DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

Report on mineral resources geophysics program for Egypt

by

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REPORT ON MINERAL RESOURCES

GEOPHYSICS PROGRAM FOR EGYPT

By

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U.S. Geological Survey

INTRODUCTION

Purpose of report

A review of geophysical data available at the Geological Survey of Egypt has been made in order to determine activities necessary to improve the capability of the Government of Egypt (GOE) to employ geophysical methods in assessing its mineral resources. The work was carried out during the period November 24-December 6, 1979, as part of Phase III, Egyptian Mineral Resources Assessment Program, being conducted in cooperation with the Egyptian Geological Survey and Mining Authority under the auspices of the Agency for International Development (AID), U.S. Department of State, under PASA IC/EGY-0026-11-78.

Nearly all the work was performed at GSE, with brief visits to the Remote Sensing Centre (RSC) and the Nuclear Materials Corporation (NMC). Time did not permit visits to either the Egyptian General Petroleum Corporation (EGPC) or the Desert Research Institute (DRI). As much data from these institutes as was available at the GSE is included in this report.

Any future work under Phase III would be concentrated on making an inventory of data held by EGPC and DRI.

Acknowledgements

The author expresses his sincere appreciation to Dr. M. A. Zaatout, Director General of GSE; Dr. El-Ramly, Chief of the Geological Sector; Dr. M. Hermina, Chief of the Geophysics Department; and to the Geophysics staff for giving so much of their time and knowledge. The kind assistance of Dr. F. K. Boulos, Chief of Regional Geophysics Division; Mr. William Kamel, Chief Mining Geophysics Division; Mr. M. Diasty, Chief of Electrical Logging Division; and Dr. Samir Kahwagi, Chief, Geophysical Laboratories was especially beneficial and most appreciated.

Mr. James B. Riley (AID) and Roger W. Shaff (USGS) provided valuable information and assistance while the author was in Cairo.

REVIEW OF THE GEOPHYSICS PROGRAM

An impressive amount of geophysical work has been done in Egypt on a regional basis by GSE, EGPC, and DRI. Airborne surveys, for example, cover approximately 65 percent of the country. Regional ground surveys cover a much smaller area but are, nevertheless, substantial. Detailed surveys by GSE of specific mineral resources targets (including water)--employing mostly electrical methods--are numerous and important. Topical studies that include microseismicity, geothermometry, and paleomagnetism have served to broaden the scope of GSE geophysics in earth science and mineral exploration.

The GSE program is staffed with 26 geophysicists, of whom only 6 are senior members. The geophysical instruments are now antiquated and difficult to maintain. As new instruments replace old ones and new data analysis techniques are acquired by the staff, the ambitious geophysics program may be expected to flourish.

Regional geophysical surveys

Several airborne surveys have been flow in Egypt for various government agencies and for such purposes as mineral resources exploration, petroleum exploration, ground-water aquifer definition, and natural radiation mapping. Figure 1 is an index map showing most of the survey areas.

The airborne survey data is principally magnetic: in several surveys total-count (TC) radiation data were recorded in addition to the magnetic data. Airborne electromagnetic data (and magnetic data) were recorded only in the Lockwood Southwest survey area (fig. 1). Information on various survey projects (flight specifications, etc.) was generally difficult (and often impossible) to obtain, mostly because of inadequate documentation and a lack of communications and coordination among the several overlapping government agencies involved in airborne geophysical surveys.

At least four government agencies have overlapping responsibilities. These are: the Egyptian Geological Survey and Mining Authority (GSE), the Nuclear Materials Corporation (NMC), the Desert Research Institute (DRI), and the Egyptian General Petroleum Corporation (EGPC).

