DP/UN/RAB-80-014/2
EGYPT AND SUDAN

UNITED NATIONS
DEPARTMENT OF TECHNICAL COOPERATION FOR DEVELOPMENT

MINERAL EXPLORATION OF THE EGYPT/SUDAN AREA OF INTEGRATION

Compilation report

Geology and Mineral Potential: Preparatory Assistance

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Geology and Mineral Potential: Preparatory Assistance

Prepared for the Governments of Egypt and Sudan
by the United Nations
Department of Technical Co-operation for Development
acting as executing agency for the
United Nations Development Programme

New York, 1986

NOTE

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Glossary

jebel	-	mountain
khor	-	dry wash or ravine
lode	-	vein or layer of metal ore
reef	-	vein or ridge of vein-type rock
wadi	-	broad, sediment-filled dry or ephemeral stream channel or valley

Spelling: In this report the spelling of Arabic names for localities, mines, prospects, etc. mostly follows preponderant usage, with preference for simple rather than whimsical forms. Other spellings used in the literature are shown in parentheses in the report text.

DP/UN/RAB-80-014/2

Abbreviations

EGSMA	-	Egyptian Geological Survey and Mining Authority
ERTS	-	Earth Resources Technology Satellite
FCC	-	false colour composite
GMC	-	Geological and Mining Centre, Area of Integration
GMRD	-	Sudanese Geological and Mineral Resources Dept.
MSS	-	multispectral scanner
RBV	-	return-beam vidicon
SGF	-	Sudan Gold Field Company Limited
SIR-A	-	Shuttle Imaging Radar-A
UNDP	-	United Nations Development Programme
UNDTCD	-	United Nations Dept. of Technical Co-operation for Development
UTM	-	universal transverse mercator
ft	-	feet
g	-	grams
ha	-	hectares
km	-	kilometres
l	-	litres
m	-	metres
mt	-	metric tons
M.a.	-	million years
oz	-	ounces
ppb	-	parts per billion
ppm	-	parts per million
t	-	tons, as quoted from earlier reports. In old reports, probably short tons; in more recent reports, probably metric tons.

Symbols

Ar - argon	Hg - mercury	S - sulphur
As - arsenic	K - potassium	Sb - antimony
Au - gold	Ni - nickel	Sr - strontium
	P_2O_5 - phosphate	
Cu - copper	Pb - lead	U - uranium
Fe - iron	Rb - rubidium	

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SUMMARY

Following a joint request by the Governments of Egypt and Sudan, the United Nations Development Programme (UNDP) provided assistance to the Geological and Mining Centre (GMC) -- established in Aswan under the auspices of the Supreme Council for Integration -- in the formulation and execution of an integrated Preparatory Phase project covering the Area of Integration, a region embraced by contiguous portions of Egypt and Sudan and bounded by latitudes 20^{o} - 24^{o} N and longitudes 30^{o}- 34^{o} E. The project's principal objective was the compilation and assessment of all available data on the Area's geology and mineral potential.

The Area of Integration is described in terms of geography, physiography and logistics; concession, map and remote sensing coverage; exploration and mining history; and previous technical investigations. Compiled information on the geology, geochronolgy and mineral occurrences is summarized.

Preparatory Assistance activities are listed and include the description and contributions of the image-geological interpretation of satellite imagery of the unmapped Sudanese Sector, satisfactorily carried out under contractual arrangements in 1983-1984, and project field investigations undertaken in 1984-1985. The latter investigations concentrated on the preliminary assessment of the mineral potential of known mineral occurrences in the parts of the Egyptian and Sudanese sectors underlain by Precambrian Basement Complex rocks.

Seven major mineral targets were identified and, through field investigations and office studies, were

delineated and described. They are well understood in terms of field requirements, logistical problems, technical applications and mineral potential. Four of the five mineral target areas in the Sudanese Sector are covered by an existing mineral concession and are consequently excluded from further exploration under this project. However, in the remaining area there are extensive unexplored territories that constitute an attractive mineral exploration package.

A broad mineral resources prognosis based on the geologic and metallogenic setting is given as a guide to long-term mineral exploration and development planning.

The Precambrian rocks in the Area of Integration have a mineral potential that justifies continued mineral exploration. The report provides the basis for designing a second-phase project and selecting the most appropriate exploration methodology. The data compiled and presented herein will acquaint those planning, financing and executing the work programme with the Area of Integration, and will orient them in terms of technical, logistical and other operational requirements.

BACKGROUND

In July 1983, the Governments of the Arab Republic of Egypt and the Democratic Republic of Sudan agreed to establish -- under the auspices of the Supreme High Council of Integration, the Egyptian Ministry of Petroleum and Mineral Resources and the Sudanese Ministry of Energy and Mining -- a Geological and Mining Centre (GMC) to promote mineral development in the Egypt-Sudan Area of Integration bounded by latitudes 20° - 24° N and longitudes 30° - 34° E.

The Centre, based in Aswan, Upper Egypt, was inaugurated in July 1984. Its main objectives are:

1. General geological mapping and mineral exploration of the Area of Integration;
2. Study of the economic feasibility of known and newly discovered mineral occurrences;
3. Assistance in the development of a social, economic and technical infrastructure for the Area of Integration.

The GMC has a projected ten-year lifespan, is materially and financially supported on an equal basis by Sudan and Egypt, and is staffed by Egyptian and Sudanese technical, office and support personnel. GMC anticipates entering into technical cooperation agreements with bilateral and multilateral funding sources. The approved/ projected administrative structure of GMC is set out in Figure 1.

This project is an outgrowth of dialogue between the Egyptian Geological Survey and Mining Authority (EGSMA) and the Sudanese Geological and Mineral Resources

GEOLOGICAL AND MINING CENTRE, EGYPT-SUDAN AREA OF INTEGRATION
APPROVED/PROJECTED ADMINISTRATIVE STRUCTURE

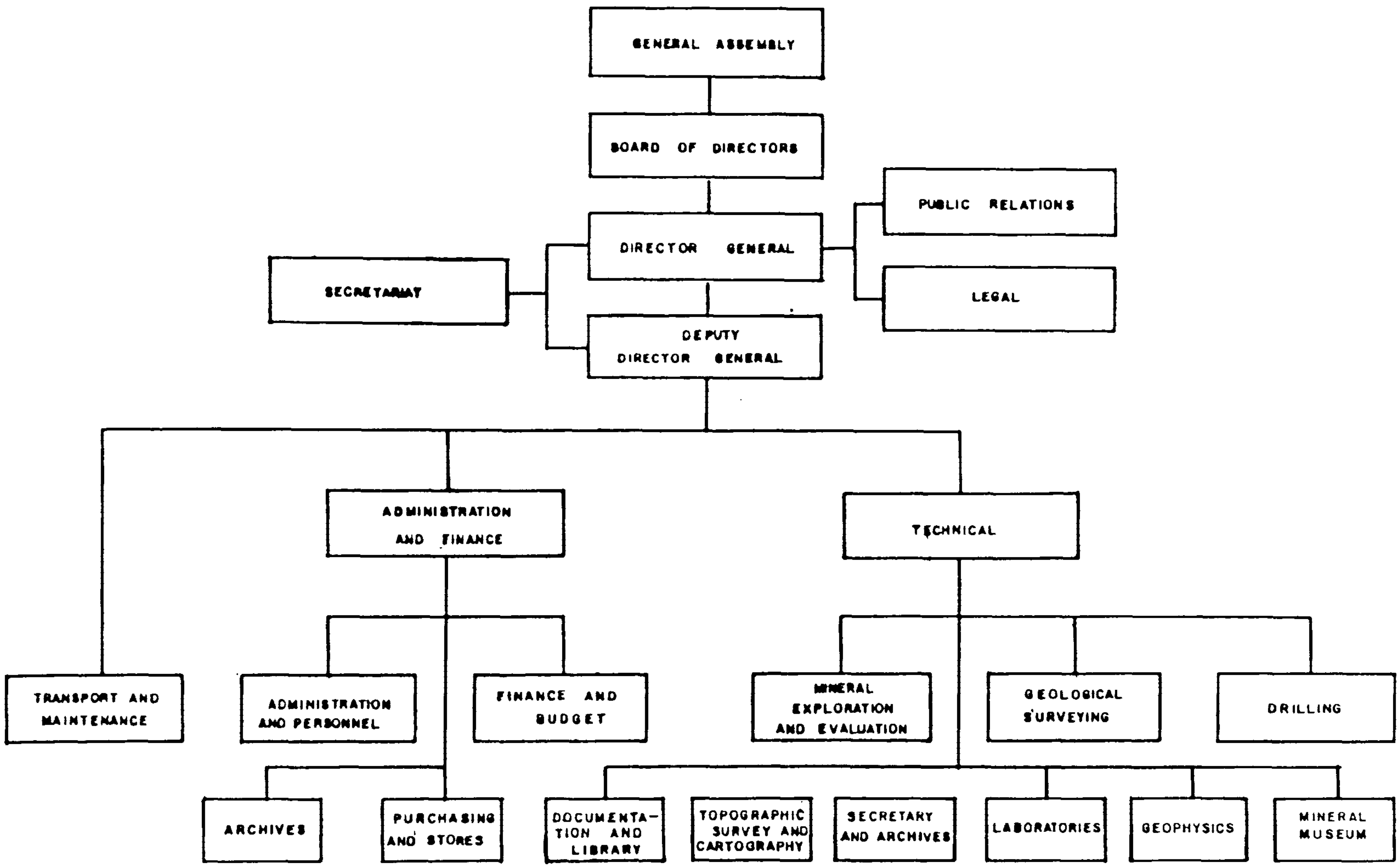


Fig. 1.

Department (GMRD). Taking into account the unexplored status of the Sudanese portion and the desirability for more survey work in the Egyptian portion, an integrated regional project involving aerial photography and airborne geophysical surveys was proposed to the Regional Bureau for Arab States in August 1979. In turn, the proposal was evaluated by the United Nations Department of Technical Co-operation for Development (UNDTCD) and the UNDP Bureau for Programme Policy and Evaluation (BPPE). In late 1979, a joint UNDP/UN fact-finding mission recommended a one-year preparatory phase, to include a geological interpretation of Landsat imagery covering the Sudanese portion and a compilation of all available information on the geology and mineral potential of the Area of Integration.

The project document (RAB/80/014) authorizing these services was approved and signed in May 1982. Project objectives were as follows:

1. To compile and assess all available information on the geology and mineral potential of the Area of Integration;

2. To conduct a geological interpretation of Landsat imagery for the 88,000 sq km Sudanese portion of the Area of Integration;

3. To formulate a project document with a detailed work programme for exploration of the Area of Integration, based on the results of 1 and 2 above;

4. To upgrade national capabilities in mineral exploration and evaluation.

UNDTCD, the designated executing agency, entered into a contract with Geosurvey International Limited for the Landsat interpretation work, which was initiated in June 1983 and completed a year later. A project co-ordinator/adviser (economic geologist) was assigned in November 1983, and UNDTCD provided technical, advisory and consultant services.

Under GMC, geological field work was harmoniously carried out in November-December 1984 and in February-April 1985 by an integrated group of Sudanese and Egyptian geologists. Work was concentrated in the eastern and southern parts of the Area of Integration, which are underlain by Precambrian Basement Complex rocks and in which there is a recognized potential for mineral deposits.

Tripartite Project Review meetings were held in Aswan and Cairo in October 1984, and technical review meetings were held in Khartoum and Cairo in October 1985.

Project staff, equipment and other services provided are listed in Appendices A, B and C. The UNDP contribution to the project amounted to US$529,747 (Revision N).

DESCRIPTION OF THE AREA OF INTEGRATION

Introduction

The region encompassed by the Area of Integration is an ancient and storied land, known as the land of Kush at the dawn of history, as Aetheopia to Herodotus and his contemporaries, and as Nubia since medieval times. Dunn (1911) observes that the original sense of the name "Nubia" is said to be "Land of Gold."

Nubia is generally defined as the portion of the Nile Valley between Aswan, which was the southern border of Egypt in Pharaonic times, and the Khartoum (Sudan) district (see Figure 14). At present, however, Nubia is effectively the area where the Nubian languages are spoken, i.e. between the First and Fourth Cataracts (Trigger, 1976).

Location and Size

Bounded by latitudes 20^{o}-24^{o} N and longitudes 30^{o}-34^{o} E, the Area of Integration covers 180,100 sq km. Straddling the 22^{o} N border between the two countries (see Location Map, Figure 2), it is divided into contiguous portions of southern Egypt and northern Sudan, with 88,385 sq km in Egypt and 91,715 sq km in Sudan. The Area includes portions of the Aswan, New Valley and Red Sea Provinces of Egypt and the Northern, Nile and Red Sea Provinces of Sudan. Precambrian Basement Complex rocks underlie 76,580 sq km, or 42.5 percent of the Area.

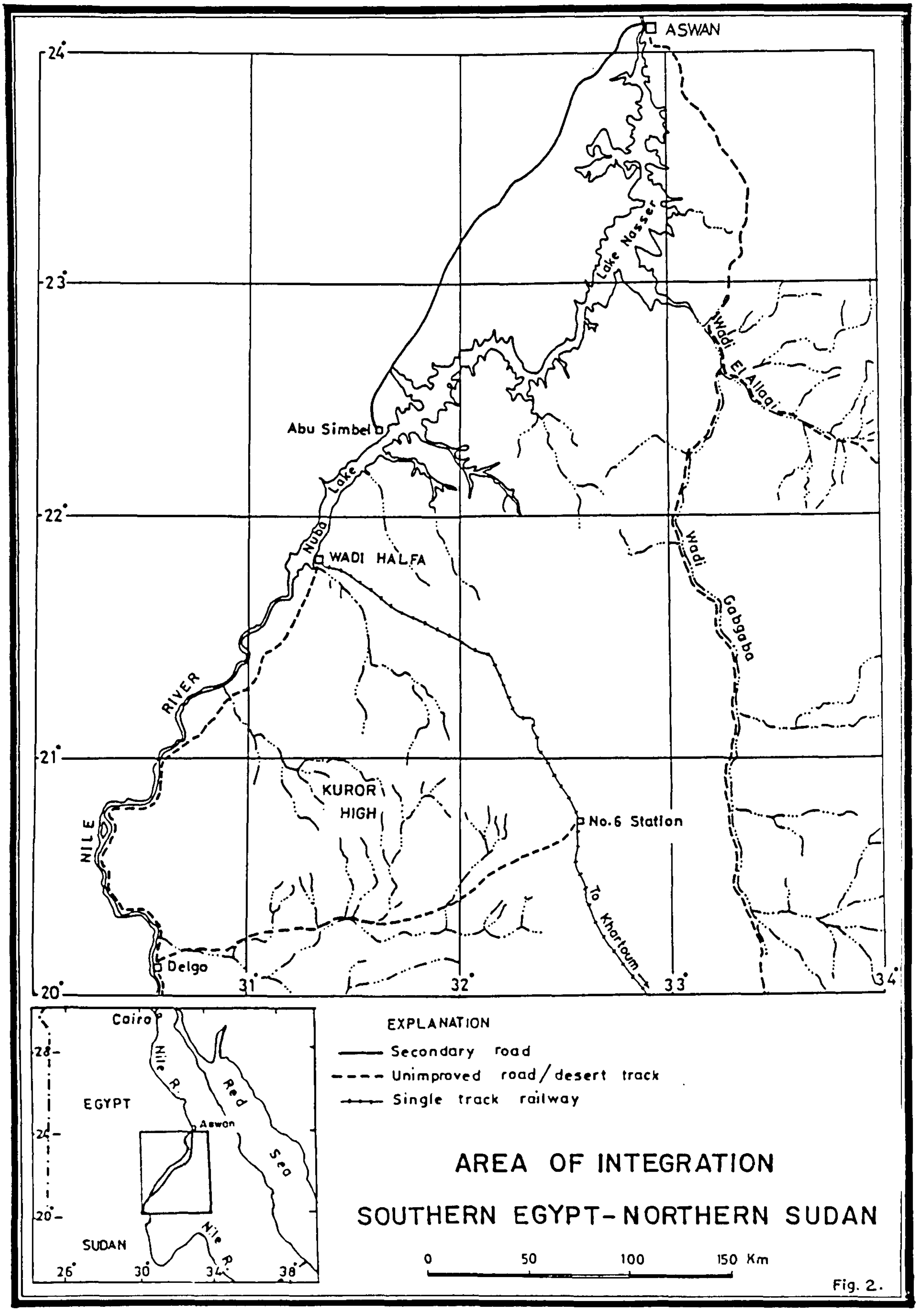
Access

From the large city of Aswan to the north, the Area of Integration is accessible by a paved road on the west side of Lake Nasser, southward to Abu Simbel near the Sudanese border. On the east side, there is access to Wadi El Allaqi in the south-central Egyptian Sector and to the region to the south via desert tracks. On Lake Nasser/Nuba Lake, there is twice-weekly passenger ferry service between Aswan and Wadi Halfa, the first major town in Sudan, south of the border. Daily train and air services exist between Aswan and Cairo/Luxor, and there is direct weekly air service to Khartoum.

Wadi Halfa has no air service but has an airstrip that will accommodate Boeing 737 aircraft. There is twice-weekly train service from Wadi Halfa to Khartoum (a 22-hour journey) on the single-track railway that traverses and provides access to the central part of the Sudanese Sector. Stations on the railway are spaced 25-40 km apart, and maintenance workers are domiciled at some. No. 6 Station is a prominent rest stop. A desert motor track parallels the railway and provides motor access to Abu Hamad, outside the Area of Integration to the south. An airstrip at No. 10 Station, 28 km northwest of Abu Hamad, is suitable for light aircraft.

From Wadi Halfa to the southwest, there is a poor road that provides access to villages on the east bank of the Nile from Akasha south to Delgo and beyond. A desert track links Delgo and No. 6 Station. To cross the Nile, there is scheduled ferry service at Delgo and unscheduled service at Abri and at Suarda, about 15 km south of Abri.

Wadi Gabgaba, a prominent north-south drainage in the eastern part of the Sudanese Sector, is a motor and camel caravan route between Abu Hamad and the Aswan area. It has been the main overland trade route to Egypt since Pharaonic times.



AREA OF INTEGRATION

SOUTHERN EGYPT - NORTHERN SUDAN

Fig. 2.

Communications, Services and Supplies

Aswan has postal, telegraph, telephone and telex services through the Post Office, and the last two services also through local hotels. Motor fuel is plentiful and cheap, although it should be noted that no diesel vehicles can be brought into Egypt. Tyres, spare parts, other equipment and supplies, and basic food items are generally available. Electrical current is 220V 50HZ. Medical services are available. There are no map reproduction facilities.

At Wadi Halfa, government microwave communication-links with Aswan and Khartoum are the only contacts with outside areas. No motor fuel or tyres, few spare parts and very limited food supplies are available. Vehicles that use diesel fuel can be brought into Sudan. Under-powered 220V 50HZ electrical current is provided for a few hours each evening when generator fuel is available. There are no medical services.

Physiography

The Area of Integration is dominated by the Nile River Valley, termed the "Nubian Corridor" by Adams (1977), a swath of water and vegetation in an otherwise waterless, lifeless desert. The Nile and the vast lake known as Nuba Lake in Sudan and Lake Nasser in Egypt (the second largest man-made body of water in the world), formed behind the High Dam at Aswan, traverse the area from southwest to northeast, separating the Libyan and Nubian deserts in Sudan, which become the Western and Eastern Deserts northwards into Egypt.

The Nile flows through this desert region in a well-defined valley. The river has placid reaches accompanied by narrow to wide vegetated flood plains, and it is punctuated by cataracts in intervals where the river traverses resistant igneous and metamorphic rocks. The High Dam on the Nile is situated at the First Cataract, lying at the threshold of Lower Nubia, which sets the river off from the great valley of Egypt to the north. The Second Cataract is immediately upstream from Wadi Halfa. This cataract, now covered by Nuba Lake, served as a "granite curtain" that impeded Pharaonic colonization to the south for a millennium.

Geology is the key to Nubia's topographic diversity and to the seemingly erratic course of the Nile. Between Abu Hamad and Wadi Halfa, the Nile skirts abruptly westward in its great arch around the west flank of a broad, prominent topographic high composed of structually complex Precambrian Basement rocks and perched pre-Nubia or early Nubia sediments, flanked by younger Nubia sediments. Geosurvey International (1984) named this prominent feature the Kuror High after Jebel Kuror, situated near its center (see Plate I). It also has been called the Nubian Swell. In several localities, the river course coincides with linear structural features and lithologic breaks that cause it to make some abrupt 90° turns.

The Nile Valley between Wadi Halfa and Aswan, now occupied by Nuba Lake/Lake Nasser, lies at the division between generally subdued, low-lying sand-blown topography to the west and areas of greater relief and more youthful topography to the east, the latter apparently due to uplift. According to Adams (op. cit.), ancient overland travelers apparently preferred the sand of the west bank to the rocks of the east bank, for the west bank is historically the main caravan route along the Nile.

The region is physiographically complex and exhibits wide variations in relief and surface features, ranging from flat arid desert to mountainous, with a minimum elevation ranging from 157 to 182 m at Nuba Lake/Lake Nasser and a maximum of 1,079 m at Jebel Kuror, the highest point between the Red Sea Hills and the Libyan border area. The Wadi Halfa-Khartoum railway climbs from a few meters above lake level to 610 m at No. 5 Station, then progressively drops to near river level at Abu Hamad.

There are extensive plains of typical desert reg deposits (semi-consolidated sand and gravel) interspersed with isolated mountain ranges consisting mainly of alkaline igneous complexes, and hilly areas of dominantly metamorphic terrain. Marble and quartz ridges stand out as knife-like prominences, salient from a distance because of their white and blue colours, which are a haven for spectacular sand dunes that cling to their lee sides. Erosion has reduced large areas laced with veins of milky quartz to broad coalescing eluvium-colluvium flats surfaced with breccioid quartz.

The hinterland east of the Nile bears evidence of an extensive Quaternary drainage system characterized by impressive but now defunct wadis, or valleys, and subordinate feeder areas that have been filled and buried by the sand and silt of subsequent erosion. In the southern part of the Egyptian Sector, Wadi El Allaqi and its north-south tributary, Wadi Gabgaba, which extends into the southern part of the Sudanese Sector, constitute a once prominent watercourse dating back to the late Tertiary that, in the early stages of its development, probably competed with the primeval Nile for drainage supremacy. Its maturity, however, was impeded by tectonic events resulting in uplift in headwater areas on the west flank of the Red Sea Hills to the east; current drainage is now limited to rare ephemeral runoff. There is no major drainage west of the Nile River.

Prevailing wind directions range from north-northwest to north-northeast, depending on the location within the Area of Integration, but the former direction is predominant. Wind directions are shown in Figure 3 and their subtle diversion around the Kuror High is noteworthy.

Winds have left their mark on the region in the form of extensive sand sheets, barchan dune fields and long trailing dunes, with the latter measuring up to 110 km from source to lee terminus and appearing prominently on MSS imagery. The dunes are especially abundant in areas in or adjacent to Nubia Formation clastic sediments, principally on the west side of the Nile. Active dune areas have a yellowish limonitic hue as compared with more whitish stationary sand.

Population

With an area of 679 sq km, the Aswan Governorate contained an estimated population of 663,000 in 1979. This included a fair share of the approximately 50,000 inhabitants of Lower Nubia who had to be resettled because of the inundation of virtually all tillable areas between the First and Second Cataracts by Lake Nasser/Nuba Lake. After resettlement, only a few people remained at Kalabsha, Wadi El Allaqi, Abu Simbel and Adindan.

In pre-High Dam years an active, landscaped Nile port of 20,000 inhabitants, Wadi Halfa is now a town of about 9,500 people, resituated on a dry, dust plain bordering Nuba Lake, about 14 km south of its original site.

In the 130 km stretch of the Nile southwards from Wadi Halfa, there are a few people at Ambikol and at one or two other isolated settlements. But from Akasha to upstream sites beyond the Area of Integration, there is a moderate population in scattered towns and small villages.

Except for a nomad or two, for workers at isolated marble quarries and baryte mines in southern Egypt, or for railway maintenance workers housed at some railway stations between Wadi Halfa and Abu Hamad, the desolate desert hinterland is uninhabited.

Climate

The Area of Integration includes extremely arid, rainless portions of the Eastern and Western Deserts of Egypt and the Nubian and Libyan Deserts of Sudan. Trigger (1976) observes that Nubia is at the centre of the hottest and most arid region in the world. Although a sprinkling of rain may occur locally in the winter and spring, a generation may elapse before rain falls a second time at the same spot. But flash floods do occur, especially in more mountainous areas, and an occasional wadi will show evidence of fairly recent water flow.

Monthly temperatures and rainfall recorded at the Aswan Meteorological Station in 1965 appear in Table 1 below (more recent data not available). In general, the climate is drier and hotter southward within the Area of Integration. Withering summer winds from the Libyan and Western Deserts accentuate the high summer heat. Conversely, cold prevailing northerly winds during the winter months can result in a sub-freezing wind-chill factor.

The sky is virtually cloudless from June through October. October to January are probably the most suitable months from the point of view of weather for aerial photography. The strong, dust-laden khamseen winds of February and March make those months undesirable for aerial survey work and occasionally hinder field work on the ground.

The most productive field months are November through March. Work can be carried out in October and April, but higher temperatures inhibit field activity.

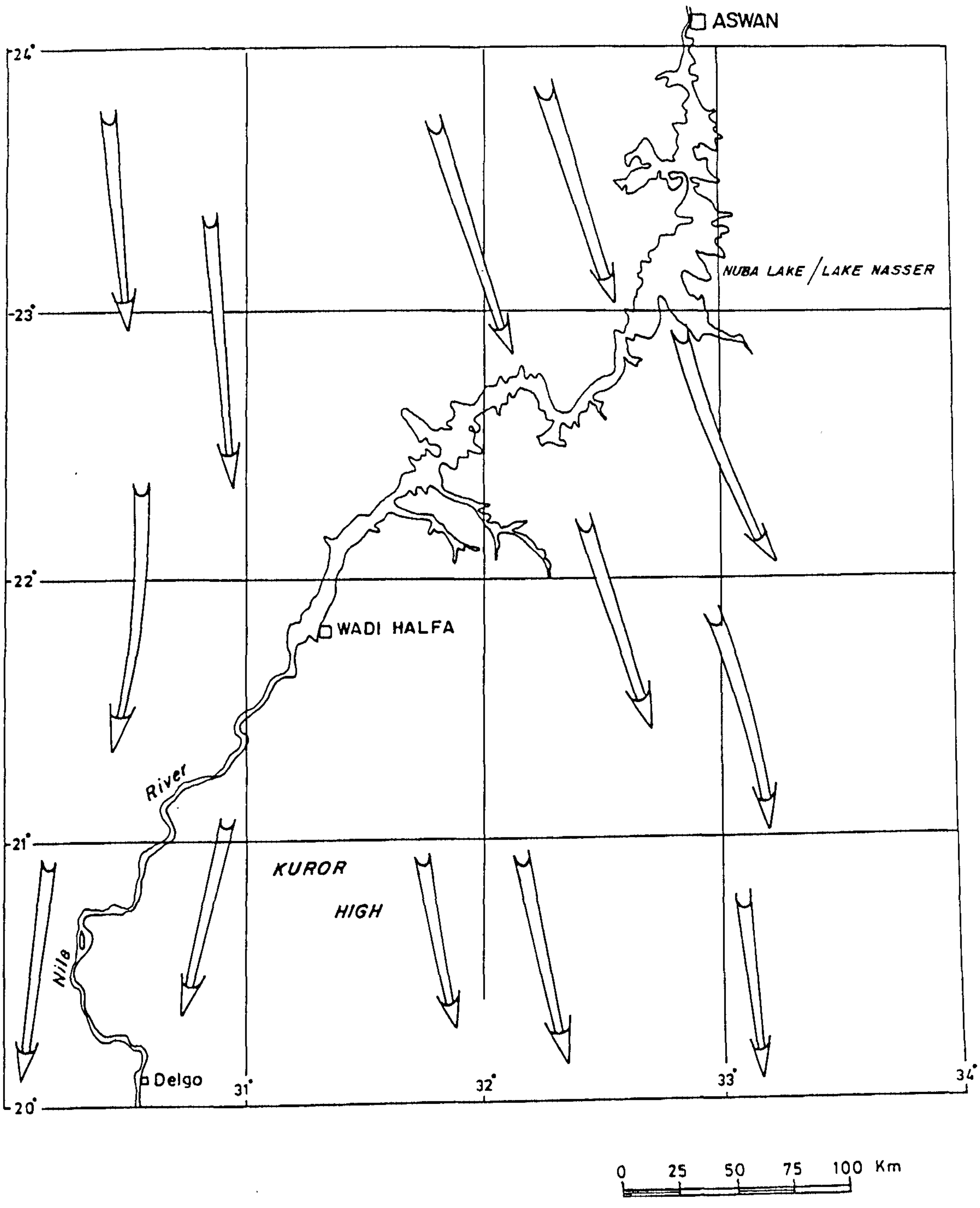


Fig. 3. Prevailing wind directions.

Table 1

Average monthly temperature and rainfall data

Aswan Meteorological Station, 1965

Temperature (°C)

Month	Maximum	Minimum	Absolute Maximum	Rainfall (mm)
January	32.7	0.9	37.8	0.1
February	25.9	11.0	39.2	0.0
March	30.4	14.3	43.4	0.1
April	35.5	16.9	48.1	0.3
May	39.6	23.4	48.0	0.8
June	41.7	25.6	50.1	0.0
July	41.5	26.3	51.0	
August	41.9	26.4	49.0	
September	39.6	24.0	48.3	
October	37.9	21.6	46.4	
November	30.8	16.4	41.7	
December	25.5	11.8	37.0	

Earlier Climatic Epoch

There is convincing evidence of higher pluvial activity in the Area of Integration during early periods of human habitation. Dunn (1917) observed that, because of the extent of the alluvial gold workings and of the mining operations at Hargaleb, Adila and Um Faham (south of Wadi Halfa), there must have been an annual water supply to result in such work since it could not be conceived as possible with the existing rainfall. Side-hill trails left by grazing domestic and/or wild animals are familiar sights in many areas and were observed by Dunn, who stated that they indicate that the entire district must have been a good grazing ground, with an ample supply of water in shallow wells or pools.

Rude habitation sites in forbidding, sand-blown areas suggest occupancy in a different climatic epoch, when the area was perhaps more savannah-like and the occupants engaged in hunting or herding grazing animals. Several wadis contain a scattering of trees, some quite large but all now dead, that relate to an earlier period when there was sufficient water to support growth.

In some mountainous areas, steep, dry stream beds show evidence of small cascading streams, waterfalls and pools fed by rains of an earlier, more active pluvial epoch. These, of course, could date back to pre-history.

Availability of Water

Culinary water in Aswan comes from the Nile River but is adequately treated. Piped water available in Wadi Halfa comes from a muddy Nuba Lake source and is untreated. Villages to the south use Nile water. Aswan, Wadi Halfa, Abu Hamad and Delgo are potential sites from which water may be trucked to work areas distant from any source.

The latest topographic sheets show 18 water wells in the Area of Integration. These are listed in Table 2. The existence of most of these wells was not verified. One, a shallow well known as Araft, or Um Gerifat, situated 8.8 km north-northeast of the Um Nabari gold prospect, is used by passing camel herds and caravans and contains drinkable water of questionable purity. This well supplied 4,000 gallons per day to the mining operation at Um Nabari in the early years of this century. Wells dug recently at Nubian settlement sites in and near Wadi El Allaqi contain limited quantities of potable water. Well water is available at Delgo. No. 4 and No. 6 stations on the railway have wells reportedly containing brackish water.

Some stations along the railway have limited water supplies brought in by rail, insufficient for outside use. Abandoned mine shafts at Abu Swayel, Um Garayat and Um Nabari contain water at generally inaccessible depths.

In remote areas where field work will be carried out for an extended period, it may be advisable to drill for a potable water source eventually.

Table 2

Water Well Locations, Area of Integration

Coordinates

Ref.	Well Name	North	East	Comments
1.	Kurkur	23°54'	32°19'30"	Brackish
2.	Bir Um Hibal	23°42'	33°13'30"	Approximate location; good water
3.	Dunqul	23°26'	31°37'	Brackish
4.	Dineiqil	23°24'30"	31°37'30"	Fair
5.	Bir Murr	23°21'30"	30°05'30"	Brackish
6.	El Magal	23°07'30"	33°31'	Approximate location; good water
7.	Haimur Wells	22°43'30"	33°47'30"	
8.	Bir Murra	22°32'	33°55'	Intermittent; salty
9.	Bir Abu Fas	22°09'	33°48'	
10.	Bir Ungat	22°07'	33°45'	Fresh
11.	Bir Tawit	21°52'	33°44'	
12.	No Name	21°50'	33°33'30"	
13.	Bir Naba	21°20'	33°54'	
14.	Bir Adarabit	21°15'30"	33°53'	
15.	Bir Naba	21°13'	33°44'	
16.	Araft (Um Gerifat)	21°11'30"	32°47'	Good water; 8.8 km NNW of Um Nabari
17.	Muftah	20°54'30"	32°38'30"	Well and pump
18.	No. 6 Station	20°45'	32°33'	Brackish wells

Magnetic Declination

As of January 1984, the magnetic declination in the centre of the Sudanese Sector was 1° 30' east of true north. The setting in the Egyptian Sector was not determined but should be somewhat less.

EXISTING EXPLORATION AND MINING CONCESSIONS

Egyptian Sector

Table 3 is a tabulation of all exploration and mining concessions held within the Egyptian Sector as of September 1985; Figure 4 shows their location. There are 28 concessions covering 7,065 ha, divided as follows: baryte - 17, feldspar and quartz - 1, kaolin - 3, marble - 2, quartz - 3, talc - 1, and vermiculite - 1. These concessions do not conflict with the two mineral target areas: North Wadi El Allaqi and Abu Swayel.

Sudanese Sector

Greenwich Resources (Minex Development), a U.K. company, holds an exclusive prospecting license covering two blocks of ground within the Sudanese Sector, as shown in Figure 5. The concession was granted on 17 June 1979 for a 21-year period, until 16 June 2000. On 14 December 1982, Minex and the Government of Sudan entered into the Sudan Minex Gold Mining Venture, which was amended on 13 March 1985. The retained ground held by the venture after its third reduction in January 1985 covers about 16,000 sq km. There will be no further size reduction. The concession includes all minerals (gold and associated minerals, metals and materials), but excludes uranium, precious stones and petroleum.

By decree of the Geological and Mineral Resources Department, the Sudanese Sector was closed to any further mining concessions on 30 June 1983. The sector was placed under custody of the Geological and Mining Centre, and all national and international groups and individuals were forbidden from working inside it without the Centre's permission.

The above-described concession covers the Um Nabari, Wadi Naba, Upper Wadi Gabgaba and Abu Sari mineral target areas, obligating exclusion of those areas from future United Nations survey work.

MAP AND REMOTE SENSING COVERAGE

Geologic Maps

The geology of the Egyptian Sector has been mapped at 1:250,000 scale west of the Nile River, and the greater part of the Precambrian has been mapped at 1:100,000 scale east of the Nile. The mapped and unmapped portions are shown in Figure 6. There is an ongoing GMC project to compile these geologic maps on $1^{o} \times 1.5^{o}$ quadrangles using a UTM base at 1:250,000 scale. Four quadrangles plus two-thirds of two others will cover the Egyptian Sector.

The Sudanese Sector is covered by image-geological mapsheets interpreted from satellite imagery by Geosurvey International (1984). There are four $1^{o} \times 2^{o}$ quadrangles showing geology and four showing geologic structure. Figure 6 shows the locations of these quadrangles.

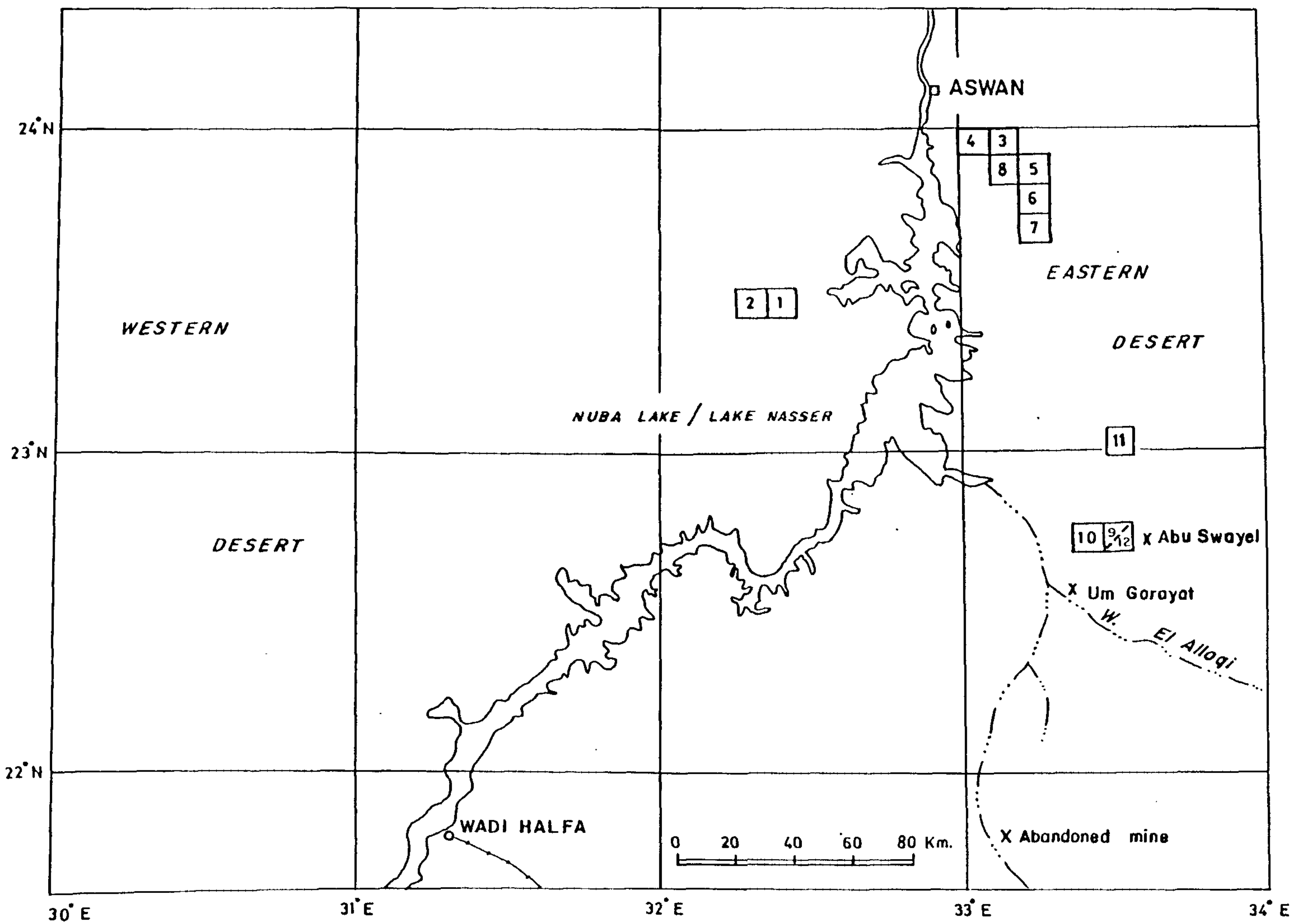


Fig. 4. Exploration and mining concessions held within the Egyptian Sector as of September 1985. (Refer to Table 3 for complete data)

TABLE 3 - EXPLORATION AND MINING CONCESSIONS HELD WITHIN THE EGYPTIAN SECTOR AS OF SEPTEMBER 1985

Map Ref. Number	Concession Holder	Concession No. and Type	Size (Ha)	Location	Mine/Quarry Product	Starting Date	Concession Period (Years)
1	Egyptian Gypsum and Marble Quarry Co.(Govt)	455 (Mng)	188	Kalabsha	kaolin	13-01-69	30
2	" " " "	483,594(Mng)	341	Kalabsha	kaolin	30-12-73 11-02-80	20 30
3	" " " "	389,390(Mng)	7	W. Arab	baryte	12-09-63	30
4	" " " "	631,632(Mng)	40	"	quartz	18-08-80	10
5	El Naser Phosphate Co. (Govt)	1518,1550(Mng)	700	"	baryte	3-05-82	4
5	" " " "	680 (Mng)	50	"	baryte	30-05-83	10
6	" " " "	563 (Mng)	8	"	baryte	8-05-78	10
6	" " " "	592 (Mng)	25	"	baryte	7-10-79	10
6	" " " "	1594(Expl)	400	"	baryte	23-02-85	4
6	" " " "	1619(Expl)	1600	"	baryte	7-05-85	4
6	" " " "	1620(Expl)	1600	"	baryte	7-05-85	4
6	" " " "	692 (Mng)	25	"	baryte	28-04-85	10
6	" " " "	620 (Mng)	25	"	baryte	10-12-80	10
6	" " " "	596 (Mng)	20	"	baryte	21-01-80	10
6	" " " "	669 (Mng)	10	"	baryte	26-07-83	10
6	" " " "	1525(Expl)	400	"	baryte	20-09-82	4
7	" " " "	1522(Expl)	400	"	baryte	20-09-82	4
7	" " " "	1523(Expl)	600	"	baryte	20-09-82	4
8	Mining Engineering Co. (MECO) (Private)	1629(Expl)	200	"	quartz	7-05-85	4
8	" " " "	1630(Expl)	200	"	vermiculite	7-05-85	4
9	Samco Mining Co.(Private)	627 (Mng)	25	Wadi Haimur	talc	9-08-81	4
10	Arabic Mining & Quarrying	1622(Expl)	200	W.Abu Gelega	feldspar, quartz	7-05-85	4
11	Maranite Company (Private)	1006(Mng)	0.5	Um Arak	marble	24-09-85	1
12	" "	1007(Mng)	0.39	W.Haimur	marble	24-09-85	1

[1]Type of concession: (Expl)= Exploration; (Mng) = Mining

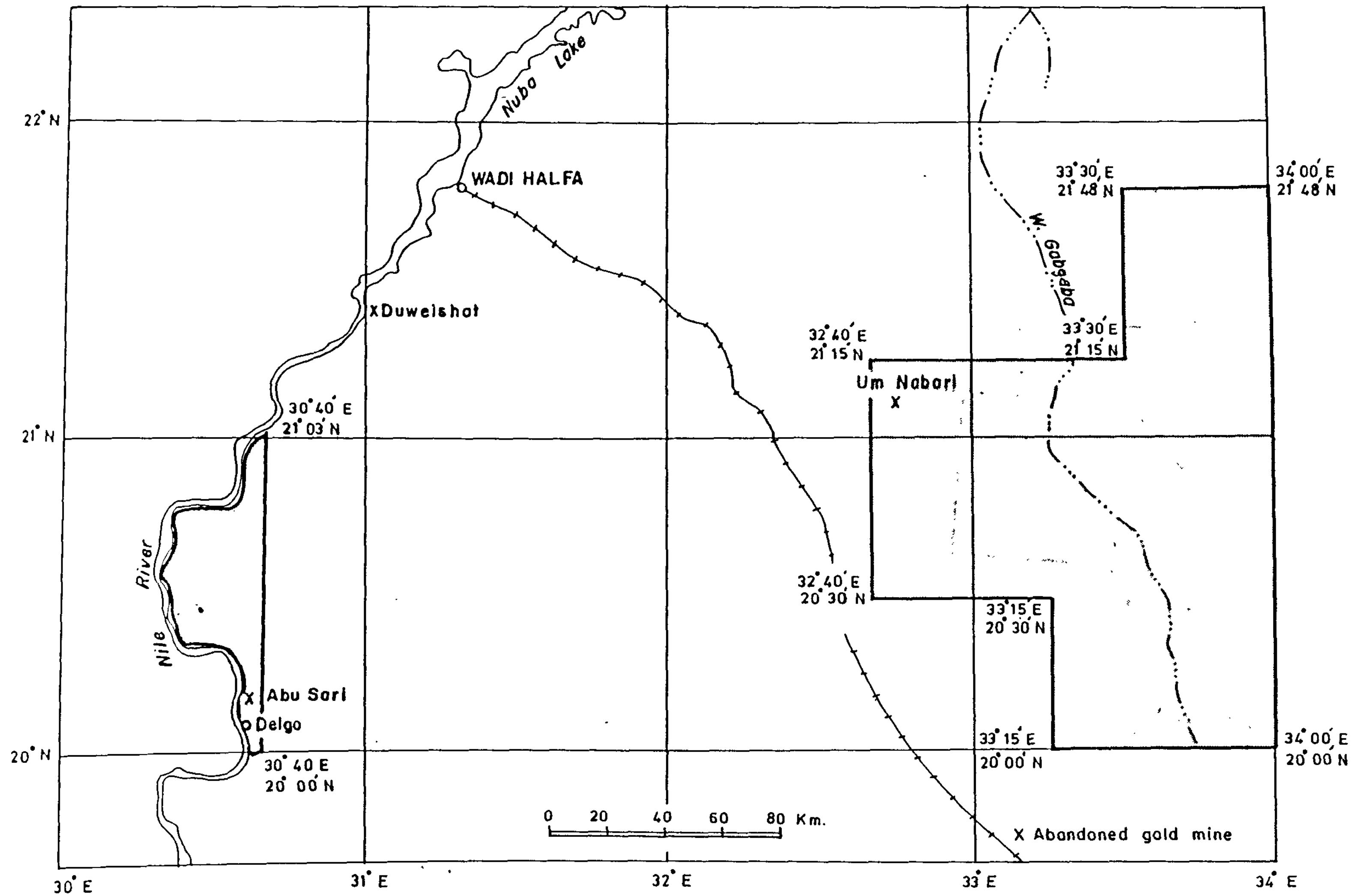


Fig. 5. Exploration and mining concessions held within the Sudanese Sector as of January 1985.

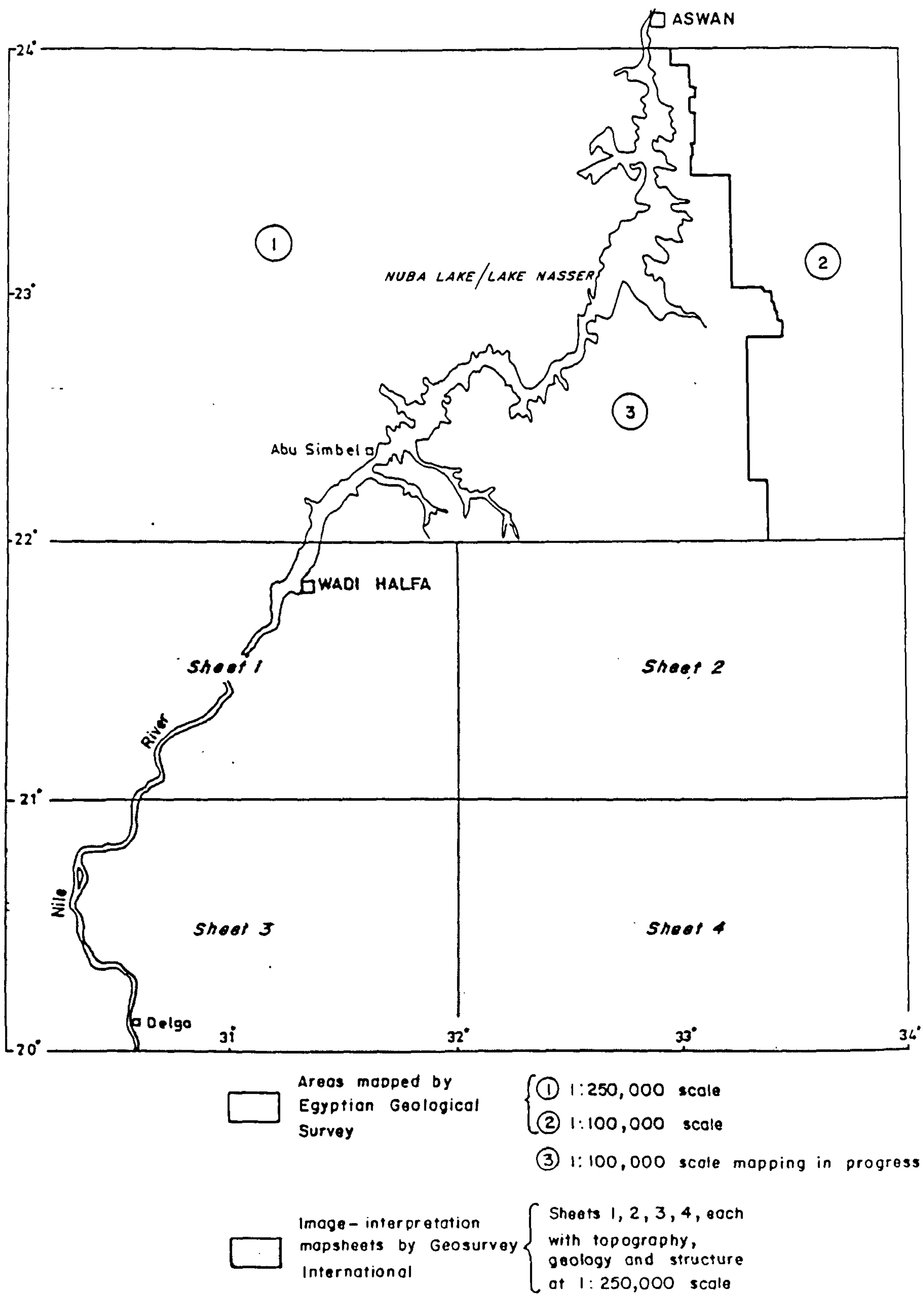


Fig. 6 Geologic map and satellite image interpretation coverage.

Topographic Maps

There is good small-scale topographic map coverage of the Area of Integration, as listed below.

