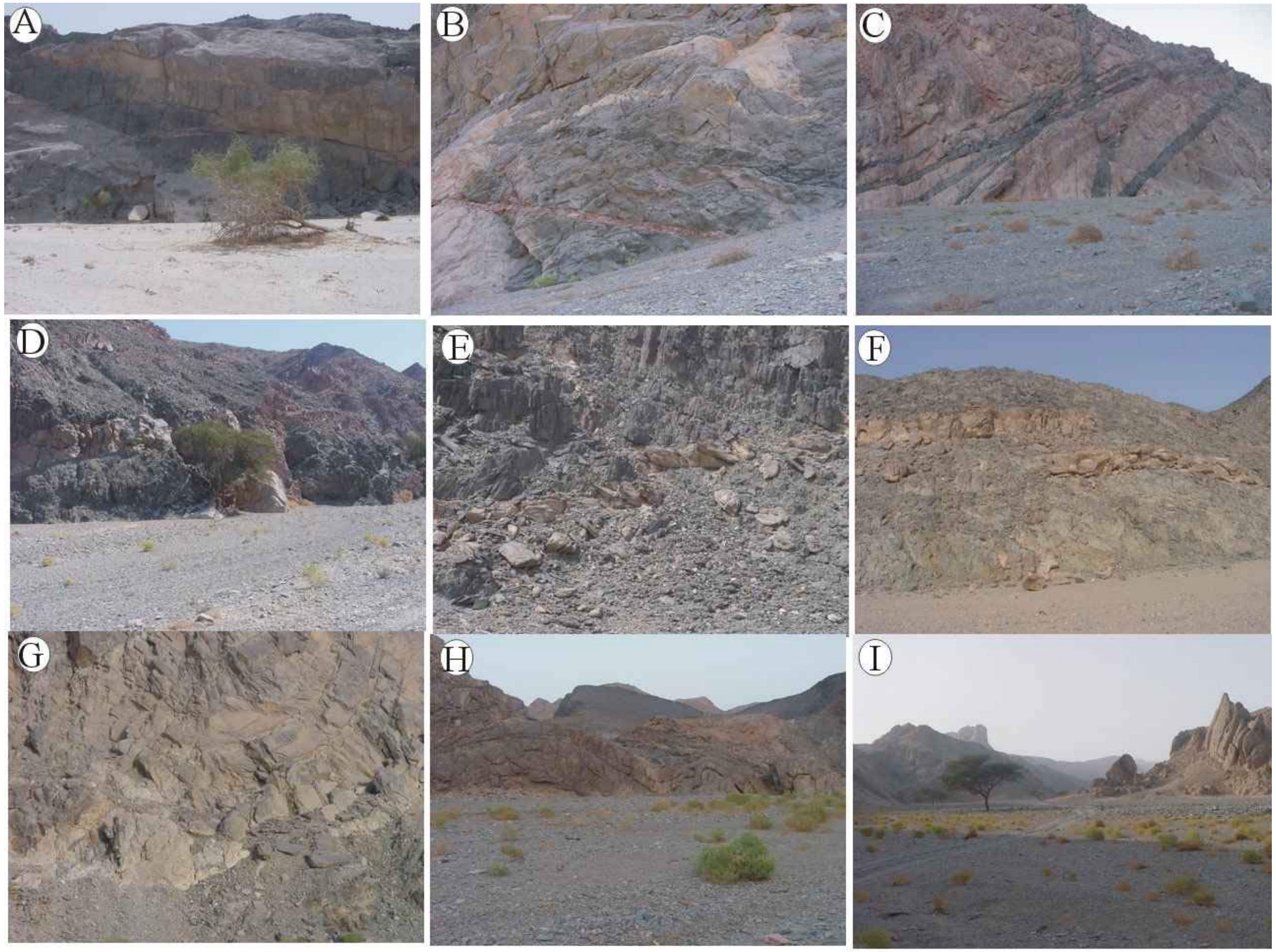

Fig. 6. Different types of geologic structures such as dykes (A, B, C, D), faults (E, F), and folds (G, H) as well as erosional structures (I) are widely distributed in different areas of the Protected Area (see text).

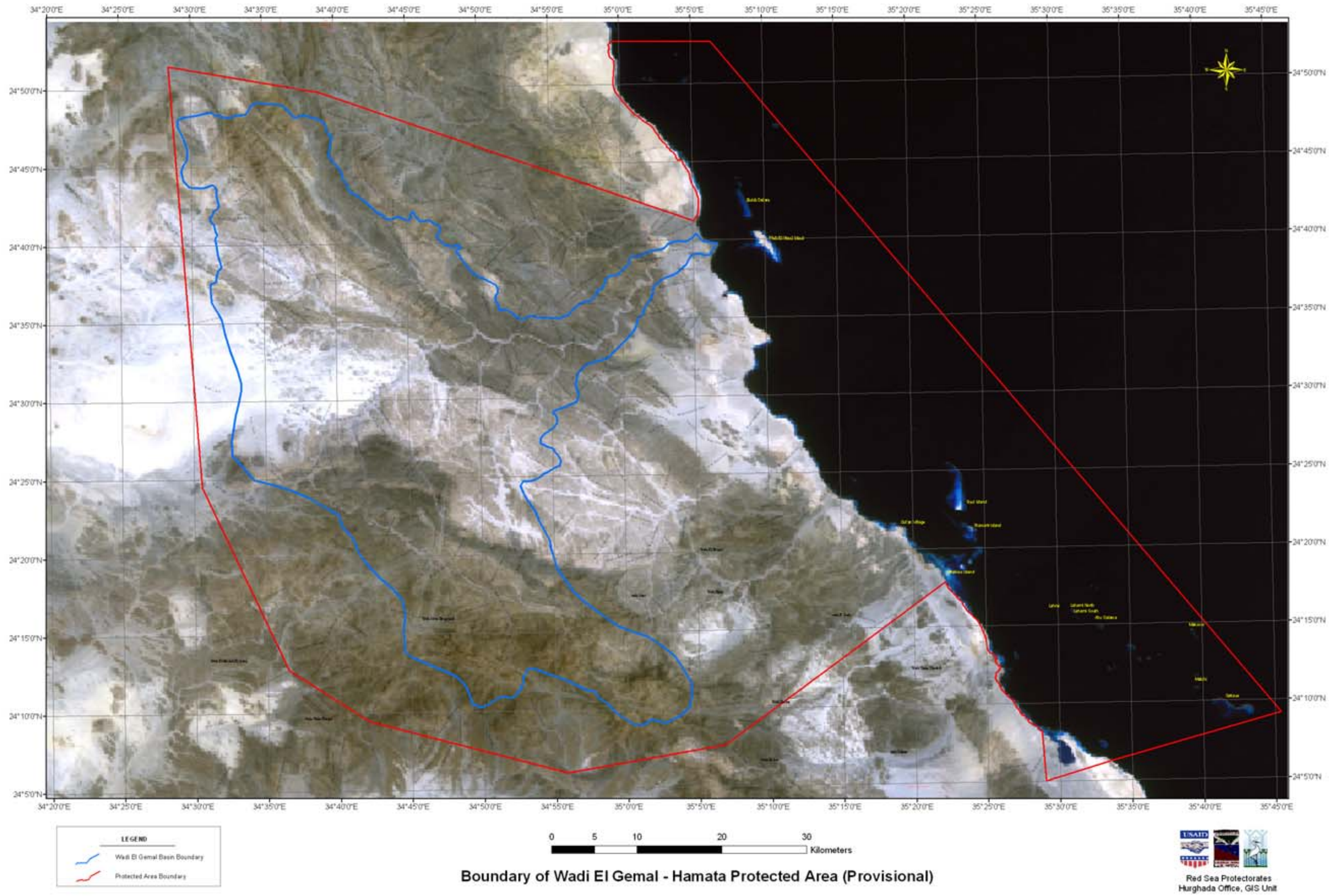

Figure 7. LandSat image of Wadi El Gemal-Hamata Protected Area

4 Drainage Basins, Ground Water and Flood Hazards

Along the Red Sea coast, flash floods represent the main natural hazard posing a great threat to life, construction, and even marine life. The coastal area is dissected by numerous parallel-pronounced valleys (wadis) that initiat from the mountainous region and run towards the Red Sea following the general eastward slope. The area is occasionally subject to heavy showers during winter, followed by sporadic torrential floods that may cause disastrous damage to roads and the scattered settlements.