1:1,000,000 Scale Maps

Operational Navigation Chart - Egypt and Sudan

Sheet designation:	ONC J-5
Coverage:	Entire Area of Integration
No. of sheets:	1
Date compiled:	July 1977
Revised:	April 1981
Source:	Defense Mapping Agency Aerospace Center, St. Louis Air Force Station, Missouri 63118, USA

Topographic Map - Egypt and Sudan (Old Coverage)

Sheet designation:	Wadi Halfa NF-36
Coverage:	Entire Area of Integration (20^{o}-24^{o}N, 30^{o}-36^{o}E)
No. of sheets:	1
Date:	July 1947
Source:	Survey of Egypt

1:500,000 Scale Maps

Tactical Pilotage Chart - Egypt & Sudan (New Coverage)

Sheet designation:	TPC J-5B
Coverage:	Entire Area of Integration
No. of sheets:	1
Date compiled:	May 1980
Source:	Defense Mapping Agency Aerospace Center, St. Louis Air Force Station, Missouri 63118, USA

Topographic Maps - Egypt and Sudan (Old Coverage)

Sheet designations:	Aswan No. 11, T/44/133, 'Elba No. 12, 45/205
Coverage:	Southern Egypt and slightly into northern Sudan
Index map:	Figure 7
No. of sheets:	2
Date:	1944-1945
Source:	Survey of Egypt

1:250,000 Scale Maps

Joint Operations Graphic - Egypt and Sudan (New Coverage)

Sheet designations:	Series 1501 Edition 2: NF36-1,2,3,5,6,7,9,10,11,13,14,15
Coverage:	Entire Area of Integration
Index map:	Figure 8
No. of sheets:	12
Date compiled:	July 1972
Source:	Defense Mapping Agency Topographic Center, Washington, D.C.
N.B.	Distribution restricted

Topographic Maps - Sudan (Old Coverage)

Sheet designations:	Wadi Halfa, Murrat, Abu Tabaq, Kosha, No. 6 Railway Station, J. Shigrib
Coverage:	Sudanese Sector
Index map:	Figure 8
No. of sheets:	6
Date compiled:	Based on 1893-1897 triangulations and subsequent surveys; later revisions
Source:	Sudan Survey Department, Khartoum

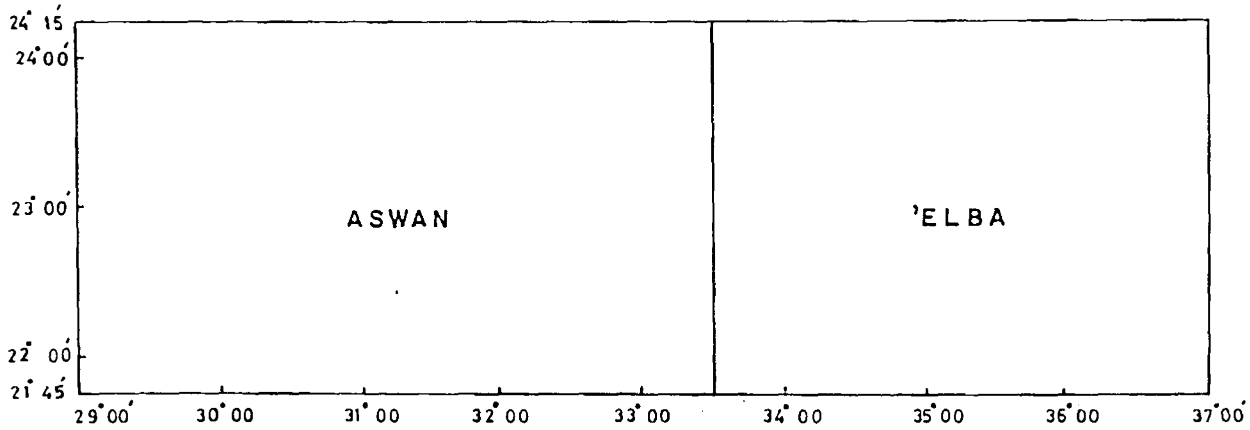
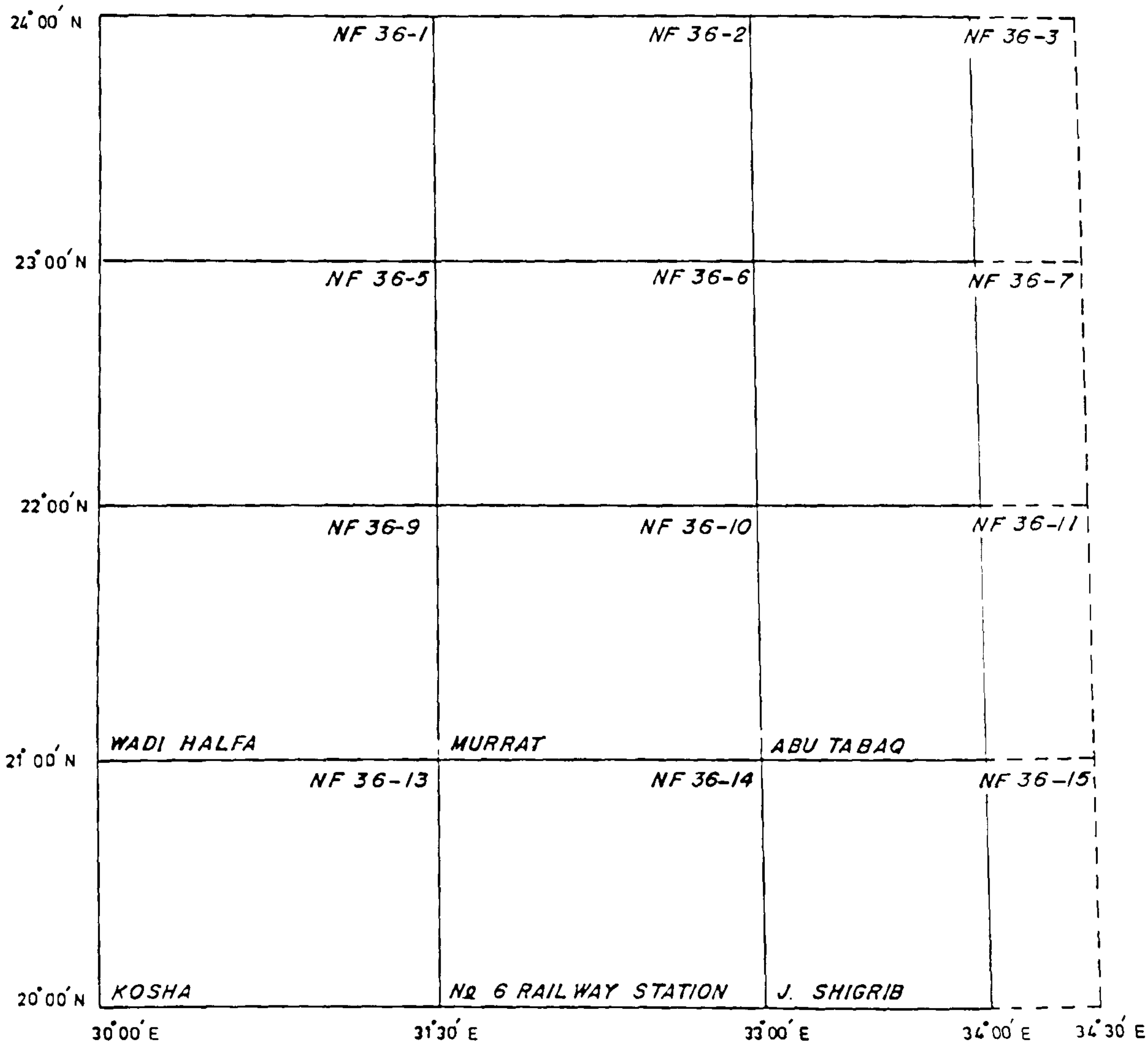
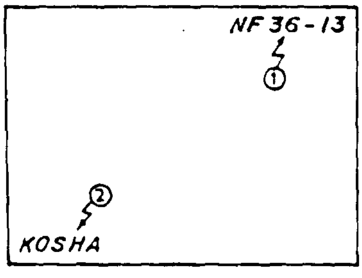


Fig. 7. Index to 1:500,000 scale topographic maps, 1944-45 coverage, Egyptian Sector and part of Sudan.



Explanation



① Topographic maps, Series 1501, Edition 2, compiled July 1972. Prepared and published by the Defense Mapping Agency Topographic Center, Washington, D.C.

② Topographic maps based on early triangulation surveys. Available from Sudan Survey Department, Khartoum.

Fig. 8. Index to 1: 250,000 scale topographic maps, Egypt and Sudan

Satellite Image-Topographic Mapsheets - Sudan

Sheet designations:	1A,2A,3A,4A
Coverage:	Sudanese Sector
Index map:	Figure 6
No. of sheets:	4
Date compiled:	1983-1984
Source:	Geosurvey International (1984) report: Production of Landsat MSS imagery of the Area of Integration and image-geological interpretation of the Sudanese Sector

Topographic Maps - Egypt (Old Coverage)

Sheet designations:	High Dam, Abu Simbel
Coverage:	Southern Egypt
No. of sheets:	2
Date:	None given
Source:	Survey of Egypt

1:100,000 Scale Maps

Topographic Maps - Egypt (New Coverage)

Sheet designations:	A-1,2,7,8,9,10,11,12,13,14,15, 16,17,18,21,24; B-7,18,19
Project name:	New Valley Project
Coverage:	Part of the Nile Valley and areas to the west
Index map:	Figure 9
No. of sheets:	19
Date:	1968
Source:	Survey of Egypt

Topographic Maps - Egypt (Old Coverage)

Sheet designations:	Kurkur, Kalabsha, Bir Um Hibaal, Bir Abu Hashim, Dungul, Bark El Sahab, Allaqi, Abu Grigal, Gebel Musrar, Bir Kusiba, Krusko, Siala, Um Greiat, Haimour, El Shab, Barkat El Shab, Adindan, Armana, Wadi Krusko, Wadi Gabgaba, Ungat
Coverage:	Southern Egypt
Index map:	Figure 10
No. of sheets:	21
Date:	1943-1944
Source:	Survey of Egypt

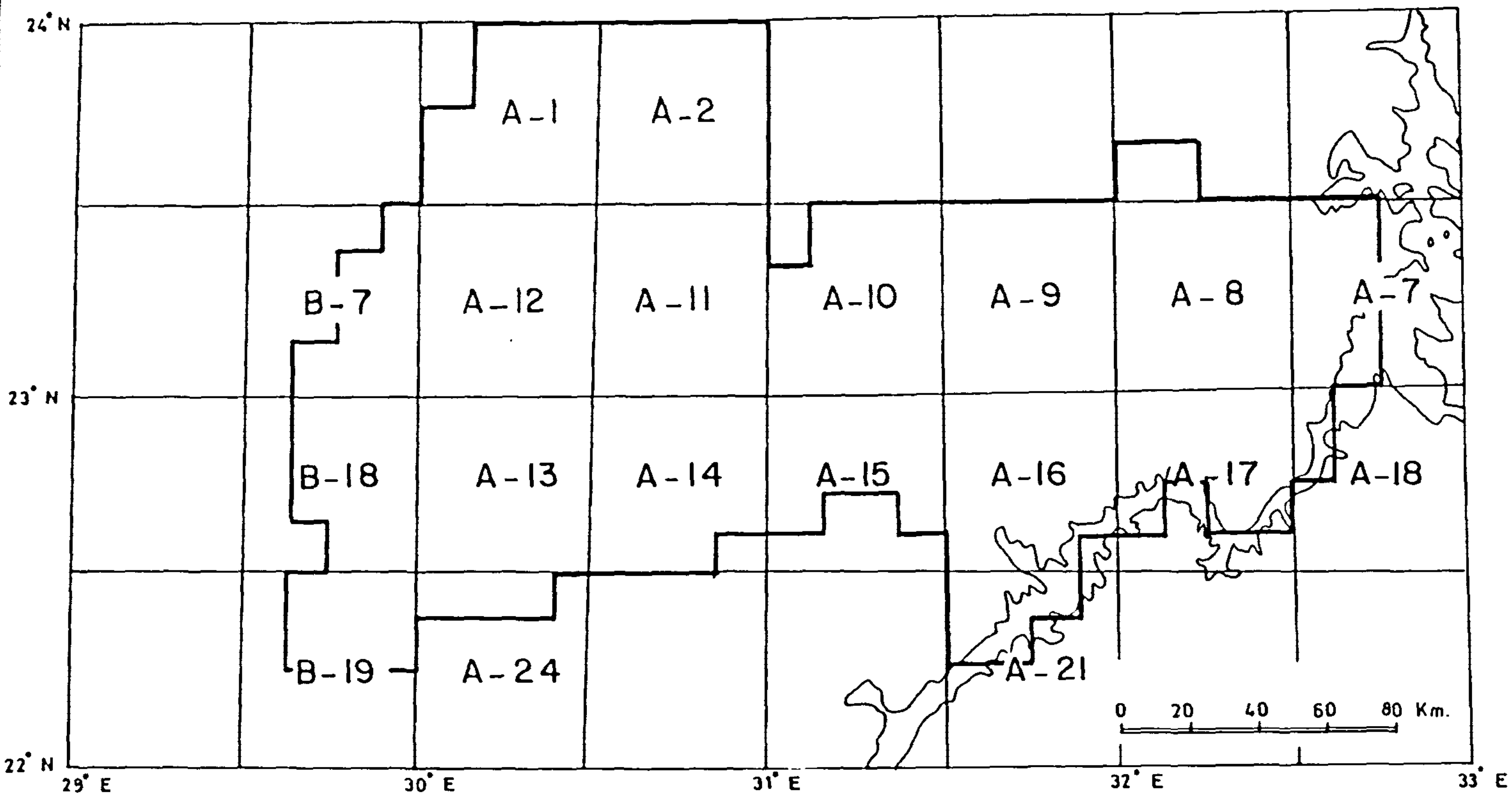


Fig. 9. Index to 1:100,000 scale topographic maps, 1968 New Valley Project coverage, Egyptian Sector.

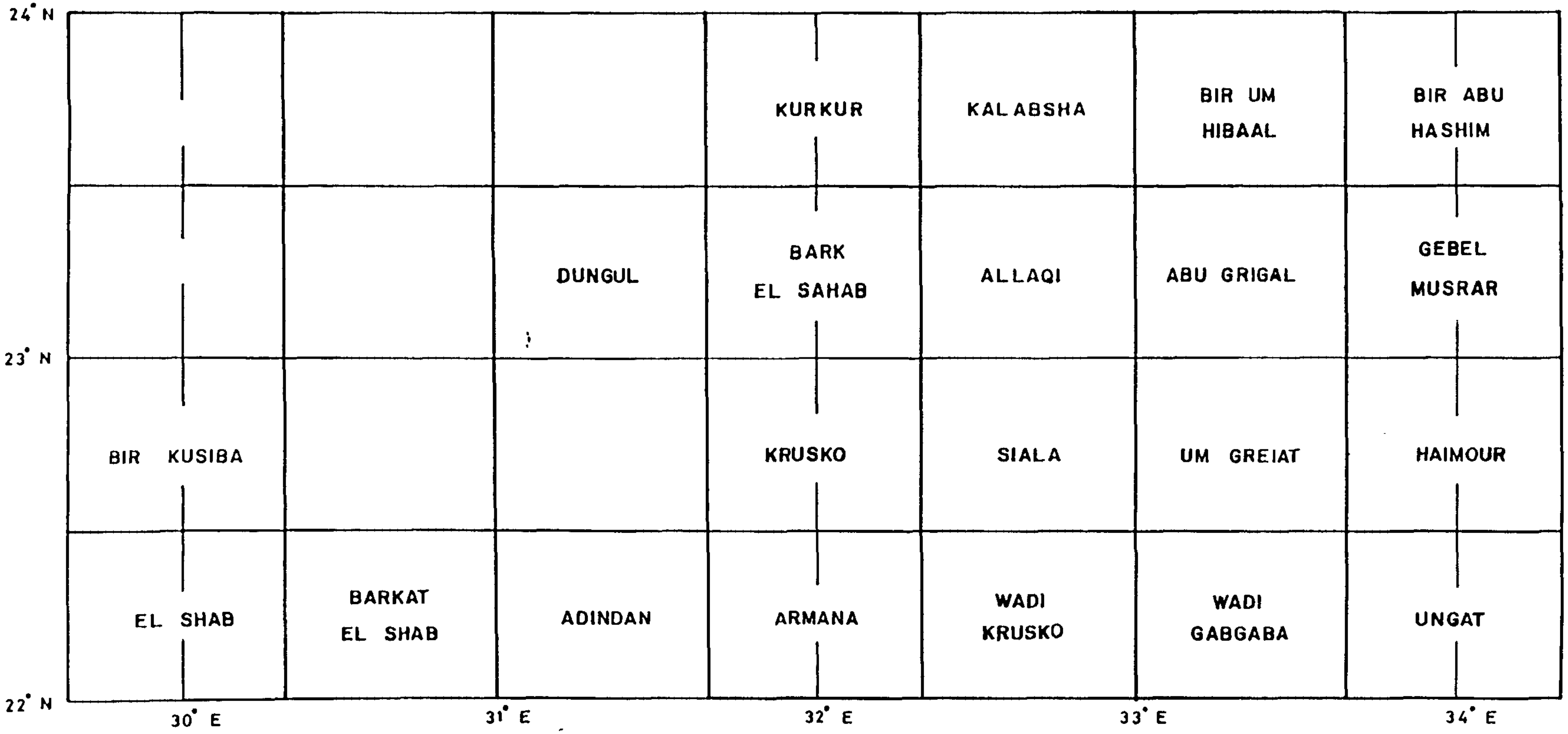


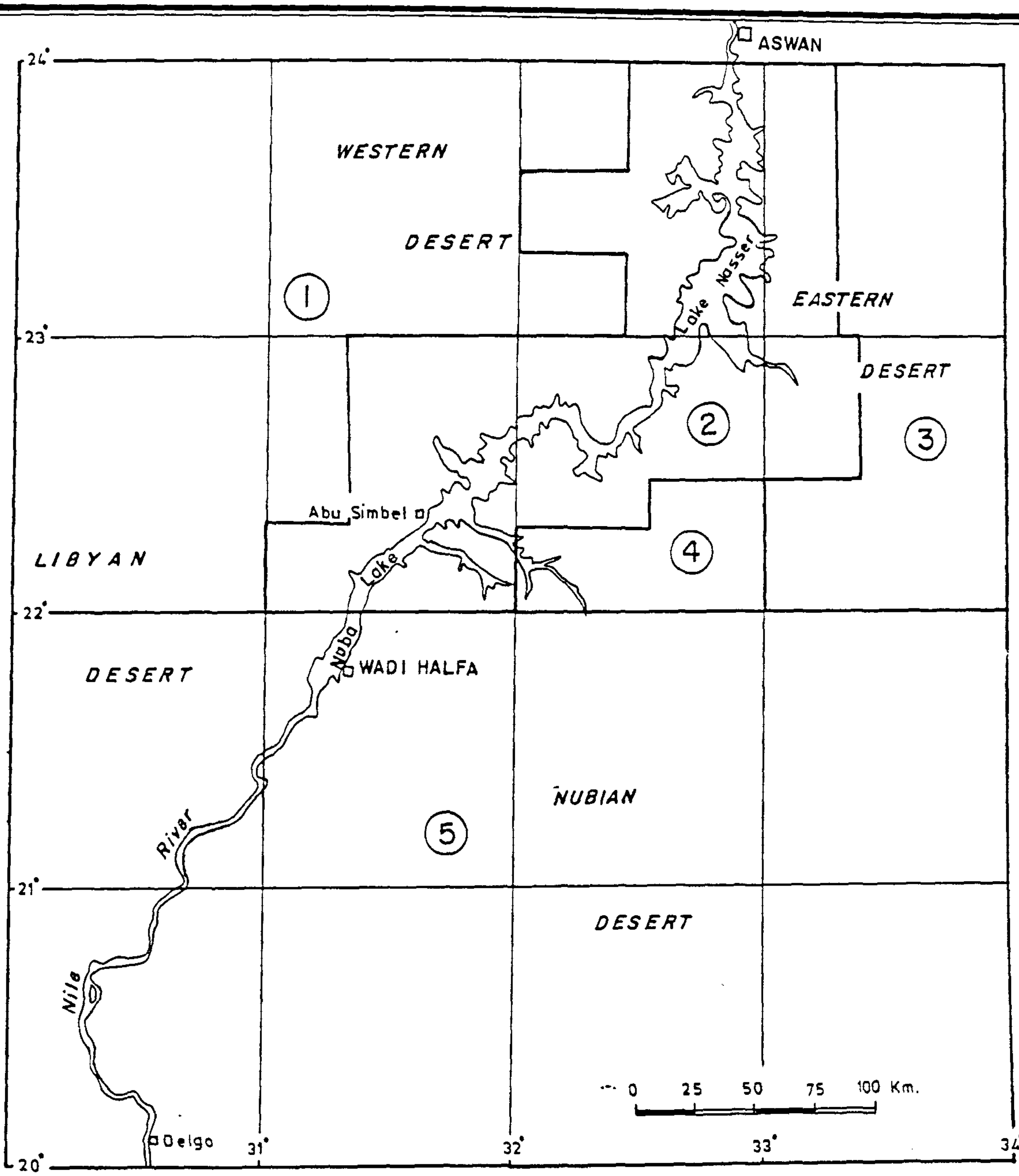
Fig. 10. Index to 1:100,000 scale topographic maps, 1943-44 coverage, Egyptian Sector.

Aerial Photographs and Mosaics

Figure 11 is an index to the existing aerial photographic and mosaic coverage of the Area of Integration, all of which is in black and white. The photos and mosaics of the eastern part of the Egyptian Sector were used in that sector's field work.

The Sudan Survey Department holds one set of the old Trimetrogon aerial photo coverage of northern Sudan totalling 3,627 vertical and oblique prints, but it has no negatives. These photos are unavailable except for office use in Khartoum. The lack of contiguous vertical coverage, except in alternate flight lines, makes this aerial photography unsuitable for systematic photogeologic interpretation but useful for reconnaissance work.

An order was placed with the U.S. Defense Intelligence Agency for the entire Trimetrogon coverage. The United Nations obtained 1,884 unclassified 9"x9" prints covering that portion for which negatives could be found. Unfortunately, as the shipment of those photos from New York to Cairo was lost, they were not available when needed for field use in early 1985.



①	1 : 50,000 scale aerial photos) 1 : 100,000 scale aerial mosaics)	1960
②	1 : 40,000 scale aerial photos) 1 : 50,000 scale aerial mosaics)	1973
③	1 : 40,000 scale aerial photos) 1 : 50,000 scale aerial mosaics)	1955
④	No coverage	
⑤	Trimetrogon photography) AMS Project 1048 AF42-43800)	1940's

Fig. 11. Aerial photograph and mosaic coverage.

Satellite Imagery Coverage

The Area of Integration is covered by the satellite imagery described below, which was purchased from Geosurvey International by the United Nations in mid-1984 for GMC use. Figures 12 and 13 are index maps of this imagery.

- Landsat 1 Multispectral Scanner (MSS) imagery, 14 false colour composites (FCC) using MSS bands 4,5,7
  Scale: 1:250,000
  Dates of imagery: September-December 1972
  Average path direction: N13°30'E
- Landsat 3 Return-Beam Vidicon (RBV) imagery, 37 images
  Scale: 1:250,000
  Dates of imagery: September-December 1980
  Average path direction: N10°E
- Shuttle Imaging Radar-A (SIR-A), two nearly parallel swaths approximately 53 km wide and 360 km apart
  Scale: 1:250,000
  Date of imagery: November 1981
  Swaths: Data Take 28 - across the Egyptian Sector, path direction = N56°E
  Data Take 7 - across the Sudanese Sector, path direction = N54°E

The imagery has proved invaluable in field and office use and will have continued utility in the future.

The MSS, RBV and SIR-A imagery tend to complement one another. Whereas the MSS imagery provides better tonal/colour discrimination and better image unit definition, the RBV and SIR-A give better ground resolution and provide greater detail on linear-curvilinear structures.

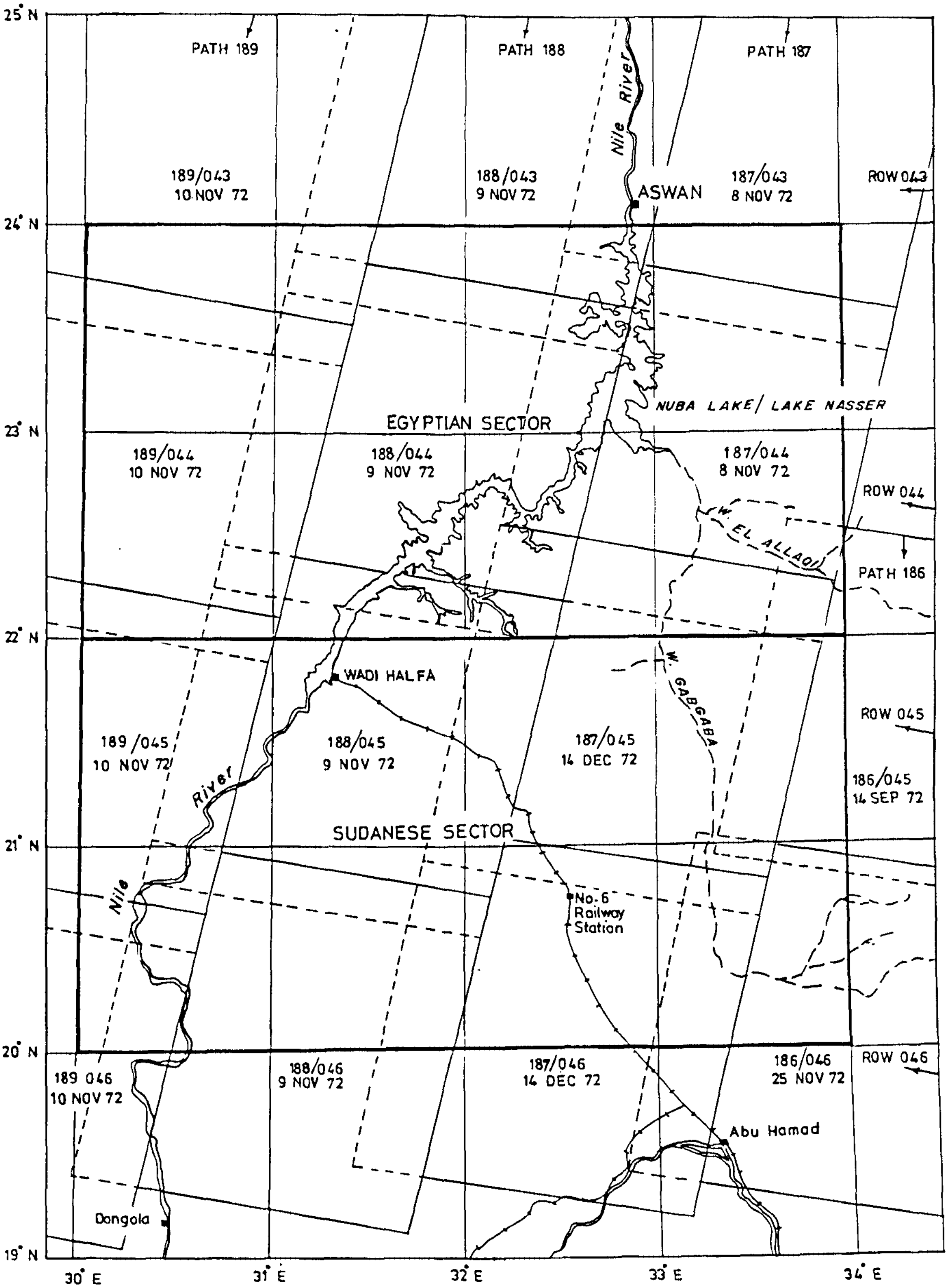


Fig. 12. MSS satellite imagery coverage.

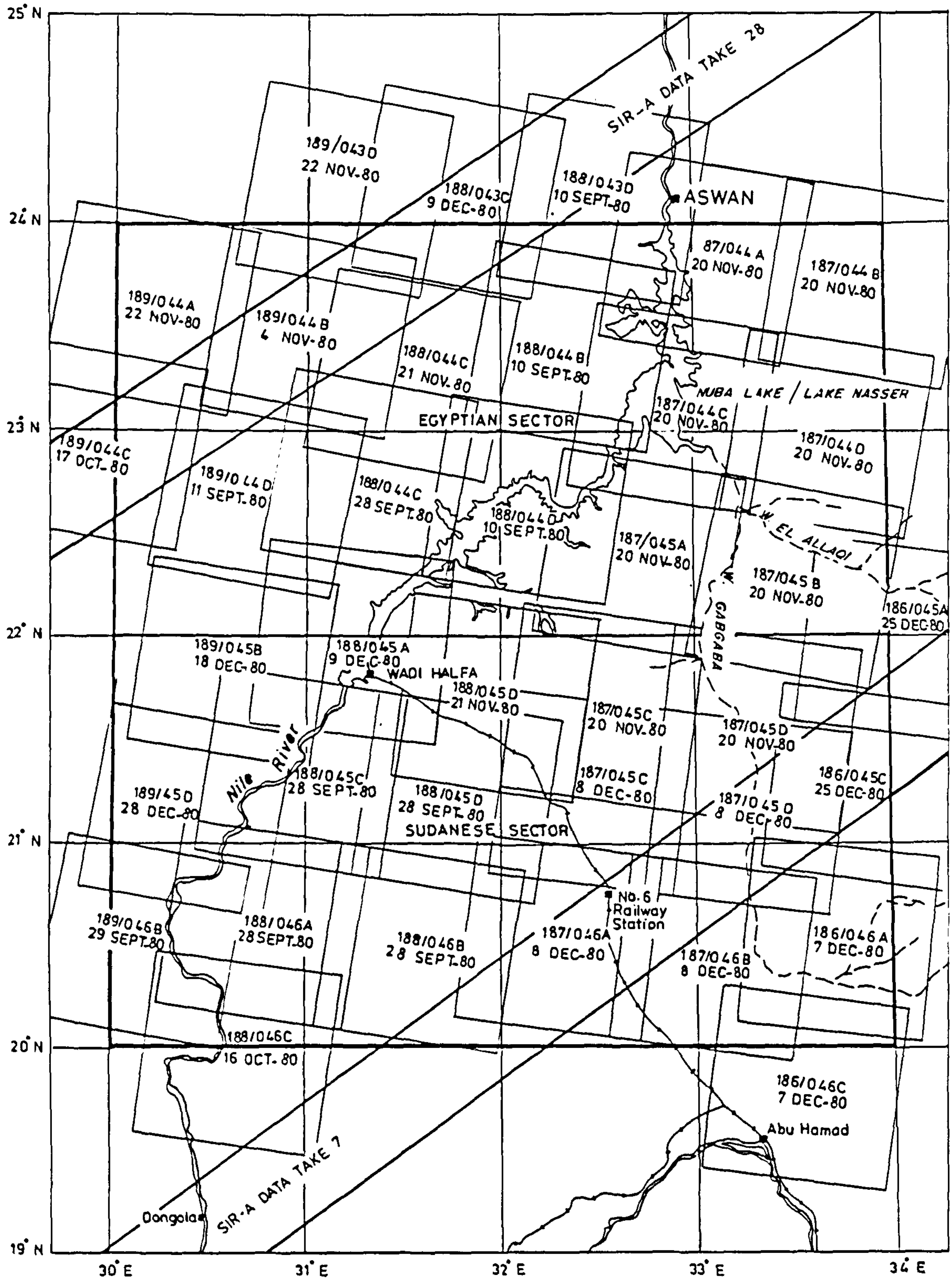


Fig. 13. RBV and SIR–A satellite imagery coverage.

EXPLORATION AND MINING HISTORY

Copper

The first metal to be discovered and exploited in Nubia was copper (Adams, 1977). There is evidence that the oldest known Egyptian settlement south of Aswan was a copper smelting centre at Buhen, on the west bank of the Nile about 12.5 km from the present site of Wadi Halfa (see Figure 14). Buhen was established during the Old Kingdom, perhaps as early as the Second Dynasty, and probably reached its copper production zenith in the Fourth and Fifth Dynasties (see Table 4). It was a sizeable town, containing three copper smelting furnaces. The source of the ore remains undetermined but most likely was Precambrian Basement Complex rocks southwest of Buhen. The copper ore was probably selectively mined from various mine sites and transported to Buhen, where wood for smelting must have been plentiful from local or upstream sources. The Adila and Um Faham prospects upstream on the east side of the Nile, and the Maro Hill prospect (location unknown) were possible copper sources. After a couple of centuries, the smelting operation ended, owing to the depletion of the ore and/or of the wood supply, or to the appearance of a more available source elsewhere.

One such source was Abu Swayel, a copper-nickel prospect in southern Egypt north of Wadi El Allaqi, where mining commenced in the Twelfth Dynasty. Furnaces and small slag heaps at the mine site indicate that limited smelting was done there. These are reminiscent of the furnaces and slag heaps so prevalent in the ancient copper mining areas of northern Oman. A shortage of wood for smelting may have forced haulage of selected ore to Quban, the ancient fortress control point for mining operations in the desert hinterland, situated at the mouth of Wadi El Allaqi. A large heap of slag found at Quban is believed to have come from ore mined at Abu Swayel. For obscure reasons, mining operations terminated at Abu Swayel, with a supply of extractable copper ore left at the prospect.

At one time or another, probably all the copper occurrences or deposits were exploited as "colour" (pigment) mines for the blue and green colours of the azurite-malachite mineralization used by the ancients in cosmetics, dyes and paints.

Brass and Bronze

Artifacts of brass and bronze found in Nubia attest to the use of these alloys by the ancients, but they were most likely not produced locally. Being harder and more resistant than copper tools, brass and bronze implements were probably in great demand prior to the use of iron, particularly in stone quarrying and shaping. For a period at least, in Nubia, there was a source of copper used in both alloys, but there is no evidence of a source of zinc used in brass or of tin (and sometimes lead) used in making bronze. Although some small, ancient zinc and lead prospects are known in the Red Sea Hills to the northeast, it is concluded that, for most of their history, the brass and bronze used by Nubia and most likely the rest of Egypt came from abroad.

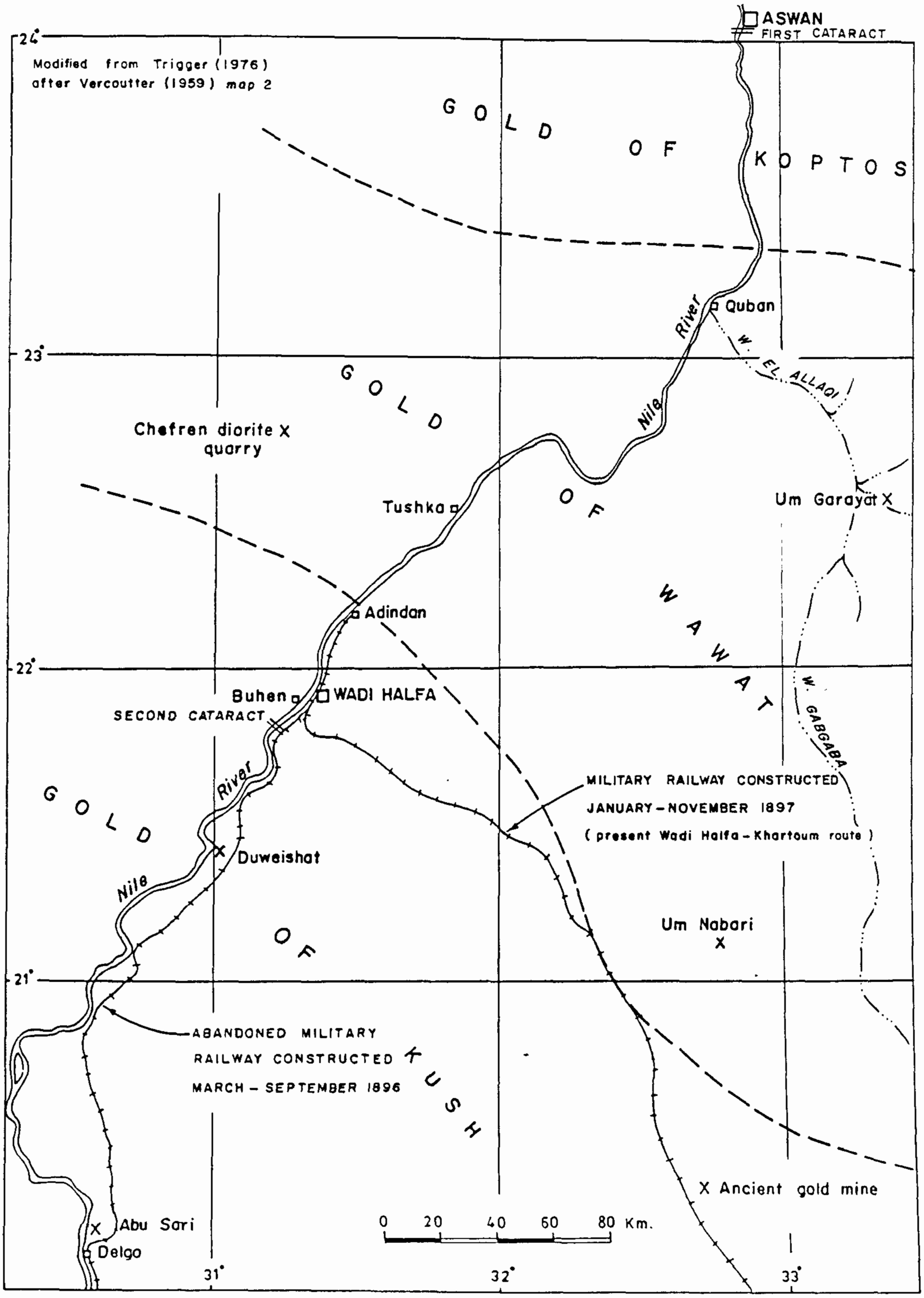


Fig. 14. Ancient gold areas and pharaonic to pre-Nubia Lake / Lake Nasser sites in Nubia. (All gold occurrences are shown on Plate II).

Table 4
Ancient Egyptian Chronology

Period	Dynasty	Approximate years B.C.
	I	3100 - 2890
	II	2890 - 2686
OLD	III	2686 - 2613
KINGDOM	IV	2613 - 2494
	V	2494 - 2345
	VI	2345 - 2181
1st Intermediate Period		2181 - 2050
MIDDLE	XI	2133 - 1991
KINGDOM	XII	1991 - 1786
2nd Intermediate Period		1786 - 1567
NEW	XVII	1567 - 1320
KINGDOM	XIV	1320 - 1200
	XX	1200 - 1085
3rd Intermediate Period		1085 - 747
	XXV	747 - 656
	XXVI	664 - 525
LATE	1st Persian Occupation	525 - 404
	XXX	380 - 343
PERIOD	2nd Persian Occupation	345 - 332
	Alexander the Great Conquest	332 - 304
	Ptolemaic	323 - 30
	Roman	30 B.C.-691 A.D.

Reference: Blue Guide Egypt, 1983: New York & London, E. Benn & W.W. Norton Co., p. 28 - 32.

Building and Ornamental Stone

Diorite. Quarrying activities for diorite at the Chefren (Chephren), or Tushka, quarries in the desert west of Lower Nubia were contemporaneous with the copper industry at Buhen. From Tushka, some 32 km downstream from Abu Simbel, an ancient track led to the quarries about 72 km to the northwest (see Figure 14). Trigger (1976) describes the site as a "desolate, cairnmarked patch of desert euphemistically called the 'Snaring Place of King Khufu'."

This black to grey crystalline rock was the favoured material for statues of Chefren in his mortuary temple and probably also for the paving blocks in the mortuary temple of Cheops.

Quarrying is recorded during the Fourth and Fifth Dynasties of the Old Kingdom and during the Middle Kingdom. Given the intermittent nature of the demand for diorite, it is probable that quarrying activity was carried on only occasionally and for relatively short periods by expeditions especially designated for the purpose.

Due to its hardness, diorite was sought for mortar and pestle stones used to grind and pulverize quartz to extract free gold. There were probably other domestic and industrial uses for the stone as an implement.

Granite. The First Cataract is formed by an extensive exposure of naked granite that gives the landscape immediately south of Aswan a harsh, forbidding aspect. This is the famous Aswan granite, occurring both within and north of the Area of Integration, which has been a source of ornamental and building stone from ancient times to the present.

The ancient quarry sites for this distinctive pink and black granite abound in the immediate vicinity of Aswan: along the Nile, on the cataract islands, and at locations away from the Nile. The precision of the ancient quarrying marks suggests the use of pointed metal chisels (bronze or iron?) impelled by some sort of hammer. The granite was highly prized for monolithic constructions, such as obelisks, columns, sarcophagi and stelae, and it was transported as far as Baalbek in Lebanon (Showker, 1983).

Gold. There is abundant evidence that the mountains and drainages between the Nile River and the Red Sea were intensively searched and worked for gold by ancient people. Traces of this activity are extensive and show that the region was thoroughly combed for the metal in the remote past. Nearly every outcrop of the region's innumerable quartz veins and ridges and associated alluvial material were prospected. Most mine sites contain ancient habitations and some are strewn with disused stone grinding mills for pulverizing the vein quartz. Dunn (1911) writes: "The ancients have everywhere panned the gravels resulting from these quartz outcrops, and the thousands of little pits they dug still leave their mark on the hillsides in spite of subsequent weathering." Numerous prospects were discovered and developed, and a widespread and systematic mining industry evolved, resulting in the production of large volumes of gold from the alluvial and vein sources.

Adams (op. cit.) shows that during the Old Kingdom "age of exploration" extensive prospecting was carried out by well-organized and regimented groups of Egyptian prospectors who ranged freely and unmolested over large areas of Nubia, including the Wadi El Allaqi area between Lower Nubia and the Red Sea. Although initial discoveries of copper and diorite ornamental stone might be credited to this effort, the prime objective of this prospecting must have been gold, and it is logical to assume that some of the Wadi El Allaqi gold prospects, such as Um Garayat, were discovered as a result of this activity. Nonetheless, there is no evidence that gold was mined there or elsewhere in Lower Nubia during the Old Kingdom, when most of the gold used by ancient Egypt came from the Eastern Desert adjacent to Upper Egypt. Gold production was developed in Upper Egypt by 3500 B.C.

Hume (1937) documents the purity of gold in First Dynasty jewelry in comparison with increasing silver and copper content in succeeding dynasties. This would suggest that early production came from more easily exploited alluvial and surficial vein sources with high gold purity and that later production came increasingly from more complex underground vein and contact mineralization.

There was some production of Nubian gold in the Middle Kingdom, but development was principally under the New Kingdom. The "Gold of Wawat" (probably Lower Nubia) and "Gold of Kush" (Upper Nubia) (see Figure 14) figure repeatedly in the annals of the New Kingdom. Trigger (op. cit.) quotes an Egyptian legal oath of the time: "If I lie, may my nose and ears be cut off and I be sent to Kush."

According to Dunn (1911), the ancients mined to depths of 40-50 m, preferring the smaller (30-90 cm) auriferous quartz veins because of the ease in breaking the rock, and also the adjacent soft, more easily worked alteration zones. Thicker veins were rarely taken away in their entirety but followed along one or both wall zones.

The most numerous and productive mines were those along Wadi El Allaqi and its tributaries, called the region of Akita in Nineteenth Dynasty inscriptions (Trigger, op. cit.). Trigger also informs that most of the gold from that region was smelted at and shipped from the ancient fortress of Quban, situated at the mouth of Wadi El Allaqi. Through the centuries, gold production varied according to the status of government and the exigencies of the ruling kings.

The Um Garayat and Um Nabari gold mines on the Wadi El Allaqi-Wadi Gabgaba drainage in Lower Nubia-Akita (see Figure 14) probably saw development and became major centres of gold production in the New Kingdom, but most likely had been discovered earlier. Concurrently, the Egyptians commenced extracting gold in areas bordering the Nile upstream from the Second Cataract. This included the Duweishat and Abu Sari mines. The proximity to the Nile accounted for the extensive working of low-grade deposits near the river.

Trigger (op. cit.) states that, soon after the end of the Twentieth Dynasty, written records as well as archaeological data concerning Lower Nubia fail completely, and it must be assumed that the region once again lacked a settled population. Final abandonment is probably correlated with a sharp decline in Nubian gold production in the course of the late Nineteenth and Twentieth Dynasties.

Adams (op. cit.) notes that, by the time of Ptolemy VI (181-145 B.C.), the desert gold mines had been reactivated. Gold exploitation continued under Roman occupation, which commenced in 40 B.C, but by the end of the third century A.D., the desert nomads were in possession of the mines. All further record ceased until medieval Arab occupancy in the ninth and tenth centuries A.D. It is known that Um Garayat was worked during the reign of Ibn Tulun (early Islamic period), but there was no apparent organized prospecting or mining until the present era.

Pottery fragments found in 1985 at a large habitation site near a copper-gold prospect in the Wadi Naba area (Plate I, Target Area 4) were ascertained to date from the twelfth or thirteenth century A.D. and are the product of a colonial pottery industry centered in Aswan.

The door to the forbidding remoteness and forgotten gold mines of Nubia was opened through the Anglo-Egyptian Nile Expedition of 1884-1885 and by Kitchener's campaign of reconquest of Sudan in 1896-1898. A railway to gain military access to Khartoum via a Nile route was thrust south from Wadi Halfa as far as Kerma (about 317 km) but abandoned due to insurmountable problems. Nonetheless it and the final trans-desert route that cuts diagonally across the Area of Integration to Abu Hamad and on to Khartoum facilitated access to the lonely gold mining areas of centuries past and opened up new frontiers for the search for gold. With the establishment of the Anglo-Egyptian condominium government in 1899, British gold mining syndicates, already with experience in the Australian and Witwatersrand gold fields, had the way cleared to venture for gold in Sudan. British and Egyptian financial interests and promoters were attracted to Sudan and the search for a possible El Dorado, and during the years that followed, many prospectors and mining interests were drawn to the region.

Whiteman (1971) lists four exploration/mining concessions that covered a part of the Area of Integration during the 1901-1907 period. The names of the concessions and their locations are shown in Figure 15. In 1903, prospector Llewellyn studied the gold-bearing country east of the Wadi Halfa-Khartoum railway between 20°00'N and 22°00'N and as far as 34°30'E. In the same period, the ancient mines at Um Nabari, Duweishat and Abu Sari (Figure 15) were prospected and worked. But according to Dunn (op. cit.), only one company, Sudan Gold Field Company Limited (SGF) -- which had access to the Um Nabari mine area and 23 other ancient workings within the Area of Integration -- retained its concession after 1907. Dunn visited Um Nabari in 1907, and at the time of his report (Dunn, 1911), he pointed out that Um Nabari was the only mine in Sudan where gold was produced at that time by mining and crushing gold-bearing quartz.

There is a paucity of records after Dunn's report cited above. SGF continued mining at Um Nabari until December 1919, when operations ceased apparently for economic reasons. The mining lease was surrendered in June 1925.

Work at Um Garayat was initiated by the Nile Valley Company in about 1901. After the erection of a heavy stamp mill in 1904, gold was produced through 1908. Records are nebulous, but the mine appears to have been worked until World War I, then again as late as 1950. The adjoining Nile Valley Block E was reportedly worked before World War I.

There are reports of mining activity, apparently by British interests, at Um Nabari in the 1940s, stopping in 1945, and at Duweishat in the 1950s, stopping perhaps as late as 1962.

Silver. The silver used in ancient Egypt was a refinement product of gold and at one time exceeded gold in value. No other source or ore of silver was apparently used. The silver/gold ratio was variable, but as an example, the ratio at the Um Garayat gold mine was 1:6.5 (Hume, 1937). In comparison, the ratio at the Homestake gold deposit in South Dakota is 1:4.9.

Iron. In ancient times, any hard, dense, metalliferous rock was probably the object of repeated investigation in an attempt to shape it, to extract or concentrate the contained metal, or to otherwise use it for domestic or industrial implements. This would be the case with the ferruginous sandstone and low-grade oolitic iron deposits found near Aswan and Wadi Halfa. But there are no slag heaps or other evidence of iron smelting in Lower Nubia. It is assumed that the first refined iron to reach Nubia came from the famous iron furnaces at Meroe, located some 350 km south of the Area of Integration about 87 km upstream from Atbara, where there was apparently a combination of more viable iron deposits and a good source of fuel for the smelting process.

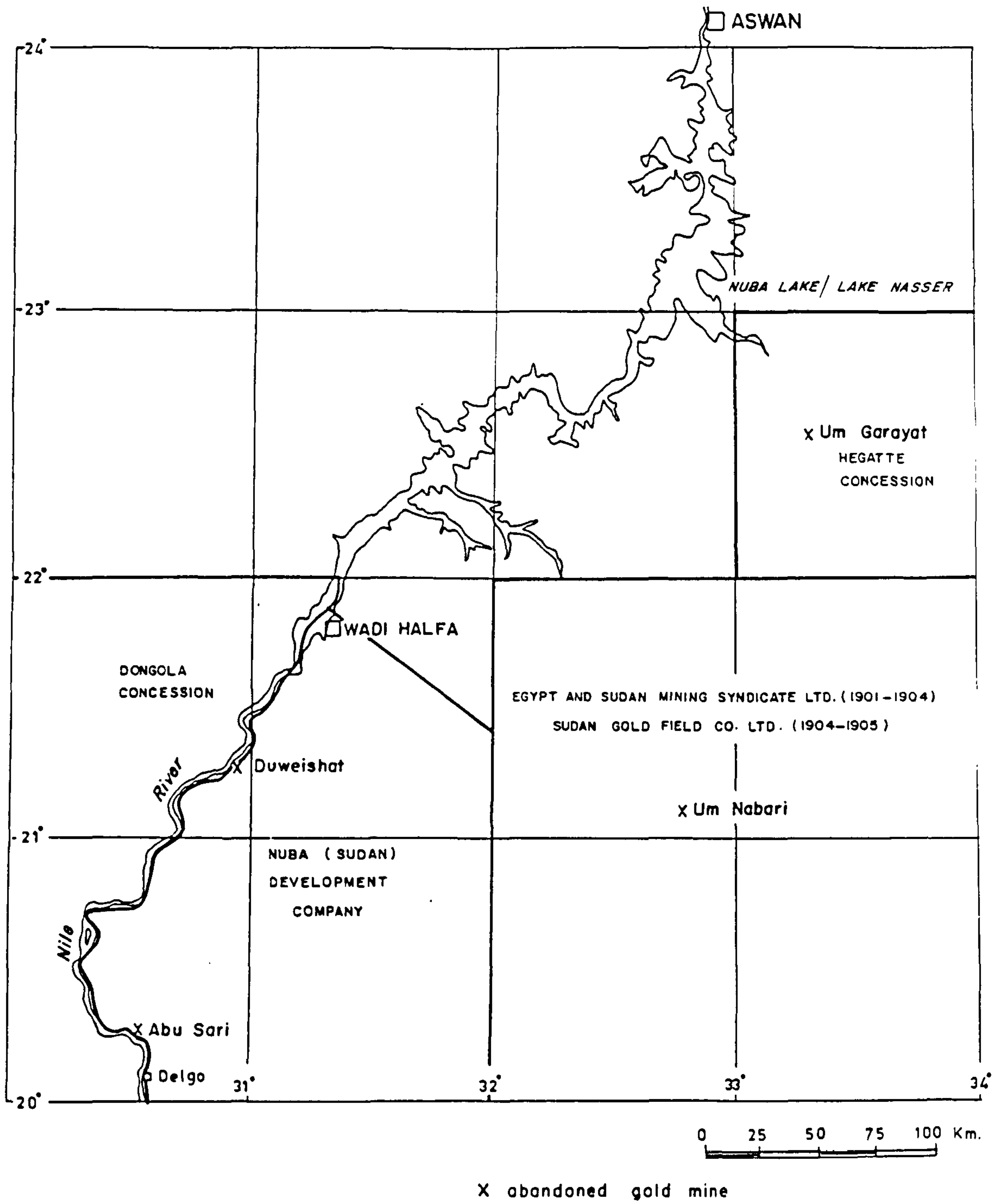


Fig. 15. Exploration and mining concessions held in the early 1900's.

Precious and Semi-Precious Stones

Emerald. Archaeological accounts make reference to emerald mines in the Nubian Desert, but the locations are unspecified even in a general sense. Two sources can be postulated: 1) pegmatite veins or bodies associated with intrusive rocks; or 2) limestones or calcareous sediments/metasediments, as in Muso, Colombia and northern Zambia.

Amethyst. Two ancient sources of this regal purple mineral are known in the Area of Integration. One is in the El Hudi area 45 km east of Aswan, in a locality also containing baryte and auriferous quartz. The other is in the same locality as the Chefren diorite quarry, west of the Nile (see Figure 14).

PREVIOUS TECHNICAL INVESTIGATIONS

Geological Work

Initially, geological work in the Area of Integration was mostly limited to the Nile Valley and its immediate adjacencies, and to those areas accessible via established overland trade routes. The cataracts of the Nile were first to draw the attention of early geologists. Ball (1907) described the First, or Aswan, Cataract, and Hume (no date) described both it and the Second Cataract near Wadi Halfa. Later, Hume (1934, 1935, 1937) traversed the Nile Valley and described the Precambrian rocks and the suprajacent Nubia sediments (refer to brief summaries in Whiteman, 1971).

Sandford (1935) made a traverse of the Libyan Desert to Wadi Halfa and described the Nubia Formation. Little and Attra (1943) investigated the Aswan district. Later, El Shazly (1954) wrote about the rocks of the Aswan area, Gindy (1954) described their plutonic history, and Higazy and Wasfy (1956) investigated their petrogenesis.

With the increasing availability of reliable topographic maps, aerial photography and four-wheel drive vehicles, and improved logistics and accessibility, geologists in the Egyptian Sector progressively ventured and mapped in hinterland areas of the Eastern and Western Deserts. But the extreme remoteness and inaccessibility of the region in Sudan limited activity to the areas bordering the Nile Valley and the Wadi Halfa-Khartoum railway.

The geology of the Abu Swayel copper-nickel prospect area was described by Bassyuni (1960, 1973).

In 1961, Whiteman (op. cit.) visited and described the Second Cataract.

In the late 1960s, mapping and stratigraphic/paleontologic studies of the sedimentary rocks of the Western Desert were initiated by Egyptian geologists, with the principal work by Issawi (1969, 1971, 1973a, 1973b, 1978, 1982), and Shawa and Issawi (1978). Klitzsch, et al. (1979) did similar work in southwestern Egypt.

Maley (1970) described the geology of the Second Cataract (since then covered by Nuba Lake), and his work constitutes the only detailed geologic mapping within the Sudanese Sector. All available geological information on the Sudanese Sector was summarized by Whiteman (op. cit.).

Ivanov and Hussein (1972) reported on geological operations carried out from July 1968 to June 1972, in part in the Wadi El Allaqi area, as part of the assessment of the mineral potential of the Aswan region. In 1973, these authors, together with I.M. Shalaby, reported on the metallogenic characteristics of the Southeastern Desert of Egypt.

Vail (1972, 1974, 1976, 1979) utilized aerial photographs and satellite imagery in interpretations of tectonic trends and distribution of the Nubia Formation, as well as in general geological interpretation of northeastern Sudan. Concurrently, Khalil (1972, 1974) described tectonic trends and Basement subdivisions in northeastern Sudan.

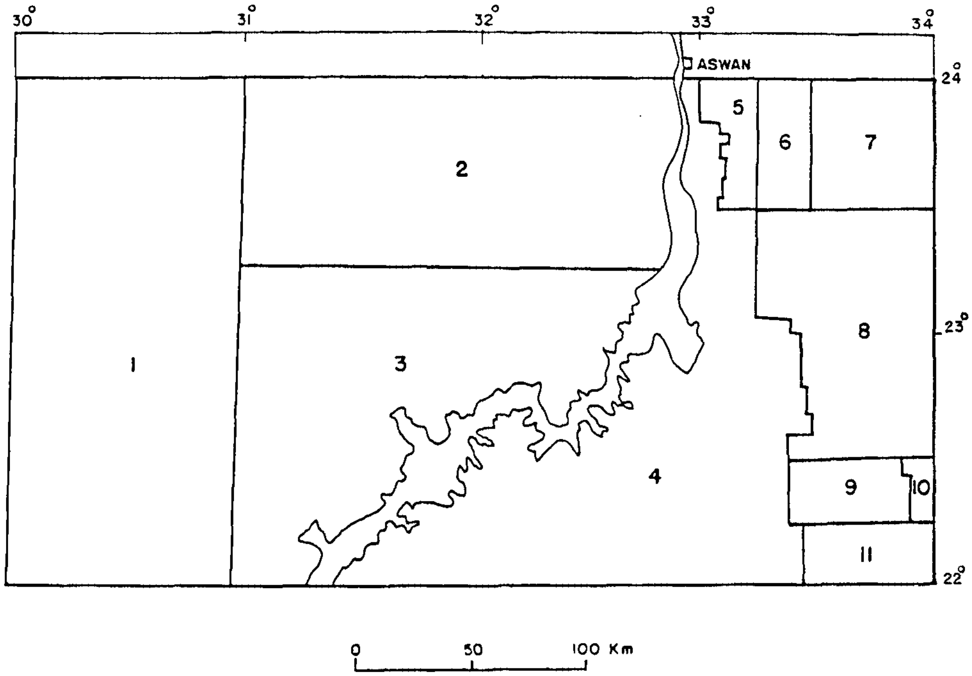
In the 1970s, Egyptian geologists initiated the mapping of the Precambrian in the Eastern Desert. El Ramly, et al. (1970, 1979, 1980) described the alkaline rocks, two ring complexes and Um Shilman granitic rocks in southeastern Egypt. Hashad (1973) wrote on the geochronology of the Abu Swayel area. Unpublished mapping and descriptive work was done by Hassan, et al. (1976), Rashwan, et al. (1976), Armanious, et al. (1977), Rashwan (1979), Mansour and Romany (1979), Aly, et al. (1980), and Nasser and Sadak (1981).

Figure 16 shows the distribution of previous geological mapping.

Photogeological Work

In 1966, Hunting Geology and Geophysics Ltd. of Elstree, United Kingdom was contracted by the United Nations to undertake the photogeological mapping of an approximately 75,000 sq km area situated between latitudes 22^{o} - 25^{o} N and between the Nile River and the Red Sea. The perimeter of the contract area was irregular in some sectors, being based on the availability of photo-cover. Approximately 18,500 sq km are within the Egyptian Sector of the Area of Integration (see Figure 17).

The area was mapped on one hundred and fourteen 1:100,000 scale overlays and compiled into 33 map sheets. Field work commenced in September 1966 and terminated in March 1967. The resultant 138-page report (Hunting, 1967) is on file at EGSMA and GMC.



Mapping References

1. Issawi (1971)
2. Issawi (1969)
3. Issawi (1978)
4. EGSMA (1981)
5. Hassan et al (1976)
6. Rashwan et al (1976)
7. Rashwan et al (1977)
8. Armanious et al (1977)
9. Mansour and Ramany (1979)
10. Nasser and Sadak (1981)
11. Abd El Gafar et al (1980)

Fig. 16. Previous geological mapping.

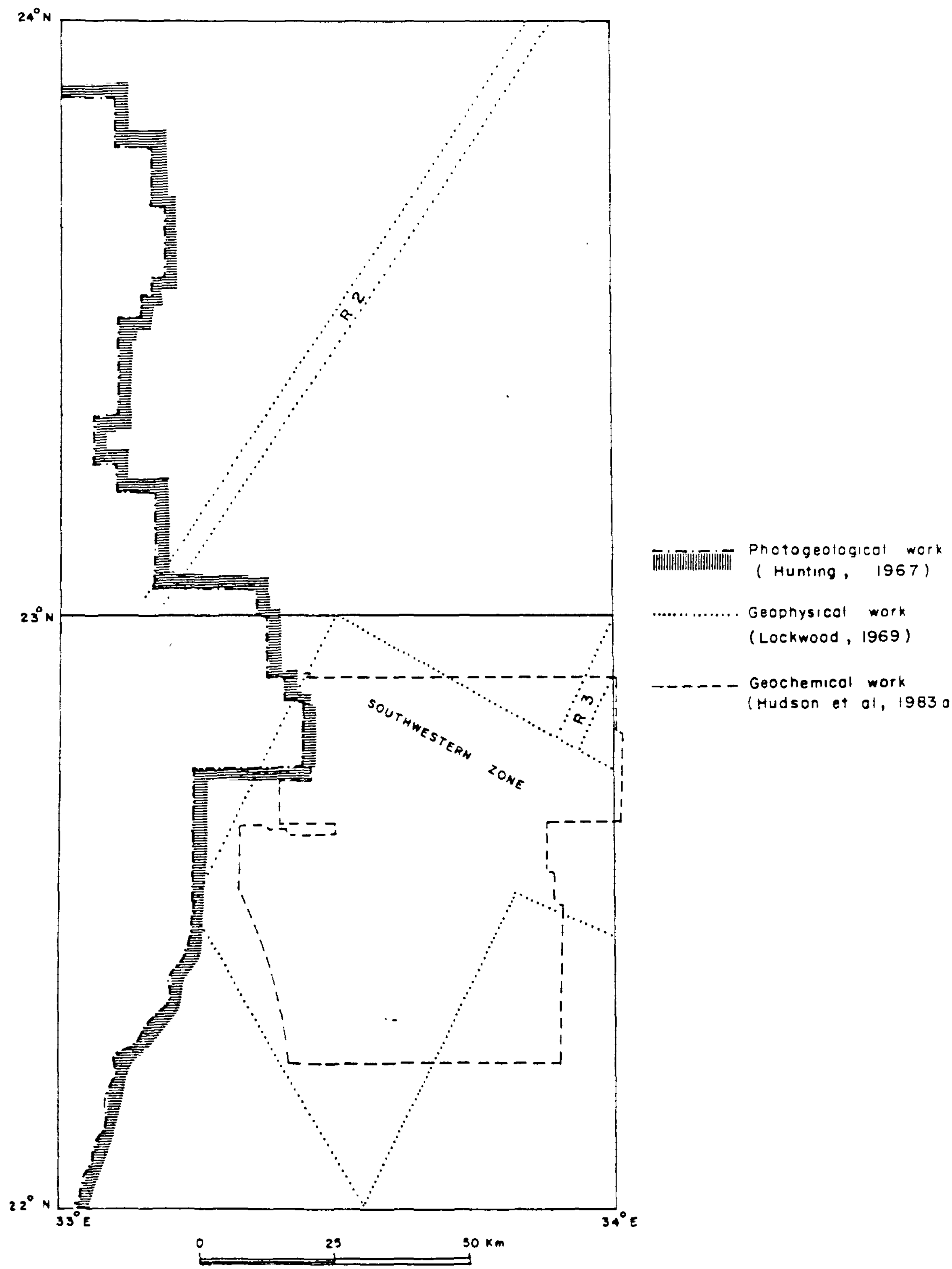


Fig. 17. Previous photogeological, geophysical and geochemical work.

Geophysical Work

In January-March 1968, the Wadi El Allaqi area in the Egyptian Sector was one of two areas in Egypt covered by a low-altitude airborne geophysical survey conducted by Lockwood Survey Corporation Limited of Toronto, Canada under contract to the United Nations. Known as the Southwestern Zone in that project, the area was selected on the basis of photogeology and other compilation data. It is shown in Figure 17. No geophysical work has been conducted in the Sudanese Sector.

The survey covered 5,000 sq km, and combined aerial electromagnetic, magnetometric and scintillometric surveys were undertaken. Survey lines had a N 25° E bearing, a spacing of 0.5 km, and a terrain clearance of 130 m with a tolerance of $\pm$ 20 m. Ten thousand line kilometres were flown.

Some ground follow-up was carried out in 1968-1972, using the ground VLF EM method. Reports giving the results of this contracted survey work are by Lockwood Survey Corporation Limited (1969), Krs (1973), Krs, et al. (1973), and the United Nations (1973).

The area surveyed included the Abu Swayel copper-nickel prospect and the Wadi Haimur copper occurrence, both situated north of Wadi El Allaqi. Geophysical anomalies indicating electrically conductive bodies of larger dimensions were not detected, nor were any revealed by the airborne dual-frequency electromagnetic method.

The UNDTCD geophysical technical adviser informs that the negative outcome of the United Nations survey should not be taken as conclusive, since neither the ground VLF EM method nor the Lockwood dual-frequency airborne EM system used at the time is considered now to be an optimum search tool for small, massive sulphide bodies. Accordingly, there is justification for new airborne and ground surveys using more appropriate geo-electric tools.

Geochemical Work

In 1982-1983, the Institute of Geological Sciences of Nottingham, England, in cooperation with the Egyptian Geological Survey and Mining Authority, conducted geochemical surveys of the Wadi El Allaqi-Wadi Haimur area and other selected areas as part of an exploration programme directed toward the discovery of economic mineral deposits. Reports on the survey work are by Bean (1983), Hudson, et al. (1983a), and Hudson, et al. (1983b).

Wadi El Allaqi-Wadi Haimur Area

The outline of this reconnaissance sampling area is shown in Figure 17. It is irregular but contained within coordinates 22°15' - 22°53'N latitude and 33°21' - 34°01'E longitude. Sample density was 1 sq km and limited to fairly narrow wadis; extremely large wadis were not sampled.

Sieved samples were analysed by optical emission spectrometry for lead, tin, niobium, molybdenum, copper, zinc, nickel, cobalt and chromium. The results were: good copper information, reasonably good nickel data, insignificant chromium results, some scattered cobalt results, and only a few isolated results on the other five elements. The nickel and chromium relate to ultrabasic/

serpentinite complexes in the northern part of the sampled area.

Two adjacent areas north of Wadi El Allaqi and a few kilometres southeast of Um Garayat carry the highest copper values recorded in the entire sampled area and are referred to collectively as the Wadi El Allaqi cupriferous zone, which is contained within the North Wadi El Allaqi mineral target area (Figure 29). High copper values are present in several drainage systems, and copper was found in rock samples at four localities.

Ring Complexes - Western Desert

Garra El Soda at 23°22'N, 31°19'E and Garra El Hamra at 23°24'N, 31°23'E are undated syenite ring complexes in the Western Desert that were geochemically surveyed by the Institute of Geological Sciences group. They contain anomalous but economically insignificant rare earth oxide values; the most abundant are lanthanum, cerium and yttrium. The two syenite bodies contain almost equal quantities of rare earths, whereas dyke rocks in each contain enhanced values. No other element of economic potential was found in these complexes.

Mineral Evaluation

Dunn (1911 and 1917) reported on some ancient gold and copper mines and occurrences south of Wadi Halfa and in the hinterland to the southeast. Ancient gold mines of Kush (Nubia) are described by Vercoutter (1959). Gold prospects relating to activities by concessionaires in the Sudanese Sector in the early 1900s are listed by Whiteman (1971).

Hume (1909) and Mansour (1956) investigated the ferruginous sandstones of the Nubia Formation between Aswan and Wadi Halfa.

The Abu Swayel copper-nickel prospect is described by Demag (1963), El Shazly, et al. (1965), El Shazly (1969) and Anderson (1985).[1/]

Sabet (1978) reported briefly on the Aswan clay deposits, the Wadi Kalabsha kaolin deposits, 12 gold occurrences, and the Abu Swayel copper-nickel prospect, all within the Egyptian Sector. Afia and Imam (1979) prepared mineral maps and explanatory lists showing and describing the metallic and non-metallic mineral deposits and occurrences of Egypt. They show 24 metallic and 21 non-metallic deposits/occurrences within the Egyptian Sector.

Fatthy (1979) reported on the mineral resources of the Egypt-Sudan Integration Area.

The kaolin deposits in the area surrounding Kalabsha, near Aswan, are described by Bean, et al. (1983). Sabet, et al. (1983) report on the Um Garayat gold prospect and associated geochemical work. The Um Nabari gold prospect is described by Dunn (1917) and by Savard (1985).[1/]

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[1]Report is a result of field work during the current project phase and is listed in References.

Satellite Imagery Interpretation

Egyptian Sector

El Shazly, et al. (1974) made 1:1,000,000 scale general drainage, structural lineation and geological interpretations of ERTS-1 satellite imagery of the Tushka Basin area (22^{o} - 24^{o} N, 29^{o} 30'-33^{o} E) west of Aswan. That area is underlain mainly by Nubia Formation sedimentary rocks.

Egypt is covered by seventy-eight 1:250,000 scale sheets based on the UTM system. Geological interpretations of the satellite imagery have been done in the south Sinai area, the Nile Delta area between Cairo and the Mediterranean Sea, and a large stretch of the Red Sea coastal/Red Sea Hills region. As yet, no image interpretation work has been done in the Egyptian Sector at 1:250,000 scale.

Sudanese Sector

Ahmed (1983) made a Landsat MSS study of northeastern Sudan, using a 1:1,000,000 scale mosaic of bulk-processed band 7 images. Apart from indicating broad structural lineaments in the Sudanese Sector, this work offers no new insight into the litho-stratigraphic and structural relationships of units of the Precambrian Basement Complex.

The reporting of contract satellite imagery interpretation work conducted by Geosurvey International Ltd. during the Preparatory Assistance Phase of this project appears in the following section.

PREPARATORY ASSISTANCE PHASE ACTIVITIES

Contract Satellite Imagery Interpretation Work

Introduction

In 1983, Geosurvey International Ltd. of Surrey, England was contracted by the United Nations to make a detailed image-geological interpretation of satellite imagery covering the Sudanese Sector, supported by an adequate field check. The ultimate objective was to assess the mineral potential of the Sudanese Sector and to recommend areas justifying further work directed toward the discovery of mineral occurrences of potential economic significance. This contract constituted the first systematic geological investigation of that portion of the Area of Integration. The final report from Geosurvey -- submitted as a two-volume study consisting of the report text (Volume 1) and a map atlas (Volume 2) -- was received by the project in February 1985.

Office Procedure

Landsat Multispectral Scanner (MSS) imagery was obtained, selectively processed and prepared as mosaics of the entire Area of Integration at 1:1,000,000 and 1:500,000 scales and as individual whole scenes covering the Sudanese Sector at 1:250,000 scale. In addition, available coverage of the Sudanese Sector by Landsat 3 Return-Beam Vidicon (RBV) and Shuttle Imaging Radar-A (SIR-A) imagery was obtained and used in interpretation at 1:250,000 scale.

Although the above three imagery data types complement one other, Geosurvey found the MSS imagery to be the most essential; its more fundamental role is due to its adaptability and general usefulness, which follow from the digital and multi-band form of this data. In particular, the MSS/FCC (false colour composite) images contributed most to the interpretation, with the colour variation resulting from the use of the three bands serving as the best basis for interpretation of image-geological units.

For image mapping purposes, the Sudanese Sector was divided into four 1^{o} x 2^{o} quadrangles. The final interpretation results were presented as a set of 12 maps consisting of three thematic map types -- topography, geology and geologic structure -- at 1:250,000 scale.

Field Checking

After an initial period of image interpretation at the Geosurvey home office, field work involving three Geosurvey geologists, one Sudanese counterpart geologist and two field vehicles was conducted to check and amplify the main results of the initial interpretation and to observe the field relationships between mineral occurrences and the interpreted geology. Over a field period of 11 weeks, observations were made at 1,118 field stations, and 17,477 km were traversed. The initial image-geological interpretation stood up extremely well under field scrutiny, with image-geological unit boundaries, unit structures and general configurations in most part turning out as interpreted.

Principal Contributions

The principal contributions of this work include:

- The first systematic geological investigation of the Sudanese Sector, resulting in a large and detailed body of information on lithology and structural variation, supported by field observations;

- Classifications of lithological and stratigraphic variations into a number of image-geological units;

- Recognition of broadly defined regional structural association zones;

- Identification of gold target areas on the basis of interpreted structure and lithological variation;

- Precise maps that have immediate field utility and location reliability;

- Overall confidence in image-interpretation work and in the application and use of satellite imagery for field locating, navigating and mapping.

1984-1985 Office Activities

Office activities in 1984-1985 included:

- The preparation of field programmes for the Egyptian and Sudanese Sectors;
- 1:250,000 scale geologic map compilation work in the Egyptian Sector;
- General information research on the Area of Integration;
- Research on previous and current mineral concessions, map and remote sensing coverage, and exploration and mining history;
- Research on and study of previous technical investigations in the Area of Integration and adjoining regions, resulting in the compilation of 150 references;
- Final preparation of this Compilation Report and its tables, figures and plates.

1984-1985 Field Activities

Egyptian Sector (1984)

In the Egyptian Sector, field work was initiated in April 1984, when three gold prospects in the Wadi El Hudi area, 45 km east of Aswan, were investigated. Later, during a period of 45 days from 13 November to 27 December 1984, field work was carried out from a base camp situated at Wadi Um Rilan (see Figure 18). Aerial photographs and mosaics and Landsat MSS and RBV imagery were used in the field activity.

The latter period involved the investigation of known gold prospects and occurrences at 12 localities, six ultrabasic complexes for gold and platinum, one copper-nickel prospect, one large metavolcanic area including occurrences of copper, the Nubia/Basement Complex unconformity in three areas, and various observations of geology and structure. Individual occurrences are discussed under Mineral Occurrences; most of them lie north of Wadi El Allaqi.

The basic work objectives were fulfilled. In all, 69 samples were collected for petrographic determinations and 145 samples for assay. Of the 145, there were 34 rock, 23 quartz vein, 27 alteration zone and 61 alluvial samples.

Sudanese Sector (1985)

Field work in the Sudanese Sector was executed during a period of 78 days, from 14 February to 2 May 1985, which included many travel and moving days. A base camp was established at Wadi Halfa and there were mini-base camps/fly camps at Duweishat, Kosha, Abu Sari, Um Nabari and Wadi Naba (see Figure 18). No aerial photographs were available, but Landsat MSS and RBV imagery were satisfactorily utilized in the field operation and proved invaluable for navigation and orientation.

This work involved the investigation of 49 target areas, including three ancient gold mines, 81 other gold occurrences, 12 ultrabasic complexes, one gold-copper and three copper occurrences, six circular features, four metavolcanic areas, and the observation of the Nubia/Basement Complex unconformity at four localities and of pre-Nubia or early Nubia sedimentary rocks at an additional four. Some individual occurrences are described under Mineral Occurrences. Because of customs and other delays, field teams were unable to visit some gold prospects, while field conditions precluded spending the time needed to properly evaluate the prospects visited.

A total of 149 samples were collected for petrographic determinations and 227 for assay.

All petrographic and assay results from the 1984-1985 field work are tabulated in Appendix F of this report.

Field Communications

Radio distances within the Area of Integration are shown in Figure 18. The maximum transmitting distance is 550 km from Aswan and 340 km from Wadi Halfa. The distance between Aswan and Wadi Halfa is 310 km.

To communicate safely and efficiently in the hostile desert areas of the region, there should be fixed

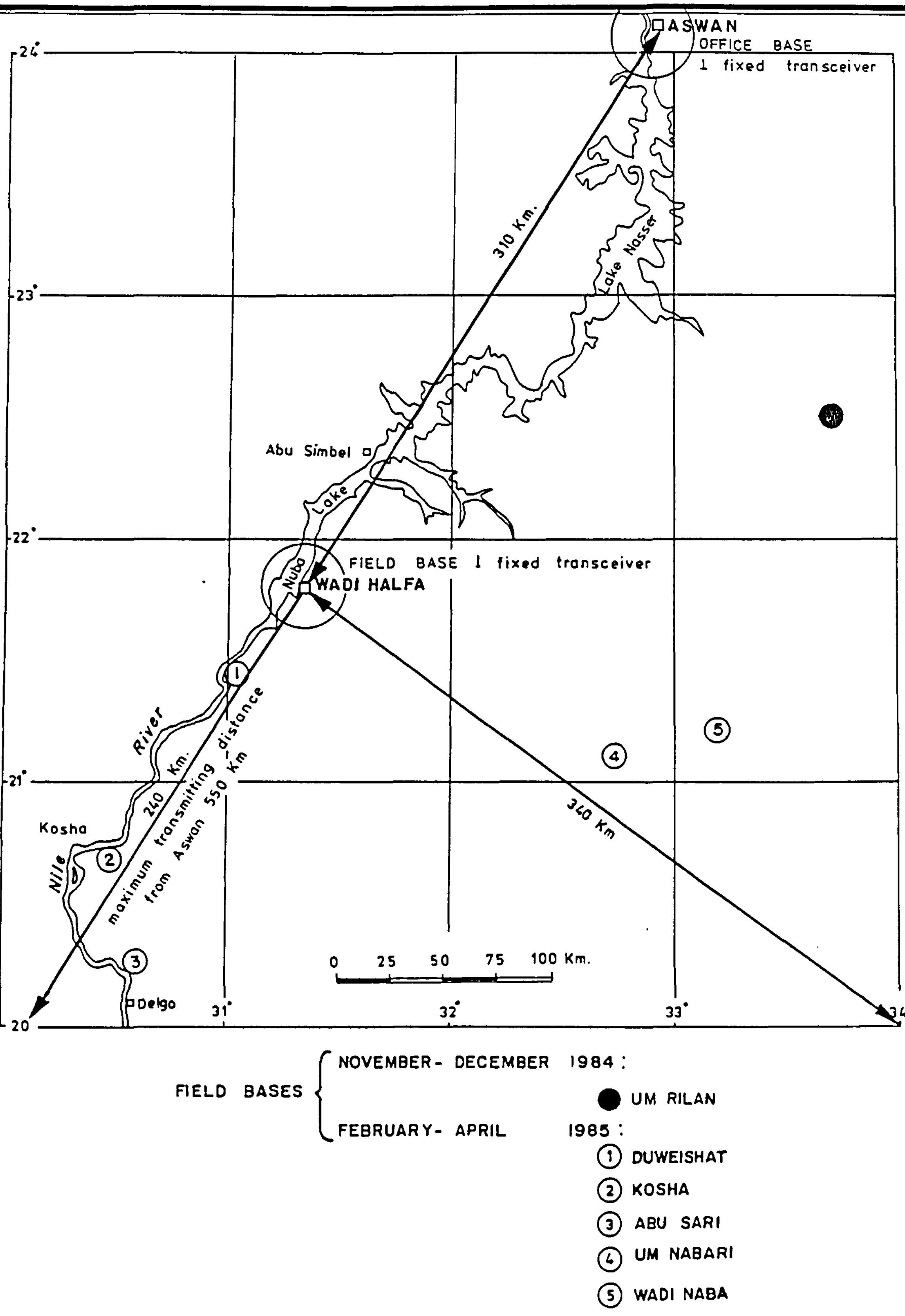

Fig. 18. Field bases and radio distances.

transceiver bases at Aswan and Wadi Halfa and at least one mobile field base. Additionally, each vehicle designated for unaccompanied travel in the desert should have a mobile transceiver and a proven antennae system. With a four-vehicle field team, there should therefore be seven transceivers. Only two transceivers were available during the 1984-1985 field season. As a consequence, undue time and motor fuel were spent in the doubling up of vehicles for safety reasons.

In any future UNDP-assisted operation, communications planning should take into account the desirability and efficiency of an independent network, with:

a) Base and mobile transceiver units as noted above;

b) Early morning and early evening reporting times;

c) Permission for government-approved foreigners to use the radio; and

d) An exclusive GMC frequency, in addition to one channel each on frequencies operated by EGSMA, GMRD, and UNDP Khartoum.

GEOLOGY

Geologic Setting

The southern and eastern portions of the Area of Integration are underlain by middle to late Proterozoic cratonic rocks of the Arabian-Nubian Shield consisting of older gneisses, metamorphic volcano-sedimentary sequences, granitoid intrusions, ultrabasic/serpentinite rocks, other volcanic rocks displaying low metamorphism, and alkaline syenite-granite complexes. The southern portion may be litho-stratigraphically and structurally correlative with the Bayuda region to the south. The eastern portion may be similarly correlative with the Red Sea Hills to the east. Table 5 shows tentative correlations. The distribution of the Shield areas is shown in Figure 19.

The foliation/stratification of these Basement Complex rocks trends northwest to north in the Egyptian Sector; in the Sudanese Sector, it trends predominantly northwest in the eastern part and northeast in the western part (see Plate I). The terrain is uparched in a broad central area called the Kuror High, which is skirted by the Nile River in its great bend to the west.

The metamorphic grade includes greenschist facies on a broadly regional plane, locally attaining almandine-amphibolite facies, especially in mineralized and shear areas.

Structurally, the Basement rocks are very complex and reflect multiple deformational epochs that have resulted in folding, faulting and uplift, with some faults parallel and transcurrent to the Red Sea rift trend. In several places, the Nile River course has been controlled by faulting/jointing. The Basement Complex has been intruded by unmetamorphosed alkaline syenite-granite plutons of late Proterozoic to Phanerozoic age that in part appear to have been emplaced along major suture lines.

In the western part of the Kuror High, a few prominent mountains are isolated inselbergs of the Basement Complex capped by siliceous sediments of pre-Nubia or early Nubia age not previously recognized in northern Sudan. Extensive areas to the south, west and north are blanketed by coarse clastic sediments of the Cretaceous-Tertiary Nubia Formation that dip shallowly away from the Kuror High. Plate I shows the distribution of the Precambrian and Nubia Formation rocks.

Precambrian (Basement Complex)

General Statement

The Precambrian (Basement Complex) rocks of the general region comprise a wide range of lithologies, the stratigraphic relationships of which are imperfectly understood and subject to controversy. Although there are several accounts of the geology, the systematic mapping programmes and studies needed to better establish relationships are lacking. Future geochronological studies will be especially important, although these would be subject to the limitations imposed by the Pan-African "reheating" event, which has overprinted its age (450-700 M.a.) over large areas of the eastern side of the African continent.

Previous interpretation of the geologic history of the Arabian-Nubian Shield (Figure 19), in terms of geosynclinal deposition and deformation of ensialic belts, has progressed -- largely as a result of extensive studies in Saudi Arabia -- to application of the plate tectonic theory involving island arcs and suture zones, resulting in a deformed and cratonized sequence of mainly late Proterozoic volcano-sedimentary rocks. There are, however, large areas of high metamorphic-grade gneisses in the region. Some proponents interpret these as representing increased metamorphism but with no fundamental stratigraphic difference; others attribute these high-grade gneisses (and metasedimentary rocks) to a Basement Complex of early Proterozoic/late Archaean age, with a major break between them and the overlying volcano-sedimentary Arabian-Nubian Shield rocks. Though sparse, there is some support for an early Proterozoic age for these high-grade gneisses, including an age determination of 1,700 M.a. (Harris, et al., 1984) in the Bayuda Desert.

While this major controversy is recognized, there is, nevertheless, some consensus on the broad older to younger stratigraphic sequence outlined below for the Precambrian rocks of the Area of Integration and adjacent areas, also depicted in Table 5.[1]

Gneiss Group (Older Gneisses)

Highly metamorphosed orthogneisses, paragneisses and coarse schists are represented in both the Egyptian and Sudanese sectors; they comprise leucocratic and melanocratic members with local interbanding of biotitic and amphibolitic types. A high degree of deformation and the

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[1]References for Table 5 are: Ahmed (1979), Barth and Meinhold (1979), Falkov (1975), Geosurvey International (1984), Hunting Geology and Geophysics, Ltd. (1967), Reis, et al. (1983), Vail (1979), and Yassin, et al. (1984).

presence of sillimanite, staurolite and garnet are demonstrative of high (probably amphibolite) metamorphic facies.

Most work on the Gneiss Group has been done in the Bayuda Desert south of the Area of Integration. Vail (1979) regards the orthogneisses (Grey Gneisses) as Archaean in age and older than the paragneisses, which Almond (1982) suggests are Proterozoic. The Sudanese-German project in the Bayuda Desert also assigns the Gneiss Group (Abu Harik Series) to the Archaean (Meinhold, 1979).

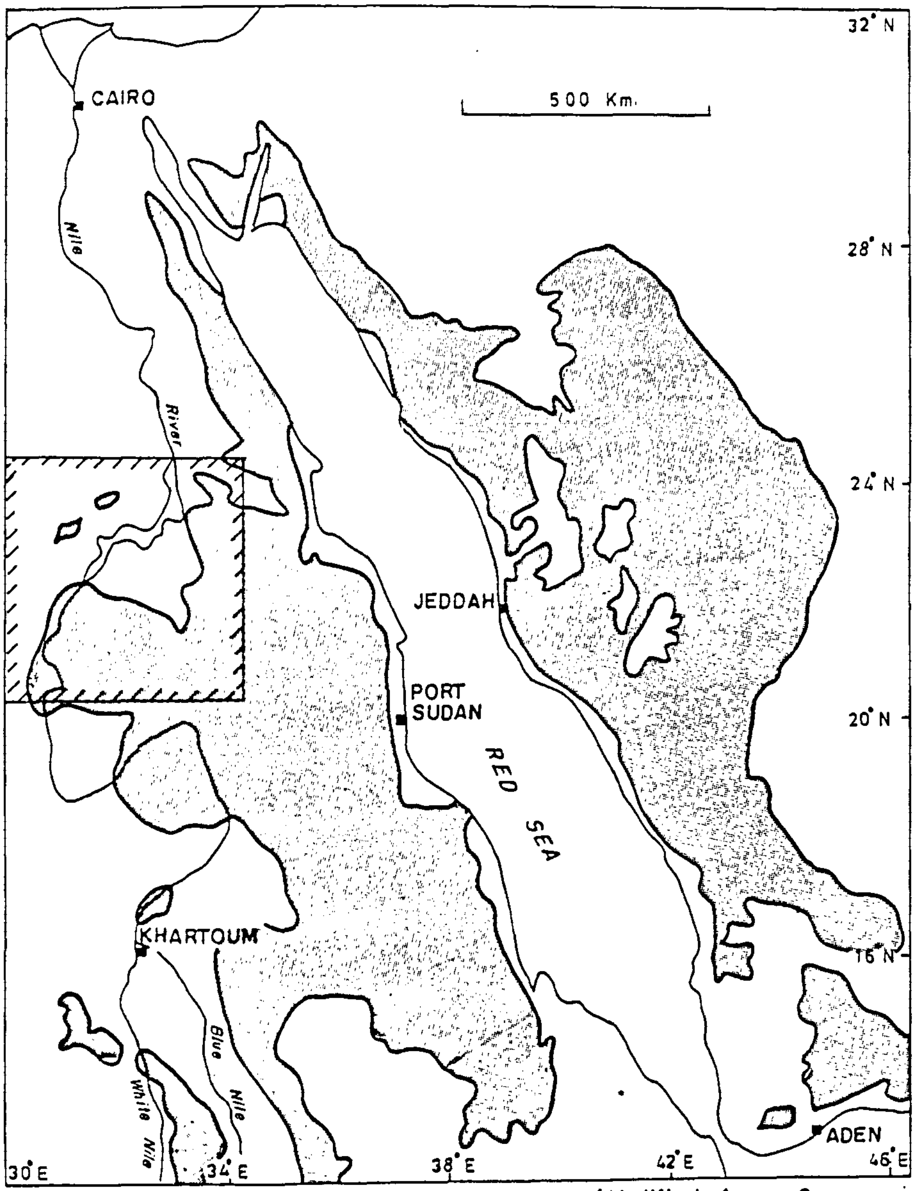
Within the Gneiss Group, there are small outcrops of relatively low-grade rocks: mafic metavolcanics, metasedimentary rocks, and marbles, as well as granodioritic-granitic rocks, an assemblage more typical of the volcano-sedimentary sequence of the Arabian-Nubian Shield. Structural relationships with the high-grade gneisses are not clear. This leaves questions open as to their relative age and whether they are in fact to be retained in this unit or to be assigned to the overlying volcano-sedimentary sequence.

Metamorphic Volcano-Sedimentary Rocks

Stratified metamorphic rocks of sedimentary and volcanic origin and of lower (greenschist) metamorphic facies are widespread over the Area of Integration. A broad range of lithologies is present, and subdivision is difficult in heterogeneous areas. Lithological subgroups can, however, be recognized, but without stratigraphic correlation.

TABLE 5
LITHOSTRATIGRAPHIC CORRELATIONS
AREA OF INTEGRATION AND ADJOINING AREAS

RED SEA HILLS, SUDAN	SOUTHEASTERN EGYPT	BAYUDA REGION, SUDAN
CENOZOIC VOLCANICS	CENOZOIC VOLCANICS	CENOZOIC VOLCANICS
RING COMPLEXES (syenites)	RING COMPLEXES (syenites)	
NUBIA FORMATION	NUBIA FORMATION	NUBIA FORMATION
ALKALINE INTRUSIVES (alkaline granite, syenite)	ALKALINE GRANITE	
RING COMPLEXES (pink granite, gabbro)	YOUNGER GRANITES (post-tectonic granite)	IGNEOUS RING COMPLEXES (granite, dyke swarms)
AWAT SERIES (weakly metamorphosed sedi- mentary and volcanic rocks)	HAMMAMAT GROUP (slightly metamorphosed sediments)	
HAMARGOR SERIES (weakly metamorphosed rock)	DOKHAN VOLCANICS (slightly met. volcanic rocks)	
BATHOLITHIC GRANITES (syn-late tectonic intrusions)	OLDER GRANITES (syn-late tectonic plutonites)	
	METAGABBRO-DIORITE COMPLEX	
ULTRABASICS (pyroxenite, serpentinite)	SERPENTINITE	SERPENTINITE
NAFIRDIEB SERIES (metasediments, metavolcanics)	GEOSYNCLINAL METAVOLCANICS	
ODI SERIES (metasediments)	GEOSYNCLINAL METASEDIMENTS	
KASHEBIB SERIES (migmatites, para/orthogneiss)	MIGIF-HAFAFIT GNEISS (para/orthogneiss, migmatite)	BAYUDA FORMATION (paragneiss, amphibolite)
		ABU HARIK (Paragneiss, orthogneiss)



(Modified from Geosurvey International, 1984)

Egypt- Sudan Area of Integration

Non- Metamorphic cover rocks

Arabian— Nubian Shield rocks

Fig. 19. Location of the Area of Integration in relation to the Arabian-Nubian Shield.

One subgroup comprises mainly pelitic-psammitic schists, slates and phyllites, with minor metaarenites and metavolcanic horizons. Another subgroup is dominantly mafic metavolcanic and includes basic to intermediate lavas and pyroclastic rocks, metabasites, amphibolites, chloritic schists and subordinate felsic volcanic rocks. Another part of the Area of Integration shows a sequence of calcareous argillites, phyllites and schists, with some marble bands. Some parts of this sequence are pyritiferous. Also prominent and widely distributed are mixed sequences of marbles, calcargillites, mafic metavolcanics and pelitic-psammitic metasedimentary rocks. While these lithologies are found in other subgroups, this sequence is characterized by the strong morphological expression of the calcareous members which form prominent strike ridges, some of variable pure marble ranging up to 25 km in length. In the Bayuda Desert region, these rocks have been named the Bayuda Formation and have been subdivided into the Kurmut, Rahaba and Absol Series (Meinhold, op. cit.).

Granite/Granitoid Intrusions

The prominent granodiorite-granite rocks of the Precambrian sequence can be subdivided into discordant and concordant bodies of variable sizes. The latter are subcircular to ovoid granitoid types which are observed to be concordant with the enclosing country rocks. Some bodies may contain a limited range of rock types, but most are both lithologically and structurally heterogeneous, ranging from diorite through quartz diorite and granodiorite to adamellite and granite, with the granodiorite-granite rocks as the most common. The texture and mafic mineral content also vary widely, and microgranitic and andesitic dykes occur in linear and, more rarely, concentric ring form. Foliation ranges from absent or weak to strong. When these rocks are adjacent or gradational to Gneiss Group rocks, it is difficult to establish structural relationships. Although the stratigraphic status of these rocks is not always clear, the concordant bodies are generally regarded as syntectonic and have been dated at about 900-1000 M.a.

Many of the discordant bodies are younger than the volcano-sedimentary group outlined above and have been regarded as of late orogenic character, with age determinations mainly in the 500-600 M.a. range.

Ultrabasic/Serpentinite Rocks

There are six main ultrabasic/serpentinite complexes in the Egyptian Sector about 50 km north of Wadi El Allaqi, and it is expected that similar complexes occur in the Sudanese Sector.

The ultrabasic rocks are usually completely serpentinized, carbonatized and silicified and are locally altered to talc and magnesite along fractures or alteration zones. Especially when it is associated in a complex relationship with metavolcanics, petrogenesis of the ultrabasics is difficult to determine. But no clear demonstration of ophiolitic affinity, as postulated by several investigators in the Red Sea Hills of Egypt and Sudan, has yet been recognized in the Area of Integration. Control of ultrabasic complex distribution by major deep-seated faulting in northwest and east-northeast directions is postulated in the Eastern Desert of Egypt and may be applicable in the Area of Integration.

Sparse podiform or thin-seam chromite mineralization occurs in the ultrabasic/serpentinite complexes but has no apparent economic significance.

Weakly Metamorphosed to Unmetamorphosed Igneous Rocks

Weakly metamorphosed volcanic rocks allocated to the Dokhan Volcanics (El Ramly, 1972), as well as apparently unmetamorphosed igneous complexes of gabbro, with rare diorite and pyroxenite, intrude the volcano-sedimentary sequence described above. The intrusive bodies are large, circular to ovoid in shape, and have associated dolerite dyke rocks. Small batches of gabbroic rock may also occur within some of the intrusive granite bodies outlined above. There is evidence that some of these bodies were emplaced late in the orogenic history of the pre-Nubia Basement.

Alkaline Syenite-Granite Complexes

These complexes form very prominent, abrupt, vertical-walled hill masses in the Area of Integration. The rocks are unaffected by any regional metamorphism or deformation apart from minor fracturing. Structural features include ring fractures, cross-cutting and concentric magmatic phases, and varying patterns of associated dyke swarms. The unit comprises: 1) plutonic types which range in composition from alkaline syenite to alkaline and peralkaline granites; 2) dominantly volcanic types, which are mainly ill-sorted pyroclastics of intermediate to felsic composition with subordinate lavas and occasionally small plutonic patches that have intruded the volcanic cover; and 3) assemblages where the intrusive and extrusive members are mixed. In adjacent areas of Egypt and Sudan, these post-metamorphic, pre-Nubia complexes are regarded as late Precambrian to Jurassic.

Sedimentary Rocks

Pre-Nubia Formation or Early Nubia Rocks

The most prominent mountains near the western edge of the Kuror High (Plate I and Figure 2) between Wadi Halfa and Delgo are capped by relatively flat-lying, indurated sedimentary sequences ranging in thickness from 21 m to about 180 m. These consist of lithic orthoquartzite, silicified sandstone, argillite, and softer clastics that, in general, are judged atypical of the Nubia Formation and are believed to be pre-Nubia or early Nubia continental sediments.

Figure 20 shows the locations of 11 prominent mountains in the region southwest of Wadi Halfa that fit the above description. Of these, the capping sediments were investigated at Jebel Brinikol, Jebel Atiri, Jebel Ed Dal and Jebel Ferka. Jebel Um Rowag and Jebel Abri were seen from moderate distances, and the remainder were interpreted from greater distances. In the hinterland area between Jebel Atiri and Akasha, there are possibly one or two other such prominences.

The sequence is represented by a lower resistant, siliceous, cliff-forming unit, a middle slope-forming argillite/soft sandstone/siltstone unit, and an upper cliff-forming unit similar to the basal one. It is 21 m thick at Jebel Brinikol, 50 km southwest of Wadi Halfa (Figure 21), and about the same at Jebel Atiri. Farther south, at Jebel Ed Dal and Jebel Ferka, the sequence is about 180 m thick, and it may be thicker at Jabel Abri.

Figure 22 is a schematic cross-section through Jebel Ferka.

Figure 23 shows the observed formation and foreset bedding dip-directions in these sedimentary rocks at four localities. In general, the dip directions are southeast to southwest, which suggest a Basement source somewhere to the north for these sediments.

Lithologically and physiographically, it is difficult to relate these rocks to the Nubia Formation. There is no feasible correlation between the Jebel Brinikol section, which unconformably overlies Basement granite at 440 m elevation, and the Nubia section near the No. 1 Railway Station some 58 km to the northeast, where the contact is at 203 m elevation, or 237 m lower (see description under Nubia Formation). Similarly, one cannot correlate between the formidable sedimentary section at Jebel Ferka (see Figure 22), which stands out so prominently and where the Basement contact is at 365 m, and the more subdued, low-lying (200 m elevation) argillaceous and ferruginous sandstones of the Nubia a few kilometres to the south and west.

In the Jebel Ferka and Jebel Ed Dal sections, what appears to be a subtle convergence in the lower two units could be evidence of an unconformity.

Either in pre-Nubia or early Nubia time, these sediments were deposited over a relatively broad region embracing the greater part of the Area of Integration or beyond. Subsequently, the region was compressionally uplifted and deeply eroded, serving as a source for the Nubia sediments and leaving the isolated remnants seen today.

Nubia Formation

Description. Clastic sedimentary rocks of the Cretaceous-Tertiary Nubia Formation are widespread in the region and underlie 57.5 percent of the Area of Integration (see Plate I), where they are composed predominantly of arenaceous and rudaceous beds and minor siltstones and mudstones. The basal unit is a conglomerate or conglomeratic sandstone overlain by generally softer, more argillaceous, locally ferruginous sandstone units and occasional thin, intercalated silty to argillaceous and shaley beds. The conglomerates are in part locally derived and appear to represent both the erosion of the Precambrian Basement Complex and the erosion and reworking of pre-Nubia sediments.

Field Observations. Observations were made of the Nubia Formation in the seven localities/areas listed below during intermittent field work in November-December 1984 and February-April 1985:

(1) 27 km east of Aswan;

(2) At Khor Rahman and Jebel Um Risha/Jebel Um Nefi between Aswan and Wadi El Allaqi;

(3) In the Wadi Um Duweilla drainage about 45 km south of Wadi El Allaqi;

(4) 6.5 km east of No. 1 Railway Station along the Wadi Halfa-Khartoum railway;

(5) 14 km northwest of the Um Nabari gold prospect;

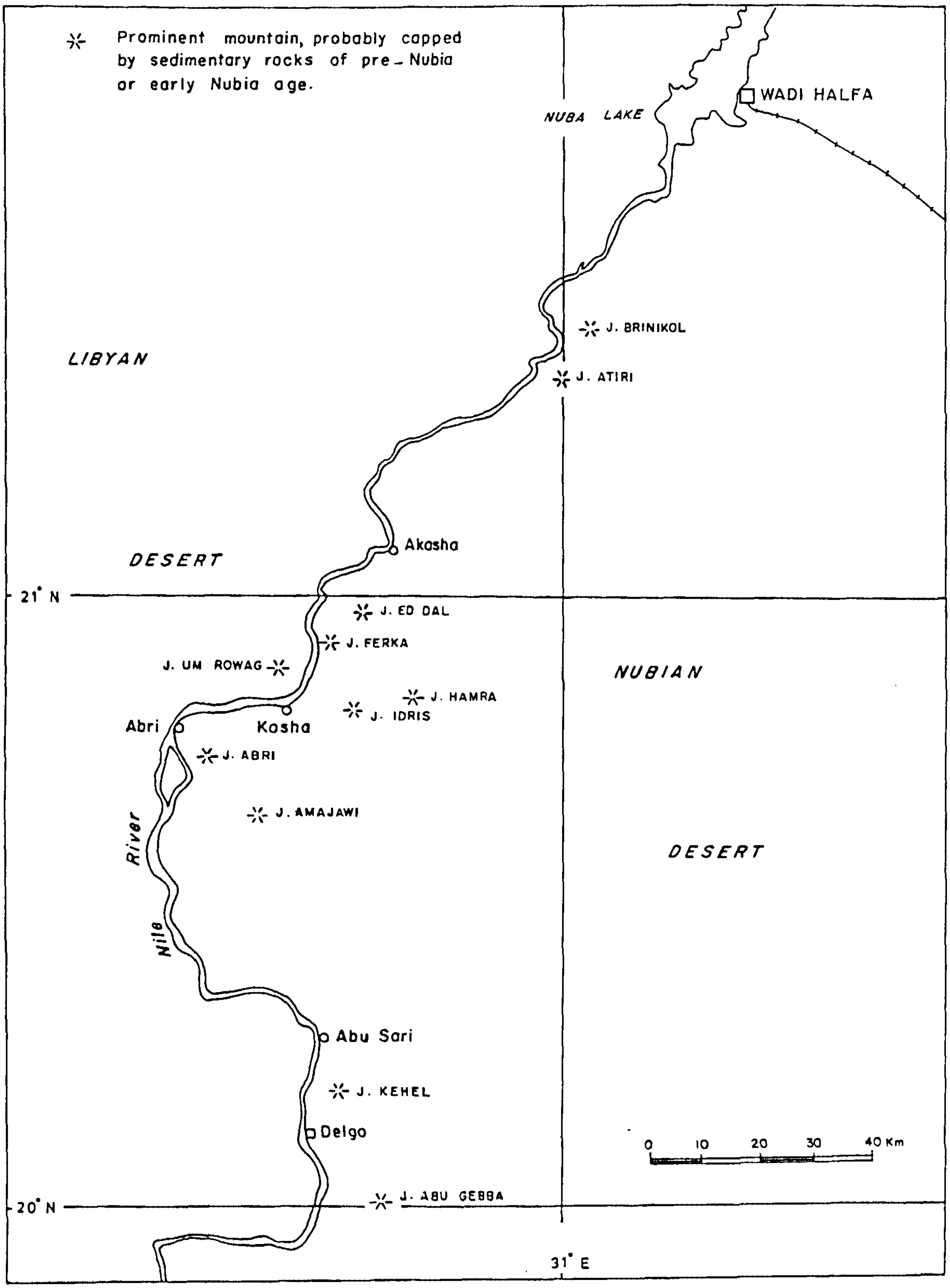


Fig. 20. Location map, pre-Nubia Formation or early Nubia sedimentary rocks in the southwestern Sudanese Sector.