In October, 1979 the area was affected by dangerous flood that damaged the Edfu-Marsa Alam road, the Marsa Alam - Ras Banas road, and Qift – Qusier road as well as destroying 500 houses and claiming the lives of 19 people. In 1980, 1985, 1991, 1994 and 1996, floods occured but with significantly less effects than that occurred during 1979. However, as the government has to plan a long-term strategy regarding flooding and ground water, especially in consideration of the ongoing tourist development along the coast. Unfortunately, the government as of yet does not have a full understanding of the flood situation, and no flood-control strategy. Unless serious steps are taken to correct this, the flood problem of the Red Sea coast is likely to become even worse with time and attain ultimately calamitous proportions.

Geomorphology studies may provide information on the areas affected by flooding. Studying the morphometric parameters of the drainage basins is very important in determining the intensity of floods, and provides information for forming suitable solutions for avoiding or reducing as much as possible flood hazards that occur, in addition to replenishing the ground water supply. Local studies in fluvial geomorphology and morphometry of some flood vulnerable areas of Egypt (Sinai and the Eastern Desert) have received particular consideration by some researchers. (Mubarek et al 1981, El kassas and El Rakaiby, 1983, Salem, 1985, El Shamy, 1985, Shick and Lekach, 1987, Saleh, 1989 a, b, c, El Rakaiby, 1989 and El Etr et al, 1994). In the area where Wadi El Gemal – Hamata Protected area lies, fluvial geomorphology and morphometry of flood vulnerable areas have been discussed by Ahmed (2001).

Twenty-three drainage basins with outlets in the Red Sea were defined in the area between Marsa Alam and Ras Banas (Mansour et al. 2003). They range between small (11.52 km^2) and large (1476.7 km^2) with a drainage density between 1.4 and 3.8. The drainage net is well developed, integrated and fairly dense but is not consistent all over the area. Wadi Ghadir and Wadi Raadi have high values of relief and ruggedness numbers, and this gives a short time of concentration of runoff. Therefore, the probability of flooding is very high. Wadi El Gemal has the highest value of maximum runoff, followed by Wadi Lahmi and Wadi Ghadir. This reflects the dangerousness of these drainage basins. However, the spread of unplanned settlement and mismanagement of the land and water resources in the down stream and catchment areas along the coast will lead to abnormal floods. Under such conditions a strategy flood mitigation and control is needed. Open embankments or boulder dams at the upstream parts of the drainage basins will minimize flood hazards and give more chance for ground water replenishment.

With an average rainfall quantity equal to 98.75 million cubic meters/year, a huge amount of rainwater can be percolated and recharge the groundwater storage if its runoff is controlled. Basins of Wadi El Ranga and Wadi Umm Abbas can be classified as less dangerous basins and consequently, they can be considered as good locations for ground water collection.

4.1 Flash Flood Vulnerability

The occasional heavy showers along the basement highland during winter maintain short period flooding. In fact, desert floods are inherently of low duration (few hours to some days) and are commonly characterized by sharp peak discharges. Peak duration is variable and may be in the range of 10-30 min. Torrential floods cause serious desert problems and excessive life and property losses, especially along the coast. They may hamper development and resource exploitation activities. Although their influence is locally very significant, sporadic fluvial (flash flood) processes have not been considered in the way that they should be during planning of new settlements and also in the major development projects.

The protected area includes a section of the Red Sea coastal road parallel to the shoreline. Substantial parts of this high way are crossed from west to east by the lower reaches of the Red Sea drainage basins and consequently are subject to flash flood hazards (**Fig. 8A**). Vulnerability is differentiated into three categories: slight, moderate and high. This assessment was based on detailed analyses of Landsat image (scale, 1:250.000), topographic maps and morphometeric characteristics of the effected drainage basins (Mansour et al. 2003). Flood hazard dose not only affect the ability of this road to handle traffic, but extends to existing and planned urban sites and development projects. It also affects the marine life at the mouth of wadis. Coral reef is completely absent in the torrent pass way and starts to appear only on the margins of sharms, increasing in density and size seawards (Mansour, 1995). The present assessment of flash flood vulnerability of the drainage basins in the area helps in the selection of the most suitable sites for developmental landuse (e.g., establishment of tourist villages), particularly along the Red Sea coastal zone. These sites were distinguished into 4 divisions from A (the least suitable) to D (the most suitable sites). Class D sites are commonly situated in the inter spaces between the drainage basin outlets (**Fig. 8B**). Unfortunately, parts of TDA area within the Protected Area lie in the least suitable divisions.

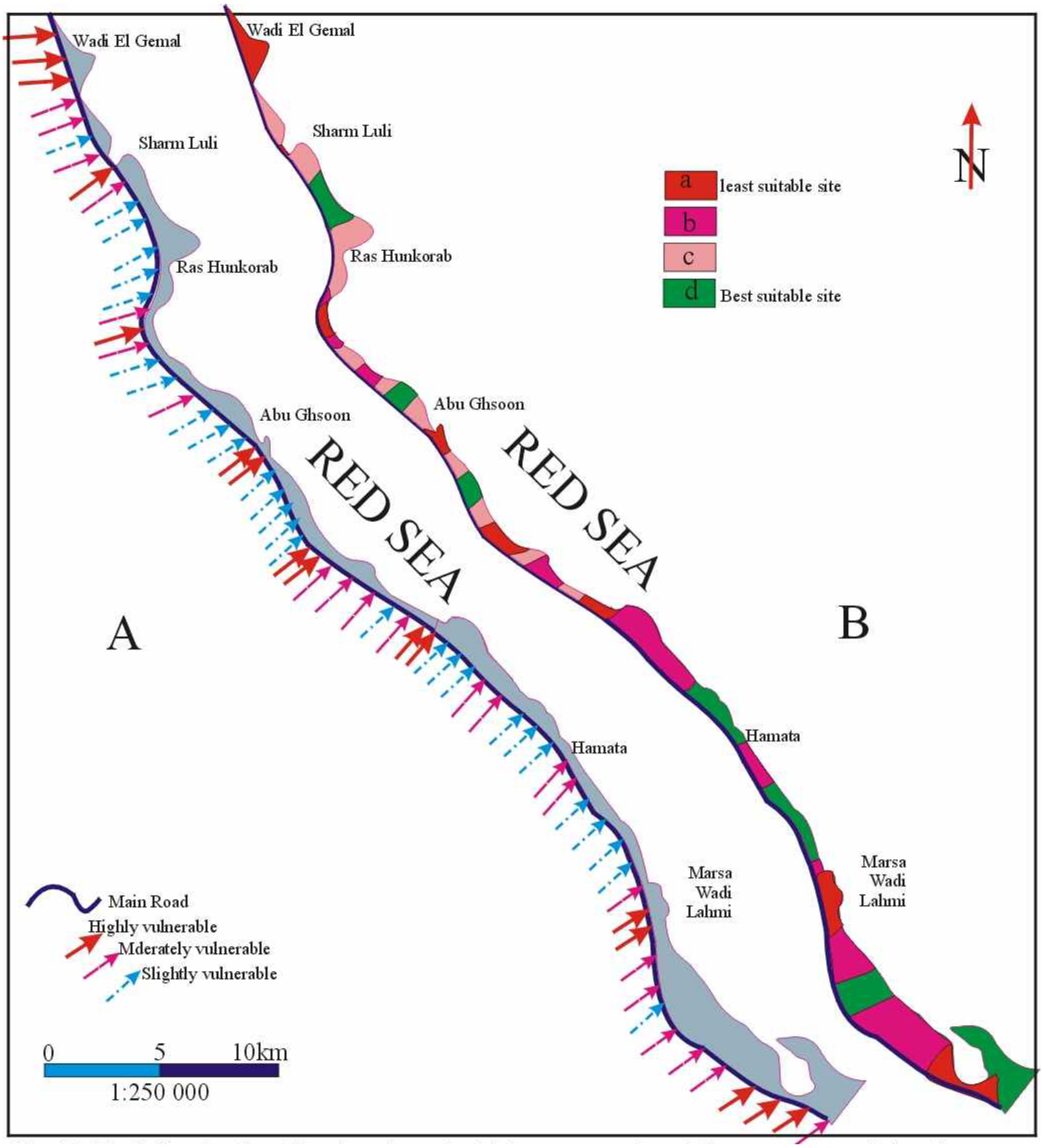

Figure 8: Flash flood-vulnerable sites along the highway and the coastal zone (A) and land use assessment (B), evaluated on a scale of four divisions (a-d) with a being the least suitable sites and b the best sites.