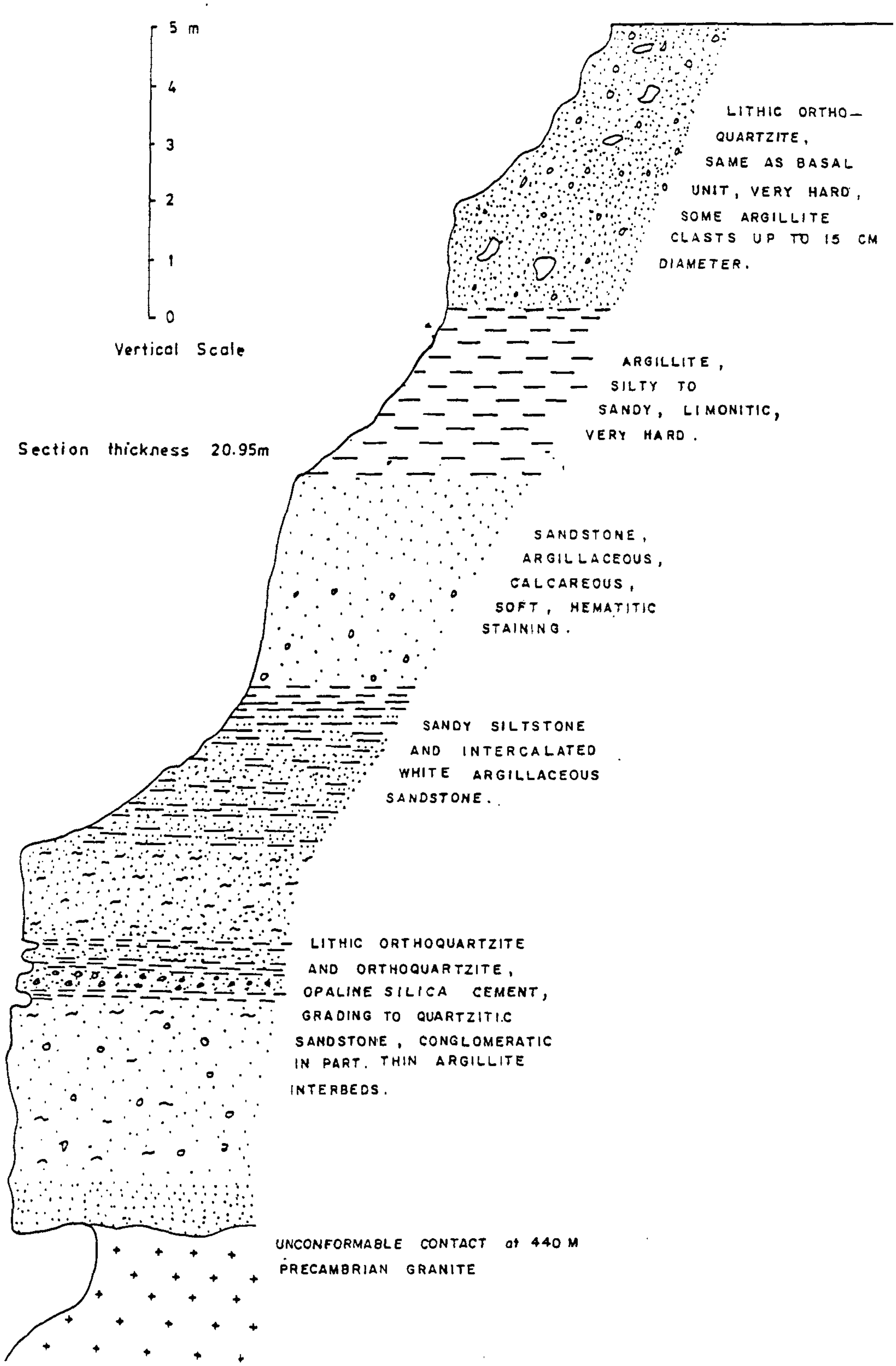
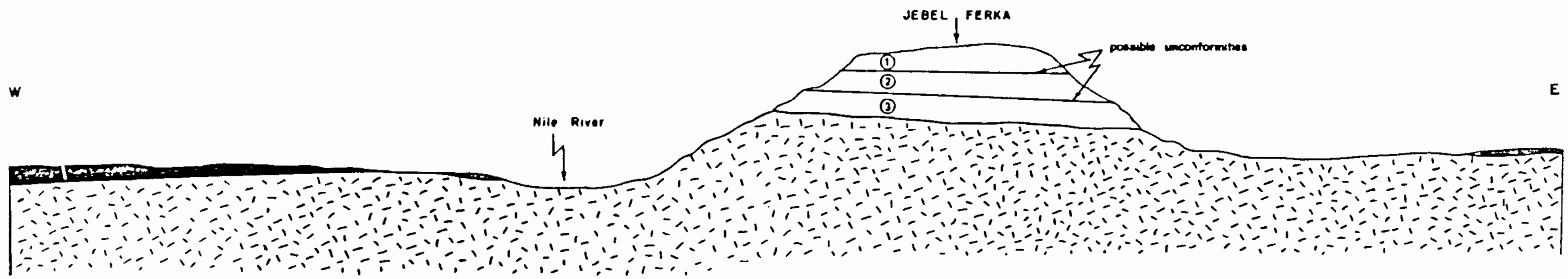


Fig. 21. Jebel Brinikol pre-Nubia or early Nubia sedimentary section, 50 km southwest of Wadi Halfa.



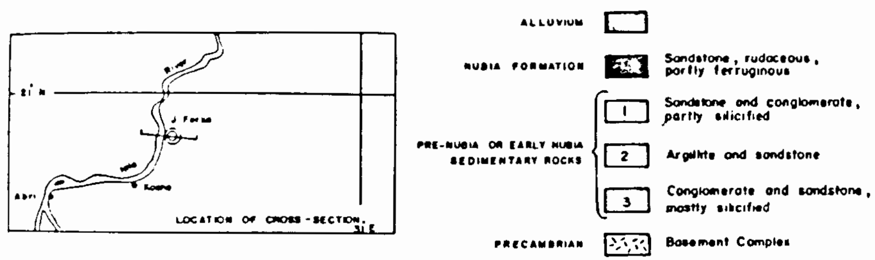


Fig 22. Schematic cross-section through Jebel Ferka, in the Kosha area of the southwest Sudanese Sector, showing the relationship between the Nubia Formation, pre-Nubia or early Nubia sedimentary rocks, and Precambrian Basement rocks.

(6) 68 km east-northeast of the Um Nabari gold prospect on the east side of Wadi Gabgaba;

(7) Southeast of Abu Sari near the southern edge of the Area of Integration.

There were two primary purposes for this work: 1) to study the Nubia-Basement unconformity in a search for channelling or other unconformity-type depositional features conducive to the accumulation of carbonaceous material and the deposition of uranium mineralization; and 2) to observe the characteristics of the Nubia Formation southward from the Egyptian Sector, where it is reasonably well known, into the Sudanese Sector, where technical observations heretofore have been limited to areas immediately adjacent to the Nile River Valley.

Only two channels were observed: a small, north-trending one at locality (1), restricted to an inselberg of Nubia clastics; and a channel at locality (6), described below. No channelling features or characteristics conducive to the deposition of uranium were observed.

Southward toward locality (3), the Nubia becomes more coarsely clastic, with an increase in conglomeratic material and a corresponding decrease in fine clastics. Whereas the basal unit is 1.2 m thick at locality (1), it is a massive 6.5 m thick at locality (3), containing cobbles to 16 cm in diameter, with high-energy deposition and possibly an easterly source. In contrast, there are only 20 cm of conglomerate at locality (4).

Massive conglomerates were seen at localities (5) and (6). The unit at locality (6) was particularly impressive; it was a poorly-sorted, torrentially deposited mass (not measured) of probable Paleocene age, contemporaneous with east-west normal faulting and associated channelling.

The Nubia at locality (7) was anomalously ferruginous.

The section at locality (4) east of Wadi Halfa was measured and is described below, from the top of the section to the base:

5.10 m	Sandstone, buff-brown, quartzose, medium- to coarse-grained, subangular to subround, calcareous, locally limonitic, thick- to medium-bedded, partly cross-bedded, scattered quartz pebbles, cliff-former, less resistant upper 1 m; incomplete section;
1.70 m	Siltstone, light grey to buff with some purple mottling, shaley, micaceous, irregularly bedded, slope-former;
0.90 m	Sandstone, brownish purple, quartzose, micaceous, fine-grained, angular to subangular, silty, shaley, medium- to thin-bedded; good potential marker horizon;
1.20 m	Sandstone, medium to light grey, very fine- to coarse-grained, poorly sorted, calcareous, local limonite cement, thin irregular bedding, lower 0.5 m very hard, resistant ledge-former;
2.30 m	Sandstone, light yellow, quartzose, medium- to coarse-grained, angular to subangular, limonite

cement, poorly cemented, prominent cross-bedding, scattered quartz pebbles;

0.20 m Conglomerate, brown to purple, subangular to subround quartz pebbles and occasional brown quartzite pebbles 0.5-8.0 cm in diameter, poorly sorted, medium hard, calcareous, partly argillaceous, limonitic upper part;

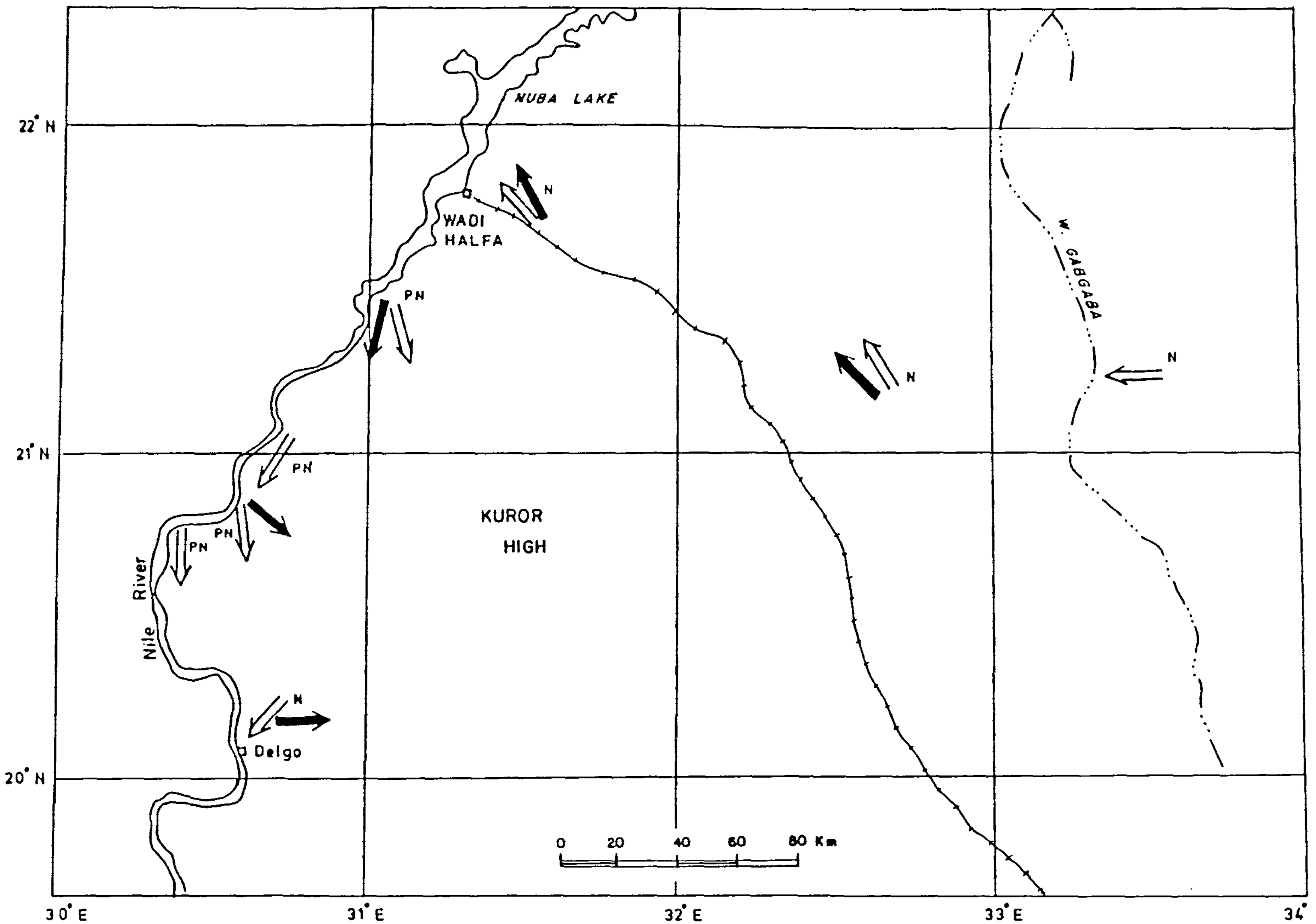
0.08 m Paleosol, brown, calcareous, sandy, scattered remnant basement debris;

Uncomformable contact at 203 m;

Weathered granodiorite Basement (unmeasured).

The lowermost sequence could represent a pre-Nubia, perhaps early Mesozoic epoch. The thin paleosol horizon and basal conglomerate indicate subaerial exposure during a relatively quiescent period. The 0.90 m brownish purple micaceous sandstone is reminiscent of some Permo-Triassic red beds in other parts of the world.

Figure 23 shows observed formation and foreset bedding dip-directions in the Nubia Formation at four localities in the Sudanese Sector. In three cases, they point to a broadly uplifted source area relating to the Kuror High in the south-central part of the Area of Integration. In the Wadi Gabgaba area, the indicated source of possible later (Paleocene) Nubia sediments is in the Red Sea Hills to the east.



N - Nubia Formation
PN - Pre-Nubia or Early Nubia
Formation dip direction 1 – 5°
Foreset bedding dip direction 13 – 26°

Fig. 23. Observed formation and foreset bedding dip directions in Nubia Formation and pre – Nubia or early Nubia rocks, Sudanese Sector.

Structure

Earlier Studies

In the systematic photogeological survey carried out by Hunting Geology and Geophysics Ltd. (1967) that covered part of the Egyptian Sector (see Figure 17), ophiolite rock assemblages were identified and serpentinites were shown to be mainly of non-intrusive origin conformable with the associated volcano-sedimentary sequence. This was nearly a decade before the plate tectonic theory was established to better explain the origin of these rocks.

The Hunting survey interpreted a broad, northwest-trending closed fold structure on which there had been superimposed a second set of folds, open to the north but becoming tighter southwards, and an overall plunge to the northeast. Major faults with considerable throw were said to trend west-northwest, northwest and northeast in the Hafafit area, with strong north-northeast fractures and shearing in Wadi El Allaqi. Locally intense dyke swarms trending east-northeast, north-northeast and north-northwest were mapped, many continuing into major fault zones and virtually all of pre-Nubia age. Horst and graben formation and east-northeast faulting during the deposition of the Nubia Formation were postulated, with later post-Nubia folding trending north-northwest and relating to underlying Basement faults. Basement inliers, Nubia outliers and major post-Nubia faulting were also aligned in this direction.

The survey indicated intersections of major east-northeast, north-northwest and west-northwest faulting as being foci for the Abu Khrug alkaline syenite complex and an east-northeast trend for associated plugs and domes in the Wadi Natash Volcanics; minor intrusions in or near the Nubia sediments appeared to be associated with the north-northwest or east-northeast trends.

Another early investigator, Vail (1972), identified broad, pre-Nubia structural trends in an interpretation of Trimetrogon photo coverage, combined with ground traverses, of a 500,000 sq km area covering the Nubian and Bayuda Deserts and Red Sea Hills of Sudan between the Nile River and the Red Sea. This included all of the Sudanese Sector. He described the metamorphic rocks as displaying well-marked bedding and foliation and as forming a heterogeneous pattern across the entire region, with major structures in the northeast, north and northwest directions. A series of open folds, with axial strikes swinging in an arc from northeast in the south to northwest towards the Egyptian border, and with refolding of previous structures, were described as being characteristic of the Basement rocks. Large dyke swarms showed a general east-west strike, but the 30 ring complexes known at the time showed no particular distribution pattern.[2/]

Structural Trends in the Arabian-Nubian Shield and the Red Sea

Investigators are in general agreement that plate tectonics and subduction zones in an island arc setting, perhaps comparable with the "modern" (late Mesozoic/Cenozoic) plate tectonic setting of the Southwest Pacific,

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[2]Later work by Vail and Kuron (1978) identified 100 anorogenic ring complexes (granites, gabbros, syenites, carbonatites) in a 700 km x 200 km belt in eastern Sudan, the intrusions and dyke swarms of which cut all Precambrian formations; structural alignments are apparently rare, but the complexes cluster along old interplate suture lines.

played a dominant role in the development of the Arabian-Nubian Shield in Proterozoic time. Figure 19 shows the location of the Area of Integration in relation to the Shield.

The recognition of ophiolite belts in southern Egypt, northern Sudan and Saudi Arabia is the most convincing evidence of the dominant role of plate tectonic processes in this region during the Precambrian. Mitchell and Garson (1981) recognize a similarity in tectonic features between Proterozoic and Phanerozoic rift-related successions.

In a large body of geophysical and geological evidence, Garson and Krs (1976) demonstrate that the direction of ocean floor spreading in the Red Sea, beginning in late Eocene time, was guided by continental Precambrian fractures that trend east-northeast and extend into transverse tectonic structures in the Red Sea in which deposits of metalliferous sediment are located. For orientation, this east-northeast (about N 60° E) trend is transverse and more or less at right angles to the Red Sea structural direction, which trends north-northwest (about N 30°-35° W). These two directions evidently represent deep-seated sutures in the earth's crust and appear to have played a dominant role in the structural evolution of the Arabian-Nubian Shield.

The transverse direction is characterized by large-scale block faulting, seismic epicentres and basic/ultra-basic crustal intrusions, occurring in deep-seated tectonic zones (Garson and Krs, op. cit.). Ring complexes and carbonatites also fall on the trace of these sutures. Such zones are defined by Stovickova (1973) as extending into the upper mantle, running for several hundred kilometres in the same direction, and surviving several geologic epochs.

The Red Sea trend is roughly parallel to the ancient geosynclinal tract and to a major structural trend that is well demonstrated in the Southeastern Desert of Egypt by aeromagnetic anomalies and deep-seated linear features lying in a 100 km wide zone along the Red Sea (Garson and Krs, op. cit.). There is evidence that alkaline ring structures, volcanic activity and dykes that persist for 60-120 km accompany this trend.

Abdel-Khalek (1979) identified the Red Sea direction as being a dominant fold axis trend in the Hafafit and Beitan areas of the Red Sea coastal belt. Further inland at Barramiya, the east-northeast transverse trend was also recognized. In superimposed structures, the Red Sea trend appears to be the older of the two. Thrust faulting may be associated with these structures. Abdel-Khalek (op. cit.) noted major fractures that extend for hundreds of kilometres along east, east-northeast and northwest trends, and block faulting along the Red Sea direction. Ultrabasic masses of ophiolitic affinity are generally concordant with the geosynclinal metamorphic rocks; some occur in arcs convex to the Red Sea and are highly compressed in the east-northeast direction at Barramiya.

Structure of the Area of Integration

Egyptian Sector. As EGSMA mapping in the Egyptian Sector was based on aerial photographic interpretation, it does not stress the large-scale structures that may be more evident through the interpretation of satellite imagery.

Major fold axes strike northwest, and this folding is well demonstrated in the southern part of the sector around Wadi El Allaqi. Major features noted also include closed basins and domes. Salient fault and fracture zones show several trends. Many wadis have been eroded along major fault zones. The prominent Wadi El Allaqi fault that in part accompanies the wadi strikes parallel to the Red Sea trend and has its downthrown block to the southwest. It is noteworthy that the Um Garayat, Nile Valley Block E, Marahik and Atshan gold occurrences are more or less on a straight line parallel to Wadi El Allaqi. Two other prominent lineaments to the southwest trend N 26^{o}-31^{o} W. In the northeastern part of the sector, two parallel faults have the Red Sea trend, with downthrown blocks to the northeast. The transverse trend is also notable, especially in Wadis Haimur and Murra. Other trends mapped are the north-northeast and east-west directions. The former is typified by strong fracture zones that run north-northeast from Wadi El Allaqi and that produce intensive shearing in the metavolcanic rocks. This trend direction corresponds to the Gulf of Aqaba-Dead Sea rift and could be a projection thereof through the area. The east-west faults are the main structural features in the Nubia terrain of southwestern Egypt, where Issawi (1971) mapped extensive, mostly normal faults, some up to 300 km in strike length, that divide the area into a number of blocks, horsts and grabens. Some east-west faults are off-set by north-south faults.

Faulting appears to be mainly vertical, although thrusting could also be expected, considering the mechanism of ophiolite obduction processes.

Sudanese Sector. In general, the structural features of the Sudanese Sector are in harmony with those outlined above for the Egyptian Sector. In its image-geological mapping of the Sudanese Sector, Geosurvey (1984) interprets major individual structures in terms of large strike-slip shear zones, together with thrusts, fold belts and related structures in the pre-Nubia Basement, and "zones of disturbance" in the Nubia Formation sedimentary cover.

Major structural trends are shown in Figure 24. Worthy of attention are the north-northwest (Red Sea) trend of the Abu Hamad Shear Zone, at the Wadi El Allaqi-Wadi Gabgaba confluence locality in the northeast (and extending as a major break well into the Egyptian Sector); terrain in Nubia in the southwest near Dongola; the east-northeast (transverse to Red Sea) trend, well displayed in the Kuror Shear Zone and in other approximately parallel alignments; and the east-west trend in the Nubia cover, well demonstrated in the Egyptian Sector and also notable in the northwestern part of the Sudanese Sector.

Shear alignment is commonly east-northeast with oblique slip as well as strike evident, although displacement geometries are often unknown.

Although Vail (op. cit.) considered that the course of the Nile was fold- rather than fault-controlled, a long section of the Nile follows the Abu Hamad Shear Zone in the Bayuda area. One might also discern some east-northeast structural control in the course of the Nile along the western side of the Sudanese Sector.

In terms of intrusive alignments, the north-northwest trend is demonstrated in the area of the Kuror High in the Sudanese Sector, where image-geological mapping by Geosurvey (op. cit.) shows three syenitic intrusions, an

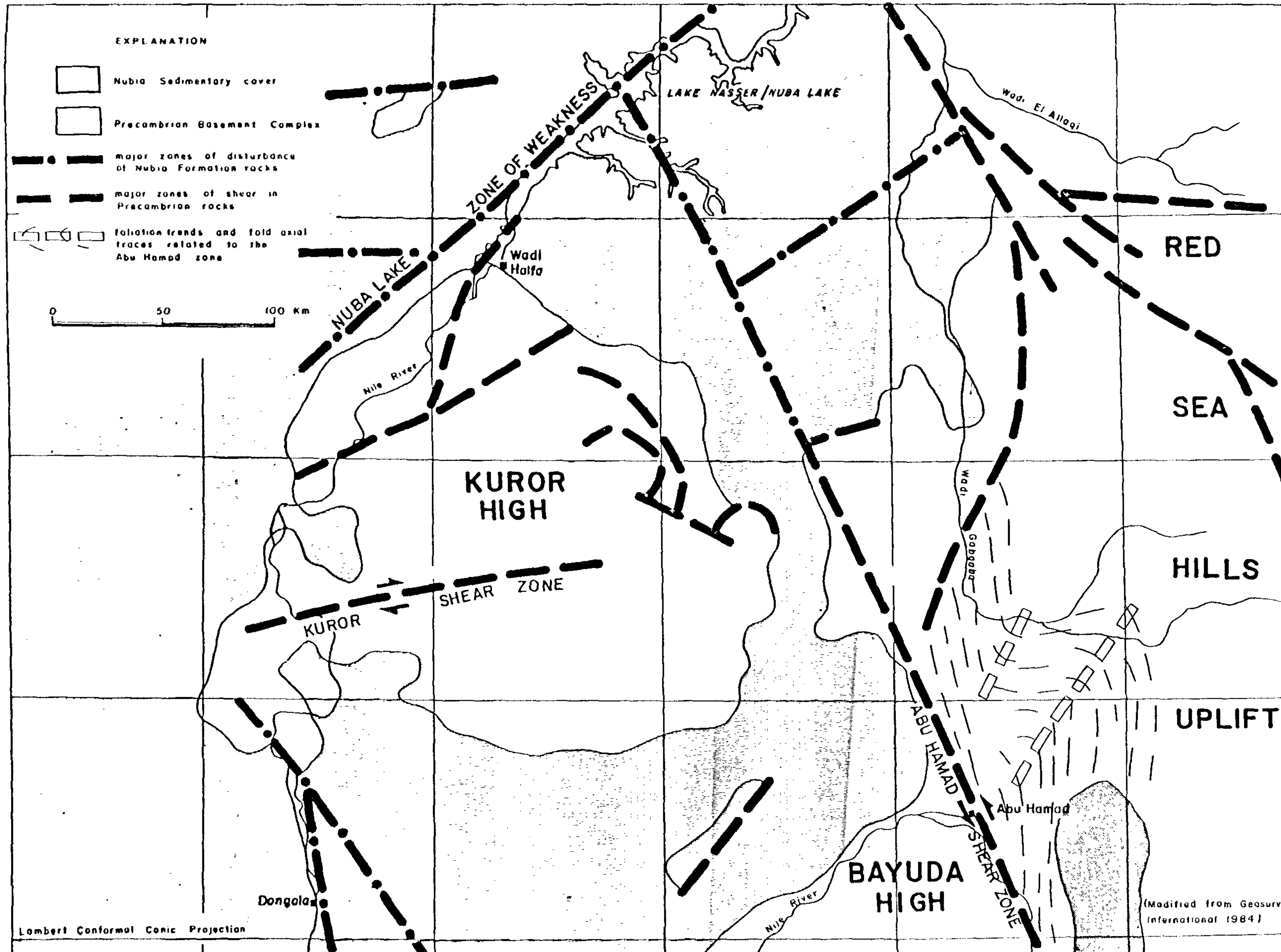


Fig. 24. General geology and major structural features Sudanese Sector

ultrabasic mass and a smaller syenitic body on a north-northwest trend over a distance of 80 km. At the southeastern terminus of the Kuror High, the intrusive/ extrusive trend has an appearance of migrating volcanic centres; a syenite in the northeastern part of the Sudanese Sector has a similar characteristic. Elsewhere, there are subtle suggestions of other alignments of syenite intrusions and to some extent of discordant granite bodies on north-northwest and east-northeast trends, especially in the eastern portion, but there is nothing salient or thoroughly obvious.

The Nubia Formation is disturbed by joints and by normal faults of low to moderate movement that strike east-west, northeast and northwest. One of the latter directions is co-linear with the Abu Hamad Shear Zone. The northeast-aligned zone, identified with the Nuba Lake zone of weakness, is not well defined by fracturing but is remarkable for the 90° strike change in Nubia beds across its alignment.

Regional Structural Associations

In interpreting and presenting data on the complex Precambrian geology of the Sudanese Sector, Geosurvey (op. cit.) also adopted the concept of tectonic domain introduced by Hepworth (1967) in the photogeological study of complex metamorphic terrain in Uganda, and adapted it to local conditions. Prior to field checking, four large domains had been defined in the pre-Nubia Basement on the basis of structural characteristics observed on the imagery -- linear/curvilinear structures, density and pattern of fracture lineaments, complexity and style of folding, etc. -- but regardless of supposed lithologies and distribution of units. After field work, it was also possible to take account of lithological variations and metamorphic grade where available and thus expand the interpretation to define and delineate eight so-called "regional structural associations." Each association comprises a specific combination of distinctive lithological and structural components as identified through image-interpretation.

Conclusions

In terms of major structural trends and favourable associations for emplacement of economic mineral deposits, it is difficult to extrapolate with confidence beyond the predominant north-northwest (Red Sea) and east-northeast (transverse) alignments. Intersections of these trends, or of these with other structural elements, would normally be expected to be favourable target zones, especially in view of their deep-seated nature.

Knowledge that the mechanism for plate obduction operated in the Proterozoic Era and of the similarity in tectonic features between Proterozoic and Phanerozoic rift-related successions will have application in the search for analogous mineral deposits and in the interpretation of Basement geology.

In view of the strong and persistent correlation between geologic structure and ore deposits in rocks of all ages on every continent, there is justification for a detailed structural survey through photogeology, image-geology and field geology, assisted by aeromagnetic and radiometric survey results, directed toward the elucidation of structures and associated mineralization possibilities.

GEOCHRONOLOGY

Introduction

Isotopic age determinations carried out by a number of investigators have been made of Precambrian rocks in the Egyptian Sector, in the Bayuda Desert in Sudan to the south, in the southern Red Sea Hills in Sudan to the southeast, in the Red Sea Hills of Sudan to the east, and in the Red Sea Hills of Egypt to the northeast. The locations of these regions are shown in Figure 25 and are numbered by region; the results of the age determinations are tabulated in Table 6.

Interpretation of these data and their utility are limited by uncertainty in relating individual samples to lithostratigraphic units that have not yet been definitively established in the imperfectly understood Precambrian Basement Complex. Moreover, the widespread Pan-African thermo-tectonic event has overprinted its age (450-700 M.a.) on many rocks in the region. In this respect, the Rb/Sr isochron determinations carried out by Egyptian investigators (Hashad, 1980; El Shazly, et al., 1973), including samples taken from the Egyptian Sector, have provided more useful data than those from generally earlier K/Ar dating done by other investigators, since such dating has very much been affected by later thermo-tectonic events. Their use of initial Sr^{87}/Sr^{86} ratios has also permitted consideration of the origin of the rocks sampled.

Bayuda Desert, Northern Sudan (1)

Meinhold (1979) has proposed a paleogeographic model for the Bayuda geosynclinal volcano-sedimentary rocks

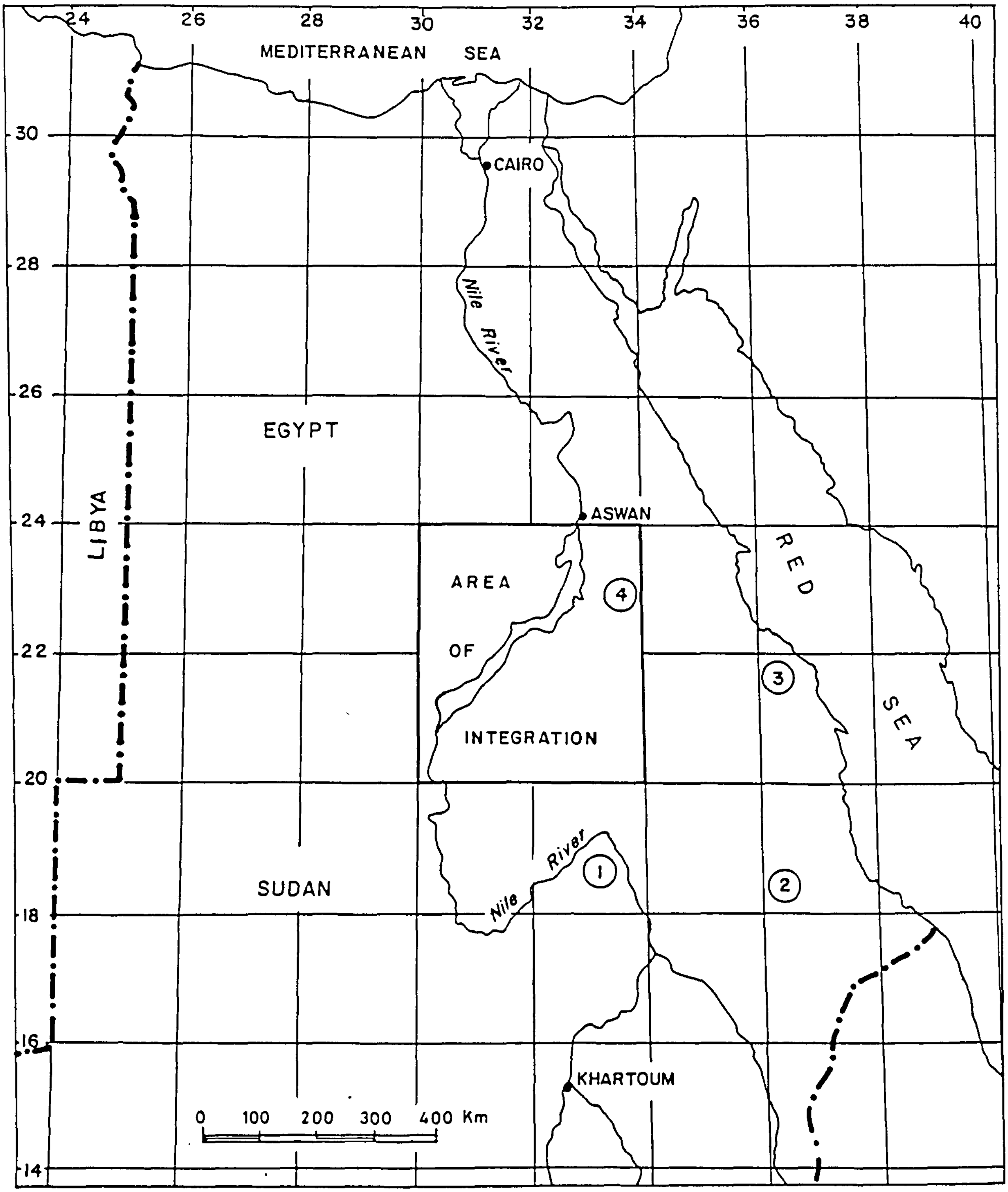
(Bayuda Formation), which he interprets as unconformably overlying an older consolidated gneissose shield (Abu Harik Series) in an island arc setting and as involving both progressive and retrogressive metamorphism. By analogy with similar gneisses in southeastern Libya, where Rb/Sr ages of 1876 to 2507 M.a. have been cited by Vail (1976), Meinhold suggests that the Abu Harik Series may be Archaean in age and the Bayuda Formation as old as Eburnean age. More recently, Harris, et al. (1984) have dated a grey gneiss (Vail's terminology) at 1700 M.a. K/Ar determinations on micas from gneisses were cited by Meinhold as yielding ages of 519-680 M.a. These are due to the Pan-African event, which he postulates as only thermal, not tectonic, in this region. From the available data, Meinhold concludes that the orogenic cycle that metamorphosed the Bayuda Formation could not have started less than 1,000 M.a. ago.

Red Sea Hills, Sudan (2,3)

In the southern Red Sea Hills in Sudan, Vail (1976) reports scattered K/Ar datings in the 540-786 M.a. range, most of which can be attributed to Pan-African event overprinting; many of the rocks, however, are considered to be older. Similarly, in the Red Sea Hills of northern Sudan, most determinations fall within the 545-740 M.a. range (Vail, op. cit.; El Shazly, et al., 1973).

Egyptian Sector, Area of Integration (4)

In the Egyptian Sector, age determinations apparently have not been made on the orthogneiss/paragneiss complex (Abu Harik Series of Meinhold, op. cit.), which probably comprises the oldest unit and therefore may possibly be of Archaean age.



1. Bayuda Desert
2. Southern Red Sea Hills, Sudan
3. Red Sea Hills, Egypt – Sudan
4. Egyptian Sector, Area of Integration

Fig. 25. Location of previous collection areas for geochronology in the Egyptian Sector and bordering regions.

Rb/Sr dating for the overlying and extensive geosynclinal volcano-sedimentary rocks (Bayuda Formation of Meinhold, op. cit.) gives a range of 1150-1300 M.a. for the metasediments and 856 M.a. for the metavolcanics, but the latter is said to be a highly uncertain age (El Shazly, et al., op.cit.). A similar range cited by Hashad (op. cit.) is up to 1200 M.a. for the metasediments and up to 1078 m.a. (a Pb/Pb determination) for the metavolcanics. The associated synorogenic (older) granitoids of granitic-dioritic composition show Rb/Sr determined ages of 900-1000 M.a. (El Shazly, et al., op. cit.).

Rhyolitic rocks within the "Emerging Geosynclinal Volcanics" show ages of around 660 M.a., while the isotopic age of the Younger Granitoids, which are late orogenic and intrude all the other units outlined above, is given as 605 M.a. by El Shazly, et al. (op. cit.) and as a range of 500-675 M.a. by Hashad (op. cit.).

Four determinations on the Aswan granite are closely grouped in the range 570-600 M.a. (El Shazly, et al., op. cit.; Meneisy and Lenz, 1982). K/Ar determinations on these and other rocks in this age range may of course show only the Pan-African event overprinting, e.g. the 450-700 M.a. range cited by Hashad (op. cit.).

Alkaline ring complexes and volcanics comprise two distinct groups in the general region: a peralkaline suite of trachytes, bostonites and syenites with ages in the 245-300 M.a. range, which is found only at Wadi Kareim in the central sector of the Eastern Desert of Egypt; and an alkaline suite characterized by nepheline syenites, dated in the 80-150 M.a. range, which is more widespread in Egypt and Sudan.

Table 6- Geochronology of Basement Rocks in the Egyptian Sector, Area of Integration, and Bordering Regions

Locality	Lat.	Long.	Rock Type	Method	Isotopic Age=(M.a.)
1. Bayuda Desert	(Harris et al,1984; Meinhold,1979; Vail, 1976)				
Rahaba Ib	$18^{o}43'$N	$33^{o}11'$E	Pegmatite	K/Ar	641 ± 26
Rahaba IIb	$18^{o}43'$N	$33^{o}10'$E	Pegmatite	K/Ar	645 ± 26
K.Rahaba 2	$18^{o}42'$N	$33^{o}12'$E	Pegmatite	K/Ar	594 ± 24
Location not specified			Grey Gneiss	Sm Isotopic	1700
Location not specified			Mica,Gneiss (4 samples)	K/Ar	519 - 680
			Nabati intrusive	Rb/Sr	573 ± 72
			Nabati intrusive	K/Ar	584
Location not specified			Paragneiss (Kurmut Series)	Rb/Sr	757 ± 29
Location not specified			Granite Gneiss (Rahaba Series)	Rb/Sr	874 ± 33
2. Southern Red Sea Hills, Sudan (Vail, 1976)					
West of Erkawit	$18^{o}48'$N	$36^{o}06'$E	Microgabbro	K/Ar	662 ± 14
NE of Erkawit	$18^{o}47'$N	$37^{o}08'$E	Microgabbro	K/Ar	663 ± 14
South of Erkawit	$18^{o}45'$N	$37^{o}06'$E	Microgabbro	K/Ar	654 ± 14
West of Barasit	$18^{o}34'$N	$36^{o}32'$E	Granite	K/Ar	637
South of Barasit	$18^{o}34'$N	$36^{o}40'$E	Diorite	K/Ar	576
North of Kass	$18^{o}30'$N	$36^{o}05'$E	Granodiorite	K/Ar	756
North of Kass	$18^{o}26'$N	$36^{o}05'$E	Granite	K/Ar	541
Tohamiyan	$18^{o}20'$N	$36^{o}32'$E	Schist	K/Ar	570 ± 22
NNE of Haiya	$18^{o}19'$N	$36^{o}16'$E	Granite	K/Ar	634
Southeast of Kass	$18^{o}15'$E	$36^{o}13'$E	Adamellite	K/Ar	562
NW of Imasa	$18^{o}08'$N	$36^{o}37'$E	Granite	K/Ar	586
North of Imasa	$18^{o}04'$N	$36^{o}04'$E	Andesite	K/Ar	763
East of Imasa	$18^{o}02'$N	$36^{o}34'$E	Diorite	K/Ar	745
West of Imasa	$18^{o}02'$N	$36^{o}06'$E	Gneiss	K/Ar	786
Imasa Station	$18^{o}00'$N	$36^{o}11'$E	Trachyte dyke	K/Ar	623
J. Hamlab	$17^{o}51'$N	$36^{o}08'$E	Amphibolite	K/Ar	570 ± 22

Cont...,

<u>Table 6 (cont'd)</u>

3. <u>Red Sea Hills, Sudan</u> (Vail, 1976)

Sol Hamid	22°14'N	36°02'E	Gabbro	K/Ar	450	
SW of Halaib	22°05'N	36°40'E	Diorite	K/Ar	662	
N.of Fodikwan	21°58'N	36°40'E	Granite	K/Ar	594	
Bathol.Granite	21°55'N	36°10'E	Granite	Rb/Sr	545	± 54
SW of Fodikwan	21°32'N	36°35'E	Diorite	K/Ar	639	
NE of Sofeya	21°25'N	36°39'E	Granite	K/Ar	722	
K.Mafdeib	21°15'N	36°20'E	Granodio-rite	K/Ar	738	
NE of Todor	21°14'N	36°12'E	Diorite	K/Ar	684	
SW of Gebeit	21°00'N	36°12'E	Gneiss	K/Ar	554	
SW of Gebeit	21°00'N	36°12'E	Granite	K/Ar	583	
J.Hamashaweb	20°40'N	37°00'E	Dolerite	K/Ar	740	± 80

4. <u>Egyptian Sector, Area of Integration</u>*

Aswan Station	24°00'N	32°53'E	Granite	Rb/Sr	590	
Aswan	23°58'N	32°50'E	Granite	Rb/Sr	600	± 20
Abu Swayel	22°50'N	33°43'E	Rhyolite	Rb/Sr	654	
Wadi Nagib	22°49'N	33°44'E	Granite	Rb/Sr	890	
Wadi Nagib	22°48'N	33°43'E	Green-stone	Rb/Sr	856	
Abu Swayel Mine	22°47'N	33°38'E	Schist	Rb/Sr	1195	
Bir Haimur	22°43'N	33°46'E	Rhyolite	Rb/Sr	665	
Um Shilman	22°40'N	33°34'E	Adam - ellite	Rb/Sr	605	
Wadi Haimur	22°40'N	33°28'E	Schist	Rb/Sr	1293	
Um Krush	22°39'N	33°43'E	Diorite	Rb/Sr	980	
Um Gerait	22°10'N	34°00'E	Meta-andesite	Rb/Sr	938	
Wadi Abu Agag	24°00'N	33°03'E	Mica, Porphyritic Granite	K/Ar	570	
Aswan	24°05'N	32°53'E	Biotite, Granite	K/Ar	570	
Aswan	24°05'N	32°53'E	Granite	Rb/Sr	586	± 37

5. <u>Red Sea Hills, Egypt</u> (Hashad, 1980)

Wadi Nugrus	24°40'N	34°47'E	Zircon grains Psammitic Gneiss	U/Pb	1770	

Cont...,

Table 6 (Con'd)

Wadi Nugrus	24°42'N	34°50'E	Schist	Rb/Sr	1200
Bir Um Khariga	25°00'N	34°50'E	Rhyolite	K/Ar	670
Um Samiuki (Hammamid)	24°25'N	35°05'E	Rhyolite Porphyry	K/Ar	825
Um Samiuki (Hammamid)	24°15'N	35°05'E	Galena, Rhyolite	Pb/Pb	1078
Hafafit Mine	24°45'N	34°30'E	Mica, Gneiss	K/Ar	456-510
Wadi Nugrus	24°40'N	34°47'E	Biotite) Psammitic Gneiss	K/Ar	584-695
" "	" "	" "	Biotite) Psammitic Gneiss	K/Ar	592-612
" "	" "	" "	Amazonite) Psammitic Gneiss	Rb/Sr	763
" "	" "	" "	Biotite) Psammitic Gneiss	Rb/Sr	601
" "	" "	" "	Psammatic Gneiss	Rb/Sr	620-725
Wadi Shaiit	24°37'N	34°05'E	Plagiogranite (Shaiitian Granite)	K/Ar	400
Um Kebash	24°48'N	34°15'E	Trondjhemite	K/Ar	450
SW Jebel El Muwelha	24°50'N	34°15'E	Grey Granite	K/Ar	500
Wadi Shaiit	24°37'N	34°05'E	Quartz Diorite	Rb/Sr	876
Um Aud	24°50'N	34°42'E	Quartz Diorite	Rb/Sr	900
Wadi Um Kheran	24°40'N	34°45'E	Pink Granite	Rb/Sr	589
Wadi Um Kheran	24°40'N	34°45'E	Mica, Pegmatite	Rb/Sr	593
Wadi Hafafit	24°40'N	34°27'E	K-Spar,Pegmatite	K/Ar	495
Jebel El-Nuhud	24°32'N	34°25'E	Pegmatite	K/Ar	590
Jebel Mulweilha	24°50'N	34°00'E	Mica, Granite	K/Ar	620

(* From El Shazly et al, 1973; Hashad, 1980; Meneisy and Lenz, 1982)

Refer to Figure 25 for the location of geochronology collection areas.

Initial Sr isotope ratios suggest that the Older Granitoids (900-1000 M.a.) are derived from mantle sources with limited crustal contaminations, while the Younger Granitoids (605 M.a.) are of mixed mantle/crustal origin. The alkaline ring complexes and volcanics (80-150 M.a.) are mantle-derived in a tensional environment (Hashad, op. cit.).

Red Sea Hills, Egypt (5)

In the Red Sea Hills of southeastern Egypt, an early Proterozoic age of 1770 M.a. (U/Pb determination) is reported by Hashad (op. cit.) from detrital zircon grains separated from psammitic gneiss in the Wadi Nugrus area; a schist from the same area gave 1200 M.a. (Rb/Sr determination). Biotites from these psammitic gneisses showed K/Ar ages of 584-612 M.a., and Rb/Sr determinations on biotite and whole rock returned 601-725 M.a. These Pan-African event ages are evident in other rocks, notably the pegmatites. There is also evidence of the synorogenic granitoid age range, as for example in quartz diorites (876-900 M.a.) and rhyolitic rocks up to 1078 M.a.

Conclusions

While there is some measure of correlation between the geochronological results of the Egyptian Sector and those on samples from the general surrounding region, the Rb/Sr determinations in the former have proved more useful in at least partially penetrating the Pan-African event overprinting of the Precambrian rocks. Most of these rocks are much older than the datings indicate and have been involved in metamorphic processes that began more than 1000 M.a. ago.

All investigators agree on the "reconnaissance" nature of the region's previous geochronological undertakings reviewed in this report. The entire Sudanese Sector, with its wide range of Precambrian rocks, remains uninvestigated, and it is concluded that a systematic, professionally executed geochronological study of the Sudanese Sector and parts of the Egyptian Sector would elucidate and more accurately define lithostratigraphic divisions. This would lead to a better understanding of the geology and metallogenesis of the Precambrian rocks of the area. The study should be coordinated with EGSMA and GMRD in view of intended geochronological studies by foreign survey/university groups.

MINERAL OCCURRENCES

Introduction

Mineral and quarry stone occurrences known in the Area of Integration are described in this section. Their locations, where documented, are shown on Plate II, and a descriptive tabulation appears in Appendix G.

In the Egyptian Sector, the known precious and base metal occurrences are of gold (12), copper-nickel (1) and copper (1). In the Sudanese Sector, Geosurvey (1984) shows map locations of 106 gold occurrences; other occurrences are of copper-gold (1) and copper (3). The gold occurrences in the Area of Integration include four large abandoned lode mines: Um Garayat (in Egypt), and Um Nabari, Duweishat and Abu Sari (in Sudan).

It should be noted that the highly prospective Wadi Naba area in the eastern Sudanese Sector is reported under Gold-Copper. Figure 26 shows the locations of the 12 gold occurrences found in the Egyptian Sector.

As a result of insufficient field time or the lack of accurate map locations, all the gold occurrences reported by Geosurvey (op. cit.) in Sudan were not found. In the large gold areas in the eastern third of the Sector, field examinations were strictly cursory in order to cover as much ground as possible, and individual occurrences remain to be properly described and evaluated during subsequent investigations. Many of them are small, unimportant family-size diggings, in large part placer-type, that do not merit a second look. On the other hand, it is expected that some additional ancient prospects will be found in the course of future field operations.

Gold - Egyptian Sector

Um Garayat

Introduction. The Um Garayat (Qareiyat/Garaiat/Garaiart) gold prospect, one of the famous ancient mines known in the southwestern part of the Eastern Desert, is immediately north of Wadi El Allaqi at 22^{o} 34' N and 33^{o} 23' E, in an area characterized by moderately high, hilly terrain (see Figure 26). It was visited by the UNDTCD technical adviser and by GMC field personnel in October 1984 and again by a GMC field party in December 1984. As a detailed investigation of the mine has recently been made (Sabet, et al., 1983), further work was not undertaken in this Preparatory Assistance stage of the project.

Previous Work. The mine was worked to a depth of 30 m by ancient Egyptian miners (Hume, 1937). Deeper modern mining was carried out off and on from 1901 to 1950. In the late 1970s, EGSMA geologists mapped the area at a scale of 1:100,000 (Mansour, 1979). The mine and its adjacencies were the object of geochemical prospecting-exploration carried out jointly by EGSMA and the High-Dam Lake Development Authority at Aswan in 1982-1983 (Sabet, et al., op. cit.). This report is on file at the GMC offices.

Geologic Setting. In most part, the general area is underlain mainly by a series of metavolcanic rocks and subordinate metasediments. From detailed geological and geochemical prospecting of the ancient mine and of a 10 sq km area surrounding it (Sabet, et al., op. cit.), the following rock types were identified: graphite schist, metamudstone, metaandesite, metaandesitic tuff, metarhyolite, metarhyolitic tuff and metagabbro. On the satellite imagery, these rocks show a distinctive rock fabric or texture over a relatively wide area designated North Wadi El Allaqi (see Figure 29). This predominance of metavolcanic rocks suggests the possible presence of a volcanic pile. It is noteworthy that no intrusive rocks have been identified in the general area.

Mineralization. There is evidence of widespread pitting over the entire area and of placer workings to the west and northwest. Quartz vein extraction was by shafts and pits, which show surface orientation along two directions: north-south in the northwest part of the area and north-northeast in the central part.

Based on reports dating back to 1902, the main quartz vein strikes N 09° E and for the greater part of its course is found between graphitic schist and a dyke that dips 60°-80° SE. The vein is a bluish white quartz, locally ferruginous, with an average thickness of 0.62 m and a maximum of 1.85 m. Ore values were enhanced where the dyke transects the vein.

Early reports describe the gold mineralization as irregular, occurring as nests, pockets and columns. The largest nest-shaped gold concentrations were 30-40 m below the surface. Auriferous veins were 4.5-15 m thick, with rich concentrations separated by low-grade to barren quartz. The gold content ranged from 7.75-155.5 g/t, with average values on the order of 12.1-13.7 g/t. In the upper levels, the vein averaged 0.76 m in thickness and 10.85 g/t. The ratio of silver to gold was 1:6.5 (Hume, 1937).

The vein was worked at depth from eight inclined and vertical shafts, with levels driven at 32.6 m and 96 m. The length of the underground workings reached 2100 m. The vein was followed for 500 m along strike and to 152 m down dip.

Reports show that an unusual supply of water issued from a fissure at the rate of 900 l/h, but that it did not pose a problem in the mine.

Assay Results (Sabet, et al., op. cit.). On the basis of atomic absorption analysis with a 0.1 g/t Au detection limit, only two of 1031 samples collected by Sabet, et al. on a 100 x 100 m grid contained anomalous gold values. Of 582 samples collected on an 80 x 20 m grid, seven contained gold between 0.2 and 7.2 g/t. The main lode zone was investigated by a series of 39 trenches having a combined length of 850 m. Nine of the 766 trench samples collected showed a gold content ranging from 0.4 to 2.0 g/t. Unfortunately, the analytical detection limit was too high for use in evaluating potential source rocks and low-grade alteration zones. For this, an analytical method offering ppb accuracy is necessary and is recommended for future work.

In the geochemical work, gold pathfinder elements, such as arsenic, mercury and antimony, were not detected. As with gold, the detection limit could be too high, and in the search for pathfinder elements, very subtle anomalies should be considered.

A total of 33 pits were dug and sampled to evaluate the placer gold potential of the three drainages adjacent to the main lode zone. Seven of these pit composites contained 1 to 7 grains of gold. The non-magnetic fraction of the alluvial material contained gold, zircon, rutile, pyrite, chalcopyrite, malachite, azurite and wulfenite.