4.2 Evaluation of Uses of Ground Water

In the desert areas of Egypt the surface water resources are generally very limited, therefore, ground water resources constitute a cornerstone for the future management of the protected area and any development project. Water needed is either transported from the Nile or from distribution centers along the Red Sea coast. The study of ground water possibilities in the Eastern Desert is therefore, of a great importance for the developments and inhabitation of desert region. Both of the quantity and quality should be considered while evaluating ground water resources. The central part of the Eastern Desert represents a watershed along the axial belt of the basement rocks, with drainage directions either to the Nile Valley or the Red Sea. The ground water resources originate mainly from occasional rainfall, that partially infiltrate through the friable loose sediments and accumulates in basement depressions or is trapped by faults and buried dykes.

In Wadi El Gemal – Hamata protected area investigations of ground water include three main wells in Wadi El Gemal basin (Bir Wadi El Gemal - Lat: 24^{o} 30’ 14”, Long: 34^{o} 42’ 34”, Bir Umm Ghanam, Bir Hafafet - Lat: 24^{o} 30’ 00”, Long: 34^{o} 49’ 00”) have been carried out (Ahmed, 2001). The average salinity of groundwater varies from one year to another as well as from one season to another. The salinity ranges between 490ppm (Bir Umm Ghanam) and 3185 ppm (Bir Hafafet) in August 2000 (**Table 3**). The minimum salinity that was recorded in Bir Umm Ghanam (490ppm) is due to location of the well closed to the recharge areas (Ahmed, 2001). This situation accelerates the direct infiltration of rainwater into the opened fractures where it comes out as springs. The average salinity of Bir Wadi El Gemal is 960 ppm. In Bir Hafafit, the evaporation process causes a considerable increase in water salinity (3185 ppm). Removal of all the total dissolved salts (TDS) from water is possible by distillation and deionization but on economical grounds this is not practical or desirable for most uses. Moreover, the water of the area is slightly alkaline where pH value range from 7.38 (Bir Wadi El Gemal) to 7.83 (Bir Umm Ghanam) (**Table 3**). However, groundwater of these locations does not exceed the suitable limits of irrigation water completely because its total dissolved salts do not exceed 3000 mg/L (**Table 3**).

From the results of chemical analysis of the collected water samples (**Table 3**), it can be deduced that: Calcium is the most dominant cation and range between 103.2 ppm (Bir Haffifite) and 66.4 ppm (Bir Umm Ghanam). Magnesium is the next dominant cation, it ranges from 78.1ppm (Bir Hafifite) to 13.6 ppm (Bir Umm Ghanam). Sulfate is the most dominant anion, which ranges between 125 ppm (Bir Haffafit) and 62 ppm (Bir Umm Ghanam). Chlorite is the second dominant anion and ranges from 784ppm (Bir Haffafit) to 62 ppm (Bir Umm Ghanam).

Water hardness is the property that causes precipitation of ordinary soap. It results from the presence of calcium and magnesium combination with carbonate and bicarbonate ions. In the area, the total water hardness (TH) ranges from 222ppm (Bir Umm Ghanam) to 578 ppm (Bir Haffafit) (**Table 3**). Dissolved solids and total hardness of the collected water samples from Bir Umm Ghanam and Bir Wadi El Gemal are mostly under WHO (1984) maximum permissible limits for drinking water and therefore, can be used safely for drinking purposes after microbiological treatment. The total dissolved and total hardness of the water samples of Bir Haffafit were above the WHO (1984) maximum permissible limits for drinking water and therefore, the water can not be used for drinking purposes.

Many trace metals present in ground water even at low concentrations if the water has been in contact with mineralized rock or ore bodies. **Table 3** shows the concentration of some trace metals (copper, manganese and iron) in water samples collected from the study area. Copper ranges from 0.6 ppm (Bir Wadi El Gemal) to 0.75 ppm (Bir Haffafit), but it is not detected in Bir Umm Ghanam. Most copper minerals are insoluble and small amounts of copper are found in water of natural origin. Biotite and hornblende are among the manganese minerals in igneous rocks. Soluble manganese exists in groundwater as manganese ion (Mn). It ranges between 0.1 ppm (Bir Umm Ghanam) and 0.03 ppm (Bir Haffafit). It is not detected in Bir Wadi El Gemal. Iron is a very common element in rocks and soils of the earth crust. In the area, iron concentration is generally less than 0.1ppm. (**Table 3**). However the amount of trace metals is totally under WHO (1984) permissible limits. With reference to FAO (1985), the guideline values from iron, manganese, copper and zinc in irrigation water are 5ppm, 2ppm, 1ppm and 5 ppm respectively. Accordingly, the groundwater of these locations can be used safely in irrigation process.

Water turbidity is not recorded in Bir Wadi El Gemal and Bir Haffafit but high (7.0%) in Bir Umm Ghanam. Therefore, primary purification should be taken place before water distribution and use. For livestock and poultry purposes, the Natural Academy of Science (NAS, 1974) constructed an international standards to evaluate water for such purposes. The application of this standard on the collected water samples revealed that the groundwater of the three locations is totally suitable for livestock and poultry requirements.

Table 3. Results of Ground Water Chemical Analysis (ppm) of Wadi El Gemal Basin Collected in August 2000 (Ahmed, 2001).

Parameters		Bir Umm Ghanam	Bir Wadi El Gemal	Bir Hafafet
TDS		490	960	3185
PH		7.83	7.38	7.40
Cations	Ca^{+2}	66.40	91.20	103.20
	Mg^{+2}	13.60	27.35	78.10
Anions	$HCO3^{-}$	106	62	228
	Cl^{-}	62	68	784
	$SO4^{-2}$	130	180	125
Total Hardness		222	340	578
Turbidity		7	--	--
Trace metals	Fe^{+2}	0.06	0.05	0.01
	Mn^{+2}	0.10	0.00	0.03
	Cu^{+2}	0.00	0.60	0.75

5 Mining and Quarrying Activities in the Red Sea

The Red Sea Governorate contains the majority of the basement rocks of Egypt. These rocks dominate Wadi El Gemal – Hamata Protected area and provide many economic metallic, and non-metallic ores, and building materials. Basically, the Red Sea is famous for the granite and marble compete with the Italian ones. Archaeological sites at Nugrus, Seket and Umm Lasaf in the area have clarified the role of Beryl mining during the Roman Time. Quarrying white, gray and black granite is widely distributed in the area, especially Gabal El Abayad along Wadi Shawab. The basic mines associated with basement rocks are iron (Ilmenite), copper, gold, vermiculite, nickel, manganese, asbestos, mica, quartz and feldspar (**Appendix 1**). Other ores associated with sedimentary rocks are iron oxides, kaolin, potash, and phosphate which is the most important ore in the Red Sea Governorate (ICP, 2000). Sedimentary sequences of the coastal area also include large amounts of gypsum, anhydrite, sand and gravel.

Alluvial fans, braided streams, and raised beach, widely distributed along the coast are mainly composed of gravel and sand (about 90%) silicicalstics (quartz and feldspars). The major uses of these are in construction, particularly as concrete aggregate, road aggregate and other construction materials. Sand is also widely used as beach fill along the Red Sea coast. Their particle size, composition and physical quality make it one of the preferred aggregates to be used for constructions. Deposits close to granite rocks are very rich with feldspars, which can be used in ceramics. The occurrence of aggregates on the surface and their proximity to the roads and cities are obvious attractions. As the development increased the demand for aggregates is becoming a target for exploration. However, the conflict between economic and environmental considerations must be anticipated.

5.1 Evidence of Adverse Effects of Mining and Quarrying Activities

During the field surveys for this study (March 2003), a lot of ore mines and granite quarries widely distributed in the basement rocks have been visited, photographed and their impacts were recorded and documented in the following paragraphs.

1. Talc mine (abandoned) at Wadi Qulan El Atshan (Lat: 24^o 16’ 00”, Long: 35^o 13’ 00”) destroys the whole landscape of two large areas. A lot of excavations and embankments of remaining materials occur everywhere in the area (**Fig. 9**). Some wadis completely dammed with the remaining materials. Remains of housing, machines and iron materials are distributed in the area (**Fig. 9**). However, the quality and quantity of the ore does not deserve this destruction.
2. An abandoned talc mine lies nearby the quartz mine at Wadi Zabara (Lat: 24^o 48’ 20”, Long: 34^o 43’ 44”). Some excavations distribute in the area.
3. Talc mines of Wadi El Lawy (abandoned) (Lat: 24^o 46’ 09”, Long: 34^o 47’ 44”). All mines are in a small tributary of Wadi El Lawy. Excavations with some remnants of rock fragments are widely distributed in the area (**Fig. 10A, B**). Some remnants of living places still remain nearby the abandoned mines (**Fig. 10C**).
4. Vermiculite mine (still working) at Gabal Hafafet (Lat: 24^o 49’ 00”, Long: 34^o 30’ 00”) along Sheikh Salem – Sheikh Shazly road (Road mark 78km).

Excavations widely distributed in a large area between Gabal Meghef and Gabal Hafafet. Remains of housing, machines and garbage (**Fig. 10D, E, F**) distribute in the area. Only a few peoples are still working in the mining area.

5. Ilmenite mine at Wadi Abu Ghalaka - Wadi Abu Ghusun (still working) (Lat: 24^o 21' 18", Long: 35^o 04' 07"): The ore occurs as large lenses (a few meters long, (**Fig. 11**) in metavolcanic rocks. Piles of the ore and overburden materials widely distribute in the nearby wadis (**Fig. 11**).
6. Quartz mine at Wadi Zabara (Lat: 24^o 48' 20", Long: 34^o 43' 44") (abandoned): Quartz fragments widely distribute in the wadi around the mine (**Fig. 12A**). Quartz occurs as a vein in metavolcanic rocks. A few excavations are distributed in the area (**Fig. 12B, C**).
7. Quartz mine at Wadi El Gemal (Lat: 24^o 37' 31", Long: 35^o 01' 46") (abandoned): Quartz occurs as a quartz vein in metavolcanic rocks. Torrents have removed all quartz fragments from the wadi and deposited them in a sheltered area behind the mine (**Fig. 12D, E**).
8. Feldspar mines at Hafafet (still working). The ore occur as small veins in granite rocks. Excavations and remaining materials are widely distributed in the area (**Fig. 13A, B, C). Figure 13** shows an excavator working in the area. The ore and its remaining dam some wadis (**Fig. 13A**). The bad quality of the ore does not deserve the area destruction.
9. Feldspar mines at the historic site of Wadi Ghazal (abandoned). Few excavations distributed north of large historic (Roman) site (**Fig. 13D, E, F**). Remnants of feldspar and quartz rock fragments still remain around the excavations.
10. Feldspar mines at Kab Marfoaa (abandoned) at the northern side of Wadi El Gemal (Lat: 24^o 31' 22"N, Long: 34^o 37' 04"E). Feldspar occurs as a small vein rich with quartz in granite rocks. A few excavations are distributed in the area (**Fig. 13G, H**). The abundance of quartz in the vein makes it unsuitable for feldspar mining. With the exception of the bad view of the excavations the landscape of the area is fascinating. The site lies between Gabal Museraibe in the south and Gabal Mukhatata in the eastern side. Moreover, a historic Roman site is close to the site of feldspar mines (**Fig. 13I**).
11. Beryl mines at Gabal Nugrus (Lat: 24^o 36' 58", Long: 34^o 46' 34"). It is a historic mine just at Nugrus Roman village. Remnants of the Roman village distribute on the mountain (**Fig. 14A, B, C**). Beryl Mines are distributed as excavations in the area surrounded by rock fragments and the remaining materials. Unfortunately, white spots probably used for ore evaluation covered the whole historic area (Fig. 15A, B). However, the authority of nuclear materials is evaluating the ore in the area and has a large camp close to this site (Fig. 15D).
12. Beryl mines at Wadi Seket (Lat: 24^o 39' 35", Long: 34^o 47' 41"). Similar to those at Gabal Nugrus, these mines are historic ones and lie close to Seket Roman village and temple (**Fig. 14E, F**). Beryl Mines are distributed as excavations and big holes in the area surrounded by rock fragments and the remaining materials (**Fig. 14E**). Unfortunately, the white spots, similar to those found at Nugrus mines also occur but with lesser amounts.

13. Beryl mines of Gabal Zabara at Wadi Umm Lasaf (Lat: 24^o 46’ 26”, Long: 34^o 43’ 23”). Similar to those at Gabal Nugrus and Seket, these mines are historic ones and lie close to the Roman village in the area (**Fig. 14G, H, I**). Beryl Mines are distributed as excavations and big holes in the area (**Fig. 14H**). Rock fragments of the excavations are piled at the foot of the mountain. Some peoples are looking for beryl in these piles (**Fig. 14I**). Unfortunately, the white spots, similar to those at Nugrus mines also occur but with lesser degree.
14. Granite quarries at Gabal El Abeyad: (some of them are still working): A lot of white granite quarries of Gabal El Abeyad widely distributed along Wadi Shawab. They destroy the whole landscape of the area along the track of Wadi Shawab (**Fig. 15**). The quarries are recorded in the following sits (Lat: 24^o 27’ 20”, Long: 34^o 51’ 12”), (Lat: 24^o 26’ 16”, Long: 34^o 51’ 57”), (Lat: 24^o 25’ 47”, Long: 34^o 52’ 03”), (Lat: 24^o 24’ 56”, Long: 34^o 52’ 34”), (Lat: 24^o 24’ 32”, Long: 34^o 53’ 38”), (Lat: 24^o 24’ 20”, Long: 34^o 54’ 44”). They use primitive and destructive ways for quarrying (**Fig. 15H, I**) and therefore a lot of rock fragments remain behind and lost a lot of granite (**Fig. 15E, G, I**). Red bricks, remnants of machines and garbage (**Fig. 15E, F**) distribute in the area.
15. Black granite quarry at the end of Wadi Shawab: Most granite of Gebel El Abeyad is white granite except for this site (Lat: 24^o 23’ 17”, Long: 34^o 59’ 32”) for black granite. This black granite constitutes only small part in the area (less than 100m wide). Blocks of granite distribute at the foot of the mountain.