The heaps of tailings relating to previous mining were calculated at 33,944 t. Analyses of 21 composite channel samples from these tailings gave values ranging from 1 to 7 g/t Au and averaged 3.5 g/t Au, for a total tailings gold content of 127.6 kg.

Conclusions. It is difficult to make any reliable vein ore estimates. But in view of the values produced, the size of the area and the favourable host rocks, it is reasonable to conclude that additional gold can be developed in the underground workings and that there is a potential for undiscovered vein gold in the general area, with grades approximating those already produced. Also, with analytical methods offering ppb accuracy, there is justification for additional geochemical work using Au and the pathfinder elements As, Hg and Sb in a search for geochemical haloes that could relate to one or more volcanic piles or plutonic bodies in the area, or to alteration zones indicating undiscovered, near-surface auriferous veins.

Nile Valley Block E

Introduction. Nile Valley Block E is centered at 22^{o} 36' N and 33^{o} 20' E, northwest of and adjacent to the Um Garayat gold prospect. The far northwestern shaft of Um Garayat is a kilometre or less distant, and mine access roads for that prospect are on the eastern side. It is in the northwestern part of the North Wadi El Allaqi target area (Figure 29).

GMC geologists visited the area in mid-November 1984 to reconnoitre the prospect and collect representative samples for gold analysis.

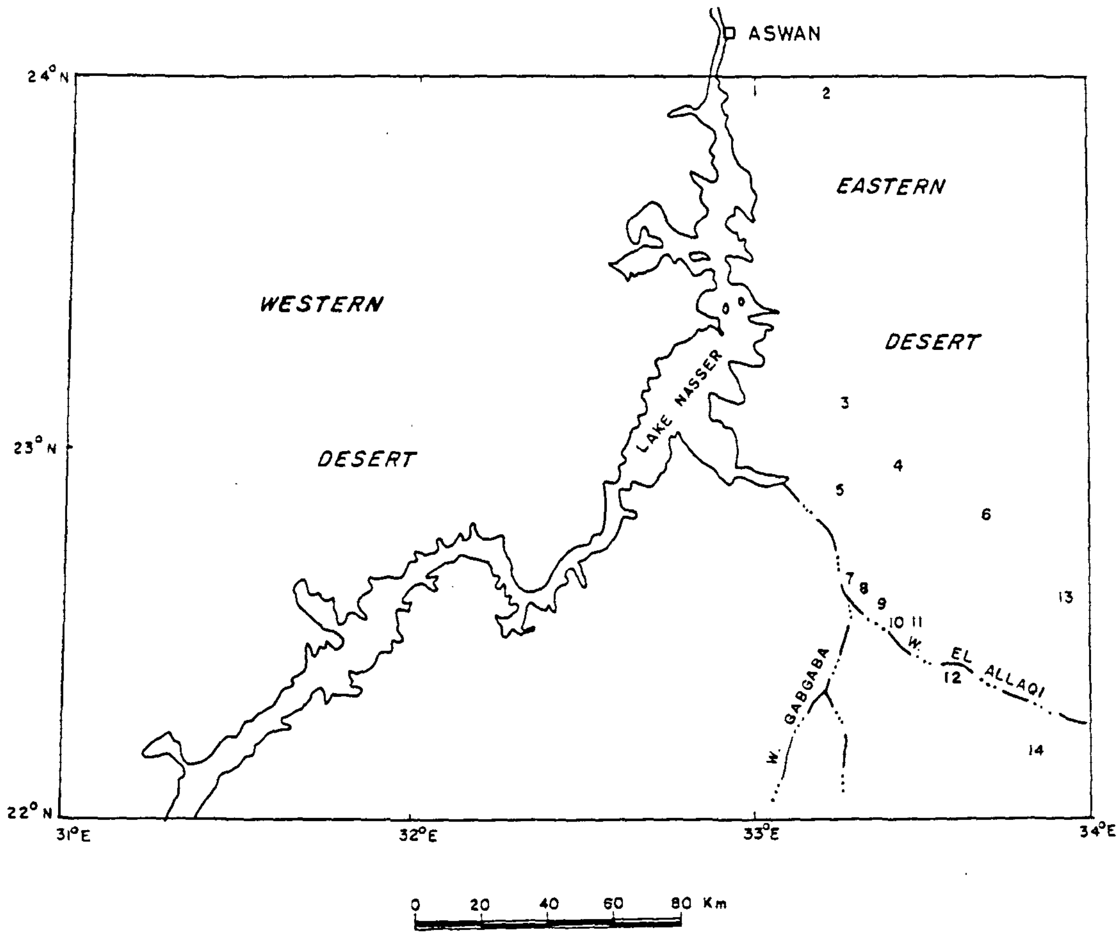
This is an area of high hills dissected by a narrow, nearly concentric drainage system that trends to a rectangular pattern towards the west. The general prospect covers about 12 sq km.

Previous Work. There are about 200 ancient dwelling sites in the northern part of the area, which would attest to extensive mining activity in Pharaonic times. The presence of modern-type dwelling ruins suggests some concurrent work at this prospect and at Um Garayat in the early part of this century, reportedly before World War I.

Hume (1937) gives a short account of the occurrence, and Sabet (1978) summarizes the previous work. In the late 1970s, EGSMA geologists mapped the area at a scale of 1:100,000 (Mansour, 1979).

Geologic Setting. The central part is underlain by dark green, compact basic metavolcanics. These become more acidic towards the east and have some intercalations of metasediments towards the west. The rocks strike N 40-60° W and dip 60-80° NE. No plutonic rocks are in evidence in the district.

Mineralization. The prospect contains probably the most extensive placer areas found within the Area of Integration. The paucity of vein quartz is noteworthy. There are broad side-hill areas where placer work has been carried out in colluvial/eluvial material and where the only conceivable gold source rock has been metatuff.



1. Kurtuns
2. El Hudi
3. Um Ashira North
4. Hariari (Um Araka)
5. Um Ashira South
6. Neqib
7. Haimur
8. Nile Valley Block E
9. Um Garayat
10. Marahik
11. Atshani
12. Filat
13. Murra
14. Abu Fass

Fig. 26. Gold Occurrences, Egyptian Sector.

There are ancient excavations in brown, altered metatuff in the eastern part of the prospect. Where present, quartz veins are small and discontinuous, more or less accompanying the foliation of the country rock. The strike ranges from N-S to N 34^{o} E, with dips 75-80^{o} E.

The quartz is mostly in small veinlets and is locally hematitic or smoky. The host rock is usually jointed and is highly weathered.

In one locality where quartz veins have been exploited, there are eight trenches ranging 2-12 m in length, six inclined shafts 3-10 m in depth, accompanying the east-dipping vein, and one 10 m vertical shaft.

Assay Results. Two samples showed anomalous gold values:

Sample No. 1513 - alluvial material, 0.330 g/mt
Sample No. 1518A - alteration zone, 1.20 g/mt

Conclusions and Recommendations. This occurrence may be considered as an extension of the Um Garayat prospect mineralization and should be included in any further investigation to be undertaken in that area.

Haimur

Introduction. This ancient gold mine is at 22^{o} 38' N and 33^{o} 18' E, close to the junction of Wadis Haimur and El Allaqi, about 10 km northwest of the Um Garayat gold prospect. It is about 2 km northwest of Wadi Haimur proper and near the northwestern extremity of the North Wadi el Allaqi target area (Figure 29).

Wadi Haimur is the largest northern tributary of Wadi El Allaqi in the general area. The moderately high hills that typify the area are covered by gray aeolian sand near the mine.

A GMC field team visited the area in November and December 1984.

Previous Work. Haimur appears to have been one of several mines along Wadi El Allaqi and its tributaries, called the region of Akita, that produced gold in the Nineteenth Dynasty (Trigger, 1976). But some excavations are apparently attributable to work in the early part of this century by the same interests that mined at Um Garayat and Nile Valley Block E.

The geology of the area of occurrence has not been mapped.

Geologic Setting. Acidic metavolcanic rocks predominate in the area, especially in the western and northern parts; basic matavolcanics are more dominant eastwards. Metasedimentary rocks forming low hills surround the acidic metavolcanics in the west. Foliation in the metavolcanics trends north-south, and the rocks display jointing and shearing. The area is folded and cut by a number of faults, notably the east-west trending Haimur fault and one trending northeast.

Mineralization. The old workings are on a single hill, and the host rocks are mainly highly silicified metavolcanics rich in iron oxides and quartz, feldspar, biotite and chlorite.

Three inclined shafts have been excavated at the foot of the hill in the southern part of the working area. One accompanies the footwall of the mineralization, which strikes N 55° E and dips 55° SW. A second one follows the hanging wall, which flattens to a 30° SW dip. The third shaft has no visible contact with the mineralization. At the working face, the vein is composed of milky quartz and is 20-40 cm thick.

Two parallel ore bodies similar in strike have been worked from the western side of the hill by two adits, an inclined shaft and a system of trenches and pits. The thickness of the veins varies along strike from a few centimetres to one metre.

Assay Results. Of 21 samples collected from the prospect, those listed below returned significant gold values:

Sample No. 554 - quartz vein, >10 g/mt
Sample No. 555 - rock sample, 0.740 g/mt
Sample No. 558 - rock sample, 0.370 g/mt
Sample No. 559 - rock sample, 0.240 g/mt

Conclusions and Recommendations. This prospect shows evidence of extensive mining in ancient and recent times. The assay values indicate it and its adjacencies to be a target warranting further work. Detailed mapping and sampling of the workings may provide justification for a limited amount of drilling. A geological/geochemical survey of the surrounding area can also be recommended. The absence of old workings in the southern part of the hill lower than the first adit is noteworthy.

Other Gold Occurrences

In addition to the Um Garayat, Nile Valley Block E and Haimur gold prospects, nine other occurrences were investigated in the Egyptian Sector during the 1984 field season. These are listed below, together with coordinates, host rocks, sample results worthy of note and conclusions. Figure 27 shows their map locations in relation to the above three prospects. Individual GMC internal reports on these occurrences contain a 1:40,000 scale sample location map based on aerial photographs for each of these occurrences.

1) Abu Fass

Coordinates: 22° 08'N, 33° 52' E

Host Rocks: acidic metavolcanites

Assay Results: 513 - quartz vein, 0.84 g/mt
517 - quartz stringers in alt. zone, 0.77 g/mt
520 - alteration zone, 0.24 g/mt
522 - alteration zone, 1.40 g/mt

Conclusions: With some positive assay results and several quartz veins in the area, further work of second priority rating appears justified.

2) Atshan

Coordinates: 22° 34' N, 33° 33' E

Host Rocks: acidic - basic metavolcanites

1502 - alteration zone, 0.51 g/mt
1503 - quartz vein, 0.24 g/mt
1504 - alteration zone, 0.62 g/mt
1509 - stream sediment, 0.11 g/mt

Conclusions: Prospect justifies more field time on low priority basis.

3) El Hudi

Three locations of old workings in one area.

Coordinates: 23° 57' 50" N, 33° 08' E
23° 57' 30" N, 33° 08' 30" E
23° 58' N, 33° 11' 30" E

Host Rock: pluton/gneiss-metasediment contact

Assay Results: Assays are pending.

Conclusions: No further work recommended.

4) Filat

Coordinates: 22° 18' N, 33° 37' E

Host Rocks: metasediments and basic metavolcanites intruded by gabbro bodies; later cut by acidic dykes

Assay Results: 5 rock and alluvial samples - trace values only

Conclusions: No further work recommended.

5) Harairi

Coordinates: 22° 57' 30" N, 33° 27' 30" E

Host Rocks: basic-acidic metavolcanites; diorite

Assay Results: 1550 - alteration zone, 3.70 g/mt
1551 - alteration zone, 0.27 g/mt

Conclusions: As the area of interest is comparatively large, a more detailed investigation may be considered in due course, but without assigned priority at present.

6) Marahik

Coordinates: 22° 30' 30" N, 33° 27' E

Host Rock: metaandesite

Assay Results: 505 - alteration zone, 0.21 g/mt
506 - quartz vein, 2.80 g/mt
507 - alteration zone, 0.16 g/mt

Conclusions: No further work at the prospect site itself is recommended, but a geological/geochemical survey of the area could be considered if resources permit.

7) Murra

Coordinates: 22° 34' N, 33° 35' E

Host Rocks: metasedimentary-metavolcanic rocks

Assay Results: 1522 - stream sediment, 0.60 g/mt
Other samples - trace values only.

Conclusions: Further work is not recommended; but in view of the fact that the quartz veins indeed appear to be mostly unmineralized, the source of the gold in the placers merits consideration.

8) <u>Neqib</u>

Coordinates: 22° 48' N, 33° 43' E

Host Rocks: basic-acidic metavolcanites

Assay Results: 1529 - small quartz vein, 1.70 g/mt
1530 - alteration zone, 2.60 g/mt
3 other samples - trace values only

Conclusions: As this is a relatively small placer with no interesting quartz veins, no further work is recommended.

9) <u>Um Ashira</u>

Two locations: North - 23° 08' N, 33° 16' 15" E
South - 22° 54' N, 33° 15' E

Host Rocks: acidic metavolcanites

Assay Results: 1555 - quartz vein remnant, >10.0 g/mt

Conclusions: Despite the high value of one sample from an extracted vein in the North area, there is no abundance of quartz veins in this relatively small area that would encourage giving priority to further work. The preponderance of placer workings and only minor vein extraction in the South area are likewise not especially encouraging.

Gold - Sudanese Sector

Um Nabari

Introduction. As the major gold prospect in the Area of Integration, Um Nabari (Umm Nabardi) was selected for detailed investigation in order to obtain first-hand knowledge of the prospect in initial evaluation work, with the expectation that this knowledge could be applied in the evaluation of other gold occurrences in the Area of Integration.

The mine area was visited in April 1985 by UNDTCD consulting field geologist Richard Savard, in company with GMC geologists and the Project Co-ordinator. A comprehensive report (Savard, 1985) was subsequently written, which includes informative maps showing mine detail and sample locations.

Um Nabari is at 21°07'24" N latitude and 32°46'08"E longitude, 156 km southeast of Wadi Halfa. It is 62 km cross-country to the east-southeast of No. 4 Station on the Wadi Halfa-Khartoum railway, and 48 km to the north-east of No. 6 Station by desert track. The mine area covers about 1.2 sq km.

The area is characterized by low rolling hills and hillocks, with a maximum relief of 70 m, and by interspersed flat-lying areas covered by typical desert reg deposits. Little khors, or dry stream beds, some of which are structurally controlled, run between hills and converge to larger wadis.

Vegetation is limited to sparse trees of the palm and acacia families, restricted to large wadis where their alignment, presumably coinciding with fault planes, could indicate the presence of underground water.

Previous Work. In ancient times, Um Nabari probably ranked as the most active and productive gold mining centre in northern Sudan. Both lode and placer mining activity are in evidence. Quartz veins and associated alteration zones were selectively mined, both superficially and at depth through narrow, sinuous caverns and shafts of irregular shapes that followed the veins. Depths of 40 m were reached.

Colluvial/eluvial mining was performed on the flanks of hills attributable to quartz veins, and through superficial digging and deeper trenching and pitting. Alluvial mining was carried out in a large area west of the mine and in small khors in the general area, as evidenced by the familiar hummocky placer workings.

In recent times, prospecting of Um Nabari started in November 1901 by Sudan Gold Field Company Limited (SGF), a London-based company that held concessions and mining leases on the area from 1901 to 1919. Serious mining commenced in 1906. The mine was developed in accordance with Cornish custom, with levels 120 ft (37 m) apart. Access to lower levels was by vertical and inclined shafts and related crosscuts. Only veins in excess of 9 inches (23 cm) were stoped. The mine was connected to No. 6 Railway Station by a 48 km light-gauge railway, and a water supply was established from two distant wells.

Geologic Setting. The satellite imagery shows a distinctive rock fabric or texture in the Um Nabari area, outlined in Figure 30, reminiscent of that observed in the

North Wadi El Allaqi area (Um Garayat gold prospect) and in portions of the Wadi Naba area.

The area is mainly underlain by a series of low-grade metamorphosed volcano-sedimentary rocks, and in the immediate mine area these have been intruded by igneous rocks of porphyritic texture.

The metasedimentary members consist of a complex series of intercalated and gradational micaceous, chloritic or felsic schists, slates, shales, quartzites and marbles. The metavolcanites are mainly acidic and include rhyolites and felsites. Regional (greenschist) metamorphism and deformation make lithological distinction difficult. Generally, the series strikes northeasterly.

In mine reports, the igneous intrusion is variously described as an acid porphyrite, quartz diabase and porphyritic microdiorite, and is said to be both foliated and non-foliated, sheared or unsheared, and commonly chloritic. These rocks evidently occur both in the mine and to the north and west of the mine area.

Early reports record faults with northeast-southwest and east-west strikes in the mine area.

Mineralization. Three main auriferous reefs, or veins, have been identified and variably exploited: a major Main Reef and Northern and Southern reefs. These have a general eastwest trend, with local off-shoots and variations.

In plan, the Main Reef is shallowly arcuate over a strike distance of about 800 m. In its western part, it strikes N 40° E and dips 85° S, then arches eastward, striking E-W and dipping 55^{o} S in the eastern part. Vein widths range from a few centimetres to 5 m, averaging about 0.6 m. The mineralization includes native gold, arsenopyrite and disseminated and massive pyrite. Some of the gold is bound up in pyrite and is not free-milling. Pyrrhotite is reported to be in the country rock. Gold values are variable; it is commonly 10-15 g/t, judging from samples taken from quartz heaps around shafts. Rich values are not unusual: 2-4 oz/t over widths up to 1 m have been cited. Values occur over the entire length of the main reef. Alteration zones are generally not pervasive and are limited to about 0.25-0.5 m widths. They carry generally low gold values (e.g. 0.9 g/t). The ancients mined the Main Reef to depths up to 40 m, and Dunn's report of his 1907 visit (Dunn 1911) states there was no stoping ore above the 120 ft (37 m) level. According to SGF sections, workings by the ancients pitch 33^{o} SW at three of the four localities worked. Dunn (1911) reports that the 120 ft (37 m) level encountered old workings at many points.

The Northern Reef veins are mostly concentrated in the "Red Hill" area of the mine. They show a strike length of around 400 m and dip at both shallow and steep angles to the north and south, reflecting the highly folded nature of the veins, and form saddle reefs and basin structures in this area. Some zones were very productive, with values such as 41 g/t Au over a 1.27 m width.

There was less prospecting activity on veins of the Southern Reef, where mining has been limited to one locality. The combined strike of veins here is 1.5 km; widths range up to 5 m. Vein and quartz-heap samples returned values as high as 18 g/t but averaged considerably less.

Little surface work has been undertaken to investigate the lateral extensions of the vein systems. Other mineralized quartz veins are known at distances of about 1 km both northwest and southeast of the mine area. In particular, significant surface sample gold values are recorded both east and west of the Main Reef, east of the Northern Reef (Red Hill) and at the northwest locality.

Old reports record: 1) gold is most abundant where the quartz is granulated and contains sulphides; 2) there is improvement at depth in vein width and quality; 3) blue vein quartz usually contains the best gold values; 4) the veins were introduced after the foliation (i.e. deformation) period, with some veins cutting across foliation but taking advantage of shear areas; and 5) the source lies to the northwest of the mine area where the greatest concentration of veins occurs. It is noteworthy that recent surface geological observations include the occurrence of a porphyry intrusion north and west of the mine.

Mine Workings and Installations. Savard (1985) records a total of 41 inclined and vertical shafts of various sizes, depths and purposes in the mine area. Some were exploration shafts in lieu of drilling. The Main Reef workings were serviced by 13 vertical and inclined main and air shafts extending from the surface, and a somewhat greater number of underground prospect/development shafts.

There is a concrete water reservoir, 10.7 m in diameter with a 450,000 litre capacity, still in a perfect state of preservation.

A large number of ruined dwellings and mine and mill buildings attest to an organized mining effort in the early part of the century.

Production. During 23 reported production months in the period 1908-1912, 26,637 t of ore were milled, yielding 15,495 oz Au, or 18.1 g/t. The best production period was in August 1912, when 186 t of ore yielded 611 oz Au, or 102 g/t. Production records for the six-year period 1913-1918 show 131,467 t of ore milled, yielding 74,809 oz Au, or 17.7 g/t. In the same period, 109,148 t of tailings and 1,535 t of slimes were processed to yield 9,485 oz Au, or 2.7 g/t.

The bulk of the production was obtained from the Main Reef, where, at the time of the visit by the Government geologist S. C. Dunn in 1907 (Dunn, op. cit.), the 120 ft (37 m), 240 ft (73 m), and 360 ft (110 m) levels had in most part been driven the full length of the reef. Development on the 480 ft (146 m) level followed. One of the main shafts (Llewellyn's) was apparently sunk to a depth of 700 ft (213 m), but records are not clear on the work done below the 480 ft (146 m) level.

Important production, including some very high-grade ore, was also obtained from the Northern Reef section of the mine, connected by a crosscut from the Main Reef workings and also served by shafts from the surface. Lesser tonnages were taken from the Southern Reef. In total, possibly more than 200,000 t of ore, with an overall average grade probably in excess of 20 g/t Au, were milled during the 1906-1919 operations. A ten-head stamp mill was used for crushing the ore.

Cyanide treatment of tailings was later established, followed by slimes treatment, which was just starting when the mine closed. Records indicate some 34,000 t of slimes remaining untreated, with an average grade of about 2 g/t Au. Untreated tailings amount to about 160,000 t, possibly averaging around 0.6 g/t Au.

Until the last few years of the mine, development was generally two or more years ahead of production. But by 1917-1919, the high operating costs resulting from wartime conditions, combined with labour and other difficulties, led to reduced reserves and ore grades, stoppage of development work, depletion of funds, discouragement of investors and closure of the mine.

Assay Results. Sixty-two samples were collected for assay: 37 from quartz vein and stringer zones, 19 from alteration zones, 5 from mine dump gangue material, and 1 rock sample.

Ten of the 30 quartz vein channel samples assayed between 1.9 and 12.0 g/mt Au and gave a weighted average of 1.18 m in thickness and 5.35 g/mt Au. The best assay value was 12.0 g/mt Au on a 3 m quartz vein in the southwestern part of Hill No. 2.

Of the seven stringer zones sampled (quartz veinlets in altered host rock), the average (arithmetic) grade was 2.45 g/mt Au. Stringer zones most consistently carry good values.

Hanging wall and footwall alteration zones range from 5 cm to 1 m in thickness and may be higher or lower in grade than the enclosed quartz vein. In most cases, the latter applies. Seven samples of combined hanging wall and footwall alteration zones ranged from 0.008 to 1.70 g/mt Au, with an arithmetic average of 0.377 g/mt Au. Four separate hanging wall samples ranged from 0.21 to 3.70 g/mt Au and had an arithmetic average of 1.53 g/mt Au. Corresponding footwall samples ranged from 0.63 to 3.00 g/mt Au and had an arithmetic average of 1.40 g/mt Au.

Thick veins tend to have thinner, lower grade alteration zones and vice versa.

Assay results of mine dump samples near Shaft 4.4 are given below for comparative purposes:

Milky quartz with small limonite-filled fractures - 0.014 g/mt Au

Grey-bluish quartz - 0.34 g/mt Au

Pyritized grey-bluish quartz - 1.70 g/mt Au

Pyritized mine dump gangue material ranged from barren to 27.20 g/mt Au. One sample of grey chloritic schistose rock containing abundant arsenopyrite assayed at 7.70 g/mt Au, +10% As, and +10% Fe, and showed a trace of copper.

One 2.16 m channel sample from mine tailings assayed at 1.70 g/mt Au. A wind-riffled concentrate of old tailings assayed at 30.30 g/mt Au.

The assay results indicate: 1) that there are some favourable yet inconsistent surficial vein and alteration zone values; 2) that there are greater values and more potential in workings and unmined areas at depth; and 3) that both types of rock might be combined to produce a mineable reserve.

Conclusions and Recommendations. With the distance from the Um Nabari mine area to No. 6 Station on the Wadi Halfa-Khartoum Railway only 48 km, Um Nabari is the most accessible mineral prospect in northern Sudan.

The ancient miners exploited most of the richest portions of workable auriferous quartz veins from the surface to as deep as 40 m. They also worked placers in colluvial/eluvial areas adjacent to hills containing quartz vein material and altered wall rock, and in associated drainages.

The Sudan Gold Field Company Limited (SGF) mined mainly the rich vein sections of the Main Reef. Undiscovered ore shoots, as well as potentially payable stringer and alteration zones, and veins thinner than 23 cm left behind by SGF, could still be present in the mine.

In addition to placer deposits, good potential remains for economic-grade gold reserves in the form of undiscovered underground lodes in areas previously worked, lateral and depth extensions of auriferous veins and associated alteration zones, and unexposed veins. A complete investigation and evaluation of the mine, its workings and the surrounding area can therefore be strongly recommended. In the sampling and assaying of quartz veins in surface exposures, it should be borne in mind that surface values at Um Nabari are generally lower than in corresponding sectors at depth.

As far as can be determined, the mine was not abandoned because of adverse mining conditions or water problems, but rather because of greatly escalated operating costs resulting from wartime conditions, labour and other difficulties.

At the gold price prevailing when the mine closed in 1919 (Pounds Sterling 3.50/oz), reserves abandoned as uneconomic then could be payable today.

It is believed that no serious geological study has been undertaken in the mine area, and this should be a high priority requirement in any future investigation. Also, there is no evidence of surface drilling on the prospect.

Early workers at Um Nabari did not have the advantage of aerial photographs, which will give an added dimension to the geological interpretation of the mine area. Using proposed new colour aerial photography at 1:25,000 scale and a good photogeological expert, it is recommended that veins, faults, lineaments and mine workings be plotted and interpreted, together with expert structural interpretation work on the ground, in the search for structural control and intersections not previously recognized, which should be the targets of new exploration.

Some old reports and maps relating to exploration, development and exploitation work carried out by SGF in the 1904-1919 period have been found, but mine sample, assay and reserve data -- which are essential for calculating the remaining mine potential -- are lacking. Such data should be sought further from GMRD and perhaps other Sudanese Government offices in Khartoum, and if results are negative, an effort to find such records in London would be justified.

After studying all obtainable underground maps, etc., qualified people should enter the underground workings that are safe and accessible:

a) To map the geology and mineralization and collect necessary samples;
b) To evaluate the gold potential in remaining stopes and headings; and
c) To determine feasible access to potential work areas, utilizing existing workings where possible.

The association of arsenopyrite and gold in the mineralization is a reminder that arsenic is a good geochemical pathfinder element. Accordingly, there is justification for geochemical survey work in selected areas to search for anomalies relating to undiscovered, unexposed auriferous veins, using arsenic, antimony, mercury and gold analyses.

Judging from SGF records, no water problems are anticipated in developing any new mine, nor in establishing an adequate supply for drilling or for future mining operations. The water in the district, however, tends to be brackish.

Duweishat

Introduction. Duweishat (Doishat/Doshat/Dowshat) is an ancient mining area situated 3.5 km east of the Nile River and 62 map kilometres southwest of Wadi Halfa, at 21° 22' N and 30° 55' E. It is accessible from Wadi Halfa by travelling 70 km southwest on the road to Delgo, then 6.9 km west on an unimproved road to the old mine area.

Geological investigations were conducted at Duweishat in February 1985 by a GMC field party. A sketch map was made (Figure 27) and samples collected.

The area is mountainous; the most prominent mountain is Jebel Atiri to the northeast, reaching 460 m with its pre-Nubia or early Nubia sedimentary capping. The main part of the mine complex is in an area of relatively subdued relief within the mountains from which two dry streams drain northwesterly and southwesterly into the Nile. They divide the mine area into northeast and southwest sectors.

Previous work. Having visited the area in the early part of the century, Dunn (1917) writes unfavorably on the prospect and cites evidence of ancient mining activity at Duweishat to a maximum depth of 10 m. The proximity to the Nile probably contributed to the longevity of activity. Whiteman (1971) reports that the area was prospected by the Nuba (Sudan) Development Company in 1903 and that mining started in 1904. Mining reportedly was in moderately rich gold-bearing veins below ancient workings. No grades were reported. Dunn (op. cit.) reports it was the poverty of the ore that resulted in the abandonment of Duweishat.

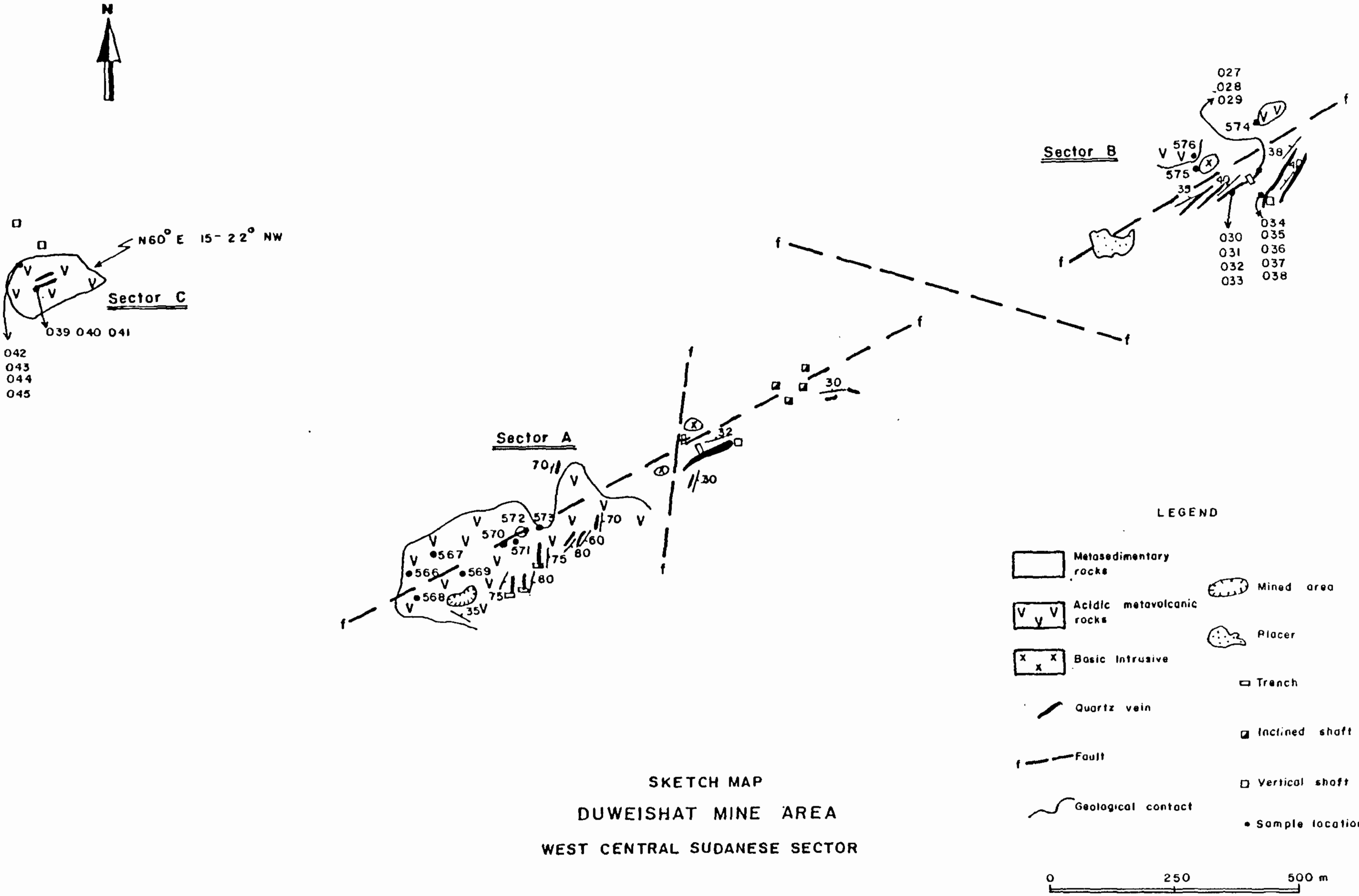
In recent times, the prospect was worked from 1951 to 1962. Bonifica (1985) reports that during this latter mining period, four different auriferous quartz veins were mined simultaneously in open pits and at depth from four shafts, numbered 1 through 4, whose depths were 170 m, 50 m, 10 m and 130 m, respectively. About 350 mine workers were employed.

Geologic Setting. The area is underlain by a variety of Precambrian Basement Complex rocks that include acidic metavolcanic and intercalated metasedimentary rocks, subordinate biotite gneiss, and minor intruded gabbroic rock. The metavolcanites, which include metatuffs, are the hosts for auriferous quartz mineralization in the southwestern sector, where there are minor interbeds of relatively unmetamorphosed grey limestone. In the northeastern sector, the observed host for the gold is a red, brown, tan and grey calcareous garnet-mica schist.

The foliation is variable but has a general east-northeast to east trend and dips 20° - 35° S. Contained quartz veins are parallel to subparallel to the foliation, with strikes and dips of N 60° E/30° NW, N 30° E/18-35°NW, and N 30° E/35° NW recorded.

Faults striking northwest, north and east-northeast were identified.

Mineralization. The gold-bearing quartz veins are lenticular and range in thickness from 0.5 to 5 m, averaging about 2 m. One prominent vein in the northeast sector has been exploited over a 360 m strike length. Two types of quartz veins occur in the area: 1) hematite-stained white quartz, investigated by ancient pits and trenches but essentially unexploited; and 2) numerous lenses of white and smoky quartz that follow the irregular foliation of the host rocks. Mine workings are concentrated in the latter veins and accompany alteration zones at three localities. Two of them are on the same N 60° E trend, interrupted by a 200 m fault displacement. The



SKETCH MAP
DUWEISHAT MINE AREA
WEST CENTRAL SUDANESE SECTOR

Fig. 27

third is about 1 km west-northwest of the southwest mine sector and has the same general strike direction. The alteration zone extends for about 25 cm on either side of the quartz veins.

Mine Workings and Installations. The mine area is divided into northeast and southwest sectors and covers an area of about 1.5 sq km. Ancient workings in most part consist of crude inclined excavations and caverns that accompany the relatively shallow-dipping veins over rather broad open-pit and shallow underground areas, which become narrow and sinuous at depth.

In the northeast sector, there are two mine buildings and one dwelling. In the southwest sector, there are two mine buildings and 23 dwellings, giving evidence of a serious, well-organized mining operation.

The work in this century has included the installation of a large crushing and grinding plant on the east bank of the Nile River, where mill buildings, a large water reservoir and nine settling tanks are on a lower level. A garage, two large houses and four other houses are on an upper level.

Assay Results. Samples numbered 027 to 043 were collected from mine sectors B and C (see Figure 27 for location and Appendix F for assay results). There were persistently low values in the hanging wall alteration zone, ranging from 0.24 to 1.10 g/mt Au. Samples from five quartz veins assayed from 0.048 (essentially barren) to 9.10 g/mt Au, with the two best values being 9.10 g/mt Au over 1.4 m in Sector B and 5.2 g/mt Au over 1.94 m in Sector C. The footwall alteration zone assayed appreciably better than the hanging wall, with values from

0.11 g/mt Au (essentially barren) to 5.00 g/mt Au. The latter is from a 25 cm zone in Sector B underlying a 4.94 m thick quartz vein with uneconomic values.

The assay results indicate: 1) that thin quartz veins generally carry better gold values than thick ones; and 2) that gold values in the footwall alteration zone are superior to those in the hanging wall. It might be noted that the highest footwall alteration zone value, 5.00 g/mt Au, underlies the thickest quartz vein in the area.

Conclusions and Recommendations. The quartz veins unpredictably pinch and swell laterally and down dip, and the gold content is similarly erratic and unpredictable. Meager sampling results suggest that thinner intervals carry higher gold values, and there are enhanced values in footwall alteration zones corresponding to thick quartz vein intervals. It is questionable whether this type of mineralization will average, say, 3.0 g/mt Au over intervals that can be blocked out as mineable for a small heap-leach operation. Other factors, such as climate and availability of water are favourable, but access is burdensome.

Although the general outlook is nebulous, there is justification for a more thorough appraisal of Duweishat based: 1) on closer-spaced sampling of exposed vein and altered wall rock intervals to disclose the continuity and overall grade of the gold mineralization at and near the surface; and ultimately 2) on some probing at depth by drilling and/or opening of abandoned shafts and inclined workings.

Abu Sari

Introduction. This abandoned gold mining area is in a hilly district 7 km east of the Nile River and of the small village of Abu Sari, in the southwestern part of the Sudanese Sector. The geographic coordinates are 20° 16' N and 30° 35' E. It was visited in March 1985 by a GMC geological field party. A sketch map was made (see Figure 28) and samples collected.

Previous Work. Ancient mining activity in the Abu Sari area included the exploitation of small quartz veins and some placer excavations.

Commencing in 1901, the area was covered by an exploration and mining concession under the name of Nuba (Sudan) Development Company. After some initial exploration work, development started on the main quartz reef in April 1904. The record is vague thereafter, but the houses, mine buildings and mine workings at the site, plus an apparent milling installation adjacent to Abu Sari village, attest to a rather extended mining effort.

Geologic Setting. The area is underlain by volcano-sedimentary rocks of the Precambrian Basement Complex that display greenschist facies metamorphism. They are strongly folded and foliated, and the contained quartz veins are elongated parallel and subparallel to the foliation, which has a general northeast strike. Bonifica consultants encountered at the mine site spoke of an adjacent, reportedly similar area west of the Nile.

Mineralization. Gold mineralization at Abu Sari is in quartz veins and lenses ranging in thickness from a few centimetres to 3 m, with a maximum length of about 450 m.

They form a zone of mineralization that trends northeast, dips 70° SE, and extends for 1.5 km. This is bisected by a northwest-trending fissure zone that could be fault-related (see Figure 28).

The contact zone between quartz veins and the host rocks shows ferruginous alteration. This zone has been mined out along with the gold veins, indicating the presence of local gold enrichment.

Mine Workings. Within the mine area, there are four vertical shafts, plus various trenches, pits and caverns that have been excavated on the outcrops of auriferous quartz veins. According to Bonifica (1985), the deepest shaft is 50 m and partly sand filled, and the shafts are probably interconnected by underground workings.

Assay Results. Samples 2601 to 2620 were collected at four vein localities (see Figure 28). Salient values are listed below:

Sample No.	g/mt Au	Description
2601	1.90	Quartz vein, NNE-trending, white, sugary
2604	1.90	Metasedimentary host rock
2607	4.00	Quartz vein, NW-trending, light grey, 1 m channel
2608	6.70	Alteration zone, NW-trending, 0.5 m channel
2612	3.40	Alteration zone, NE-trending, 0.5 m channel
2618	3.80	Quartz vein, NNE-trending, 0.7 m chip sample
2619	6.60	Alteration zone, 0.4 m channel
2620	44.90	Fragments of quartz dump material

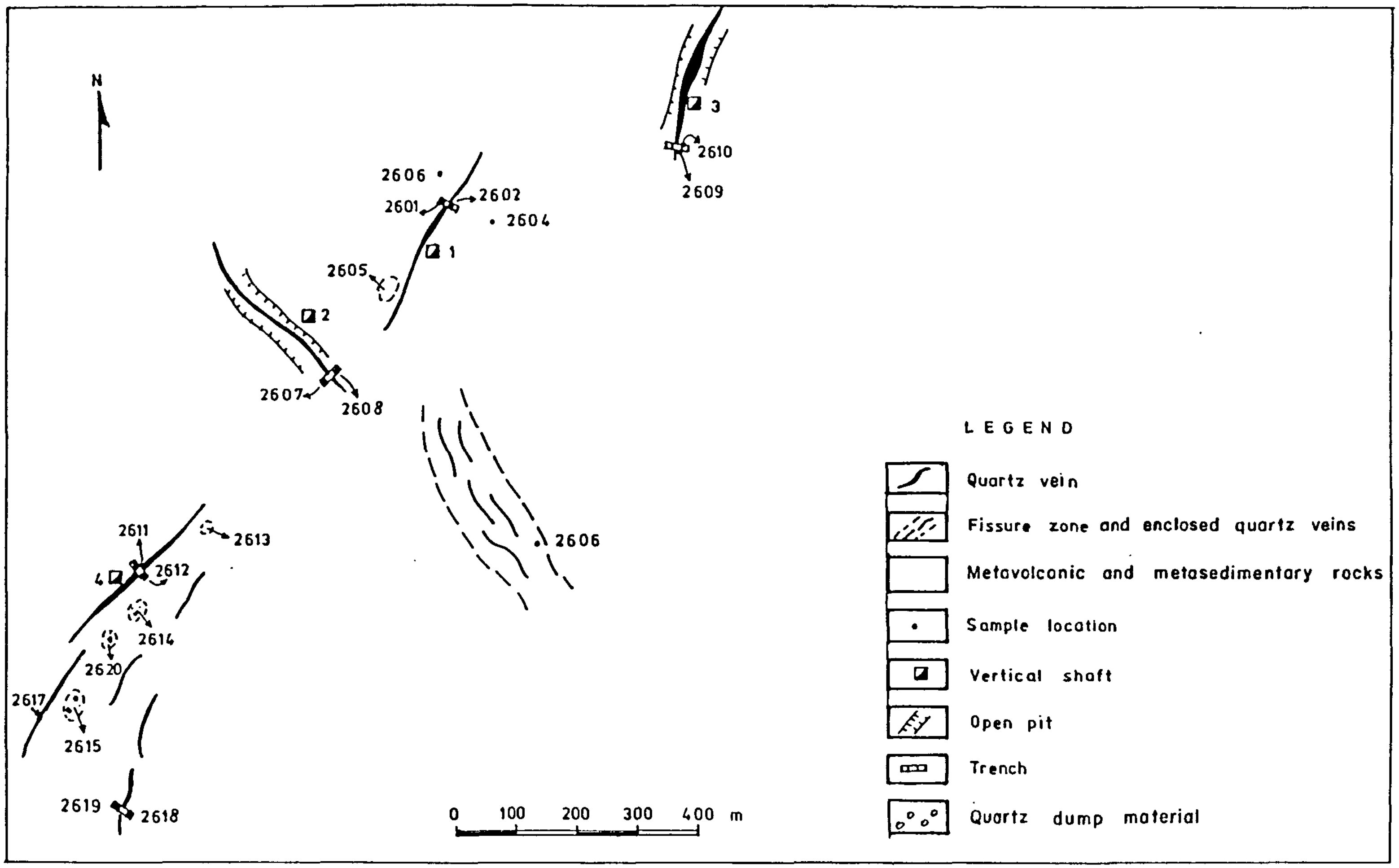


Fig. 28. Sketch map, Abu Sari mine area, southwestern Sudanese Sector.

Seven quartz veins have gold values ranging from 0.024 to 4.00 g/mt Au. Three alteration zones are 0.4-0.5 m thick and have a weighted average of 5.49 g/mt Au, which is greater than the figure for associated quartz veins. It is noteworthy that a sample of the metasedimentary host rock collected somewhat away from the fissure zone assayed at 1.90 g/mt Au. As usual, dump material showed a high gold value, indicating stronger mineralization at depth.

Conclusions and Recommendations. Abu Sari shows a gold potential that merits more detailed investigation. The adjacent area west of the Nile reportedly similar to Abu Sari warrants reconnaissance and follow-up work where applicable.

Upper Wadi Gabgaba Area

This promising 700 sq km area in the southeastern corner of the Area of Integration is underlain by metasedimentary and metavolcanic rocks of the Precambrian Basement Complex (see Plate I, Area 5). The 15 gold occurrences in the area, visited in April 1985, show abundant evidence of ancient placer mining activity in colluvial/eluvial and alluvial gravels and sands, which resulted from the mechanical weathering of a myriad of small auriferous quartz veins and stringers. These are spread all over the area like a type of stockwork. At one quartz vein superficially disturbed by the ancients, a piece of colluvial vein material containing a two- to three-gram irregular gold nugget was found. These veins could be the surface expression of a complex vein system with favourable depth potential. Consequently, the entire area merits thorough investigation/evaluation to determine vein continuity and grade.

Some salient gold assays from this area:

Sample No.	g/mt Au	Description
2628	16.60	Highly altered basic metavolcanite
2631	2.10	Sands and clays in placer area
2637	8.30	Remnant of excavated white quartz vein
2642	3.00	Remnant of small cupriferous quartz vein

Other Gold Occurrences

In addition to the two occurrences listed below, several small placer and lode prospects bordering the east side of the Nile River Valley were subjected to cursory examination during the early 1985 field campaign in Sudan, and none was found to merit further investigation. The many gold prospects situated in the eastern part of the Sudanese Sector are in most part included under the Upper Wadi Gabgaba Area (gold) and the Wadi Nuba Area (gold-copper).

Sarras Gold Area. This abandoned gold area is situated about 2 km east of the confluence of Wadi Ahmed Sherif and the Nile River, near the area generally known as Sarras East. The coordinates are 21° 33' N and 31° 05' E. According to Bonifica (1985), who had helicopter access to the area, there are at least five different main workings and several very small workings, all relating to milky quartz bodies and partly excavated by trenches and caverns.

Only one small prospect, located on the north side of Wadi Ahmed Sherif, was found in the 1985 ground reconnaissance of the area, but it is judged typical of the occurrences at Sarras. The quartz vein is distinctly lenticular, about 40 m long and up to 40 cm thick, in a metavolcanic/metasedimentary host rock. The strike is west-northwest and the dip about 35° SE. Sinuous excavations accompany the hanging wall, apparently to exploit alteration material supradjacent to the vein. The vein is mostly intact.

There is no evidence of gold recovery activity. The mined rock probably was hauled to a Nile water source for washing and grinding.

Intrusive granite is within 150 m of the prospect.

It is concluded that the Sarras gold occurrences are too small to merit further investigation.

Haisub. This occurrence is at 21° 25' N and 31° 26'E, about 30 km southwest of Wadi Halfa and east of the Nile River. It was investigated in February 1985.

Host rocks are calcareous, micaceous schists that strike N 60° E, dip 60° SE and are highly deformed. The mineralization is restricted to quartz veinlets that occur normal to the foliation. The old workings are superficial.

Aside from about ten ancient dwelling sites and some broken grinding stones, there is no other evidence of mining work in this area. No follow-up investigation is recommended.

Um Fitfit. This small, ancient lode mine is situated 18 km northwest of Station No. 6, at 20° 40'

N. latitude and 32° 23' E. longitude. The location corresponds to that given by Whiteman (1971) for the Um Fitfit prospect, which figured in a list of prospects and small mines under control of the Sudan Gold Field Company Limited in the early 1900s.

The country rock is a soft, green, micaceous schist that strikes N 20° W and dips 50° SW.

Workings have been concentrated on veins of smoky quartz that strike N 20-60° W, measure from a few centimetres to 1.5 m thick, and are usually parallel to the foliation of the country rock. Some iron-stained quartz is present. Two long trenches and several short ones accompany the veins, some of which are exposed in the trenches. There are also two deep vertical shafts and four houses probably related to activity early in this century. There are no placer workings.

Three quartz vein samples were collected. Fine visible gold was reported present in sample 1575 that assayed at 1.90 g/mt Au.

This prospect merits further investigation and evaluation.

Isolated Occurrences. Two isolated occurrences with anomalous gold values are worthy of mention and warrant follow-up investigation:

Sample No.	Location	g/mt Au	Description
3008	21° 14' N 31° 10' E	3.50	Pegmatite vein in ring structure

Sample No.	Location	g/mt Au	Description
3017	21° 10' N 31° 58' E	8.00	Chip sample of quartz vein from ancient trench

Gold-Copper

Wadi Naba Area

Introduction. This highly prospective area in the eastern part of the Sudanese Sector covers 2,800 sq km and is encompassed by latitudes 21° 05'-21° 30' N and longitudes 33° 25'-34° 00' E (see Plate I, Area 4). It was visited in April 1985 by three GMC geologists and by DTCD consultant R. Savard. The latter wrote a comprehensive report on the area (Savard, 1985) and assigned prospect numbers to interesting localities.

The topography of the area is rugged. Metavolcanic and metasedimentary rocks form rounded hills of less than 100 m relief, while contiguous intrusive bodies more resistant to erosion rise in steep ridges and peaks up to 200 m over adjacent reg-covered terraces and dry stream beds. Wadi Naba, an eastern affluent of Wadi Gabgaba, traverses the area from east to west.

Previous Work. This area was the scene of extensive mining and prospecting in past millennia by ancient miners as evidenced by the pits, trenches and placer excavations that abound in the area, together with large groups of ancient habitation sites.

Geologic Setting. The area is underlain by metavolcanic and metasedimentary rocks, granodiorite and diorite. Tuffs and agglomerates are also present. There appears to be a predominance of metaandesite. The foliation is mainly N 03^{o} - 25^{o}W, with some northeast strikes also recorded.

The area is laced with quartz veins of moderate thickness (0.60-1.5 m), with strike directions mainly in the N 20^{o} - 77^{o} W range and steep northeast dips.

Mineralization. Of the 60 reported gold occurrences in the district, the 1985 field party succeeded in finding 52, and it recorded three new occurrences.

Gold occurs in some quartz veins and related alteration zones in a free state and associated with iron, copper and lead sulphide minerals. Placer gold is found in colluvial/eluvial and alluvial sands and gravels resulting from the weathering of mineralized vein and alteration material. Many panned heavy mineral concentrates contain visible gold. Some quartz veins are completely barren and were left undisturbed in a process of selective mining by the ancients.

Copper mineralization was previously unreported in the area. On a regional scale, felsic to basic rock series seem to define an east-west trending volcanic "greenstone" belt that shows mineralogical and lithological similarities to copper-bearing greenstone belts that occur in the Canadian Shield. Mainly malachite copper mineralization, possible unidentified copper oxides, and chalcopyrite (reported at one prospect), together with associated gold and some disseminated pyrite, occur in basaltic to andesitic, andesitic to dacitic and even rhyolitic rocks. The belt is roughly east-west, 15 x 40 km in extent, and it is covered by Target Area 4 on Plate I.

In one area, five possible gossan bodies that strike N 20° E and N 46° W occur in a metaandesite host rock. They are reddish brown, limonitic, dolomitic, slightly siliceous and contain unidentified black minerals. There are three prospects in the gossan area that were exploited by the ancients for copper-gold.

Ancient copper mining in the area could have been for the colourful copper pigments, but some selectively mined oxide-zone copper mineralization could have made its way to Buhen or to Quban (Figure 14) for refining into copper metal.

Assay Results. Of the 22 samples collected for assay, four were misplaced; all of the remainder were assayed for Au, while six were assayed for Cu and As. The arsenic results were noticeably low; the highest was 0.022% As. There were two anomalous Cu values: 6.93% and 0.28%.