Figure 9:Destruction of landscape in the area of the talc mines at Wadi Qulan El Ashtan

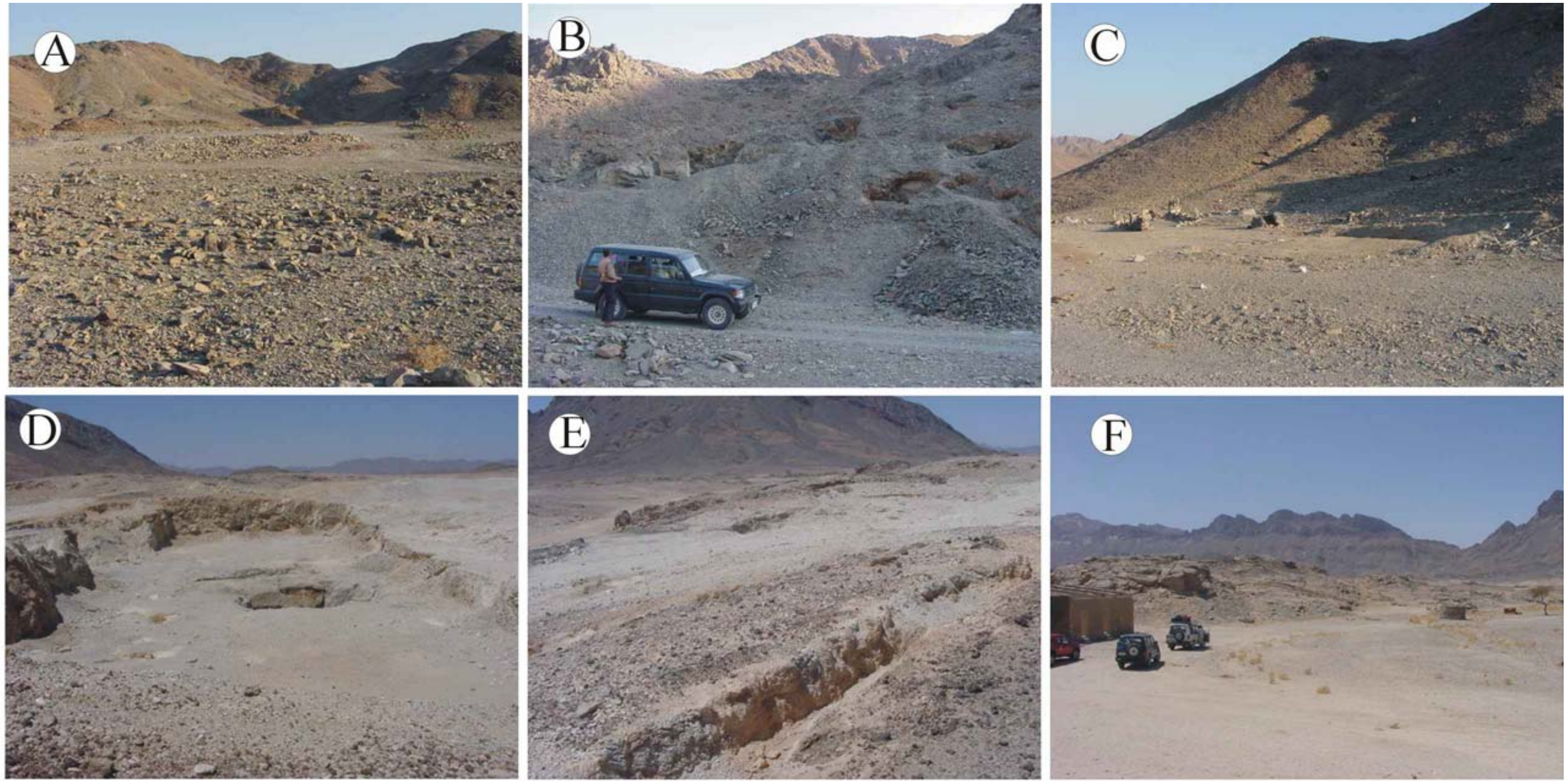

Figure 10: Situation of talc mines of Wadi El Lawy (A, B, C) and vermiculite mines of Hafafet (D, E, F).

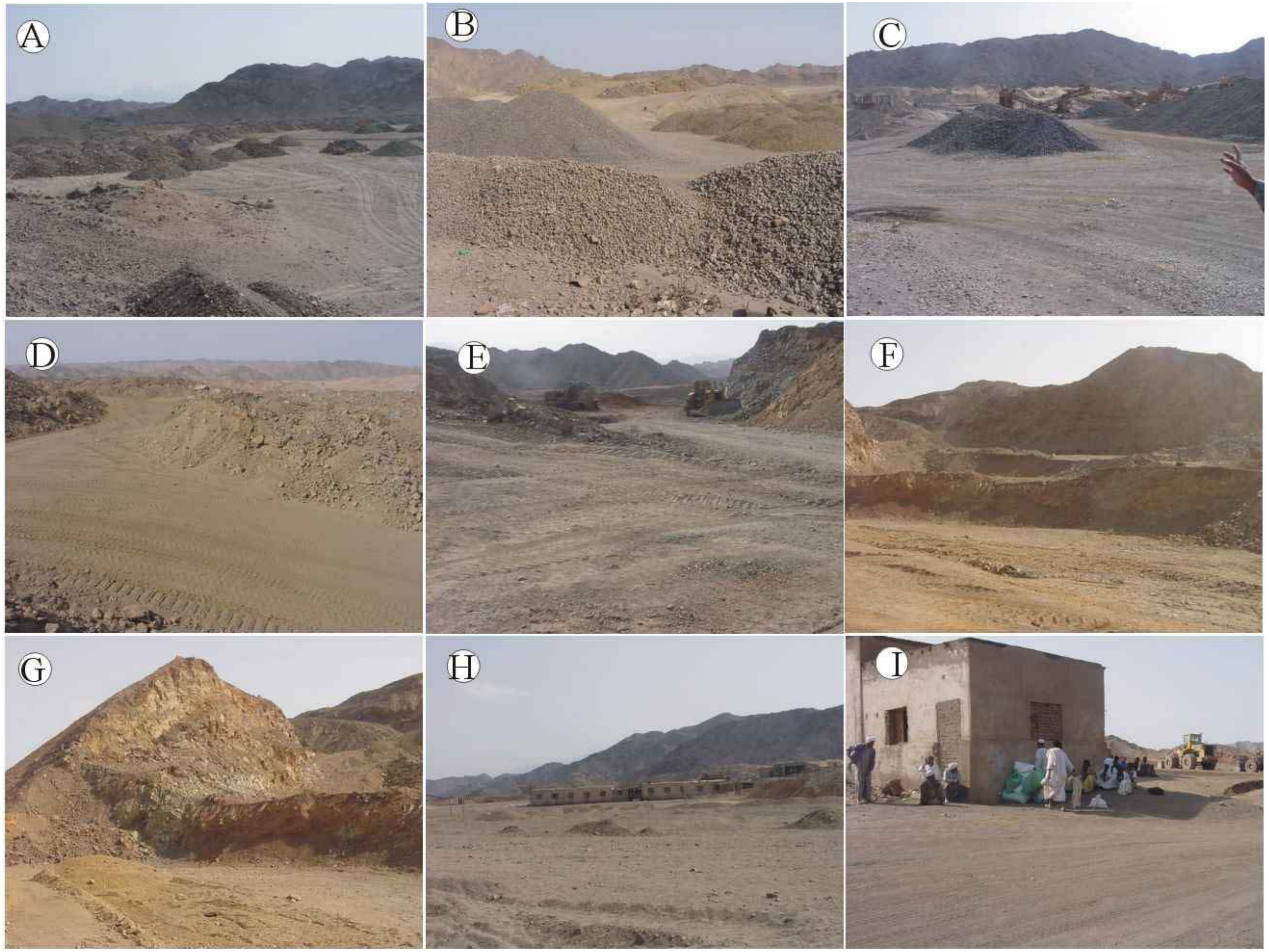

Figure 11: Situation of ilmenite mine at Wadi Abu Ghalaka from Wadi Abu Ghusun (A, B, C) show a lot of piles from the ore and overburden materials. D, E, F, G sho the mine, H, I show the buildings and many workers at the end of the work day.

Figure 12. Quartz Mines at Wadi Zabara (A, B, C) and Wadi Gema(D, E).