Salient gold values are tabulated below:

Prospect No.	Sample No.	g/mt Au	Description
5	4583	3.80	60-80 cm quartz vein
31	4591	4.50	Unexcavated quartz vein
33	4593	8.03	1.3 m quartz vein
35	4576	3.10	Cupriferous, limonitic quartz
35	4577	130.00	60 m long trench; sample of dark rock coated by red iron oxide; no quartz

Prospect No.	Sample No.	g/mt Au	Description
A	1585	6.50	Quartz reject material with galena, pyrite and malachite from 8 m long ancient trench
Scattered	2000	3.10	Sandy clay material
Locations	2011	2.20	Alluvial material ancient trench
	2006	5.10	Quartz vein
	2015	2.40	Alluvial material near shear zone of metavolcanic rock
	2017	6.90	Rock sample from ancient trench
	4588	19.20	High Cu andesitic dump material

Sample results from possible gossan areas reported by Savard (1985) were disappointing but not conclusive. Reddish brown, gossan-looking hills at Prospect B had the following assays: sample 4584A - 27 ppb Au, 70 ppm Cu, 220 ppm As; sample 4584B - 15 ppb Au, 99 ppm Cu, and 100 ppm As. Sample 4580 from the cupriferous quartz blow at Prospect C assayed at 58 ppb Au, 0.28% Cu, and 8 ppm As.

Gold values in the four alluvial samples collected were consistently low and not worthy of mention.

Conclusions. The presence of widespread gold and copper mineralization, possible gossans and appropriate host rocks provide an attractive setting for a mineralized area with potentially economic gold and sulphide mineralization. In this large virgin area, there is potential for both volcanic- and plutonic-hosted mineral deposits, justifying detailed investigation and application of all the technical know-how of the mineral industry toward the discovery of such deposits.

Copper

North Wadi El Allaqi Area

This copper locality -- shown in Figure 29 -- is about 18 km east-southeast of the Um Garayat gold prospect and 7 km north of Wadi El Allaqi. The coordinates are 22° 32' 15" N and 33° 31' 42" E. It was investigated in December 1985 during field checking of copper geochemical anomalies resulting from geochemical survey work in the general area reported by Hudson, et al. (1983b).

Copper mineralization is found in greenish brown, partly altered metavolcanites (metaandesite tuff?) on three hillsides covering an area about 75 m x 150 m and containing several ancient pit-like excavations. The copper is in the form of malachite and azurite staining and impregnations, in part associated with minor smoky quartz veining and in part within more resistant metatuff rock.

There are several ancient habitation sites in the locality.

Assay results of cupriferous metatuff samples:
Sample No. 024 - 2.20% Cu
Sample No. 025 - 1.40% Cu; 0.230 g/t Au

The mineralization is sufficiently widespread to justify additional investigation.

Adila

Introduction. This copper occurrence is described by Government geologist S. C. Dunn in his 1917 report on some ancient mines near Wadi Halfa. The 1985 field team made two visits to the area to make certain of the location, and there is a resultant disparity between the description by Dunn (1917) and that of Savard (1985).

Adila is at 21° 19' N latitude and 31° 08' E longitude, approximately 79 km south of Wadi Halfa. Dunn describes it as a small hill west of Jebel Adila, approximately 1 km northwest of an old well, with ancient engravings in outcrops near the well. The elevation above the drainage and the northwest-southeast ridge direction do not fit the locality.

Mineralization. According to Dunn's report (op. cit.), old workings were in a bed of cupriferous ironstone shale, with stringers of quartz 5-8 cm wide; excavation was among bands of brightly coloured copper-bearing material; and there was an open quarry in soft and richly coloured red hematite. Analyses in 1971 showed 1% copper and very little gold. Savard (1985) found none of this and only a few specks of malachite in ancient diggings on the north flank of the hill.

Conclusions and Recommendations. It is concluded that in most part Adila was an ancient "colour" mine that supplied red iron pigment and green and blue copper pigment for ancient cosmetic and decorating needs. Perhaps some selected copper-bearing material was shipped to Buhen (see Figure 14) for refining into copper metal. Subsequent erosion and wind-blown sand have progressively covered these workings, which apparently were partly exposed at the time of Dunn's 1917 visit. But by the time of Savard's visit, they were mostly hidden from view.

Two samples assayed for gold gave negligible results.

No further work is presently justified at Adila, but the area merits close checking for anomalies after future airborne geophysical survey work.

Um Faham

Introduction. Um Faham (Om Fahm) is 2.5 km southwest of the Adila copper occurrence and about 28 km southeast of the Duweishat gold prospect, centred on coordinates 21° 18' N latitude and 31° 17' E longitude. The workings are situated on a high mountain ridge, which is part of a chain that strikes east-west in an area of rugged topography with up to 300 m relief.

There are about 20 ancient habitation ruins on the hill slope and in the wadi bed. The proximity of the Nile makes it possible that copper "ore" could have been carried to the river for transport to an ancient smelting centre, such as Buhen (see Figure 14).

Geologic Setting. The fine- to medium-grained garnetiferous mica schist that crops out in the area is friable, soft, and grey, except where stained pinkish by iron oxides. The strike is east-west and the dip 60° S.

Mineralization. In most part, the ancient workings consist of trenches. One observed is 25 m long and 1.5 m wide, and now shows only a trace of malachite staining. A second, similar trench is curved and at one end is deeper and adit-like. There, the country rock is highly deformed and has a strike and dip of N 50° W/75° SW; some cupriferous material remains in this second trench. A 25 cm quartz vein in proximity has had a very small quantity removed, probably in prospecting. One sample assayed for gold gave negligible results.

Conclusions and Recommendations. Um Faham probably served as a small source of copper for smelting at Buhen and also as a "colour" mine. Consideration of further work in this area should await the results of the proposed airborne geophysical survey.

Near No. 3 Railway Station

Introduction. Attention was drawn to the area of interest by the Geosurvey International imagery interpretation. The coordinates are 25° 21' N and 32° 10' E, situated 10 km southeast of No. 3 Railway Station. The area, visited by a GMC field team in March 1985, is low-lying, with slopes and large intervening wadis covered with aeolian deposits.

Geological Setting. Geosurvey allocates the area to the metavolcanic image-geological unit designated Sv with undifferentiated relief. The main observed rock type is a foliated basic metavolcanite in sharp contact with intruded granitic rocks. The strike and dip of the foliation are N 20° W/80° SW. The metavolcanic rock is composed mainly of plagioclase, hornblende and epidote, and has a dark green to greyish green colour. The granite is buff to pink and is composed mainly of quartz, alkali feldspar and biotite.

Mineralization. Copper staining (malachite) was observed in hand specimens. Appropriate samples were collected.

Assay Results. Three samples collected at this site gave the results listed below:

Sample No.	g/mt Au	%Cu	%As
586	0.025	0.29	0.0052
588	0.84	1.55	0.042
592	0.32	2.08	0.0007

Conclusions and Recommendations. The results of the proposed airborne geophysical survey should be awaited before considering whether further investigation is warranted.

Copper-Nickel

Abu Swayel

Introduction. The Abu Swayel (Swail/Swayeil/Sweil) copper-nickel prospect was one of two known major sources of copper from Lower Nubia during Pharaonic times. This ancient mine is situated 41 km north of Wadi El Allaqi, at 22° 47' N latitude and 33° 38' E longitude, in an area of low hills and intervening wadis, regs and desert flats (see Plate I). The area was visited by GMC geologists in October and December 1984.

Previous Work. The mine was worked to a depth of 6-10 m by ancient Egyptian miners (DEMAG 1963). Work in the early 1900s by the Nile Valley Company included sinking an exploration shaft to 22 m depth and driving a cross-cut to intersect the mineralized body.

The mine and its adjacencies were the object of field work by EGSMA geologists during three field seasons in 1957-1959. In 1958, magnetic, electrical and radiometric measurements were carried out by Ustav Pro Vyzkum Rud of Czechoslovakia, but results were inconclusive. In 1963, economic-geological and preliminary mining studies were conducted by DEMAG of West Germany. This work included deepening the shaft to 69 m, collection of samples from oxide and sulphide zones, cross-analysis of core samples from concurrent drilling by EGSMA of ten core holes totalling 1206.20 m, plotting and interpretation of results, and ore-dressing tests. DEMAG concluded that the occurrence was uneconomic.

In 1973, the United Nations flew an airborne dual-frequency electromagnetic survey over the area, with no resultant anomaly. Also, they conducted a very-low-frequency ground electromagnetic survey over the site, and results were generally negative. No electric conductor that would correspond to a mineralized body was detected, and they concluded that the mineralized copper body was evidently of very limited dimensions.

Geologic Setting. The mineralized host unit is an elongated, lenticular amphibolite body traceable for some 500 m along a northwest-southeast strike and enclosed by a garnet-mica schist. The strike of the foliation ranges from N 42° W to N 60° W; dips range from 62-81° NE. Ustav Pro Vyzkum Rud (1958) reports dips in the range of 75-85° NE. In local flexures involving schistose rocks, there are some steep southwesterly dips.

A 110 m wide wadi transects the amphibolite into two main prominences or ridges. The amphibolite pinches out to the northwest and southeast, with an attendant decrease in ridge prominency and increase in schistosity in those localities. In the main mineralized area, the amphibolite is anomalously thick, with low-angle, irregular and unpredictable dips.

In the immediate mineralized area, there is no apparent fault offsetting, but of interest is the observed linearity of the host amphibolite in the exploited area, where it is reported to be sheared along its strike. The transecting wadi is probably due to superposition of drainage, combined with jointing or a less resistant schistose facies.

Mineralization. The main mineralization pinches and swells unpredictably for about 180 m. Based on the ancient workings, it is bifurcated for about 90 m at the southeastern end; this was verified by drilling. There is about a 75 m strike length representing the most massive mineralization, into the centre of which the cross-cut was driven from the shaft. To the northwest, the mineralization tends to thin before being covered by alluvium and wadi sediments. On the northwest side of the transecting wadi, the amphibolite is not mineralized.

DEMAG (1963) reports the presence of chalcopyrite, pyrite, nickel-bearing violarite, and ilmenite. The relict textures of the pyrite and the violarite show the primary ores to be pyrrhotite, pentlandite and chalcopyrite.

There is a persistent, apparently stratiform, sulphide-bearing zone of variable thickness, intersected by the 10 drill holes, that hosts the mineralized amphibolite body. Drill and surface data show this unit to be a garnet-mica schist containing disseminated low-grade copper-nickel values. Drill hole intercepts in the northwestern sector show this as a single mineralized unit 3-8 m in true thickness, in most part thinning at depth.

Potentially economic copper-nickel mineralization occurs both in the amphibolite body and in enclosing host schists. Sixteen samples taken at intervals of 0.5 m in the cross-cut averaged 4.11% Cu, 1.76% Ni, 17.81% Fe and 9.94% S. The sole drill intersection of the amphibolite was a 2.1 m interval in DH 14, which averaged 2.1% Cu and 0.21% Ni.

Conclusions and Recommendations. The down-dip projections of the amphibolite-bearing sulphide mineralization have not been adequately tested, and the mineralization could continue at depth in two localities, giving justification for additional drilling. Intrusive ultramafic or volcanogenic sources for the mineralization should be considered.

The amphibolite is a discrete lenticular body, and there could be similar mineralized bodies, interspersed within the confines of the sulphide host zone, elsewhere in the area.

It is possible that high-grade mineralization could exist within schistose rocks of the sulphide host zone near the subject body and elsewhere in the area, completely independent of and isolated from that currently known and without the presence of amphibolite.

After studying all the reports on Abu Swayel, the UNDTCD geophysical specialist concluded that none of the geophysical techniques used to date were entirely suited to the task. A new detailed ground survey is recommended, utilizing horizontal loop EM, induced polarization/ resistivity and magnetometry. Specifications will be provided.

Chromium

Of 380 chromite occurrences in the Eastern Desert of Egypt, 152 are recorded by Ivanov, et al. (1973) as being in an area, within the Area of Integration, termed the Abu Swayel zone. Within the zone, there are six main ultrabasic complexes, called Shilman, Biam, Gezira, Um Douimi, Murra and Duneibat, and a few subordinate bodies. The large complexes were the object of field investigations during the late 1984 field programme. At the Shilman complex, serpentinized dunite and dunite-harzburgite zoning was observed. Also, chromite in the form of scattered, vari-sized float was found on the slope of a hill in the northern part of the complex. The chromite was coarse-grained, dense and high-grade. A search for the source and additional mineralization proved unsuccessful.

Wadi sediment geochemical work by the Institute of Geological Sciences and EGSMA (Hudson, et al., 1983b) in the general area shows strongly anomalous chromium values in the vicinity of the Shilman ultrabasic.

As far as can be determined, none of the 152 chromite occurrences have economic significance, and it is concluded that the mineralization is restricted to small podiform or discontinuous seam occurrences. Additional investigation for chromium in the Abu Swayel zone is not recommended.

Iron

Iron mineralization occurs in six known localities in the Egyptian Sector within the Nile Valley south of Aswan. It consists of ferruginous sandstones and oolitic hematite bands, in sandstone and variegated clayey shales of the Cretaceous-Tertiary Nubia Formation, respectively. Most of the occurrences have been known since ancient times. Four of them (Kalabsha, Garf Hussein, Kurusko and Abu Simbel) are now covered by Lake Nasser/Nuba Lake. The other two are on the east side of the Nile, south of Kalabsha and north of Bir El Hassin.

Bedded iron occurrences are found in Nubia Formation sandstones near Wadi Halfa, where two thin bands occur on both sides of the Nile. They are described by Vail (1978) as oolitic hematite in bands up to 1 m thick. Afia, et al. (1966) report grades from 34% to 45% Fe.

Whiteman (1971) indicates an "irregular" iron occurrence associated with Basement limestones and Nubia sandstones in the vicinity of No. 7 Railway Station, in the south-central part of the Sudanese Sector.

Uranium

Radioactive minerals have been discovered at various localities in the Precambrian Basement Complex of the Egyptian Sector, but location information is deficient and they have been excluded from the mineral occurrence map.

Hussein, et al. (1985) describe four occurrences of radioactive minerals southeast of Aswan that were explored by Nuclear Materials Corporation:

1. Jebel El Hudi - about 15 km southeast of Aswan, 349 sq km, in metasedimentary and metavolcanic rocks. There are several anomalies, up to 20-times background, especially in dykes that cut schistose rocks. There is an appreciable number of anomalies in northwest-trending dykes. Chemical analyses show thorium values up to 250 ppm and uranium up to 180 ppm.

2. Wadi Abu Agag - north of El Hudi, 347 sq km, in gneisses and granites. Radiation is up to four-times background, with anomalies related to faults and fractures. A thorium high of 22 ppm and a uranium high of 21 ppm were recorded.

3. Wadi El Shum - 65 km southeast of Aswan, about 574 sq km, in pink granite. The highest anomalies are in the granite near the contact with Nubia sandstone, with readings up to 740-times background. Analyses show 2900 ppm thorium and 600 ppm uranium.

4. Jebel Um Ara - south of the Abu Swayel copper-nickel prospect and near the upstream mouth of Wadi Shilman, south of latitude 22° 40' N, 229 sq km, in Shilman serpentinite, metavolcanites and metasediments. Many anomalies are present, especially in the Um Ara granite pluton. This granite is the most radioactive of all granites in the Eastern Desert, with values up to 44-times background. Field geologists report "disseminated uranium mineralization that is scattered as yellow spots on the rock".

Hudson, et al. (1983b) report a significantly high level of radioactivity in a large dyke situated along the western side of upper Wadi Um Dawila, south of Wadi El Allaqi. The dyke is a microgranite, several kilometres in length, that strikes N 37° E. Some granite bodies in the report area are distinguished by a higher level of radiation than is typical of most granites. The highest is at Jebel Um Arimass, with consistent readings of 250 to 700 counts per second compared with 80 to 120 counts over most granites.

In radiometric surveys conducted at Garra El Soda and Garra el Hamra in the Western Desert, Bean, et al. (1983) report some of the highest levels of radioactivity of the entire Western Desert, in short, reddish, thorium-rich veins and patches in syenite bodies.

Non-Metallic Minerals

There are some talc, graphite and reported vermiculite occurrences, plus a number of small, producing baryte mines and marble and quartz quarries situated in the Egyptian Sector east of the Nile and operated mostly by Government-owned enterprises. Some of these are covered by exploration and mining concessions, as shown in Figure 4 and tabulated in Table 3. Locations are on Plate II.

For the sake of time and priority, only one baryte mine (Wadi Safiha - an affluent of Wadi Araba) and one marble quarry (Wadi Abu Swayel) were visited during the field work in the Egyptian Sector; nonetheless, a study of these non-metallic minerals is warranted to determine their economic potential.

Talc

There are three known occurrences of talc in the Egyptian Sector north of Wadi El Allaqi: Wadi Haimur, near Jebel Urf Um Shilman; Wadi Quleib; and Wadi Um Araka. The talc at the first two locations occurs in large patches in low hills composed of talcose schist rocks, which are associated with serpentinite. At Wadi Um Araka, the talc occurs as small patches within basic metavolcanic host rocks.

Graphite

In the Egyptian Sector, two occurrences of graphite are recorded. One is in Wadi Haimur, in the Abu Swayel area, where the graphite occurs as lenses within metasedimentary rocks. The other occurrence is situated 2 km northeast of Jebel Ghadir, near Wadi Haimur. At that location, the graphite is in a bed, about 30 cm thick and 1 km long, within metasedimentary rocks.

Baryte

All baryte mines in the Area of Integration are near Aswan and concentrated in Wadi El Hudi, Wadi El Shome and Wadi Arab. As far as can be determined, all are small-sized open-pit mines on steeply-dipping baryte veins.

Wadi El Hudi. This mine is about 45 km southeast of Aswan, at 23° 58'N latitude and 33° 09'E longitude. Access is via the Aswan asphalt road and a desert road leading to the site.

The baryte occurs in seven veins having a general strike of N 40-45° W and varying lengths, with widths of

40 cm to 1.5 m; depths are variable. These veins cut granitic rocks, which intrude metasedimentary rocks along a shear zone.

Mine production is about 300 mt per year, and there are approximately 400,000 mt in reserves. The grade of the baryte is 94% $BaSO_4$. All production is marketed in Egypt at a price of L.E. 300/mt.

Wadi El Shome and Wadi Arab. These two wadis are close to Wadi El Hudi, about 50 km southeast of Aswan, at 23^{o} 45' to 23^{o} 52' N latitude, and 33^{o} 10' to 33^{o} 14' E longitude, where a number of small, discrete deposits are mined by El Naser Phosphate Company, a Government enterprise.

Within this area, there are 12 baryte veins having a general strike of N 40-60^{o} W. They range in width from 0.1 to 7 m and extend to variable depths in a metasedimentary shear zone.

These mines produce about 300 mt per year and have a reserve of 300,000 mt. All production is marketed in Egypt to petroleum companies and other industries.

Marble

Seven marble quarries -- which are worked by the Marnite Company -- are in an area bounded by latitudes 22^{o} 40' and 22^{o} 50' N and longitudes 33^{o} 20' and 33^{o}40'E. The information listed below is provided by the Regional

Planning Authority of Aswan:

Name of Quarry	Distance from Aswan (km)	Reserves (m^3)
Allaqi	200	366,100
El Kulib	189	1,665,275
Um Arak	176	100,665,397
Abu Mura	136	403,801
Wadi Shilman	145	230,000,000
Wadi Haimur	186	1,400,000
Wadi Abu Swayel	185	5,000,000

The marble in this area occurs as bands associated with schistose rocks which are in contact with serpentinites. The colour range is from white to black, including grey and banded varieties.

The Marnite Company extracts about 2,000 cu m per year from the above quarries. Total reserves are 358,000,000 cu m. All production is marketed in Egypt at a price of L.E. 400/cu m and at L.E. 50 for square metre slabs.

Quartz

Quartz quarries are in the Egyptian Sector, southeast of Aswan, at two locations: Um El Tahiuat at 23° 56' N latitude and 33° 01' E longitude, and Bir El Hamer at 24° 00' N latitude and 33° 03' E longitude. Access to these quarries from Aswan is by desert roads.

The quarries cover about 40 ha and are worked by the Government-owned Egyptian Gypsum, Marble and Quarries Company. The quartz occurs as veins and plugs, or blows, that cut granitic and metamorphic rocks. They extend for about 100 m of strike length, with widths ranging from 1 to 4 m and averaging 1.5-2.0 m. The reserves in each quarry amount to about 6,000 mt.

The extracted material is composed of 97-99% silica and 1% iron. Annual production of about 8,000 mt is marketed in Egypt.

Another occurrence also located near Aswan, at Wadi Um Agiel, is now being explored by the Mining Engineering Company. Quarry production is sold to two Government companies in Egypt: Ferrosilicon Industry and Kema Industry, in the Aswan region. The price is L.E. 24/mt.

Other Non-Metallics

It is recognized that there are dormant or low-production mines/quarries within reasonable road access of Aswan that at one time or another have produced kaolin, clay, quartzite, sandstone, feldspar and granite for local and Upper Egypt consumption. Some sites have been covered by Lake Nasser. Unfortunately, no further information could be obtained for this report.

MINERAL POTENTIAL

General Statement

The most prospective parts of the Area of Integration include:

1) The entire Precambrian Basement Complex;

2) Within the Basement Complex, seven specific areas that merit special investigation (see Target Areas);

3) The Nubia/Precambrian unconformity and associated rocks;

4) Selected drainages and localities for alluvial gold.

Sedimentary rocks of the Cretaceous-Tertiary Nubia Formation are potential hosts for coal, uranium and phosphate. But because of the low probability of discovering deposits of economic size and grade, combined with the high cost and difficulty of exploring for them, the Nubia Formation is excluded from this study.

It should be emphasized that small, mostly insignificant showings of copper are not uncommon in Precambrian metamorphic and igneous terrain; nonetheless, care must be taken not to treat isolated occurrences too casually, because of the widespread potential for and geologic habitat of sulphide ores of copper.

Expected Incidence of Metals/Minerals

Some knowledge of the age and description of the subject Precambrian rocks allow reasonable prediction of the expected incidence of certain metals and minerals in the Area of Integration. Allowing for the overprint of the Pan-African event, the age range is concluded to be mainly middle to late Proterozoic. The lithologies include metavolcanic-metasedimentary, granitoid, ultra-basic and paragneiss-orthogneiss rocks.

Goossens (1983) summarizes mineral deposition during the Proterozoic as follows:

1) Sedimentary and volcano-sedimentary ore deposits became very important. Proterozoic basins contain rich stratiform deposits of Cu, Pb, and Zn, plus Ag, Co and Au.

2) Except for anorogenic intrusions and their ores, plutonic ores became less important.

3) Volcanogenic ores continue to dominate but with less intensity than during the Archaean.

4) The deposition of copper ores in sandstones increased greatly in the upper-middle Proterozoic.

5) The komatiitic Ni-Cu ores were conspicuously of no importance in the Proterozoic.

6) There was deposition of large Zn-Pb deposits in the middle Proterozoic.

7) The Precambrian does not possess porphyry copper or tin provinces such as those developed during the Phanerozoic in western America and southeastern Asia.

The Area of Integration does not fall into a recognized metallogenic belt. But the widespread occurrence of gold, especially in the eastern third of the Area, constitutes a regional specialization, and at least that portion falls into a metal, or gold, province category.

The predicted discovery potential for economic deposits of major metals and minerals is tabulated overleaf. The metals and minerals are arranged alphabetically by category and the references are Goossens (op. cit.) and Mitchell and Garson (1981).

Low Discovery Potential

Chromite	No important podiform or layered deposits expected
Diamonds	No known kimberlite bodies or projected kimberlite trends
Gold) Uranium)	No recorded development of auriferous and/or uraniferous quartz pebble conglomerates in later Proterozoic
Iron	Possible ironstones but not in substantial quantities
Manganese	No important deposits expected
Molybdenum) Tungsten) Tin)	Large economic deposits of molybdenum, as well as of tin and tungsten, are very strongly biased toward the Phanerozoic
Nickel	Minimal incidence of sulphide or laterite deposits

Significant Discovery Potential - Low Category

Carbonatite) Minerals)	Carbonatite bodies containing apatite, magnetite, pyrochlore, rare earths, titanium and vanadium minerals; zircon, fluorite, uranium minerals and exceptionally copper and lead
Copper	Mafic intrusions White Pine-type native copper deposits Ophiolites Volcanogenic porphyry copper deposits
Copper) Zinc) Lead) Silver)	Massive sulphides in phyllite belts
Copper) Zinc) Lead)	Sedimentary sulphide deposits
Tin) Tungsten)	Smaller deposits in ring-like granite complexes relating to mantle hot spots/ intracontinental rifting

Significant Discovery Potential - High Category

Copper) Cobalt)	Zaire-Zambia Copper Belt-type deposits and associated uranium and nickel, occurring in stratiform black shale and fine-grained carbonate clastic sequences
Copper) Zinc) Lead) Silver)	Volcanogenic, massive sulphides in volcanic and volcano-sedimentary host rocks
Gold	Vein gold, lenticular in strike and dip, mostly in metavolcanic/metasedimentary rocks; also in placer deposits
Lead) Zinc) Copper)	Stratiform bodies in metasediments and metavolcanics, as occur in Australia, Canada, U.S.A. and Zambia
Phosphate	In middle Proterozoic rocks in India; worldwide, in the late Proterozoic-early Cambrian, in many platform sedimentary basins occurring in shelf environments on continental margins
Uranium	In Proterozoic metasediments: marble, schists, carbonaceous shales and slates; in veins, stockworks and breccias; in unconformities; and in calcrete-type deposits

The expected potential for metals/minerals in Precambrian rocks of the Area of Integration is, in order of importance: 1) gold, 2) base metals (copper, zinc, lead), 3) uranium, and 4) phosphate. For the most part, the anticipated host rocks would have volcano-sedimentary affinities.

Gold

Introduction

As in Pharaonic times, the forbidding hinterland areas of Koptos, Wawat and Kush (Figure 14) remain as favourable potential sources of gold in Nubia. In their thorough, persistent search in every corner of the waterless desert, ancient prospectors probably discovered and superficially exploited all the lode gold and coarse-fraction placer gold that was to be found in the region. But the desert still has much to offer in the form of: 1) additional quartz vein gold in four known ancient lode mines and their adjacencies; 2) several smaller, isolated quartz vein gold prospects or occurrences having an unknown depth potential, with some prospects yet to be "rediscovered"; 3) possible bulk-tonnage deposits of disseminated gold too fine for the ancients to find or exploit; and 4) placer deposits of fine gold, partly in the vicinity of ancient placer sites, and coarse gold at unexploited depths. Through modern exploration, development and beneficiation techniques, such gold occurrences are potentially profitable despite the remoteness of the host areas.

Prior to any desert gold mining, the economic viability of the venture should be established by a complete feasibility study.

There is a need to undertake a more thorough, systematic evaluation of all known gold occurrences in the Sudanese sector than could be effected during the 1985 field season.

Quartz Vein Lode Prospects

The four known ancient lode mines in the Area of Integration are Um Garayat in the southeastern Egyptian Sector and Um Nabari, Duweishat and Abu Sari at scattered locations in the Sudanese Sector. These prospects, described under Mineral Occurrences, have variable grade and reserve potentials, which possibly justify a small, simple heap-leach operation at Duweishat to a possible large-scale operation at Um Nabari. Each will require extensive technical and economic evaluation, including an investigation of accessible underground workings and the grade/reserve potential of remaining auriferous vein material and altered wall rock.

The size potential of these prospects is relatively small and might be compared to the announced reserves of 151,000 mt, grading 39 g/mt Au, (more recently 175,800 mt, grading 30 g/mt Au) for Greenwich Resources' (Minex) Gebeit gold mine in the Red Sea Hills. But it is doubtful that the grade of any of the above prospects will attain that of Gebeit. For example, the grade of 20 g/mt for 200,000 t mined at Um Nabari during the period 1912-1920 is probably attributable to selective mining; otherwise, it might have been appreciably less.

An example of the smaller, isolated quartz vein gold prospects is Um Fitfit, situated northwest of Station No. 6, with a quartz sample having visible gold and assaying at 1.90 g/mt Au. One listed under Isolated Occurrences assayed at 8.00 g/mt Au. The sizeable gold nugget in a quartz vein sample from the Upper Wadi Gabgaba area, described earlier, is encouraging. Whiteman (1971) listed several prospects and small mines under the control of the Sudan Gold Field Company in the early 1900s that fall into the same category; some of these need to be located in the field. In summary, quartz veins like the above examples could be the surface expression of complex vein systems with favourable depth and grade potential, but the size potential is comparatively small.

Bulk-Tonnage Disseminated Gold

Discussion. In Target Area 2 - North Wadi El Allaqi area, the Nile Valley Block E prospect, adjacent to the Um Garayat lode prospect, contains the most extensive placer workings found to date in the Area of Integration, but there is a distinct paucity of quartz veins (most of those present are apparently barren) and a complete absence of plutonic rock, the basic ingredients for the classic lode/pluton association.

Of nine metatuff rock samples collected in the Um Garayat Nile Valley Block E Area, six show 2 ppb Au, but values of 28 ppb, 12 ppb and 10 ppb are recorded for the other three. The highest value came from an altered metaandesite tuff.

Hodder, et al. (1980) show the gold content of igneous rocks to range from 3 to 7 ppb. Tilling, et al. (1973) state that the gold content of igneous rocks rarely exceeds 10 ppb and is generally below 5 ppb, but they conclude that "gold abundances that are significantly higher (or lower) than background levels for a given rock type in a given region seem best accounted for by local aberrations related to alteration and secondary introduction or remobilization."

Evans (1981) gives convincing evidence that laterization of very low-grade auriferous source rocks through peneplanation, sub-tropical weathering, solution and supergene transport of the gold, followed by re-precipitation and aided by mechanical concentration, can result in economic placer gold deposits. It might be concluded that the gold in Target Area 2 had a volcanogenic exhalative origin, and that, in the Cretaceous-Tertiary, the anomalously auriferous and locally altered metavolcanic country rock was subjected to the above process. Visible gold particles were mobilized, precipitated, and subsequently winnowed into colluvial/eluvial side-hill placer pay streaks and accumulated in alluvial concentrations that resulted in the extensive Nile Valley Block E workings seen today. The peneplanation and laterization could have been extensive over the general region, providing an explanation for many other side-hill workings otherwise difficult to comprehend.

Potential in the Area of Integration. In the Canadian Shield, tuffaceous rocks at the Doyon mine at Bousquet, Quebec are hosts for disseminated gold deposits. Similarly, within the North Wadi El Allaqi target area and geologically comparable areas in the region, auriferous, tuffaceous, and other metavolcanic rocks -- the apparent sources of gold for placers like those at Nile Valley Block E -- have a potential for bulk-tonnage concentrations of disseminated gold in proximity to exhalative source areas. In the search for such deposits through surveys of potential host areas, it is recommended that gold and arsenic geochemistry using neutron activation analysis be employed because of its low detection limit.

Elsewhere in the Canadian Shield, other Precambrian rocks are hosts for disseminated gold deposits. Examples are sedimentary rocks in mines of the Kirkland Lake

District, Ontario, and the stratabound deposits such as occur in the Eastern Red Lake area of northwestern Ontario (Hodder and Petruk, 1980). Fine-grained mica schists can host up to 8 g/mt Au in microscopic form (Colvine, 1983). Volcanic rocks of intermediate to acid composition are considered the source of gold in black shales of the Canadian Shield.

Analogous rocks in the Area of Integration have a potential for bulk-disseminated gold deposits. As geologic mapping and other interpretive work proceeds in the region, new targets in the form of appropriate host rocks, structural settings, etc. will evolve and justify future investigation.

Placer Potential

Within the Area of Integration, the major ingredients exist for the deposition of colluvial/eluvial and alluvial gold placers: 1) auriferous source rocks and related gold vein occurrences; and 2) periods from the late Tertiary to Recent of tectonic quiescence, deep weathering and erosion, and remobilization and mechanical concentration of the gold.

Areas of obvious gold concentration and facile recovery were found and exploited by ancient peoples. In prolific areas, they worked the gravels to depths of perhaps 1-1.5 m, leaving the fine, unrecoverable surficial gold and all gold at unexploited depths.

Potential placer areas are best selected by:
1) locating and plotting areas of previous lode and placer activity and related appropriate-sized drainages and paleodrainages (no wide valley-like wadis); and

2) selecting areas where geologic features, such as faults, dykes, intrusions, etc., cause interruption of the drainages and a depositional setting for placer gold.

In the remote Nubian and Eastern Deserts, the lack of water and of proper access and logistics are negative factors. Basic water requirements can be developed but are generally insufficient for hydraulic operations. Applicable dry recovery methods might be developed or perfected.

In summary, there is a potential for placer gold deposits, but exploitation logistics will be troublesome, and the return on investment may be minimal at best.

Base Metal Sulphide Deposits

The greatest base metal (copper, zinc, lead) potential lies in volcanogenic, massive sulphide deposits having volcanic and volcano-sedimentary affinities. Goossens (1983) cites the best known examples of these deposits in Proterozoic rocks in the Scandinavian countries, where there are copper-cobalt-zinc (with some nickel), various proportions of copper-zinc-lead, and minor gold and silver. The host rocks range from carbonates, quartzites and graphite-rich black shales to a variety of volcanic and metavolcanic rocks. A massive sulphide deposit rich in zinc, lead and silver at Perkoa, Burkina Faso, is hosted by a sequence of volcanic and volcano-sedimentary rocks very similar to those containing the Archaean Noranda-type massive sulphides of Canada. Proterozoic rocks of similar type can be expected to occur in many parts of the Area of Integration.

Moreover, volcanogenic massive sulphides are already known in the Arabian-Nubian Shield, specifically in Saudi Arabia and at Um Samiuki in the Red Sea Hills of Egypt.

There is recent evidence of the occurrence of ophiolitic sequences in areas to the east of the Area of Integration, and these rocks and associated Cyprus/Oman-type copper mineralization could occur in the Basement Complex of the Area of Integration.

Sedimentary/metasedimentary rocks of the Proterozoic Basement Complex are potential hosts for Zaire-Zambia copper belt-type deposits of stratiform base metal and associated cobalt and silver, such as are found in a variety of fine clastic sequences in several prolific mineral districts throughout the world. According to

Goossens (op. cit.), the age range of 15 such deposits in Australia, Canada, USSR, USA, Zambia, Zaire and Sweden is about 2000 to 750 M.a., which should amply include most Area of Integration Proterozoic rocks.

Uranium

Potential Host Units/Types of Deposits

Within the Area of Integration, there is a potential for uranium deposits in the following associations:

1. Proterozoic Basement Complex

   a) Stockwork, vein and breccia deposits

   b) Concentration in metasediments, some containing organic material

   c) Alaskite (Rossing-type) deposits

2. Nubia Formation/Basement Unconformity

   a) Unconformity-type deposits, both in basement rocks and overlying clastic sedimentary rocks

3. Nubia Formation-Sedimentary Basin/Sandstone-Type Deposits

   a) Deposits in fluviatile sandstones
      i. Tabular or peneconcordant deposits
      ii. Wyoming-type roll deposits
      iii. Plateau-type roll deposits

   b) Deposits in aeolian sandstones

4. Tertiary-Recent Calcrete-Type Deposits

   a) Uraniferous valley calcretes

Main Potential

Proterozoic Basement Rocks. Within the variable lithologies of the Proterozoic Basement Complex, there is a potential for Canadian-type uranium deposits, such as stockwork and vein mineralization in brecciated and mylonitized rocks, and pitchblende in cataclastic zones and in fractures, pods, pockets and lenses in quartzite and in chlorite and graphite schists. As in Australia, there can be deposits in dolomitic marble, schists, carbonaceous shales and chloritic slates, and in fracture zones, breccias and dykes. Radioactive mineralization is not uncommon in pegmatitic granitoid rocks, where in many cases thorium is more abundant than uranium, and the mineralization tends to occur in thin, discontinuous veins, fractures or low-grade dykes in subeconomic proportions.

Calcrete-Type Deposits. There is a potential for uraniferous valley calcretes, such as the Langer Heinrich deposit in the Namib Desert of Namibia and the Yeelirrie deposit in arid Western Australia. These are a relatively new type of uranium occurrence. Of an abundance of known occurrences, only a few are of economic grade.

Mode of Occurrence. The uranium is derived from weathering of granitoid rocks, pegmatite bodies or carbonatites followed by lateral transport in groundwater within the regolith. Ancient stable surfaces of low relief are most favourable. Concentrations of uranium occur in areas of constricted flow or where waters are forced close to the surface. Precipitation of carnotite occurs in, adjacent to, and commonly just below a calcrete mass, apparently close to the existing water table. The calcretes are crudely lenticular masses of alluvium and soil cemented by calcium or calcium-magnesium carbonate, which are up to tens of metres thick, several hundred metres to a few kilometres wide, and tens of kilometres in length, in the axial portions of paleostreams or existing drainage systems.

Bedrock barriers or constrictions that narrow the channel of subsurface flow, or that act as sills and thus force the water close to the land surface, where it is subject to loss of dissolved CO_2 by evaporation and oxidation, greatly favour the formation of uraniferous calcretes. Ore-grade mineralization is roughly horizontal in attitude and probably related to past or present groundwater tables. Important source rocks are: Proterozoic migmatites, pegmatites, alaskites and granites. The granitic terrain may be a sufficient source of vanadium to permit carnotite deposition; or other rocks, such as schists, may be abnormally rich in vanadium.

Favourability of Area of Integration. The Precambrian terrain of the Area of Integration provides a favourable setting for calcrete-type uranium deposits, having: 1) ancient stable surfaces of low relief; 2) a wide assortment of granitoid and other Proterozoic rocks as sources of uranium and vanadium; 3) a 2 x 8 km playa deposit mapped by Geosurvey (1984) in a constricted part of lower Wadi Gabgaba, and possibly other playas; and 4) various drainage constrictions and diversions as a result of faults, dykes, veins, etc.

Conclusions

1. There is insufficient potential for sedimentary basin/sandstone-type uranium deposits in the area underlain by the Nubia Formation to justify a

separate airborne radiometric survey of that vast 103,520 sq km part of the Area of Integration. This conclusion is borne out by the apparent absence of economic uranium in the Nubia in other regions and the paucity of economic-sized deposits in similar rocks elsewhere in the world.

2. Although an incomplete study of the Nubia/Basement contact failed to show channelling features or characteristics conducive to the deposition of uranium, there remains a potential for unconformity-type deposits. Consequently, in radiometric aerial survey work to be specified for Precambrian areas, it is recommended that survey lines adequately overlap the Nubia/Basement contact to evaluate this potential.

3. There is sufficient potential for uranium in the Proterozoic Basement Complex and in any supradjacent calcrete accumulation to justify a radiometric survey, but only in conjunction with other proposed aerial survey work. Care must be taken to evaluate very subtle anomalies.

Phosphate

In many places of the world, there are extensive stratabound deposits of sedimentary phosphate hosted by rocks ranging in age from middle Proterozoic to early Cambrian, and there is a potential for such deposits in similar rocks in parts of the Area of Integration. These are in platform sedimentary basins deposited on continental margins in a shelf environment. Reserves are huge, and grades range up to 30% P_2O_5.

In part, such deposits are not readily manifest. One in central Brazil was only discovered through an extensive regional geochemical programme and complicated follow-up mapping; hand specimens gave no clue to the contained phosphate. Photogeological and surface mapping are essential prerequisites for an exploration programme directed toward such deposits.

Tin and Tungsten

Several ring-like features from 3 to 9 km in diameter occur in areas south of Wadi Halfa and east of Wadi Gabgaba and stand out prominently on Landsat imagery. They are the surface expression of plutonic to volcanic, low to high relief syenite-granite complexes, and low to high relief, discordant and concordant granodiorites and granites, as image-mapped by Geosurvey (1984). Several of them are probably attributable to mantle hot spots in part associated with intracontinental rifting or aborted rifting. Within these bodies, there is a potential for tin- and tungsten-hosted ring-like granite complexes like those occurring in a similar geologic and age setting in Rondonia, Brazil described by Mitchell and Garson (1981). There, the tin mineralization is in greisen-like zones and topaz-quartz veins that cut both the complexes and country rocks, and is characterized by a topaz/cassiterite association and the local presence of wolframite and columbite-tantalite.

The ring-like features could also include carbonatites (described overleaf) or caldera complexes that might host uranium, beryllium, fluorite, mercury and other mineralization.

Alluvial deposits of present and paleo-drainage systems covering the complexes should be sampled as an initial approach, followed by pitting for grade and reserve data in mineralized sectors. Radiometric survey work will facilitate classification of the complexes.

Niobium, Rare Earth Elements and Associated Minerals

Description

Carbonatites are deep-seated intrusive bodies, akin to kimberlites, whose surface expressions are circular to ovate, with either positive or depressed relief, and which measure less than 500 m to several kilometres in diameter. There are often small satellite bodies adjacent to larger, parent carbonatites. Throughout the world, these intrusions are hosts for economic deposits of pyrochlore (niobium and tantalum), rare earths, apatite, magnetite, titanium and vanadium minerals, plus zircon, baddeleyite, fluorite, uranium minerals, vermiculite, and exceptionally copper and lead.

Mode of Occurrence

These unique intrusions tend to occur along major structural trends in Archaean and older Proterozoic cratonic rocks but can also occur in younger Proterozoic rocks. They may be found in any type of terrain, whether flat or hilly. In desert environments, they appear on aerial photographs as light-coloured, circular to ovate-shaped bodies. They normally occur within circular structured hills of under-saturated alkaline massifs, such as syenites, ijolites, urtites, phonolites, nepheline syenites and foyaites. Outcrops of carbonatite are rather common within these rocks, thus facilitating discovery.

In southeastern Egypt, carbonatite bodies are found in the adjacencies of the Mansouri ring complex and downward, extending southwesterly into Sudan. The ring complexes and carbonatites in that region are reported to lie along the continental trace of a zone of transform faults that extends across the axis of sea-floor spreading in the Red Sea.

Conclusions

There is a potential for carbonatite-hosted mineral deposits in the Basement Complex of the Area of Integration, and all circular features in the Area merit investigation.

Chromium

In extensive field mapping by EGSMA geologists of six large ultrabasic/serpentinite complexes and subordinate bodies in the Eastern Desert within the Egyptian Sector, and subsequent late 1984 field work by GMC geologists, only small, insignificant chromite occurrences have been found, and it is concluded that these rocks have little potential for economic-sized chromium deposits, especially in view of the remote location.

There remains an uninvestigated chromium potential in similar rocks in the Sudanese Sector, where there is little question that suitable ultramafic host bodies or complexes exist. It is a matter of identifying, mapping and evaluating them.

Platinum/Gold

In field work carried out in the Egyptian Sector in 1984, six serpentinite-ultrabasic complexes and related alluvials were investigated and sampled in a search for possible concentrations of platinum or gold. The results were negative, but there remains a gold and platinum potential in similar complexes in the Sudanese Sector, which will be eventually located and mapped.

The concentration of these metals is expected in alluvials relating to serpentinite-ultrabasic bodies that have undergone extensive laterization and weathering processes. When these rocks are found, they and associated alluvials merit adequate investigation.

Non-Metallic Minerals

Baryte

Of the non-metallic or industrial minerals occurring in the Area of Integration, baryte appears to have the best development potential, and the exploration, production and marketing of this mineral, which is an imported commodity, should be undertaken in future GMC work programmes. There appears little doubt that the local market can absorb any new production.

All known deposits of baryte in the Area of Integration occur in the Egyptian Sector southeast of Aswan and appear to be restricted to vein-type. The potential for finding new vein occurrences or deposits in that sector is low, but bedded or lensoid bodies are possible. On the other hand, the potential for finding new occurrences in the vast, unexplored areas underlain by Basement Complex rocks in the Sudanese Sector is good. Whether or not such occurrences would prove profitable is in part dependent on their proximity to the Khartoum-Wadi Halfa railway and/or fluvial transport on Nuba Lake/Lake Nasser. Field geologists on future exploration programmes should be mindful of the variety of major modes of occurrence of baryte: as veins in tensional and shear structures, as bedded sequences, and as lensoid bodies associated with volcanism.

Cement Raw Materials

Both Basement Complex and Nubia Formation rocks are potential sources of raw-material ingredients (alumina, silica, lime) for the manufacture of cement, and there is justification for inclusion of these materials in future industrial mineral programmes and marketing studies. The latter should include the viability of both Aswan and Wadi Halfa as potential production centres. The studies should indicate viable transport distances from raw-material sites to both cities, and future exploration for these raw materials should be restricted to that perimeter. Exact chemical requirements should be specified.

GROUNDWATER POTENTIAL

Groundwater is an essential mineral commodity that can be developed in selected localities in the Area of Integration where optimum source and aquifer conditions exist. Foreseen uses of groundwater would be for future mining and milling operations, for domestic use in camps and habitation areas, and for agricultural development in areas of geologically recent humus accumulation.

Apart from the Nile River and Nuba Lake/Lake Nasser, there is no other permanent surface water in the Area of Integration. But the influx of water from Nuba Lake/Lake Nasser and permanent charging of heretofore dry sedimentary aquifers of the Nubia Formation, prominent fault zones and joint systems, and wadi/khor sediments in perched, inundated areas have opened up a new potential for groundwater in the environs of the High-Dam lake and in some cases for extended distances away from it.

Geosurvey (1984) cites their map blocks GW1 and GW2 in the southwest Sudanese Sector adjacent to the Nile Valley as having a potential for groundwater development. The areas coincide with possible shallow basins of Nubia strata and may be permanently recharged.

In view of a perhaps overall dessication trend in past centuries, as evidenced by the large dead trees in some wadis, it is perceivable that the water table may have lowered perceptibly in small and partly non-rechargeable aquifers associated with the extensive system of "defunct" wadis and khors of the desert hinterland. Geosurvey (op. cit.) describes Wadi Gabgaba north of 21^{o}N latitude as particularly interesting because of its large size and the possibility that a "proto-Wadi Gabgaba" is infilled in this area by a broad tongue of Nubia strata. A similar area is northeast of No. 6 Railway Station, about midway between it and the Um Nabari gold prospect. There, Muftah Well, situated 26.5 km from Um Nabari and one of two sources of water for the mine in the early part of this century, produced 10,000 gallons of water per day from a 61 m depth in a Nubia sandstone aquifer. It is difficult to ascertain if such aquifers contain non-rechargeable formation water or if they are rechargeable via seasonal rains in the Red Sea Hills, a fault/joint system that taps Nuba Lake, etc.

At Wadi El Allaqi, a large affluent of Nuba Lake/ Lake Nasser in the southeastern Egyptian Sector, there is a prominent fault in part coincident with the wadi trace that transects the lake. It enhances the groundwater potential of this extensive wadi.

Initial exploration should be through aerial photo and satellite imagery interpretation in a search for structural features combined with Nubia Formation or wadi aquifers. Topographic breaks, abrupt changes in wadi or khor directions and geological discontinuities caused by igneous dykes or fault off-setting could result in subsurface damming and areas of water retention. Zones of fault or other lineament intersections, especially involving tree lines in wadi areas, are prime targets.

About 28 percent of the known wells in the Area of Integration contain brackish or salty water.

MINERAL TARGET AREAS

The Precambrian Basement Complex, including those extensive virgin areas without designated mineral targets, constitutes a formidable target area for future airborne and ground exploration surveys.

Within the Basement Complex, seven specific mineral target areas were identified as a result of the 1984-1985 field effort. They are listed below; the area reference numbers correspond to map locations on Plate I.

Plate I Ref.No.	Name of Prospect or Area	Sector	Size of Area (km^2)	Mineral Potential
1	Abu Swayel	Egyptian	4	copper-nickel
2	North Wadi El Allaqi	Egyptian	530	gold, base metals
3	Um Nabari	Sudanese	400	gold
4	Wadi Naba	Sudanese	1460	gold, base metals
5	Upper Wadi Gabgaba	Sudanese	700	gold
6	Duweishat	Sudanese	35	gold
7	Abu Sari	Sudanese	365	gold

Abu Swayel and Adjacencies

At this ancient copper-nickel prospect where the reported grade is 4.11% Cu and 1.76% Ni, the sulphide mineralization could be related to a covered ultramafic intrusion in the vicinity, and there is a remaining potential for economic sulphide mineralization. Further ground geophysical survey work and possibly additional diamond drilling are warranted to investigate untested down-dip projections of the mineralized amphibolite and schist host rocks and to search for possible mineralization in adjacent areas.

North Wadi El Allaqi

This large area embraces the Um Garayat and Nile Valley Block E gold prospects, both in the western part, together with a copper occurrence in the north-central part (see Figure 29). The main mineral potential is for vein-type, bulk-disseminated, and placer gold and for base metals in volcanogenic, massive sulphides.

The area is underlain mainly by intermediate to acidic metavolcanic rocks that exhibit on RBV satellite imagery a distinctive rock fabric similar to that at Um Nabari and portions of the Wadi Naba target area. The metavolcanic rocks could correspond to one or more volcanic piles. There are no recognized plutonic rocks in the area.

The southwest flank appears to be in contact with the Wadi El Allaqi fault. On RBV imagery, a northwest-southeast band-like feature about 1.5 km wide wraps concavely around the northeast side of the area and could correspond to a major structural break. Within the area, drainage accompanies a prominent joint set that strikes N35°-45°E. Subordinate sets strike N 06° W, N 25° E and N 80° W.

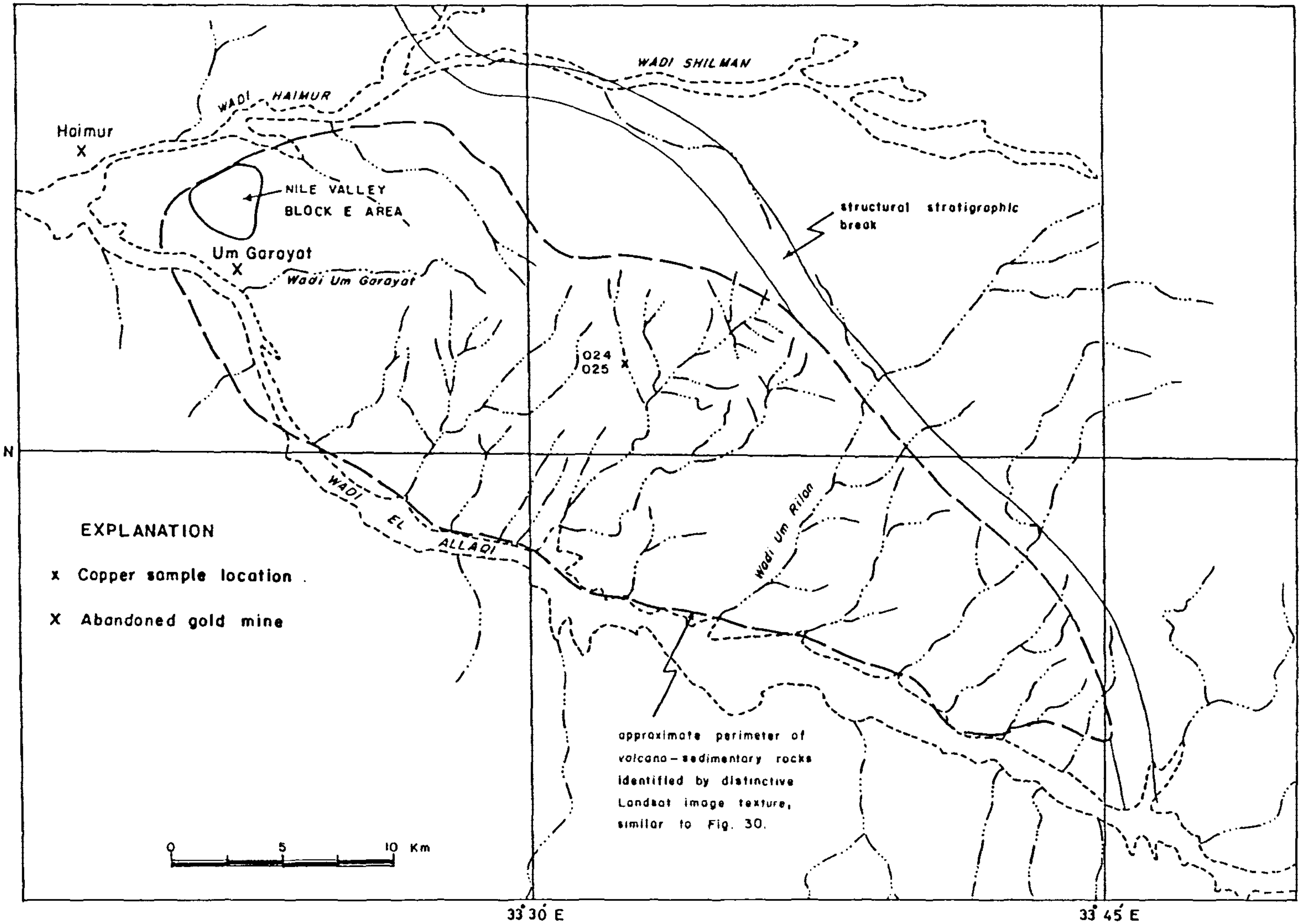


Fig. 29. North Wadi El Allaqi target area.

Um Nabari

This area is the host for the Um Nabari gold prospect, which is situated in the western extremity and probably has the best economic potential of all prospects in northern Sudan (see Figure 30). The main mineral potential is for lenticular, auriferous quartz veins and associated altered wall rock, both with a plutonic source. The area could also host some base metals.

This target area is mainly underlain by metavolcanic and metasedimentary rocks that exhibit the same distinctive rock fabric on RBV imagery as at the North Wadi El Allaqi and Wadi Naba areas. These host rocks occur in a cup-like mass, as outlined in Figure 30, apparently unconformably overlying contorted metasediments to the east. There is a possible N 10^{o} E intrusive trend across the narrow part of the area. The foliation strikes N 75^{o} E in the western half, arching over to N 78^{o} W in the eastern half and perhaps corresponding to a shear direction. Some north-south faulting is present.

Wadi Naba

This large area in the eastern part of the Sudanese Sector was the scene of extensive gold and some copper mining activity in ancient times and is highly prospective for vein, placer and disseminated gold and for base metals in volcanogenic sulphide deposits. It warrants thorough geological, geophysical and geochemical investigation.

Upper Wadi Gabgaba

This mineral target in the southeastern corner of the Area of Integration contains 15 occurrences of

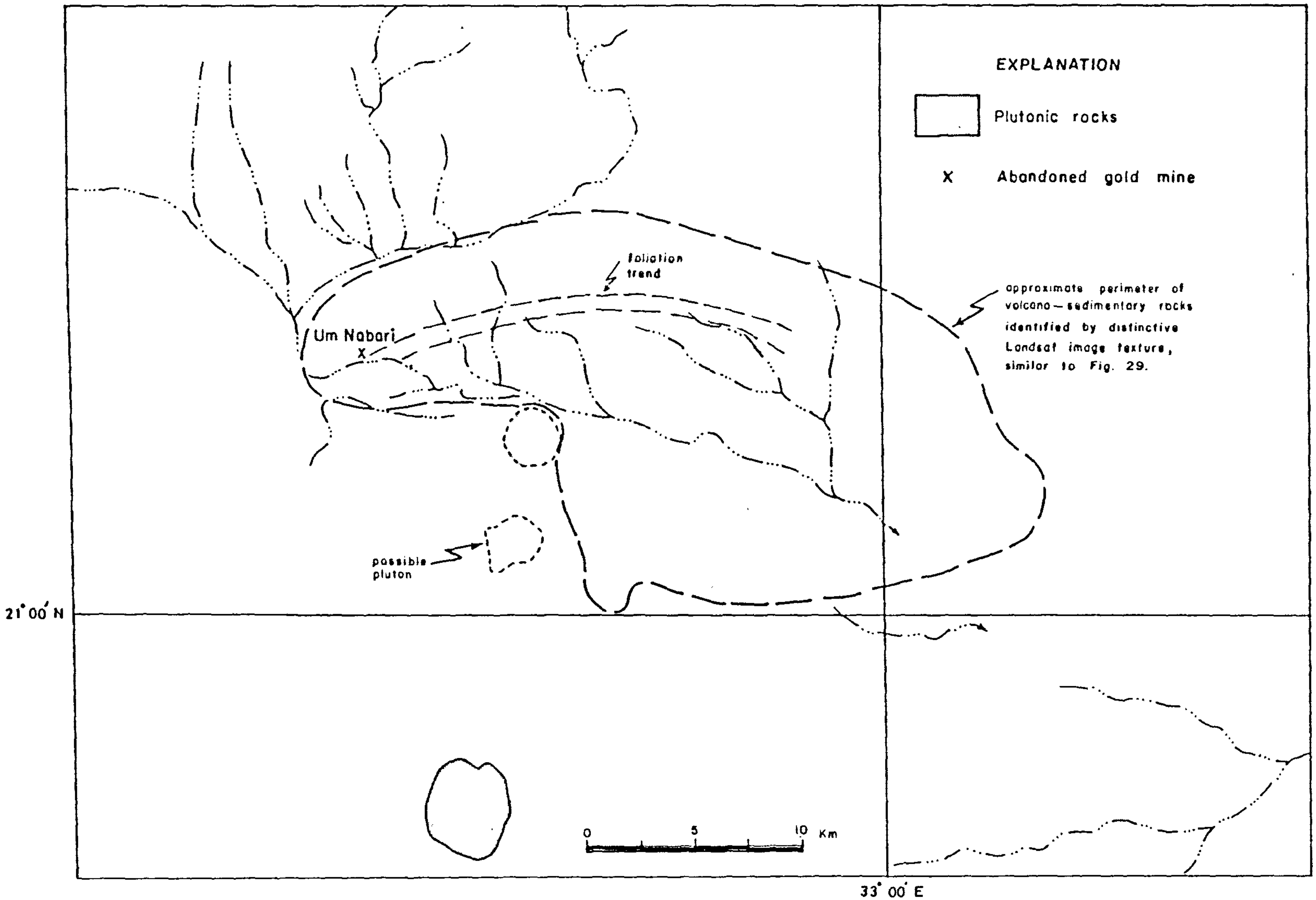


Fig. 30. Um Nabari target area.

auriferous quartz veins and associated placers that merit thorough investigation and evaluation. The veins could be the surface expression of a complex vein system with favourable depth potential.

Duweishat

In this ancient mining area, gold mineralization occurs in quartz veins and altered wall rock. Although Dunn (1917) reported that it was the poverty of the ore that resulted in the abandonment of Duweishat in that epoch, there is justification for a more thorough evaluation of the prospect area for a small, efficient heap-leach operation utilizing both auriferous quartz vein and associated alteration zone material.

Abu Sari

As at Duweishat, quartz veins and altered wall rock in this ancient mining area, on the east side of the Nile River, host gold mineralization that merits further investigation and evaluation directed toward a small, efficient heap-leach operation.

A similar mineralized area is reported on the west side of the Nile opposite Abu Sari; it too should be investigated.

CONCLUSIONS AND RECOMMENDATIONS

Technical

1. Within the Area of Integration, the entire 76,600 sq km area underlain by Precambrian Basement Complex rocks is prospective for mineral deposits, and the Sudanese Sector constitutes one of the very few remaining large areas of the world untouched by systematic mineral exploration.

2. In the Sudanese Sector, a pre-existing mineral concession is held by the Sudan Minex Gold Mining Venture. If the two concession blocks (see Figure 5) and some peripheral areas are excluded, the prospective Precambrian portion of the Area of Integration is effectively reduced to two discrete areas: 1) a 31,300 sq km area encompassing the Kuror High in the southwestern part of the Sudanese Sector, east of 30°40' E longitude (the western Minex Concession block east-line), and south and west of the Wadi Halfa-Khartoum railroad; and 2) a 13,700 sq km area north of 21°48' N latitude (the eastern Minex concession block north-line). The Um Nabari, Wadi Naba, Upper Wadi Gabgaba and Abu Sari target areas in Sudan are covered by the concessions, but the remaining 45,000 sq km area comprises extensive unexplored territories that constitute an attractive mineral exploration package.

3. The greatest potential for metals/minerals is in Precambrian rocks of volcano-sedimentary

affinities and includes:

a) Gold in auriferous quartz veins, in placer deposits, or, more remotely, in bulk-disseminated deposits;
b) Polymetallic base metal ores (copper, zinc, lead) in volcanogenic, massive sulphides, Belt-type stratiform deposits, or in other stratiform bodies;
c) Uranium in Proterozoic metasediments, in veins, stockworks and breccias, unconformities and calcrete deposits;
d) Sedimentary phosphate.

4. The most prospective parts of the Area of Integration include:
   a) The entire Precambrian Basement Complex;
   b) Within the Basement Complex, seven specific target areas covering gold and base metals prospects that merit special investigation (see Plate I);
   c) The Nubia/Precambrian unconformity and associated rocks;
   d) Selected drainages and localities for alluvial (placer) gold.

5. Although the remoteness of most of the Area of Integration, in terms of sizeable centres of population and communication, is a limiting factor in respect of the development potential for lower-valued industrial minerals, GMC should include this category in its future work programme, especially in the general Aswan area and wherever good access and communications offer economic possibilities. At the present time, baryte and cement raw materials appear to have the best development potential. Marketing

studies should be a critical requirement for all non-metallic minerals.

6. In future work programmes involving mineral exploration, evaluation or exploitation, serious attention should be given to factors affecting the economic viability of an undertaking, such as the extreme remoteness and aridity of the region, inherent difficulties of access and logistics, and augmented operational costs.

7. Before undertaking radiometric survey work, it is recommended that GMRD and the Egyptian Nuclear Materials Authority be contacted regarding policies and procedures.

8. The Pan-African thermo-tectonic event dating from 450-700 M.a. left its overprint on the Precambrian rocks of the region, masking their true age. Whereas earlier investigations classified all the Precambrian rocks of the region as late Proterozoic, some geologists now believe that rocks as old as Archaean may be present. This increases the age range and consequently the mineral deposit diversity and potential of the region.

9. Geologic structure is the key to many mineral deposits, and there is justification for a thorough study of the structure of the entire Precambrian Basement Complex, through photogeology and field investigations, including those areas in the Egyptian Sector already mapped, to analyze the association of structure and known mineral occurrences, and to optimize the selection of new mineral target areas.

10. New colour aerial photography of those portions of the Area of Integration underlain by Precambrian Basement Complex rocks is recommended to replace antiquated black-and-white photographic coverage as an essential exploration tool in the search for new mineral deposits.

11. The geological interpretation of Landsat imagery of the Sudanese Sector was successful, and the resultant report and maps have proved invaluable in subsequent field work. It is recommended that a similar study, restricted to areas underlain by Basement Complex rocks, be made of the Egyptian Sector. This would complete the Area of Integration coverage of Precambrian rocks and would provide image-structural interpretations that are currently lacking in the Egyptian Sector.

Operational

1. Aswan Location

The advantages of Aswan as a project centre and base of operations are its proximity to the work area and the relative ease in accomodating vehicles, equipment and supplies. The disadvantages are its remoteness from Cairo, the associated communication problems, and the lack of certain support facilities.

It is recommended that Aswan be the base for any future exploration programme.

2. Training

The following training is recommended:

a) Photogeological interpretation, using both colour and black-and-white aerial photographs;

b) General office and personnel management;

c) Mineral exploration, development and exploitation, with emphasis on small deposits and mines.

3. Field Communications

Future field communications should take into account the desirability and efficiency of an independent radio network, with:

a) Fixed transceiver bases at Aswan and Wadi Halfa;

b) One mobile transceiver base, and a mobile transceiver and proven antennae system in each vehicle designated for unaccompanied travel in the desert;

c) Early morning and early evening reporting times;

d) Permission for Government-approved foreigners to use the radio; and

e) An exclusive GMC frequency, in addition to one channel each on frequencies operated by EGSMA and GMRD, and by UNDP Khartoum for any future UNDP-assisted operations.

4. Field Operations and Logistics

Based on the experiences of the 1984-1985 field season, the following recommendations are made for consideration in any future campaign:

a) A reliable expediter should be engaged in Wadi Halfa to handle customs and visa requirements, to obtain ferry tickets, and to handle any other documentation or supply requirements, thereby removing this responsibility from the technical staff. Similarly, there is a need for an expediter in Cairo with time and funds plus authority to handle the delivery of couriered post and other materials, map reproduction, equipment and supply purchases, documentation requirements, etc.

b) A courier service should be established between Aswan/Cairo and Aswan/Wadi Halfa.

c) There should be standing and continuing customs permissions from both Egypt and Sudan to move personnel, equipment, supplies and samples both ways across the Egypt-Sudan border.

d) A co-ordinated leave system and travel allowance applicable to both Egyptian and Sudanese personnel should be implemented.

e) At field camps, there should be an established evening hour for daily staff meetings to discuss the results of the day's field activities, and to plan and make assignments for the following day's activities.

f) Geologists should be encouraged to perform chores like driving, radio communications, drafting, etc.

g) The size of field crews should be reduced, especially in remote, waterless field areas, such as the Nubian Desert, by doubling up on assigned work and eliminating full-time positions demanding only part-time work, for example:

i. By eliminating the position of radio operator and training selected people, such as drivers and geologists, to operate the radios;

ii. By possibly having mechanics serve as drivers and drivers as mechanics' helpers;

iii. By encouraging all support staff to perform field chores outside their normal tasks, such as cook's helper, radio operator, or geologist's helper.

h) For the supply of water to field camps:

i. A reliable 4WD heavy-duty flat-bed truck should be obtained for transporting both water and benzine.

ii. For remote desert locations south of Wadi El Allaqi, plastic water containers of a minimum 40 litre capacity, if possible stackable, should be used. Their use offers greater flexibility in transporting water to, and storing water at, remote desert locations. They are also good for fly camp use.

i) Portable canvas cots (beds) and chairs, portable mattresses, light-weight folding tables, etc. should be obtained for fly camps.

j) An adequate supply of tyres, tubes, tyre tools, other tools, spare parts, filters, fan belts, etc. should be maintained at the Wadi Halfa base for field operations in the Sudanese Sector.

5. **Field Safety**

a) Utmost consideration should be given to proper safety precautions to assure survival in the event of a vehicle or communications breakdown.

b) An emergency procedure should be established to handle a sickness or accident requiring quick evacuation from remote desert areas.

c) A complete field first-aid kit is needed, and field personnel should know how to use it. All personnel should take and pass a course in first-aid, such as the one offered by CARE in the Aswan area in 1984, which should include the procedure for handling snake and scorpion bites.

FURTHER WORK

Work Area

The Precambrian area for proposed follow-up survey work will comprise two discrete areas totalling 45,000 sq km, as described in item 2 (Technical) of Conclusions and Recommendations, with 31,300 sq km in Sudan and 13,700 sq km in Egypt.

Work Period

The most productive field months are November through March, and it is recommended that all field work be planned for that period. Work can be carried out in October and April, but higher temperatures in those months inhibit field activity.

The strong, dust-laden khamseen winds of February and March make those months undesirable for aerial survey work and occasionally hinder ground field work.

Recommended Activities

1. **Colour aerial photography, with colour aerial mosaics of established mineral target areas.**

    a) Best apparent photography period: October - January;
    b) Where desirable, establish ground elevation control for aerial mosaics;
    c) Recommended scale: 1:25,000.

2. **Photogeological interpretation/mapping.**

a) Priority to mineral target and other selected areas;

b) Emphasis on geologic structure of mineralized areas, especially those where development work is anticipated;

c) Selection of new mineral target areas based on anomalous structure, colouration, etc. for ground follow-up;

d) Initiation of systematic photogeological mapping, with priority to areas of higher mineral potential.

3. **Geological interpretation of satellite-imagery -- Egyptian Sector.**

4. **Contract airborne thematic mapping survey.**

a) To be carried out over one or more areas of known mineralization having economic potential.

5. **Geophysical surveys.**

a) Airborne surveys: aeromagnetic, electromagnetic and radiometric surveys.

i. Establish operations base in Wadi Halfa;

ii. Establish field support and procedures for field checking of airborne geophysical anomalies.

b) Ground surveys: magnetic, electromagnetic, induced potential and resistivity surveys.

i. A thorough ground survey of the Abu Swayel copper-nickel prospect and its adjacencies;

ii. Surveys of a number of mineral target test areas to evaluate the geophysical characteristics for gold and sulphides;

iii. Establish field support.

6. Geochemical surveys.

a) Surveys of selected mineral target areas or localities;

b) Line and sample spacing to adequately evaluate target;

c) Minimal number of selected elements, to include:

   i. For gold targets: Au, As, Hg, Sb, Cu;

   ii. For base metal targets: Cu, Zn, Pb, Co, As, Sb, Au.

d) Analyses to ppb accuracy where essential/applicable.

7. Ground follow up.

a) Ground follow-up to check:

   i. Photogeological anomalies;

   ii. Geophysical anomalies;

   iii. Thematic mapping anomalies.

8. Geological traversing and mapping of selected areas.

a) Use new colour aerial photographs and mosaics;

b) Use Landsat imagery;

c) Detailed mapping where justified, using workable map scales;

d) Initiation of systematic field mapping:

   i. Commence with priority areas based on mineralization, lithology or structure;

   ii. Scales: 1:100,000 or 1:50,000 for regional mapping;
   1:10,000 or 1:5,000 for mapping moderate-sized areas;
   1:2,000 or 1:1,000 for mapping small areas or localities.

9. Pitting, trenching, sampling.

a) In areas requiring detailed mineral evaluation.

10. Selection of drill sites and follow-up percussion and diamond drilling.

11. Underground mapping in old mine workings where applicable and safe.

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APPENDIX A

FUNDING AND OTHER SUPPORT

Governments

The Sudanese and Egyptian Governments contributed equally in annual budget cash amounts, vehicles and other equipment, and secondment of GMRD and EGSMA technical, office and support personnel to the Geological and Mining Centre.

United Nations

The United Nations Development Programme (UNDP) contribution to Project RAB/80/014 amounted to US$529,747 (Revision N) during this Preparatory Assistance Phase.

Through the United Nations Department of Technical Co-operation for Development (UNDTCD), a Project Co-ordinator/Adviser (Economic Geologist), a remote sensing consultant, and technical advisers and other consultants were supplied to the project.

A 4-wheel drive vehicle, complete satellite imagery and topographic map coverage of the Area of Integration, a photocopying machine, and miscellaneous office, drafting and field items were supplied.

A sub-contract for interpretation of Landsat imagery and specialized training (see Appendix B) were provided.

APPENDIX B

TRAINING

Overseas training was provided as follows:

1. January 1985 - a two-week course by Geosurvey International in London, England in the geological interpretation of satellite imagery, attended by one geologist from Egypt and one from Sudan.

2. April 1985 - a technical conference in Rabat, Morocco, "Prospecting in Areas of Desert Terrain," plus a technical tour, attended by one geologist.

APPENDIX C

TECHNICAL PERSONNEL

Geological and Mining Centre

From GMRD (Sudan)

Mohamed A. Karfis, Director General
Mohamed E. M. Jaren Nabi, Senior Geologist
Dr. Yassin H. Karrar, Senior Geologist
Sir E. A. Fadl, Geologist
Tag El-Sir Ateia, Geologist Assistant
Merghne H. Arbab, Draftsman*

From EGSMA (Egypt)

Abdel A. Rashwan, Deputy Director General
Zeinhom S.A.S. El Alfy, Senior Geologist
Khalil A. Khalil, Geologist
Sobhy A. E. Anan El Fiki, Geologist

*Mr. Arbab drafted all maps and figures in this report.

United Nations

The project was the object of missions and assignments by UNDTCD technical advisers and consultants as listed overleaf.

J.V. Guy-Bray
Position: Project Technical Adviser
Period: 9-16 October 1984; 29 September - 13 October 1985
Purpose: Office and field visits; TPR and technical reviews

Richard Savard
Position: Field Geologist Consultant
Period: 2 April - 14 May 1985
Purpose: Field geology - Sudanese Sector

Michael Lewis
Position: Technical Adviser, Geophysics
Period: 12-15 August 1985
Purpose: Consult./planning; geophysical specs.

Daniel Harkin
Position: Compilation Geologist Consultant
Period: 13 August - 10 September 1985
Purpose: Compilation report work

W.L. Anderson
Position: Project Coordinator (Economic Geologist)
Period: 10 December 1983 - 16 December 1985
Purpose: Project coordination/compilation

APPENDIX D

DESCRIPTION OF SAMPLE PROCESSING FOR ASSAY

A total of 371 field samples were processed into assay pulps by the EGSMA Dokki (Cairo) Laboratory in January and July 1985. On recommendation of X-Ray Laboratories Ltd. of Don Mills, Ontario, Canada, the procedure listed below was followed, starting with a ± 2 kg sample:

1. Crush to 5 mm size in large jaw crusher;

2. Crush to 2 mm size in small Retsch BV2 jaw crusher;

3. Using a fine Jones splitter, carefully split the sample into equal portions weighing 100-125 grams: for assay and for duplicate storage;

4. Separately pulverize the individual portions in the BICO Type UA pulverizer to minus 200 mesh.

APPENDIX E

LABORATORY ASSAY METHODS

The 100-125 gram sample pulps were shipped to X-Ray Assay Laboratories Ltd., 1885 Leslie Street, Don Mills, Ontario, Canada for analysis by geochemical methods. The following assay methods were employed:

Gold:	FADCP -	A combination of the fire assay method with DC plasma emission spectrometry to yield a highly sensitive system giving ppb accuracy;
Copper:	DCP -	DC plasma emission spectrometry;
Arsenic:	NA -	Neutron activation. Solid samples or powders are irradiated in a high-density neutron flux to produce isotopes of the elements present in the sample. Element concentrations are determined with a multi-channel gamma-ray spectrometer.

APPENDIX F

ASSAY RESULTS

Sample No.	Location	Assay Value	Element	Type of Sample	Description
010	22°35'N, 33°23'E	- 2 ppb	gold	rock sample	metatuff in area of high Cu anomaly
012	" "	- 2 ppb	gold	rock sample	altered metafuff
014	" "	- 2 ppb	gold	rock sample	metaandesite in area of high copper anomaly
016	" "	28 ppb	gold	rock sample	metatuff in area of high Cu anomaly
017	22°24'N, 33°23'E	- 2 ppb	gold	rock sample	metatuff
018	22°24'N, 33°23'E	- 2	gold	rock sample	agglomeratic metarhyolite from area of high Cu anomaly
020	22°36'N, 33°21'E	- 2 ppb	gold	rock sample	altered acidic metavolcanic
021	" "	12 ppb	gold	rock sample	metatuff
022	" "	10 ppb	gold	rock sample	brown, altered metatuff
024	22°32'15"N 33°31'42"E	2200 ppm 24 ppb	copper gold	rock sample	visible malachite/azurite in metatuff
025	"	1400 ppm 230 ppb	copper gold	rock sample	soft, altered metatuff
	(Duweishat Sector A)				
027	21°22'N, 30°58'E	400 ppb	gold	alt. zone	upper zone, 25 cm thick
028	" "	1400 ppb	gold	qtz vein	48 cm quartz vein
029	" "	2700 ppb	gold	alt. zone	lower alteration zone, 25 cm thick, mostly schist
	(Duweishat Sector B)				
030	" "	460 ppb	gold	alt. zone	upper alteration zone, 25 cm thick, altered schist
031	" "	550 ppb	gold	qtz vein	grab samples across 4.94 m qtz vein
032	" "	5000 ppb	gold	alt. zone	lower alt. zone, 25 cm thick
033	" "	2100 ppb	gold	alt. zone	same as 032 but more weathered and closer to surface
034	" "	9100 ppb	gold	qtz vein	1.4 m qtz vein + 35 cm alt. material
035	" "	560 ppb	gold	alt. zone	footwall host rock
	(Duweishat Sector C)				
036	" "	110 ppb	gold		
037	" "	48 ppb	gold	qtz vein	milky qtz vein 2 m thick; chip samples over entire vein width
038	" "	1200 ppb	gold	qtz vein/ alt. zone	10 cm of basal qtz vein + 25 cm altered footwall
039	" "	240 ppb	gold	alt. zone	metatuff hanging wall for qtz vein
040	" "	110 ppb	gold	alt. zone	1.27 m section of footwall
041	" "	940 ppb	gold	alt. zone	36 cm of footwall below qtz vein
042	" "	5200 ppb	gold	qtz vein	1.44 m qtz vein with 3 argillaceous layers
043	" "	320 ppb	gold	alt. zone	hanging wall tuff 25 cm thick.
	(Um Nabari)				
059	21°07'N, 32°46'E	1700 ppb	gold	tailings	N1 dump, 2.16 m channel at trench
060	" "	78 ppb	gold	tailings	N2 dump, 2.50 m channel
061	" "	880 ppb	gold	tailings	2.75 m channel sample
062	" "	12 ppb	gold	tailings	old dump, 30 cm pit sample
063	" "	30300 ppb	gold	tailings	old dump, wind-riffled concentrate
064	" "	49 ppb	gold	alluvial	56 cm stream sediment sample in centre of 35 m khor
066	" "	97 ppb	gold	alluvial	lower 55 cm of channel sample

Sample No.	Location	Assay Value	Element	Type of Sample	Description
067	(Um Nabari) 21°07'N, 32°46'E	26 ppb	gold	alluvial	upper 1.0 m of channel
069	" "	120 ppb	gold	mine dump	
501	(Marahik) 22°30'N, 33°27'E	3 ppb	gold	alluvial	10 kg of sieved sand and clay
502	" "	4 ppb	gold	alluvial	10 kg of sieved sand and clay
503	" "	3 ppb	gold	alluvial	10 kg of sieved sand and clay
505	" "	210 ppb	gold	alt. zone	fine-grained, ferruginous material
506	" "	2800 ppb	gold	qtz vein	milky hematitic quartz
507	" "	160 ppb	gold	alt. zone	soft, rich in iron
508	" "	6 ppb	gold	alluvium	10 kg of sieved sandy gravel
509	" "	4 ppb	gold	alluvium	10 kg of sieved sandy gravel
510	(Abu Fass) 22°10'N, 33°51'E	- 2 ppb	gold	alluvium	10 kg of sieved sandy clay
511	" "	6 ppb	gold	alluvium	10 kg of sieved sandy clay
513	" "	840 ppb	gold	qtz vein	milky qtz with some talcose min.
514	" "	11 ppb	gold	qtz vein	milky qtz with some talcose min.
516	" "	7 ppb	gold	qtz vein	hematitic quartz vein
517	" "	770 ppb	gold	alt. zone	stringers of qtz with iron oxide min.
518	" "	3 ppb	gold	alluvium	10 kg of sieved sandy clay
519	" "	5 ppb	gold	alluvium	10 kg of sieved sandy clay
520	" "	240 ppb	gold	alt. zone	fine-grained, rich in iron oxide
521	" "	27 ppb	gold	qtz vein	milky, slightly hematitic
522	" "	1400 ppb	gold	alt. zone	fine-grained, pyrite, talc, iron oxide
523	" "	11 ppb	gold	qtz vein	milky quartz
524	" "	3 ppb	gold	rock sample	fine-grained metavolcanic rock
526	(Haimur) 22°38'N, 33°18'E	21 ppb	gold	qtz vein	ferruginous quartz from adit
527	" "	511 ppb	gold	alt.zone/ contact	ferruginous, fine-grained
528	" "	74 ppb	gold	qtz vein	milky quartz with blackish lines
529	" "	65 ppb	gold	alluvium	10 kg of sandy clay, 40 cm pit channel to bedrock
530	" "	390 ppb	gold	alluvium	35 cm pit channel to bedrock
531	" "	17 ppb	gold	alt. zone	60 cm sample, both sides of vein
533	" "	12 ppb	gold	alluvium	75 cm pit channel
534	(Filat) 22°19'N, 33°37'E	50 ppb	gold	rock sample	fine-grained acidic dyke
536	" "	- 2 ppb	gold	rock sample	fine-grained, dark colour, abundant mafics
537	" "	- 2 ppb	gold	alluvium	10 kg of sandy clay
538	" "	- 2 ppb	gold	alluvium	10 kg of sandy clay
539	" "	10 ppb	gold	alluvium	10 kg of sandy clay
540	(Abu Fass) 22°10'N, 33°51'E	110 ppb	gold	qtz vein	milky quartz vein 0.5 m thick

Sample No.	Location	Assay Value	Element	Type of Sample	Description
	(Um Garayat)				
543	22°34'N, 33°23'E	83 ppb	gold	alluvium	1.2 m pit channel to bedrock
544	" "	5 ppb	gold	alluvium	1.0 m pit channel to bedrock
545	" "	180 ppb	gold	alluvium	1.0 m pit channel to bedrock
	(Um Ashira South)				
546	22°54'N, 33°15'E	8 ppb	gold	qtz vein	hematitic qtz vein 2.5 m thick
549	" "	43 ppb	gold	alluvium	65 cm pit channel to bedrock
550	" "	5 ppb	gold	alluvium	45 cm pit channel to bedrock
551	" "	- 2 ppb	gold	rock sample	metavolcanic rock
553	" "	14 ppb	gold	alluvium	10 kg of sieved sandy clay
	(Haimur)				
554	22°38'N, 33°18'E	>10000 ppb	gold	qtz vein	smoky qtz vein 0.6 m thick in adit
555	" "	740 ppb	gold	rock sample	acidic metavolcanic rock from adit
556	" "	66 ppb	gold	rock sample	contact zone in adit
557	" "	35 ppb	gold	qtz vein	smoky quartz in adit
558	" "	370 ppb	gold	rock sample	contact zone in adit
559	" "	240 ppb	gold	rock samole	contact zone in adit
560	" "	7 ppb	gold	qtz vein	vein in adit
561	" "	10 ppb	gold	alt. zone	from adit
562	" "	14 ppb	gold	alt. zone	from adit
563	" "	98 ppb	gold	qtz vein	from adit
564	" "	45 ppb	gold	qtz vein	from adit
565	" "	24 ppb	gold	qtz vein	from adit
	(Copper Prospect SE Sta. 3)				
587	21°25'N, 32°10'E	25 ppb 2400 ppm 52 ppm	gold copper arsenic	chip sample	basic metavolcanic rock, malachite stained
588	" "	840 ppb 15500 ppm 420 ppm	gold copper arsenic	chip sample	basic metavolcanic rock, malachite stained
592	" "	320 ppb 20800 ppm 7 ppm	gold copper arsenic	chip sample	basic metavolcanic rock, malachite stained
593	20°45'-21°00'N 31°15'-31°30'E	13 ppb	gold	alluvium	60 cm pit channel to bedrock
595	" "	- 2 ppb 55 ppm 8 ppm	gold copper arsenic	rock sample	gabbroic rock
	(Atshan)				
1501	22°30'N, 33°30'E	110 ppb	gold	alt. zone	from trench
1502	" "	510 ppb	gold	alt. zone	from shaft
1503	" "	240 ppb	gold	qtz vein	from shaft
1504	" "	620 ppb	gold	alt. zone	from trench
1506	" "	5 ppb	gold	alluvium	40 cm pit channel to bedrock
1507	" "	5 ppb	gold	alluvium	70 cm pit channel to bedrock
1508	" "	12 ppb	gold	alluvium	1.0 m pit channel to bedrock
1509	" "	110 ppb	gold	alluvium	55 cm pit channel to bedrock
1510	" "	60 ppb	gold	alt. zone	from trench
1512	" "	- 2 ppb	gold	alluvium	90 cm pit channel to bedrock

Sample No.	Location	Assay Value	Element	Type of Sample	Description
	(Nile Valley Block E)				
1513	22°36'N, 33°20'E	330 ppb	gold	alluvium	80 cm pit channel to bedrock
1514	" "	9 ppb	gold	alluvium	75 cm pit channel to bedrock
1515	" "	5 ppb	gold	alluvium	60 cm pit channel to bedrock
1516	" "	4 ppb	gold	alluvium	60 cm pit channel to bedrock
1517	" "	21 ppb	gold	qtz vein	hematitic quartz
1518A	" "	1200 ppb	gold	alt. zone	
1520	" "	37 ppb	gold	qtz vein	
1521	" "	120 ppb	gold	alt. zone	
	(Murra)				
1522	22°34'N, 33°55'E	600 ppb	gold	alluvium	1.10 m pit channel to bedrock
1523	" "	3 ppb	gold	alluvium	95 cm pit channel to bedrock
1524	" "	3 ppb	gold	alluvium	60 cm pit channel to bedrock
1525	" "	2 ppb	gold	qtz vein	
1527	" "	67 ppb	gold	rock sample	calcareous rock
1528	" "	85 ppb	gold	alt. zone	
	(Negib)				
1529	22°48'N, 33°43'E	1700 ppb	gold	qtz vein	whitish to pale red
1530	" "	2600 ppb	gold	alt. zone	sample is from trench
1533	" "	2 ppb	gold	alluvium	94 cm pit channel to bedrock
1534	" "	3 ppb	gold	alluvium	90 cm pit channel to bedrock
1535	" "	- 2 ppb	gold	alluvium	74 cm pit channel to bedrock
	(Harairi)				
1537	22°57'N, 33°27'E	57 ppb	gold	alluvium	60 cm pit channel to bedrock
1538	" "	7 ppb	gold	qtz vein	
1539	" "	51 ppb	gold	alt. zone	sample is from trench
1541	" "	47 ppb	gold	alt. zone	sample is from trench
1542	" "	4 ppb	gold	rock sample	basic rock
1544	" "	4 ppb	gold	alluvium	90 cm pit channel to bedrock
1545	" "	- 2 ppb	gold	rock sample	gneissose rock
1546	" "	49 ppb	gold	qtz vein	broken quartz near old pit
1549	" "	23 ppb	gold	qtz vein	hematitic, 5-50 cm thick
1550	" "	3700 ppb	gold	alt. zone	alt. zone of hematitic·quartz vein
1551	" "	270 ppb	gold	alt. zone	alt. zone of hematitic quartz vein
1552	" "	8 ppb	gold	alluvium	64 cm pit channel to bedrock
	(Um Ashira North)				
1553	23°08'N, 33°16'E	- 2 ppb	gold	alluvium	1.00 m pit channel to bedrock
1555	" "	>10000 ppb	gold	qtz vein	sample from remnant of extracted vein
	(Jebel Um Faham)				
1560	21°18'N, 31°07'E	150 ppb	gold	rock sample	copper occurrence, malachite staining
1561	" "	- 2 ppb	gold	qtz vein	malachite staining
	(NE of No. 6 Station)				
1571	20°47'N, 32°36'E	110 ppb	gold	rock sample	intermediate metavolcanic
1572	" "	- 2 ppb	gold	qtz vein	smoky quartz vein
	(Um Fitfit)				
1573	20°46'N, 32°23'E	3 ppb	gold	alt. rock	carbonaceous rock sample

Sample No.	Location	Assay Value	Element	Type of Sample	Description
1574	(Um Fitfit) 20°46'N, 32°23'E	3 ppb	gold	rock sample	micaceous schist
1575	" "	1900 ppb	gold	qtz vein	mineralized vein
1585	(Wadi Naba) 21°11'N, 33°28'E	6500 ppb	gold	rock sample	metasedimentary rock
1589	(Adila) 21°19'N, 31°08'E	4 ppb	gold	rock sample	volcanic rock, copper occurrence
1590	" "	- 2 ppb	gold	rock sample	hematitic
1592	(Wadi Ambikol) 21°17'N, 30°53'E	4 ppb	gold	alluvium	samples from pits 70 to 92 cm deep
1593	" "	- 2 ppb	gold	alluvium	" " "
1594	(Wadi Ambikol) 21°16'N, 30°54'E	- 2 ppb	gold	alluvium	" " "
1595	" "	5 ppb	gold	alluvium	" " "
1596	(Wadi Ambikol) 21°13'N, 30°55'E	42 ppb	gold	alluvium	" " "
1597	" "	- 2 ppb	gold	alluvium	" " "
1598	(Wadi Ambikol) 21°13'N, 30°56'E	4 ppb	gold	alluvium	" " "
1599	21°13'N, 30°58'E	- 2 ppb	gold	alluvium	" " "
1600	" "	7 ppb	gold	alluvium	" " "
2000	(Wadi Naba area) 21°15'-21°18'N 33°37'-33°44'E	3100 ppb	gold	alluvium	sandy clay material
2001	" "	2200 ppb	gold	alluvium	trench sample
2002	" "	- 2 ppb	gold	qtz vein	
2003	" "	17 ppb	gold	alluvium	60 cm pit channel to bedrock
2004	" "	2 ppb	gold	alluvium	60 cm pit channel not to bedrock
2006	" "	5100 ppb	gold	qtz vein	
2007	" "	11 ppb	gold	alluvium	placer in metavolcanics
2008	" "	43 ppb	gold	alluvium	50 cm pit channel not to bedrock
2009	" "	16 ppb	gold	qtz vein	30 m long vein 70 cm thick
2010	(Wadi Naba area) 21°23'-21°25'N 33°44'-33°46'E	8 ppb	gold	alluvium	near chloritic schist
2011	" "	31 ppb	gold	qtz vein	milky quartz vein
2012	" "	9 ppb	gold	alluvium	near andesitic rock
2013	" "	8 ppb	gold	qtz vein	milky quartz vein 70 cm thick
2014	" "	- 2 ppb	gold	dump	small-sized widespread dump material
2015	" "	2400 ppb	gold	alluvium	80 cm pit channel not to bedrock
2016	" "	- 2 ppb	gold	alluvium	near metavolcanic shear zone
2017	" "	6900 ppb	gold	rock samples	3 samples collected from trench
2018	" "	600 ppb	gold	alt. zone	from same trench as spl 2017, 20 m long, 0.8 to 3.0 m wide, 5.0 m deep
2019	" "	1400 ppb	gold	alt. zone	" " " "
2020	" "				sample misplaced
2021	" "	180 ppb	gold	rock sample	quartz vein

Sample No.	Location	Assay Value	Element	Type of Sample	Description
	(SE of Duweishat)				
2583	21°12'N, 31°30'E	12 ppb	gold	alluvium	50 cm pit channel in gravels, sands and clays near basic rocks
2585	21°14'N, 31°26'E	850 ppb	gold	alluvium	30 cm pit channel to bedrock (gabbro), in gravels, sands and sandy clay
2589	not sufficient sample				
2590	21°27'N, 31°51'E	- 2 ppb	gold	alluvium	
2593	21°27'N, 31°32'E	- 2 ppb	gold	alluvium	
2594	" "	11 ppb	gold	alluvium	
	(Abu Sari)				
2600	21°16'N, 30°35'E	24 ppb	gold	qtz vein	channel sample
2601	" "	1900 ppb	gold	qtz vein	" "
2602	" "	140 ppb	gold	qtz vein	" "
2603	" "	290 ppb	gold	alt. zone	" "
2604	" "	1900 ppb	gold	alt. zone	in metavolcanic rock
2607	" "	4000 ppb	gold	qtz vein	channel sample
2608	" "	6700 ppb	gold	alt. zone	" "
2609	" "	39 ppb	gold	qtz vein	" "
2610	" "	250 ppb	gold	alt. zone	" "
2611	" "	78 ppb	gold	qtz vein	chip sample
2612	" "	3400 ppb	gold	alt. zone	channel sample
2613	" "	11 ppb	gold	dump	pile of quartz vein material
2614	" "	12 ppb	gold	dump	pile of quartz vein material
2615	" "	41 ppb	gold	dump	pile of quartz vein material
2616	" "	59 ppb	gold	qtz vein	channel sample
2617	" "	24 ppb	gold	qtz vein	chip sample
2618	" "	3800 ppb	gold	qtz vein	chip sample
2619	" "	6600 ppb	gold	alt. zone	channel sample
2620	" "	44900 ppb	gold	alt. zone	channel sample
	(Upper Wadi Gabgaba)				
2624	21°04'N, 33°21'E	- 2 ppb	gold	rock sample	gabbroic rock
2627	21°09'N, 33°07'E	- 2 ppb	gold	rock sample	gabbroic rock
2628	20°12'N, 33°03'E	16600 ppb	gold	rock sample	
2631	20°14'N, 33°22'E	2100 ppb	gold	alluvium	placer area
2632	20°14'30"N, 33°21'E	7 ppb	gold	rock sample	
2633	" "	88 ppb	gold	alluvium	placer area
2635	20°18'N, 33°18'E	26 ppb	gold	alluvium	placer area
2637	(2636?)" "	8300 ppb	gold	qtz vein	chip sample
2637A	" "	11 ppb	gold	qtz vein	veinlet
2638	" "	100 ppb	gold	rock sample	schistose rock
2639	" "	34 ppb	gold	alluvium	placer area
2640	20°26'N, 33°19'E	40 ppb	gold	alluvium	placer area
2641	" "	15 ppb	gold	alluvium	placer area
	(Wadi Naba Area)				
2642	21°14'N, 33°56'E	3000 ppb 450 ppm	gold copper	qtz vein	chip sample

Sample No.	Location	Assay Value	Element	Type of Sample	Description
	(Shilman Serpentinite)				
2502	22°43'45"N,33°44'E	22 ppb	gold	rock sample	serpentinite/dunite
2503	22°43'45"N,33°45'E	8 ppb	gold	rock sample	massive chromite
2504	22°41'N, 33°40'E	- 2 ppb	gold	alluvium	wadi channel sample near serpentinite
2505	" "	- 2 ppb	gold	alluvium	" " " " "
2506	22°40'N, 33°40'E	- 2 ppb	gold	alluvium	" " " " "
2507	" "	- 2 ppb	gold	alluvium	" " " " "
2508	" "	- 2 ppb	gold	alluvium	" " " " "
2509	22°40'N, 33°47'E	- 2 ppb	gold	alluvium	" " " " "
2510	22°39'N, 33°44'E	- 2 ppb	gold	alluvium	" " " " "
2511	22°38'N, 33°44'E	5 ppb	gold	rock sample	serpentinite
	(Biam Serpentinite)				
2512	22°46'30"N,33°53'E	- 2 ppb	gold	alluvium	gravel and sandy clay
2513	22°46'N, 33°53'30"E	2 ppb	gold	rock sample	altered ultrabasic
2514	22°46'N, 33°54'E	- 2 ppb	gold	alluvium	gravel and sandy clay
2515	22°48'30"N, 33°55'E	- 2 ppb	gold	rock sample	talc carbonate rock
	(Gezira Serpentinite)				
2517	22°20'N, 33°41'30"E	3 ppb	gold	rock sample	metavolcanic
2519	22°19'N, 33°43'E	16 ppb	gold	rock sample	metavolcanic
2521	22°20'N, 33°44'20"E	3 ppb	gold	alluvium	gravel and sandy clay
2522	" "	3 ppb	gold	alluvium	gravel and sandy clay
2523	" "	- 2 ppb	gold	alluvium	" " "
2524	" "	2 ppb	gold	alluvium	" " "
2525	22°22'N, 33°58'E	- 2 ppb	gold	alluvium	" " "
2526	22°12'N, 33°57'E	410 ppb	gold	alluvium	" " "
2527	22°12'N, 33°57'30"E	- 2 ppb	gold	alluvium	" " "
2528	22°11'N, 34°00'E	- 2 ppb	gold	alluvium	" " "
	(Um Duimi Serpentinite)				
2530	22°16'N, 33°58'E	- 2 ppb	gold	rock sample	serpentinite/dunite
2532	22°38'N, 33°50'E	- 2 ppb	gold	rock sample	serpentinite/dunite
2533	22°39'N, 33°48'E	- 2 ppb	gold	alluvium	sandy gravel
2534	" "	- 2 ppb	gold	alluvium	sandy gravel
	(Abu Fass Serpentinite)				
2535	22°14'N, 33°53'E	- 2 ppb	gold	rock sample	serpentinite
2536	22°17'N, 34°00'E	2 ppb	gold	rock sample	serpentinite
	(Shilman Serpentinite)				
2539	22°44'N, 33°45'E	3 ppb	gold	rock sample	altered serpentinite
2540	" "	24 ppb	gold	rock sample	serpentinized dunite
	(Duneibt El Kuleib Serp.)				
2543	22°39'N, 33°48'E	- 2 ppb	gold	rock sample	ultrabasic rock
2544	22°47'N, 33°30'E	- 2 ppb	gold	rock sample	altrabasic rock
2545	" "	- 2 ppb	gold	rock sample	chromite
	(SE of Duweishat)				
2562	21°01'N, 31°14'E	47 ppb	gold	rock sample	Brown marble from contact between metasedimentary rock and syenite R.C.
2580	21°06'N, 31°29'E	- 2 ppb	gold	alluvium	sandy clay; 50 cm pit channel to gabbroic bedrock
2581	21°08'N, 31°27'E	- 2 ppb	gold	alluvium	" " " "
2582	21°01'N, 31°22'E	69 ppb	gold	rock sample	gabbroic rock

Sample No.	Location	Assay Value	Element	Type of Sample	Description
	(Wadi Naba Area)				
2643	21°14'N, 33°56'E	96 ppb	gold	alluvium	placer area
2644	" "	59 ppb	gold	alluvium	" "
2652	21°13'N, 33°48'E	6 ppb	gold	alluvium	" "
2653	" "				sample missing
2655	21°13'N, 33°46'E	15 ppb	gold	rock sample	metavolcanic rock
2657	" "	51 ppb	gold	alluvium	placer area
2658	" "	34 ppb	gold	alluvium	placer area
2659	" "	8 ppb	gold	alluvium	placer area
	(NE Gabgaba - Esmat Omar)				
2660	21°50'N, 33°46'E	14 ppb	gold	alluvium	sample from pit
2664	21°47'N, 33°40'E	300 ppb	gold	alluvium	placer area
	(Talat Abda)				
2666	21°20'N, 33°26'E	10 ppb	gold	qtz vein	chip sample
2669	21°19'N, 33°33'E	270 ppb	gold	alluvium	placer area
2670	21°20'N, 33°33'E	18 ppb	gold	rock sample	basic metavolcanic
	(SE of Duweishat)				
3003	21°14'N, 31°15'E	2 ppb	gold	alluvium	placer area
3004	21°15'N, 31°05'E	6 ppb	gold	alluvium	" "
3006	" "	- 2 ppb	gold	alluvium	" "
3008	21°14'N, 31°10'E	3500 ppb	gold	rock sample	pegmatitic vein
3009	" "	14 ppb	gold	alluvium	placer area
3010	21°08'N, 31°03'E	53 ppb	gold	rock sample	pegmatitic vein
3011	" "	4 ppb	gold	alluvium	placer area
3012	21°08'N, 31°21'E	- 2 ppb	gold	rock sample	dioritic rock
3014	" "	(sample missing)		alluvium	placer area
	(South of No. 3 Station)				
3016	21°10'N, 31°53'E	23 ppb	gold	rock sample	quartz vein
3017	" "	8000 ppb	gold	qtz vein	ancient trenching; chip samples of qtz vein 1.5 m thick and 50 m long
	(Kosha Area)				
3018	20°56'N, 30°34'E	26 ppb	gold	alluvium	placer workings
3019	20°34'N, 30°36'E	9 ppb	gold	alluvium	" "
3020	20°34'N, 30°24'E	18 ppb	gold	alluvium	" "
3021	20°38'N, 30°28'E	30 ppb	gold	alluvium	" "
	(Near Abud Village)				
3022	20°32'N, 30°21'E	31 ppb	gold	alluvium	" "
	(Near Wawa Village)				
3025	20°20'N, 30°24'E	3 ppb	gold	alluvium	" "
	(Harairi)				
3542	22°57'N, 33°47'E	6 ppb	gold	alluvium	90 cm pit channel
3543	" "	- 2 ppb	gold	alluvium	97 cm pit channel
	(Um Nabari)				
4501	21°07'N, 32°46'E	4 ppb	gold	qtz vein	contains unidentified mineral
4502	" "	12000 ppb	gold	qtz vein	3.0 m thick
4503	" "	300 ppb	gold	alt. zone	hanging and footwall of qtz vein
4504	" "	400 ppb	gold	alt. zone	red clayish limonitic material
4505	" "	44 ppb	gold	qtz vein	0.8 m thick

Sample No.	Location		Assay Value	Element	Type of Sample	Description
4506	(Um Nabari) 21°07'N,	32°46'E	150 ppb	gold	alt. zone	limonitic material
4507	"	"	1400 ppb	gold	stringer zone	chip sample
4508	"	"	2600 ppb	gold	qtz veinlet	has pyritized alteration zone
4509	"	"	750 ppb	gold	rock sample	sericitic, chloritic schist
4510	"	"	27200 ppb	gold	dump material	dark quartz
4511	"	"	3700 ppb	gold	dump material	milky quartz with black mineral
4512	"	"	2600 ppb	gold	qtz veinlets	channel sample
4513	"	"	4100 ppb	gold	alt. zone	contains 2 cm quartz veinlet
4514	"	"	270 ppb	gold	qtz vein	2.5 m thick
4515	"	"	510 ppb	gold	qtz vein	channel sample 10 cm wide in hanging
4516	"	"	630 ppb	gold	qtz vein	wall of vein 4514
4517	"	"	31 ppb	gold	stringer zone	1.0 m thick
4518	"	"	21 ppb	gold	qtz vein	2.0 m thick
4519	"	"	2100 ppb	gold	rock sample	70 cm interval across host rock enclosing a 2 cm quartz veinlet
4520	"	"	930 ppb	gold	qtz vein	20 cm thick
4521	"	"	300 ppb	gold	qtz vein	chip sample
4522	"	"	3000 ppb	gold	alt. zone	channel sample
4523	"	"	3700 ppb	gold	alt. zone	hanging wall channel sample
4524	"	"	14 ppb	gold	dump material	yellowish altered gangue material
4525	"	"	6500 ppb	gold	stringer zone	60 cm channel sample
4526	"	"	4300 ppb	gold	qtz vein	2.0 m thick
4528	"	"	3900 ppb	gold	qtz vein	4.0 m thick
4529	"	"	8 ppb	gold	alt. zone	limonitic hanging wall material
4530	"	"	3100 ppb	gold	qtz vein	55 cm thick
4531	"	"	28 ppb	gold	alt. zone	channel sample
4532	"	"	1900 ppb	gold	qtz vein	40 cm thick
4533	"	"	770 ppb	gold	alt. zone	footwall 1.0 cm from the vein
4534	"	"	1700 ppb	gold	alt. zone	45 cm hanging wall channel sample
4535	"	"	450 ppb	gold	rock sample	soft, soily altered rock
4536	"	"	5600 ppb	gold	qtz vein	
4537	"	"	+10 % +10 % 7700 ppb trace	arsenic iron gold copper	dump material	grey, chloritic, schistose gangue material with abundant arsenopyrite
4538	"	"	3600 ppb	gold	qtz vein	chip sample
4539	"	"	2800 ppb	gold	alt. zone	channel sample
4540	"	"	200 ppb	gold	qtz vein	30 cm channel sample
4541	"	"	1700 ppb	gold	alt. zone	hanging wall channel sample
4542	"	"	120 ppb	gold	qtz vein	70 cm thick
4543	"	"	79 ppb	gold	qtz vein	50 cm thick
4544	"	"	53 ppb	gold	alt. zone	5 cm hanging wall sample
4545	"	"	8 ppb	gold	qtz vein	60 cm thick
4546	"	"	12 ppb	gold	qtz vein	80 cm thick
4547	"	"	360 ppb	gold	qtz vein	45 cm thick