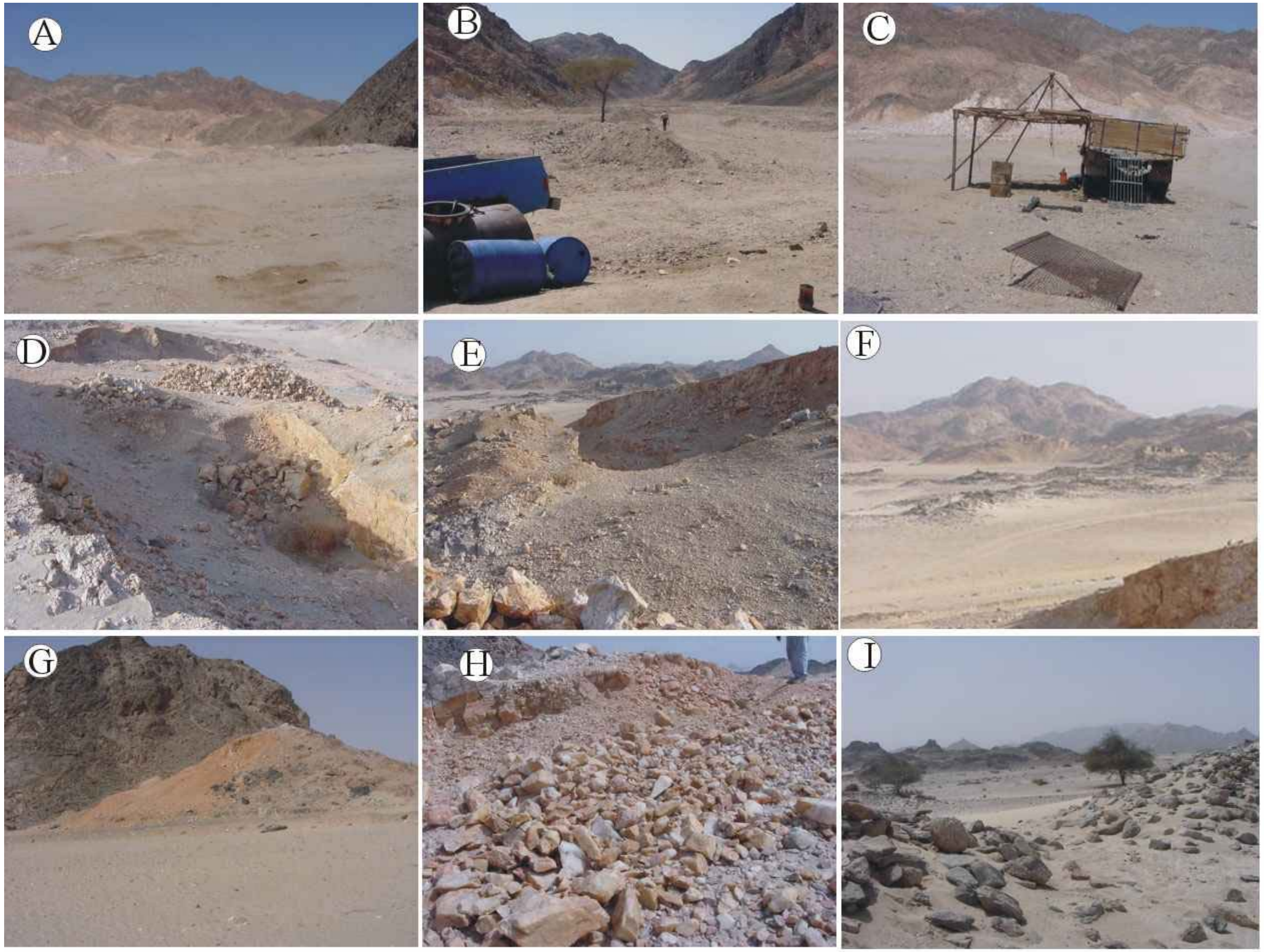

Figure 13: Situation of feldspar mines at Hafafet (A, B, C), Wadi Ghazal (D, E), and Kab Marfu'a from Wadi El Gemal (G, H, I). Note: feldspar mines at Wadi Ghazal and Kab Marfu'a lie nearby historic sites.

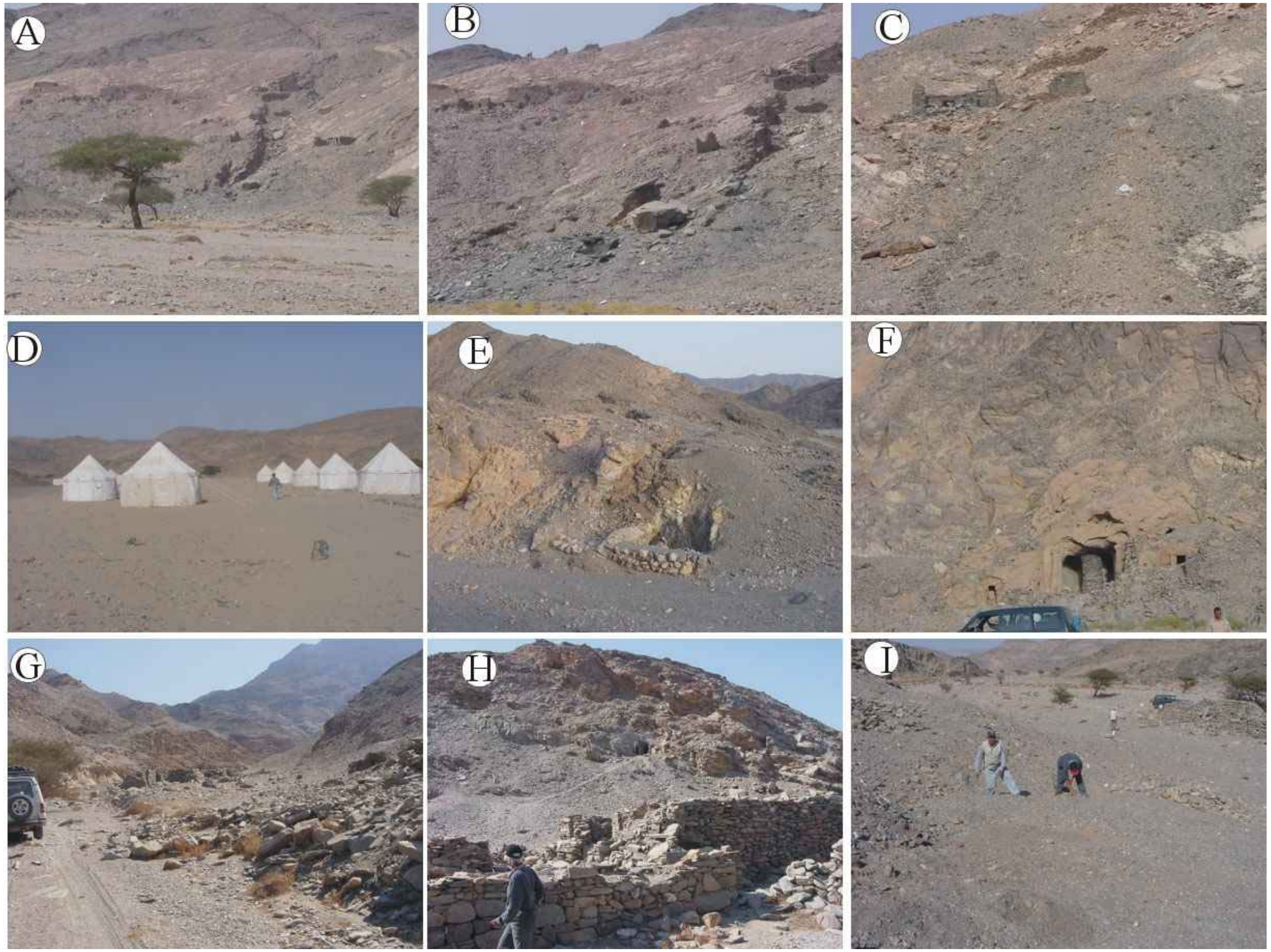

Figure 14: Situation of historic beryl mines at Nugrus (A, B, C, D), Sekeit (E, F) and Umm Lasaf from Wadi Zabara (G, H, I).

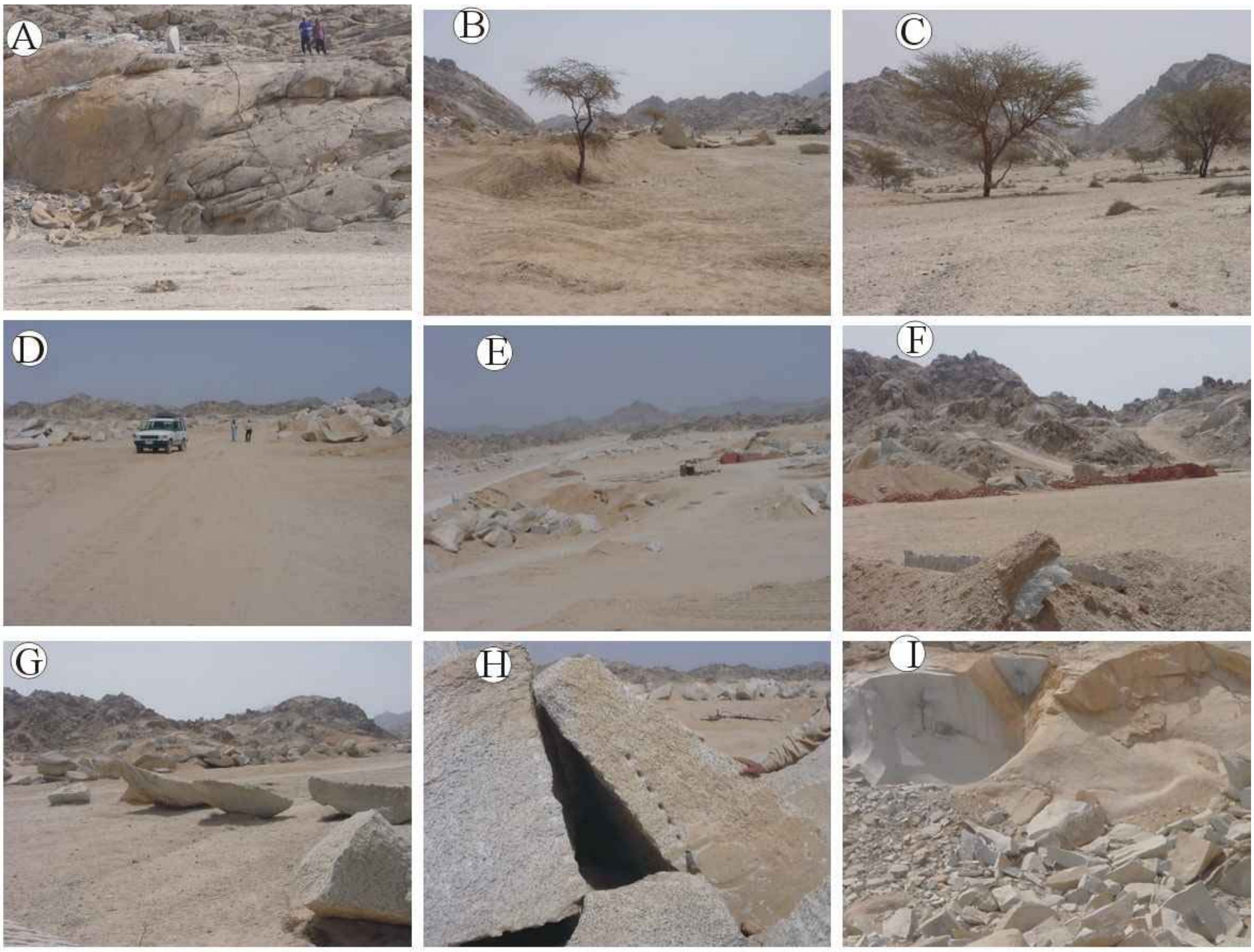

Figure15: Situation of granite quarry along Wadi Shawab at Gebal El Abayed (A, B, C) shows destruction of the landscape and other natural environment. D, E, F, G show distribution of granite fragments everywhere in the area. H, I show the methods used for quarrying: nails (H) and explosives (I)..

6 Management Recommendations

6.1 General Recommendations

Mining and quarrying development is recommended only for high economic mineral resources and in areas away from viewers (sheltered areas) and has no other significant resources. Moreover, the stipulation may be approved if it can be demonstrated that operations can be conducted without causing unacceptable impacts to the critical cultural or natural values. Any decision to grant an exception or modification would be based on field inspection. An Environmental Impact Assessment is also recommended.

A variety of supporting management activities may be taken to implement the management prescriptions. These generally include: posting boundaries, installing information signs, inventory and monitoring, acquisition of access, where appropriate, acquisition of additional lands from willing parties as necessary to meet management objectives, and resolution of unauthorized uses.

Collection of wood, plant material or minerals specimens, other than casual collection requires a permit.

EEAA should provide opportunities for bedouin (native people who are living in the PA) to assist in the management of cultural and natural resources in the Protected Area.

Preparing a field trip program explores the changes that have occurred throughout the Red Sea complex and fascinating geologic history and focuses on the human interaction with this geology over the past centuries. The historic mining, the archeological sites, the mining activity, and volcanic and structural geology are the main topics of this field trip. Stops or topics of discussion include Nugrus, Skeit and Zabara Beryl mines.

The PA would remain open to exploration and development under its laws and regulations. Management objectives and guidelines would be utilized to evaluate applications for development of mineral material resources.

Parts of Wadi Ghadir are included in the Protected Area, however, the whole Wadi Ghadir is an interesting area, highly diverse with many beautiful landforms and geologic structures. Therefore, it is necessary to include in the present Protected Area.

6.2 Mitigation of Flash Flood Hazards

The spread of unplanned settlement and mismanagement of the land and water resources in the down stream and catchment areas along the coast causes abnormal flooding. The flood hazard risk depends upon exposure to floods, which has to be measured in terms of population and land use activities (Chan and Parker, 1996) and the demands on natural resources exerted in either an unsustainable or sustainable manner (Woube, 1999). In thinking about the flood problem, the volume of fresh water lost in the sea needs to be taken into account. This water is urgently needed for the development projects in the area and management of the Protected Area. Floods also help recharge aquifers. To avoid or alleviate flash flood damages and possibly to aid in exploitation of floodwater for recharging near surface aquifers the following preventive and control measures should be considered. However, particular attention was given to urban areas at the mouth of the main wadis and to the main desert highways.

The appropriate flood control approach is to open as much space as possible to accommodate stream overflow. This is the way to the future. This follows from the following simple arithmetic: given the volume of water and gradient, the height of flooding decreases proportionately with the increase of area over which water can spread. This is a strategy not of flood prevention but of flood mitigation and control.

The open strategy for flood control has many dimensions. However, the most crucial task in this strategy is to excavate the wadis. Excavation will keep streambeds wide, open, and deep so that peak flow can pass through easily and rapidly. It will also enhance surface water storage capacity, which will thereby lower the flood height. Adoption of the open approach is also necessary for a long run solution to the flood problem.

The other important thing in the open approach is to ensure free passage of water to the sea. The main structure crosses the passage of flood is the Marsa Alam – Ras Banas road. Unfortunately, not all of this road has been carefully tailored to the necessity of free passage of water in the wadis. Roads are certainly needed. Therefore, roads should be constructed with culverts and bridges of adequate number and size. At points where these roads do not have adequate passage for water, they need to be reconstructed. Another obstacles are the rock fragments and the remaining of quarries and mines in some wadis in the desert. Therefore, these industrial activities should be minimized and allowed only for important and economic ores and materials. Moreover, the remaining rock fragments should not expose to floods and extraction of these resources should be in a sustainable manner.

Open embankments can very well be part of the open approach to flood control, especially in the areas away from the development zone. These embankments will allow water to spread onto adjoining areas. They mitigate flood by spreading water overflow over a larger area. They do not create a destabilizing and risky situation, and do not create new problems of drainage and sanitation (Islam, 2001). Moreover, it is necessary to cordon off urban and project areas in order to protect them from flooding. The idea is to let the floodwaters remain confined only to their channels and pass directly to the sea.