Sample No.	Location	Assay Value	Element	Type of Sample	Description
	(Um Nabari)				
4548	21°07'N, 32°46'E	2200 ppb	gold	alt. zone	channel sample
4549	" "	29 ppb	gold	qtz vein	60 cm thick
4550	" "	93 ppb	gold	qtz vein	1.3 m thick
4552A	" "	14 ppb	gold	qtz vein	milky quartz
4552B	" "	340 ppb	gold	qtz vein	bluish-gray quartz
4553	" "	1700 ppb	gold	qtz vein	pyritized quartz
4555	" "	- 2 ppb	gold	qtz vein	35 cm thick
4556	" "	8 ppb	gold	qtz vein	chip sample
4558	" "	4900 ppb	gold	qtz vein	60 cm thick
4562	" "	5200 ppb	gold	qtz vein	60 cm thick
4563	" "	350 ppb	gold	qtz vein	2.0 m thick
4564	" "	2200 ppb	gold	qtz vein	2.0 m thick
4565	" "	210 ppb	gold	alt. zone	hanging wall 5 cm from vein
4566	" "	1200 ppb	gold	alt. zone	footwall 5 cm from vein
4567	" "	5 ppb	gold	qtz vein	chip sample
4569	" "	160 ppb	gold	qtz vein	1.0 m thick
4570	" "	12 ppb	gold	qtz vein	1.4 m thick
	(Wadi Naba Area)				
4573	21°12'N, 33°35'E	6 ppb	gold	qtz vein	1.0 m thick
4575	" "	110 ppb	gold	alluvium	40 cm pit channel to bedrock
4576	21°24'N, 33°45'E	3100 ppb	gold	qtz vein	milky, porous quartz in trench
4577	" "	130000 ppb	gold	qtz vein	quartz in trench
4578	" "	45 ppb	gold	alluvium	60 cm pit channel to bedrock
4580	" "	58 ppb	gold	rock sample	andesitic rock
4581	" "	10 ppb	gold	rock sample	rhyolitic rock with pyrite
4582	" "	15 ppb	gold	qtz vein	1.0 m thick
4583	" "	3800 ppb	gold	qtz vein	60-80 cm thick, with pyrite
4584	" "	59 ppb	gold	alluvium	70 cm pit channel to altered bedrock
4584A	" "	27 ppb	gold	rock sample	gossanous, silicified
4584B	" "	15 ppb	gold	rock sample	gossanous, black oxidized
4586	21°08'N, 33°25'E	62 ppb	gold	alluvium	60 cm pit channel to bedrock
4587	" "	830 ppb	gold	qtz vein	milky to smoky quartz
4588	21°09'N, 33°36'E	19200 ppb 69300 ppm 71 ppm	gold copper arsenic	rock sample	andesitic, cupriferous rock
4592	21°10'N, 33°39'E	4500 ppb	gold	qtz vein	vein in old workings
4593	" "	8030 ppb trace	gold copper	qtz vein	1.2 m thick

APPENDIX G

PETROGRAPHIC DESCRIPTIONS

Sample No.	Location	Description	Rock Name
007	22°34'N, 33°23'E	plagioclase, qtz, amphibole, chlorite, calcite	metaandesite
008	22°34'N, 33°23'E	qtz, plagioclase, sericite, calcite	metasediment
009A	22°50'N, 33°36'E	plagioclase, feldspar, amph.	metaandesite
011	22°35'N, 33°23'E	feldspar, sericite, quartz, amphiboles, pyroxene	andesite
013	22°35'N, 33°23'E	feldspar, quartz, amphibole, sphene	andesitic rock
015	22°35'N, 33°23'E	feldspar, qtz, mafic minerals	rhyolite
019	22°36'N, 33°21'E	qtz, plagioclase, chlorite, sericite	granite
026	22°50'N, 33°36'E	serpentine, chlorite, ore minerals	serpentinite
044	21°22'N, 30°58'E	qtz crystal in muscovite chlorite matrix	metatuff
050	20°56'N, 30°36'E	feldspar, quartz, muscovite, hematite	conglomeratic sandstone
053	20°15'N, 30°35'E	plagioclase, quartz, epidote, calcite	metaandesite
054	20°15'N, 30°35'E	quartz, calcite, plagioclase	metarhyolite
057	21°07'N, 32°46'E	biotite, chlorite, sanidine, epidote	epidote quartz chlorite schist
504	22°30'N, 33°27'E	chlorite, feldspar, epidote	metavolcanic rock
512	22°10'N, 33°51'E	amphibole, biotite, plagiocl.	gabbro
515	22°10'N, 33°51'E	plagioclase, feldspar, amphibole, magnetite	intermediate volcanic rock
525	22°38'N, 33°18'E	epidote, sericite, quartz, opaque minerals	metavolcanic rock
532	22°38'N, 33°18'E	amphibole, biotite, feldspar	intermediate to basic rock
535	22°19'N, 33°37'E	plagioclase, epidote, chlorite, quartz, muscovite	basic metavolcanic
541	22°10'N, 33°51'E	amphibole, plagioclase, biot.	altered acidic rock
547	22°54'E, 33°15'E	quartz, feldspar, fibrous amphiboles, chlorite	acidic metavolcanic

Sample No.	Location	Description	Rock Name
548	22°54'N, 33°15'E	qtz, plagioclase, biotite, amphibole, epidote	metabasic tuff
552	22°54'N, 33°15'E	chlorite, epidote, plagioclase, sericite, quartz	metavolcanic
566	21°22'N, 30°58'E	qtz, untwinned feldspar	quartzite
568	21°22'N, 30°58'E	quartz, biotite flakes	biotite quartzite
569	21°22'N, 30°58'E	qtz crystals, biotite flakes	biotite quartzite
570	21°22'N, 30°58'E	calcite crystals, chlorite, quartz	qtz-chlorite-calc schist
571	21°22'N, 30°58'E	hornblende, plagioclase, minor biotite	hornblende schist
572	21°22'N, 30°58'E	hornblende, qtz, calcite, minor biotite	calcareous quartz-hornblende schist
573	21°22'N, 30°58'E	biotite, muscovite, calcite	biotite-qtz schist
574	21°22'N, 30°58'E	quartz, biotite, muscovite	micaceous qtz schist
575	21°22'N, 30°58'E	hornblende, plagioclase, quartz, apatite	amphibolite
576	21°22'N, 30°58'E	amphibole, epidote, calcite	actinolite-epidote schist
577A	21°00' to 21°15'N 31°00' to 31°15'E	dolomite crystals, epidote, calcite	epidotized dolomite
578	" "	quartz, feldspar, epidote, muscovite	metavolcanic
581	21°00'N, 31°30'E	feldspar, plagioclase, biot.	alkali granite
582	21°00'N, 31°30'E	calcite, epidote, actinolite	epidotized marble
583	21°00'N, 31°30'E	plagioclase, muscovite, qtz	muscovite-quartz-feldspar schist
585	21°15' to 21°30'N 31°00' to 31°15'E	quartz, muscovite, biotite	biotite-quartz-muscovite schist
588	21°25'N, 32°10'E	sericite, quartz, epidote, biotite	quartz-sericite schist
589	21°25'N, 32°10'E	plagioclase, hornblende, quartz, biotite	quartz monzonite
591	21°25'N, 32°10'E	quartz, plagioclase, chlorite, muscovite	quartz-sericite schist
592	21°25'N, 32°10'E	hornblende, pyroxene, epidote, plagioclase	actinolite amphibolite
594	20°45' to 21°00'N 31°15' to 31°30'E	hornblende, actinolite, plagioclase, calcite	metagabbro

Sample No.	Location	Description	Rock Name
595	20°45' to 21°00'N 31°15' to 31°30'E	plagioclase, hornblende	metagabbro
596	20°15' to 20°22'N 30°30' to 30°37'E	andesine, epidote, calcite	metaandesite
598	" "	plagioclase, epidote, seric.	metaandesite
1505	22°30'N, 33°30'E	hornblende, amphibole, plagioclase	andesitic rock
1511	22°30'N, 33°30'E	quartz and feldspar	sandstone
1519	22°36'N, 33°20'E	feldspar, quartz, mafic mineral, sericite	trachytic rock
1526	22°34'N, 33°55'E	serpentine, calcite	serpentinite
1527	22°34'N, 33°55'E	amphibole, hornblende, plagioclase	rhyolite
1531	22°48'N, 33°43'E	quartz, sericite, muscovite, ore mineral	sericite schist
1532	22°48'N, 33°43'E	hornblende, plagioclase, biotite, serpentine	basic volcanic rock
1540	22°57'N, 33°27'E	quartz, feldspar, amphibole, biotite	granite
1547	22°57'N, 33°27'E	sericite, muscovite, calcite, quartz, plagioclase	sericite schist
1548	22°57'N, 33°27'E	qtz crystal and plagioclase	quartzite
1554	23°08'N, 33°16'E	amphibole, plagioclase, epidote, calcite	metabasic rock
1556	23°08'N, 33°16'E	hornblende, epidote, plag.	epidote amphibolite
1557	23°08'N, 33°16'E	amphibole, plagioclase, epidote, sphene	metabasic rock
1562	20°57'N, 30°52'E	plagioclase, clinopyroxene	gabbro
1563	20°57'N, 30°52'E	plagioclase, quartz, epidote, muscovite	metarhyolite porphyry
1566	20°53'N, 31°10'E	qtz, orthoclase, plagioclase	biotite gneiss
1568	20°52'N, 31°18'E	quartz, plagioclase, minor feldspar	metagreywacke
1570	20°23'N, 30°44'E	plagioclase, orthoclase, hornblende, biotite	biotite gneiss
1576	20°46'N, 32°23'E	hornblende, epidote, plag.	epidote amphibolite
1577	20°46'N, 33°08'E	amphibole, actinolite, calc.	actinolite schist
1578	20°40'N, 33°08'E	quartz, feldspar	acidic metavolcanic

Sample No.	Location	Description	Rock Name
1579	20°42'N, 33°06'E	chlorite, epidote, calcite, plagioclase	chlorite-epidote schist
1580	20°26'N, 33°06'E	hornblende, plagioclase, feldspar, quartz	amphibolite
1581	20°37'N, 33°02'E	calcite, plagioclase, epid.	calc schist
1582	20°31'N, 32°52'E	plagioclase, qtz, biotite	biotite granite
1583	20°31'N, 32°52'E	altered talc	talc
1584	20°31'N, 32°52'E	bastite, antigorite	serpentinite
1585	21°07'N, 33°31'E	quartz, chlorite, calcite, apatite	quartz-chlorite schist
1586	21°07'N, 33°31'E	quartz, plagioclase, feldspar	epidotized diorite
1586A	21°11'N, 33°28'E	plagioclase, chlorite, epidote, quartz	chlorite-andesite schist
1587	21°11'N, 33°28'E	quartz, calcite, muscovite, sphene, zircon	calcareous quartzite
1588	21°19'N, 31°08'E	quartz, muscovite, orthoclase, sphene, iron	muscovite quartzite
1591	21°19'N, 31°08'E	epidote, chlorite, muscovite, calcite	chlorite schist
2501	22°44'N, 33°45'E	serpentine, pyroxene, biotite, chlorite	serpentinite
2502	22°44'N, 33°44'E	serpentine, chromite	serpentinite
2511	22°38'N, 33°44'E	antigorite, talc, magnesite	serpentinite
2516	22°47.5'N 33°53'E	amphibole, plagioclase	amphibolite
2517	22°20'N 33°41.5'E	feldspar, chlorite, epidote, amphibole	metavolcanic rock
2519	22°19'N, 33°43'E	serpentine minerals, talc, magnesite	serpentinite
2520	22°18'N, 33°45'E	serpentine minerals, magnesite, quartz	silicified serpentinite
2529	22°10'N, 33°59'E	epidote, plagioclase, felds.	metavolcanic rock
2530	22°16'N, 33°58'E	feldspar, epidote, opaque mineral	basic metavolcanic
2531	22°38'N, 33°50'E	serpentine, calcite, ore mineral	serpentinite
2532	22°38'N, 33°50'E	amphibole, plagioclase, iron	andesitic rock

Sample No.	Location	Description	Rock Name
2535	22°14'N, 33°53'E	serpentine, calcite,ore min.	serpentinite
2536	22°17'N, 34°00'E	olivine, pyroxene, iron min.	ultrabasic rock
2537	22°44'N, 33°45'E	amphibole, biotite, plag.	basic rock
2538	22°44'N, 33°45'E	antigorite, crysotite	serpentinite
2539	22°44'N, 33°45'E	antigorite, bastite, magnetite, talc, chromite	altered serpentinite
2540	22°44'N, 33°45'E	dunite, talc, chromite	serpentinite
2541	22°39'N, 33°50'E	amphibole, chlorite	altered basic volcanic
2542	22°39'N, 33°50'E	antigorite, bastite	metaserpentinite
2543	22°39'N, 33°48'E	serpentine, calcite	serpentine
2544	22°47'N, 33°30'E	amphibole, hornblende, tremolite	basic volcanic rock
2545	22°47'N, 33°30'E	serpentine, chromite	serpentinite
2564	21°09'N, 31°30'E	plagioclase, pyroxene, biot.	gabbro
2569	21°05'N, 31°28'E	plagioclase, pyroxene, biot.	gabbro
2581	21°08'N, 31°27'E	plagioclase, iron, biotite	granite
2582	21°01'N, 31°22'E	epidote, zeolite, plagiocl.	metagabbro
2583	21°12'N, 31°30'E	amphibole, plagioclase, calc.	gabbro
2584	21°14'N, 31°26'E	amphibole, plagioclase, calc.	uralitized pyroxene
2597	21°05'N, 32°52'E	hornblende, pyroxene, plag.	gabbro
2599	21°05'N, 32°52'E	pyroxene, plagioclase, calc.	altered gabbro
2630	21°13'N, 33°08'E	quartz, feldspar, muscovite	quartz-muscovite schist
2632	20°14'N, 33°21'E	oligoclase, andesine, plag.	listwanite
2645	21°09'N, 33°55'E	quartz, feldspar, oligoclase, biotite	biotite granite
2646	21°14'N, 33°56'E	epidote, calcite, plag., qtz	metaandesite
2647	21°11'N, 33°44'E	plagioclase, quartz, epidote, calcite	altered diabase
2650	21°13'N, 33°48'E	epidote, chlorite, quartz, feldspar, hornblende	hornblende trachyte
2661	21°50'N, 33°46'E	hornblende, plagioclase, epidote	metaandesite
2665	21°03'N, 33°54'E	plagioclase, epidote, hornblende	meta-hornblende andesite
2668	21°20'N, 33°33'E	plagioclase, epidote, sericitized quartz	micro-plagio granite

Sample No.	Location	Description	Rock Name
3002	$21^{o}15$'N, $31^{o}05$'E	quartz, biotite, muscovite	granitized gneiss
3012	$21^{o}07$'N, $31^{o}23$'E	plagioclase, kaolin, feldsp, quartz, biotite, hornblende	biotite-hornblende diorite
3013	$21^{o}07$'N, $31^{o}23$'E	plagioclase, hornblende, biotite, quartz	hornblende diorite
3015	$21^{o}15$'N, $31^{o}58$'E	muscovite, quartz, microlite	quartz-muscovite schist
3023	$20^{o}22$'N, $30^{o}24$'E	qtz, calcite, clay matrix	tuffaceous slate
3505	$22^{o}50$'N, $33^{o}36$'E	amphibole, biotite, plag.	andesitic rock
3506	$22^{o}50$'N, $33^{o}36$'E	quartz, plagioclase, epidote	felsite
3513	$22^{o}44$'N, $33^{o}45$'E	plagioclase, epidote, musc.	serpent. metaandesite
3516	$22^{o}44$'N, $33^{o}45$'E	quartz, feldspar, antigorite, serpentine	serpent. acidic metavolcanic
3517	$22^{o}44$'N, $33^{o}45$'E	serpentinite, orthopyroxene	serpentinite
3518	$22^{o}44$'N, $33^{o}45$'E	quartz, plagioclase, feld-spar, biotite	granite
3519	$22^{o}44$'N, $33^{o}45$'E	amphibole, biotite, epidote, dark mineral	metavolcanic rock
3521	$22^{o}44$'N, $33^{o}45$'E	serpentine, chlorite, ore mineral	serpentinite
3522	$22^{o}18$'N, $33^{o}54$'E	augite, plagioclase, chlor-ite, biotite	metabasic rock
3523	$22^{o}18$'N, $33^{o}54$'E	biotite, chrysotile, oliv.	serpentinite
3524	$22^{o}50$'N, $33^{o}36$'E	quartz, feldspar, plagio-clase, orthoclase	gneiss
3525	$22^{o}50$'N, $33^{o}36$'E	amphibole, plagioclase, biotite, magnetite	andesite
3526	$22^{o}50$'N, $33^{o}36$'E	olivine, chlorite, talc, carbonate	amphibolite
3528	$22^{o}50$'N, $33^{o}36$'E	antigorite, quartz, hematite, carbonate	serpentinite
3534	$22^{o}46$'N, $33^{o}30$'E	plagioclase, feldspar, seric.	metaandesitic rock
3539	$22^{o}48$'N, $33^{o}43$'E	qtz, feldspar, plagioclase	rhyolitic rock
4509	$21^{o}07$'N, $32^{o}46$'E	microcline, quartz, oligo-clase, muscovite, garnet	muscovite granite
4510	$21^{o}07$'N, $32^{o}46$'E	qtz crystals, sericite, carb.	quartz vein
4537	$21^{o}07$'N, $32^{o}46$'E		polymetallic pyrite
4544	$21^{o}07$'N, $32^{o}46$'E	epidote, quartz, chlorite, plagioclase	chlorite-epidote rock

Sample No.	Location	Description	Rock Name
4551	21°07'N, 32°46'E	calcite, quartz, iron min.	calcareous schist
4552	21°07'N, 32°46'E	quartz crystal, talc, muscovite, plagioclase	muscovite schist
4554	21°07'N, 32°46'E	quartz, talc, muscovite, minor chlorite	quartz-talc schist
4557	21°07'N, 32°46'E	quartz, plagioclase, hematite	ferruginous rhyolite
4559	21°07'N, 32°46'E	calcite crystals, clay matrix	calcareous slate
4560	21°07'N, 32°46'E	quartz crystals, feldspar, kaolin	spotted slate
4561	21°07'N, 32°46'E	biotite, quartz, feldspar	biotite-quartz schist
4568	21°07'N, 32°46'E	quartz, plagioclase, calcite, sericite	sericite-quartz schist
4571	21°07'N, 32°46'E	plagioclase, calcite, iron, misc. fragments	agglomeratic andesite
4572	21°12'N, 33°35'E	plagioclase, rock fragments, basic composition	andesitic agglomerate
4584A	21°24'N, 33°45'E	limonite, hematite, clacite, quartz	silicified marble
4584B	21°24'N, 33°45'E	quartz hematite	ferruginous acidic volcanic
4585	21°08'N, 33°25'E	pyroxene, hornblende, olivine, apatite	gabbro
4591	21°10'N, 33°39'E	quartz, feldspar, plagioclase	rhyolite

APPENDIX H

MINERAL OCCURRENCE DATA

Explanation

A = amethyst
Au = gold
Au-Cu = gold-copper
Ba = baryte
Cr = chromium
Cu = copper
Cu-Ni = copper-nickel
D = diorite
Dm = dolomite
Fe = iron
Fs = feldspar
Gp = graphite
Kn = kaolin
M = marble
Q = quartz
T = talc

Map Ref. No.	Type Occurrence	Name/Location	Description
A 1	Amethyst	El Hudi 23°55'N, 33°10'E	No available information. Ancient workings. Inactive.
A 2	Amethyst	Chefren quarries 22°55'N, 31°18'E	Ancient workings.
Au 1	Quartz vein	Sarras area south of J. Quarali 21°33'N, 31°04'E	Ancient mine, probably Pharaonic.
Au 2	Quartz vein	Duweishat 21°22'N, 30°58'E	Ancient, inactive mine, reworked in recent times.
Au 3	Placer	Kosha area 20°52'N, 30°34'E	Ancient placer workings in loose gravel and fract. country rocks.
Au 4	Placer	Kosha area 20°48'N, 30°34'E	Same as Au 3.
Au 5	Placer	Kosha area 20°48'N, 30°29'E	Same as Au 3.
Au 6	Placer	20°48'N, 30°24'E	Same as Au 3.
Au 7	Placer	20°32'N, 30°20'E	Lowland area underlain by schistose and gneissose rocks.
Au 8	Placer	South Wawa area 20°20'N, 30°22'E	Ancient workings on lowland schistose rock area.
Au 9	Placer	Abu Sari area 20°17'N, 30°36'E	Ancient workings.
Au 10	Quartz vein	Abu Sari 20°16'N, 30°35'E	Ancient, inactive mine, reworked in recent times.
Au 11	Placer	Abu Sari area 20°15'N, 30°35'E	Ancient placer workings related to Au 9 and Au 10.
Au 12	Geosurvey map location	20°21'N, 30°49'E	Description unknown. Site not found.
Au 13	Placer and quartz vein	Haisub 21°25'N, 31°26'E	Ancient placer workings, probably in metasedimentary rocks.
Au 14	Not determined	20°53'N, 31°20'E	Only ancient buildings; no workings found. On Geosurvey map.
Au 15	Placer	SW of Station 3 21°16'N, 31°58'E	Ancient placer workings on metasedimentary rocks.
Au 16	Quartz vein	J. Um Fitfit 20°46'N, 32°24'E About 18 km NW of Station 6.	Very interesting abandoned mine, reworked in recent times. One quartz vein.

Map Ref. No.	Type Occurrence	Name/Location	Description
Au 17	Quartz stringers, placer workings	20°47'N, 32°36'E, 9 km NE No.6 Sta.	Ancient workings on smoky quartz veins in metavolcanic area. Mostly placer workings.
Au 18	not reported	20°43'N, 32°34'E	On Geosurvey map; not visited. May be related to Au 17.
Au 19	Quartz vein, large abandoned mine	Um Nabari 21°07'N, 32°46'E	Worked by ancients and re-worked by British. Several veins and shafts.
Au 20	not recorded	Murrat, SE of Um Nabari 21° 04'N,32°53'E	Shown on Geosurvey map but otherwise unrecorded. Probably related to the Um Nabari area.
Au 21	Placer	21°16'N, 33°07'E	Placer north of Um Nabari.
Au 22	Placer	21°15'N, 33°08'E	Au 21 thru Au 26 all in volcano-sedimentary host rocks.
Au 23	Placer	21°14'N, 33°08'E	
Au 24	Placer	21°09'N, 33°08'E	
Au 25	Placer	Dayot 21°10'N, 33°05'E	
Au 26	Placer	21°08'N, 33°06'E Mosei	
Au 27	Placer	20°42'N, 33°06'E North of Jebel Abu Siha ridge	Metavolcanic host rock.
Au 28	No trace of any working	20°37'N, 33°02'E On ridge of Jebel Abu Siha	On Geosurvey map but no trace. Country rock pink syenite.
Au 29	No trace of any working	Adarawib 20°26'N, 33°06'E	On Geosurvey map but no trace. Two graves - probably Roman.
Au 30	Au 30 thru 33 on low ground, all placer workings and some small workings on quartz veins	21°09'N, 33°25'E	Au 30 thru 33 extensive placer workings and some quartz vein workings at mouth of Wadi Naba in sequence of metasedimentary and granodiorite rocks.
Au 31		21°08'N, 33°25'E	
Au 32		21°07'N, 33°25'E	
Au 33		21°07'N, 33°25'E	
Au 34	Au 34 thru 44 are extensive placer workings	Nasb El Hosan 20°33'N, 33°17'E	Au 34 thru 44 are extensive placer workings along Wadi Gabgaba where wadi is filled with quartz gravel. Au 37 comprises about six placers in linear group. All these are similar and have same host rock.
Au 35		20°32'N, 33°18'E	
Au 36		20°26'N, 33°20'E	
Au 37		20°18'N, 33°19'E	

Map Ref. No.	Type Occurrence	Name/Location	Description
Au 38		20°17'N, 33°19'E	See description on previous page.
Au 39		20°15'N, 33°22'E	
Au 40		20°15'N, 33°21'E	
Au 41		20°15'N, 33°20'E	
Au 42		20°14'N, 33°23'E	
Au 43		20°14'N, 33°22'E	
Au 44		Omar Khabash 20°13'N, 33°16'E	
Au 45	Not recorded	20°07'N, 33°55'E At Jebel Omudi	On Geosurvey map but not found.
Au 46	Not recorded	21°00'N, 33°59'E Dabhlakaa	On Geosurvey map but not found.
Au 47	Not recorded	21°09'N, 33°58'E	On Geosurvey map but not found.
Au 48	Quartz vein	21°20'N, 33°27'E	Quartz stringers and veinlets; ancient workings.
Au 49	Possible placer	21°20'N, 33°33'E At J. Tulat Abda	Country rock excavated this locality.
Au 50	Placer	21°24'N, 33°30'E	Ancient workings.
Au 51	Not recorded	21°27'N, 33°31'E	On Geosurvey map but not found.
Au 52	Possible placer	21°46'N, 33°42'E Wadi Howe	Au 52 thru 55: no quartz veins; some trenches in country rock; some placer workings in wadis. Au 55 comprises about three localities shown on Geosurvey map.
Au 53	Possible placer	21°49'N, 33°43'E Esmat Omar	
Au 54	Possible placer	21°48'N, 33°44'E	
Au 55	Possible placer	21°50'N, 33°45'E	
Au 56	Undetermined	21°36'N, 33°45'E	Ancient trenching in metavolcanic country rock probably for gold; no quartz veins.
Au 57	Not recorded	20°52'N, 32°46'E	On Geosurvey map but not found.
Au 58	Quartz vein	23°59'N, 33°00'E Kurtuns	Situated 15 km SE of Aswan. Reported by Hume.
Au 59	Quartz vein	23°58'N, 33°13'E	Extensive excavations.
Au 60	Possible placer	Harairi or Um Um Araka 22°57'N, 33°27'E	Ancient workings in metavolcanic rocks.

Map Ref. No.	Type Occurrence	Name/Location	Description
Au 61	Quartz vein	Abu Fass 22°10'N, 33°51'E	Worked by the ancients and reworked in recent times. Many shafts, adits and trenches.
Au 62	Quartz vein and placer	Um Ashira 1 (South) 22°54'N, 33°15'E	Ancient gold workings composed of long trenches and some placers.
Au 63	Quartz vein	Um Ashira 2 (North) 23°08'N, 33°16'E	One long trench in metavolcanic-metasedimentary rocks.
Au 64	Quartz vein and placer	Atshan 22°30'N, 33°30'E	Vein workings in metavolcanic sequence, and extensive placer workings all around the area.
Au 65	Quartz vein	Haimur 22°38'N, 33°18'E	Probably ancient gold mine reworked in recent times. Several long adits and cross-cuts.
Au 66	Quartz vein and placer	Marahik 22°30'N, 33°27'E	On top of metavolcanic ridge. Many trenches and placer workings.
Au 67	Placer	Negib 22°48'N, 33°43'E	Ancient placer workings.
Au 68	Placer	Murra 22°34'N, 33°55'E	Extensive ancient placer workings. Many pits in metavolcanic-metasedimentary rocks.
Au 69	Quartz vein and placer	Nile Valley Bk E 22°36'N, 33°20'E	Ancient and recent workings. Minor quartz veins. Impressive placer workings.
Au 70	Quartz vein	Um Garayat 22°34'N, 33°23'E	Ancient gold mine reworked in recent times. Largest mine in Egyptian Sector. Many deep vertical and inclined shafts.
Au 71	Placer	Filat 22°19'N, 33°37'E	Placer workings on mountain slopes and nearby wadis and khors.
Au-Cu 1	Gold-copper, 7 occurrences	Wadi Naba 21°19'N - 21°24'N, 33°40'E - 33°47'E	North of W. Naba, about 170 km^2. Ancient gold and copper workings. Some malachite in trenches.
Au-Cu 2	Gold-copper, 32 occurrences	Wadi Naba 21°05'N - 21°18'N, 33°32'E - 33°58'E	Large area, about 675 km^2. Ancient gold and copper workings. Several ancient habitations. Good mineral potential.
Ba 1	Baryte vein	El Hudi 23°57'N, 33°02'E	Active mine in baryte veins that cut granite.

Map. Ref. No.	Type Occurrence	Name/Location	Description
Ba 2	Baryte vein	Wadi El Shom 23°35'N, 33°11'E	About 12 veins in shear zones in metasedimentary rocks. Active mine.
Ba 3	Baryte vein	Gara El Soda 23°22'N, 31°17'E	Thin baryte vein. No economic significance.
Cr 1	Chromium occurrence	Wadi El Allaqi 32°42'N, 33°46'E	
Cu 1	Copper staining	Jebel Um Faham 21°18'N, 31°07'E	Ancient, probably "colour" mine.
Cu 2	Copper	Jebel Adila 21°19'N, 31°08'E	Ancient mine, probably "colour" mine for pigments.
Cu-Ni 1	Copper-nickel	Abu Swayel 22°50'N, 33°36'E	Ancient and recent workings. Amphibolite and garnet-schist host.
Cu-Ni 2	Copper-nickel	Haimur north 22°48'N, 33°32'E	About 25 km SW of Abu Swayel. Oxide zone mineralization.
Cu-Ni 3	Copper-nickel	Wadi Haimur 22°45'N, 33°45'E	No information available.
D 1	Diorite	Chefren quarries 22°50'N, 31°13'E	Ancient quarries. Source of diorite for Chefren statues.
Dm 1	Dolomite	Allaqi dolomite 23°09'N, 33°10'E	No information available.
Dm 2	Dolomitic limestone	Jebel Shirshir 23°54'N, 30°20'E	Inactive quarry NE J. Shirshir. Yellowish to brown, partially replaced by calcite.
Fe 1	Iron occurrence	So. of Kalabsha 23°20'N, 32°20'E	Ferruginous sandstone. No economic significance.
Fe 2	Iron occurrence	No. Bir Hassein 23°08'N, 31°12'E	Ferruginous sandstone. No economic significance.
Fe 3	Iron occurrence	23°08'N, 30°45'E	North of Darb El Arbain. Ferruginous sandstone. No economic significance.
Fs 1	Feldspar	Chefren quarries 22°55'N, 31°12'E	Pegmatitic rock covering large area up to 100 km².
Gp 1	Graphite	Wadi Haimur 22°43'N, 33°38'E	Inactive prospect. Occurs as lenses in sedimentary rocks.
Kn 1	Kaolin	Um Hebal 23°46'N, 33°09'E	No information available.
Kn 2	Kaolinitic clay	Kalabsha 23°30'N, 32°18'E	Kaolin quality is pure to low-grade. Reserve of 16 million tons kaolinitic sandstone.

Map Ref. No.	Type Occurrence	Name/Location	Description
Kn 3	Clay	Jebel Shirshir 23°58'N, 30°20'E	Intercalated siltstone, sandstone and clay. Thickness from few metres to 100 m.
M 1	Marble	Bir Um Hobal 23°41'N, 33°11'E	White marble. Previously exploited. Now inactive.
M 2	Marble	Abu Swayel 22°52'N, 33°40'E	Whitish grey and banded marble. 5 million m^3 reserves.
M 3	Marble	Allaqi marble 22°47'N, 33°13'E	White to greyish marble. Reserve is 366,100 m^3.
Q 1	Quartz mine	Um Taheiwat	White quartz. Exploitation of veins up to 100 m max. length.
T 1	Talc	Jebel Um Aruga 23°00'N, 33°25'E	Bands of talc in chloritic schist associated with serpentinite.
T 2	Talc	Haimur 22°48'N, 33°36'E	Occurs as lenses. Forms wadi bed surrounded by granitic rocks.
T 3	Talc	Wadi Keleib 22°44'N, 33°19'E	No information available.

APPENDIX I

LIST OF INTERNAL GEOLOGICAL AND MINING CENTRE REPORTS

GMC 85-01 Anderson, W. L., Abu Swayel copper-nickel prospect, an in-depth review.

GMC 85-02 El Alfy, Z. S., and Fadl, S. E., Field investigations of the Abu Fass gold prospect, southeastern Egypt.

GMC 85-03 ----- Field investigations of the Atshan gold prospect, southeastern Egypt.

GMC 85-04 El Alfy, Z. S., El Fiki, S. A., and Khalil, K. A., Field investigations of the El Hudi area, southeastern Egypt.

GMC 85-05 El Alfy, Z. S., and Fadl, S. E., Field investigations of the Filat gold prospect, southeastern Egypt.

GMC 85-06 ----- Field investigations of the Hariari gold prospect, southeastern Egypt.

GMC 85-07 ----- Field investigations of the Marahik gold prospect, southeastern Egypt.

GMC 85-08 ----- Field investigations of the Murra gold prospect, southeastern Egypt.

GMC 85-09 ----- Field investigations of the Negib gold prospect, southeastern Egypt.

GMC 85-10 ----- Field investigations of the Um Ashira gold prospect, southeastern Egypt.

GMC 85-11 El Alfy, Z. S., Summaries on the ring complexes in the northern portion of the Area of Integration.

GMC 85-12 ----- Karrar, Y. H., and Khalil, K. A., Field investigations of the Duweishat gold mine area, west-central Sudanese Sector.

GMC 85-13 Karrar, Y. H., Khalil, K. A., and El Fiki, S. A., Field investigations of the Abu Sari gold mine area, southwestern Sudanese Sector.

GMC 85-14 El Alfy, Z. S., and Fadl, S. E., Field investigations of the Nile Valley Block E gold prospect, southeastern Egypt.

GMC 85-15 ----- Field investigations of the Haimur gold prospect, southeastern Egypt.

GMC 85-16 El Alfy, Z. S., Summaries on the iron, talc and graphite occurrences in the Egyptian Sector.

GMC 85-17 ----- General structural features of the Area of Integration.

GMC 85-18 ----- Field investigations of the Haisub gold occurrence, west-central Sudanese Sector.

GMC 85-19 Khalil, K. A., Lithostratigraphic correlations, Egyptian Sector and adjacent regions.

GMC 85-20 Fadl, S. E., Investigations of the Um Faham ancient copper workings, west-central Sudanese Sector.

GMC 85-21 El Alfy, Z. S., Field investigations of the copper occurrence southeast of Station No. 3, central Sudanese Sector.

GMC 85-22 Fadl, S. E., Field investigations of the Um Fitfit gold prospect, central Sudanese Sector.

GMC 85-23 ----- Investigation of ultrabasic rocks at 20° 31' N and 32° 52' E.

GMC 85-24 ----- Report on gold/copper prospects in the Wadi Naba area, east-central Sudanese Sector.

GMC 85-25 Karrar, Y. H., A summary of the chromite mineralization in the Egyptian Sector.

GMC 85-26 El Alfy, Z. S., and Fadl, S. E., Some geological information about Jebel Mansuri, south-central Sudanese Sector.

GMC 85-27 El Alfy, Z. S., Some geological information on the metavolcanic region northwest of Abu Sari, southwestern Sudanese Sector.

GMC 85-28 ----- Field investigation of the metavolcanic-metasedimentary rock units southeast of Station No. 3, central Sudanese Sector.

GMC 85-29 El Fiki, S. A., Mineral resource information on baryte, marble and quartz in the Egyptian Sector.

GMC 85-30 Fadl, S. E., Investigation of an intrusive body at 20° 57' N and 30° 52' E.

GMC 85-31 ----- Investigation of an intrusive body at 20° 53' N and 31° 10' E.

GMC 85-32 ----- Investigation of an ancient gold occurrence at 20° 52' N and 31° 18' E.

GMC 85-33 ----- Investigation of a metavolcanic area at 20° 21' N and 30° 33' E.

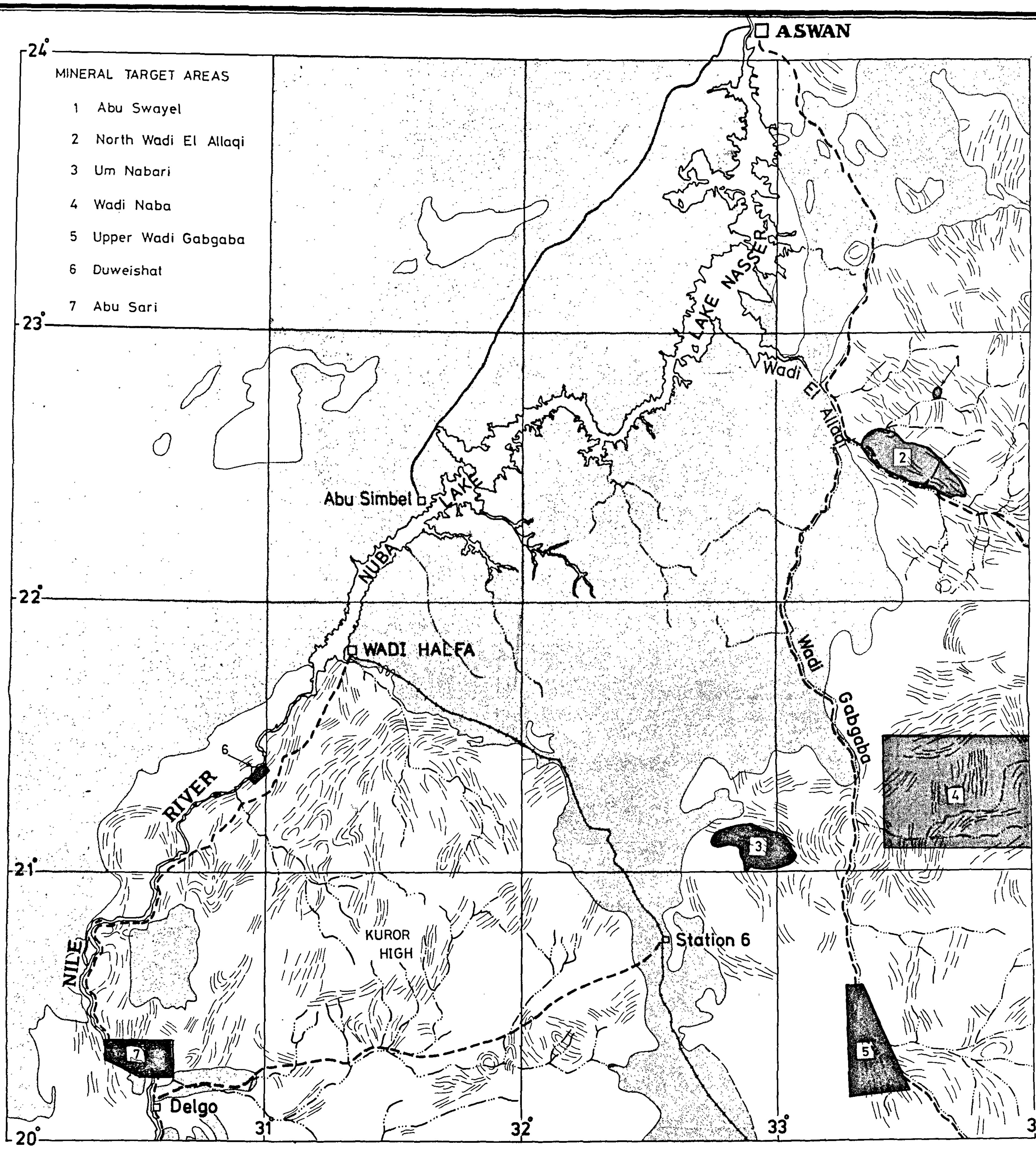
GMC 85-34 ----- Investigation of an ancient gold occurrence at 20° 27' N and 32° 36' E.

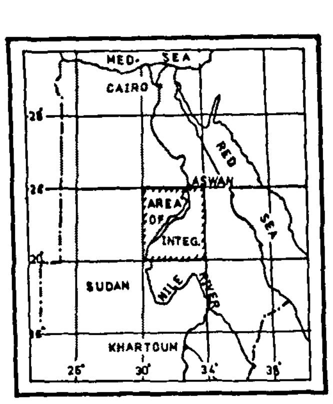
GMC 85-35 ----- Investigation of an impure grey marble ridge at 20° 46' N and 33° 08' E.

GMC 85-36 ----- Investigation of an ancient gold occurrence at 20° 26' N and 33° 06' E.

GMC 85-37 ----- Investigation of an ancient gold occurrence at 20° 42' N and 33° 06' E.

GMC 85-38 ----- Investigation of an ancient gold occurrence at 20° 37' N and 33° 02' E.





Secondary road

Unimproved road/desert track

Single track railway

Cretaceous – Tertiary Nubia Formation

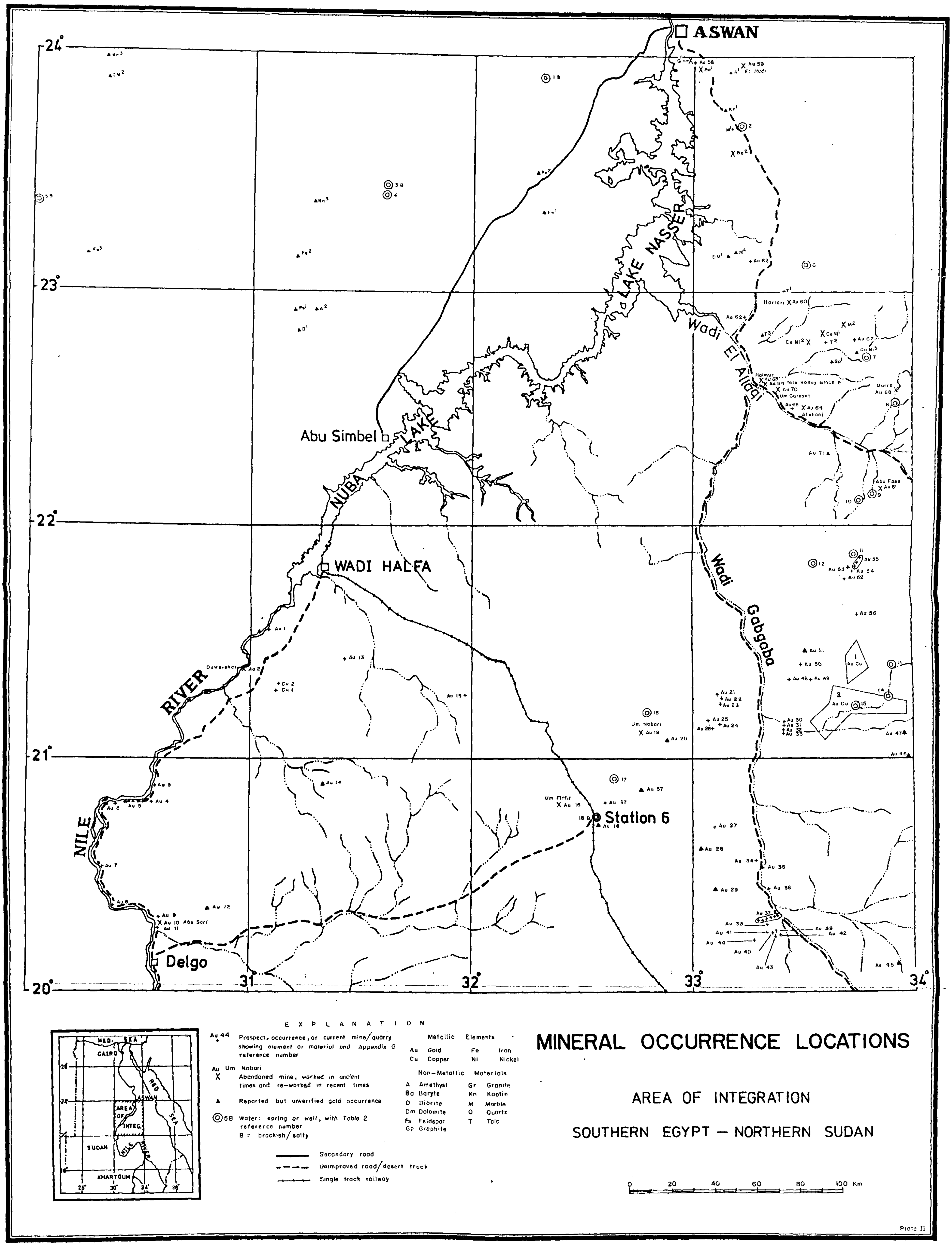
Precambrian Basement Complex

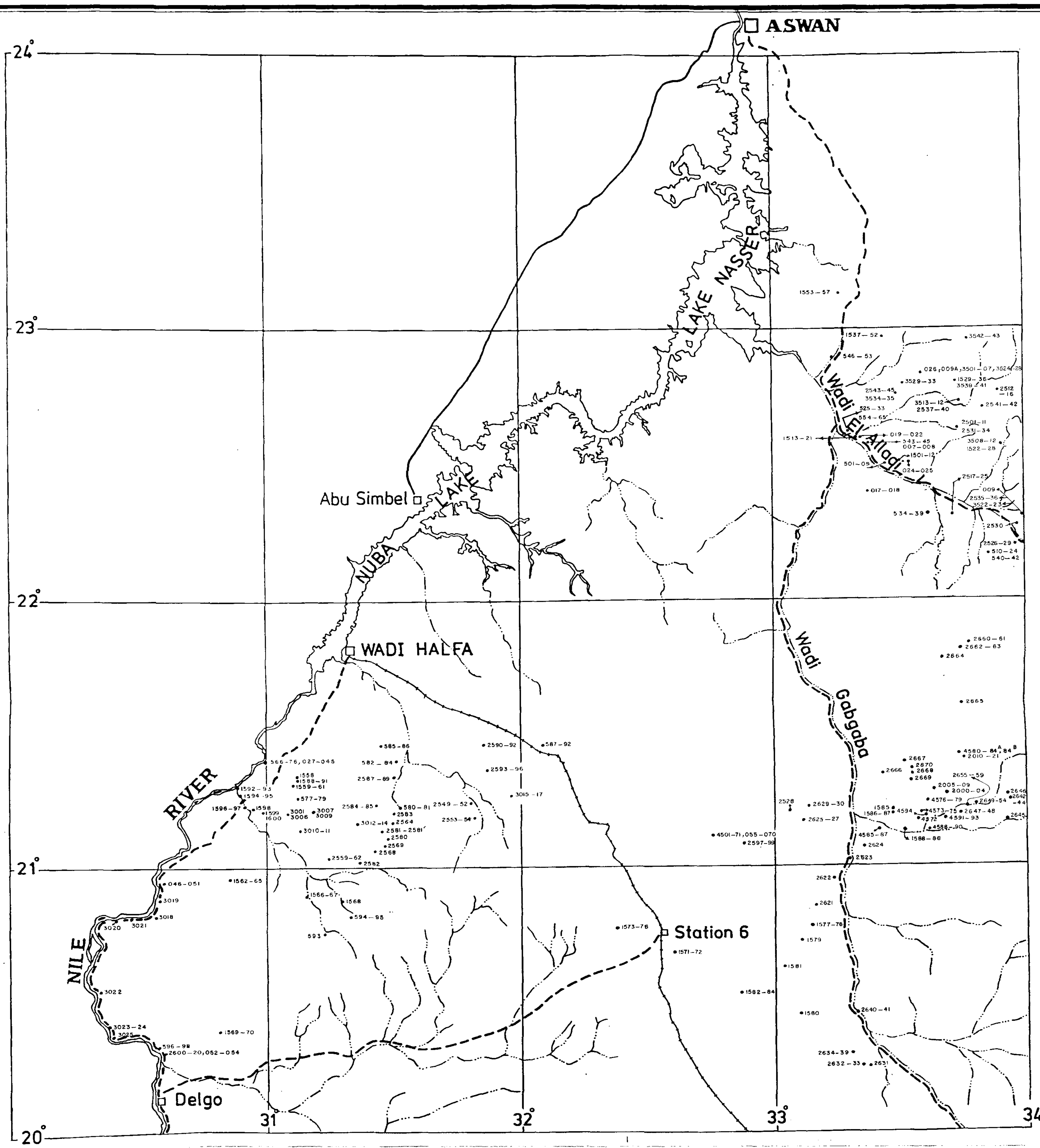
Rock foliation/stratification

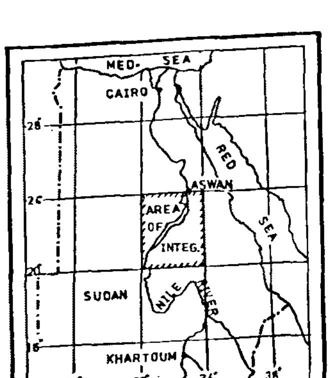
GENERAL GEOLOGY AND MINERAL TARGET AREAS
EGYPT-SUDAN AREA OF INTEGRATION

0 20 40 60 80 100 Km

PLATE I


MINERAL OCCURRENCE LOCATIONS
AREA OF INTEGRATION
SOUTHERN EGYPT — NORTHERN SUDAN
ASWAN
LAKE NASSER
NUBA LAKE
Abu Simbel
WADI HALFA
RIVER NILE
Wadi El Allaqi
Wadi Gabgaba
Station 6
Delgo
24°
23°
22°
21°
20°
31°
32°
33°
34°
EXPLANATION
Au 44 Prospect, occurrence, or current mine/quarry showing element or material and Appendix G reference number
Au Um Nabari X Abandoned mine, worked in ancient times and re-worked in recent times
▲ Reported but unverified gold occurrence
◎5B Water: spring or well, with Table 2 reference number B = brackish/salty
Metallic Elements
Au Gold
Cu Copper
Fe Iron
Ni Nickel
Non-Metallic Materials
A Amethyst
Ba Baryte
D Diorite
Dm Dolomite
Fs Feldspar
Gp Graphite
Gr Granite
Kn Kaolin
M Marble
Q Quartz
T Talc
Secondary road
Unimproved road/desert track
Single track railway
0 20 40 60 80 100 Km
MED. SEA
CAIRO
RED SEA
ASWAN
AREA OF INTEG.
SUDAN
NILE RIVER
KHARTOUM
Plate II





EXPLANATION

Secondary road

Unimproved road / desert track

Single track railway

Sample location

0 20 40 60 80 100 Km

SAMPLE LOCATIONS

AREA OF INTEGRATION

SOUTHERN EGYPT – NORTHERN SUDAN

Plate III