6.3 Surface reclamation

Conditions for the recovery of a mining or quarry site are unique to each area's ecosystem and habitat. The following examples of conditions can be developed for use within the Protected Area. The applicability of any or all of these conditions will be determined based on-site specific conditions. In the abandoned mining areas, especially at Wadi Qulan El Atshan the operator will recontour the disturbed area and obliterate all earthwork by removing embankments, backfilling excavations, and grading to re-establish the approximate original contours of the land in the area of operation. The operator will arrange to have a biologist available to assist the construction workers in the identification and avoidance of endangered species.

6.3.1 Producing Mines and Quarries

Site reclamation for producing mines will be accomplished for portions of the site not required for continued operation of the mine. Disposals of mineral materials may be authorized outside of or away from sensitive plants, and cultural resources. The following measures are typical reclamation requirements:

6.3.2 Non-producing Mines and Quarries

Rehabilitation on the entire site will be required and will commence as soon as practical, dependent upon prevailing weather conditions. Cut and fill slopes will be reduced and graded to blend to the adjacent terrain. If the disturbance surface is large (ex. Ilmenite mine at Abu Ghusun) a reclamation plan, and preparation of an environmental assessment or Environmental Impact Statement is required to rehabilitate the site. All rock fragments around quartz and feldspar mines should be collected and removed from the surrounding areas. These rock fragments can be used for excavation reclamation by filling back.

6.4 Guidelines for Roads

All lands within the Protected Area are considered as either limited or closed to vehicles. There are no open areas. At rainy and torrents season, routes may be closed. Designations are based on resource protection, the promotion of the safety of all the users of the lands, multiple use management, the need for access, and the minimization of conflicts among various uses of the lands. Specific guidelines limited to existing roads include the following:

Except as otherwise noted, travel is allowed on existing roads, which appear on management maps, landsat images, and topographical maps approved by EEAA. Routes are considered to be open unless indicated as closed on the ground by signs, barricades, or other physical considerations, which appropriately direct the user. All authorized land users that hold a special authorization (i.e. grazing permits, rights-of-way holders, mining claimants, etc) may drive off road if their authorization allows. Motorized vehicles parked adjacent to any route of travel must be kept as close to the road or trail as practical without blocking the passage of other vehicles.

Roads should be designed with to mitigate the flood hazard as explained in the above section.

6.5 Historic Mines and Cultural Resources

The greatest threat to the historic mines and cultural resources in the Protected Area is that from researches of nuclear material authority, vandalism, and natural deterioration. To deter impacts to historic mines and cultural resources a number of actions can be implemented. Preventive measures are pursued through public awareness/education programs and physical and/or administrative protection (e.g., interpretive brochures, fences, administrative closures etc.). Baseline data is gathered through field inventory and recordation of historic mines and cultural resources. Detection of impacts occurs through systematic patrol and site monitoring, report of findings, and investigations by law enforcement when necessary. Treatment as deemed appropriate is implemented through site stabilization, restoration, or reconstruction (historic building).

To prevent or reduce disturbance to unique or significant natural or historic mines or cultural resources, surface-disturbing activities may be prohibited, and some activities may be prohibited during seasonal time periods (ex. Rainy or torrential season).

7 Appendix

A listing of all existing mining and building materials in Wadi El Gemal – Hamata Protected area.

1. Metallic Iron Ore Group.

Material	Location	Longitude	Latitude	Concession	Company	Economic value
Iron Oxide	Umm El Abass	35^{o} 05’ 00	24^{o} 33’ 00	continue	Individual	Low
Ilmenite	W. Abu Ghalaka	35^{o} 03’ 30	24^{o} 21’ 23	continue	Company	High
	W. Abu Ghusun	35^{o} 04’ 07	24^{o} 21’ 18	continue	Company	High

2. Metallic Non-Iron Ore Group

Material	Location	Longitude	Latitude	Concession	Company	Economic value
Copper	Hamata-El Atshan	35^{o} 11’ 00	24^{o} 15’ 00	stopped	--	Very low
Lead & Zinc	W. Renga	35^{o} 13’ 00	24^{o} 22’ 00	stopped	--	Low
Tantalum	Umm Rasheed	34^{o} 46’ 00	24^{o} 37’ 00	stopped	--	Low
Gold	Gulan El Atshan	35^{o} 11’ 00	24^{o} 15’ 00	stopped	--	Low

3. Non-Metallic Ore Group.

Material	Location	Longitude	Latitude	Concession	Company	Economic value
Feldspars	Umm Khayam	34° 32’ 09	24° 46’ 17	stopped	Individual	Low
	W. El Gemal	34° 42’ 00	24° 31’ 00	stopped	company	Low
	Hafafet	34° 40’ 00	24° 35’ 08	continue	Individual	Low
	Abu Had	34° 40’ 30	24° 35’ 30	continue	Individual	Low
	Abu Had	34° 37’ 45	24° 36’ 56	stopped	Individual	Low
	Abu Had	34° 36’ 42	24° 37’ 30	continue	company	Low
		34° 43’ 00	24° 31’ 00	stopped	company	Low
	Kab Marfoa	34° 37’ 04”	24° 31’ 22	stopped	company	Low
Quartz	W. El Gemal	35° 02’ 00	24° 38’ 00	stopped	----	Low
	Umm Sweih	34° 53’ 00	24° 28’ 00	stopped	company	Low
	W. Raadi	35° 14’ 00	24° 14’ 00	stopped	Individual	Low
	W. Zabara	34° 43’ 44	24° 48’ 20	stopped	Individual	Low
	W. El Gemal	35° 01’ 46	24° 37’ 31	stopped	Individual	Low
Asbestos	Hafafet	34° 30’ 00	24° 49’ 00	stopped	---	Low
Talc	W. El Atshan	35° 11’ 00	24° 15’ 00	stopped	Individual	Low
	G. El Agzia	34° 57’ 00	24° 18’ 00	stopped	---	Low
	W. Raadi	35° 17’ 00	24° 13’ 00	stopped	company	Low
	W. Zabara	34° 43’ 44	24° 48’ 20	stopped	company	Low
	W. El Lawy	34° 47’ 44	24° 46’ 09	stopped	company	Low
Vermicu-lite	Hafafet	34° 30’ 00	24° 49’ 00	continue	company	Low
	Hafafet	34° 40’ 00	24° 38’ 00	continue	Individual	Low

5. Building Materials.

Material	Location	Longitude	Latitude	Concession	Company	Economic value
Gravel	W. El Gemal	35^o 04’ 00	24^o 40’ 00	stopped	--	Low

6. Decorative Stones.

Material	Location	Longitude	Latitude	Concession	Company	Economic value
White Granite	G. El Abeyad	34^o 54’ 00	24^o 25’ 00	continue	Individual	Moderate
		34^o 51’ 12	24^o 27’ 20	continue	Individual	Moderate
		34^o 51’ 57	24^o 26’ 16	continue	Individual	Moderate
		34^o 52’ 03	24^o 25’ 47	continue	Individual	Moderate
		34^o 52’ 34	24^o 24’ 56	continue	Individual	Moderate
		34^o 53’ 38	24^o 24’ 32	continue	Individual	Moderate
		34^o 54’ 44	24^o 24’ 20	continue	Individual	Moderate
Black Granite		34^o 59’ 32	24^o 23’ 17	continue	Individual	Moderate

7. Precious stone Group.

Material	Location	Longitude	Latitude	Concession	Company	Economic value
Beryl	Sekeit	34^o 47’ 00	24^o 40’ 00	stopped	--	Low
	Nugrus	34^o 47’ 00	24^o 37’ 00	stopped	--	Low
	Umm Rasheed	34^o 45’ 00	24^o 39’ 00	stopped	--	Low
	Umm Lasaf	34^o 43’ 23	24^o 46’ 26	stopped	--	Low

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