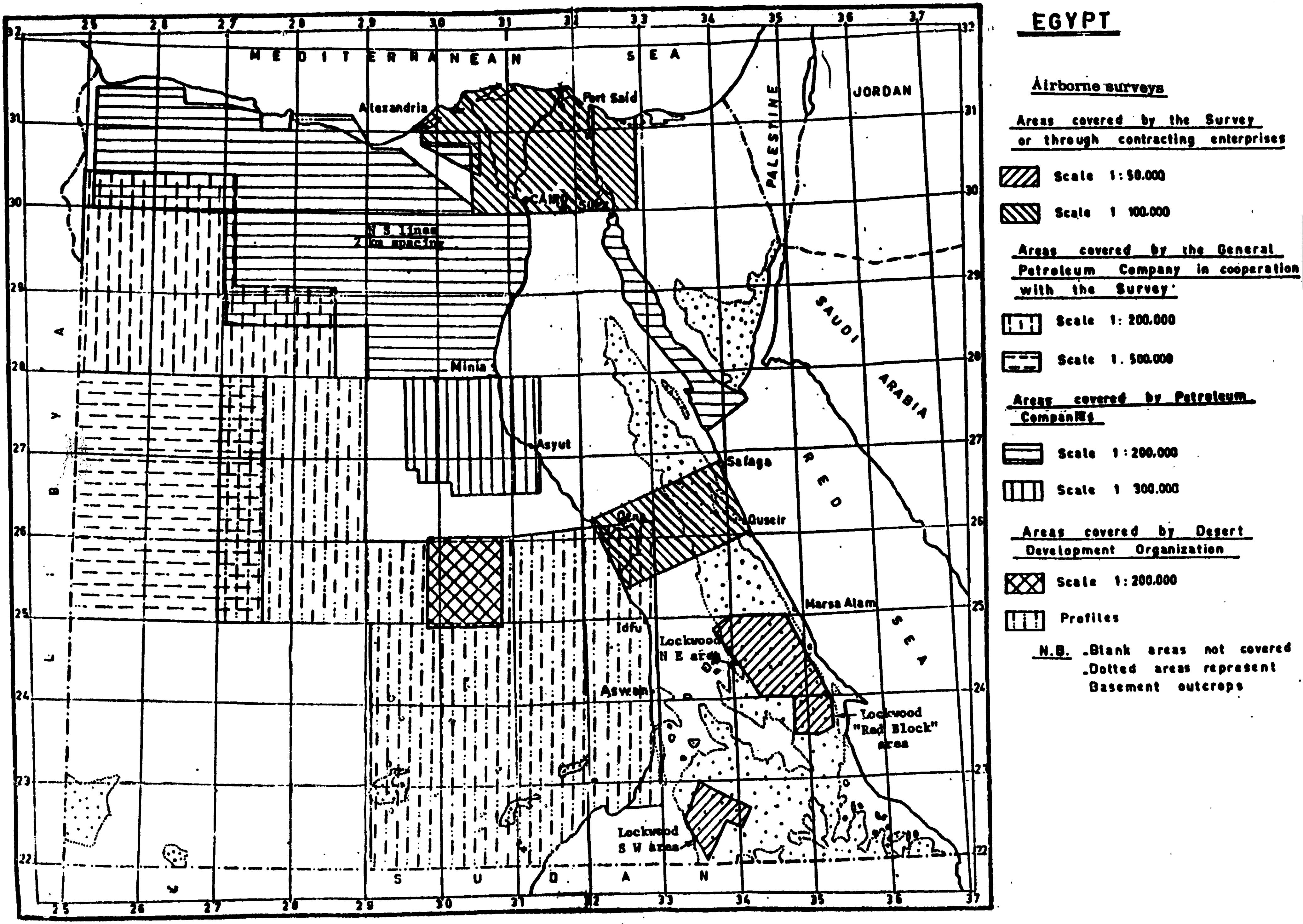


Figure 1 -- Index map showing locations of principal mineral deposits of Egypt.
(compiled by the Egyptian Geological Survey of Egypt 1979)

As a result of the independent interests of the several agencies, a patch work of surveys that are inconsistent in flight line spacing, flight direction, and flight elevation has been flown. Nevertheless, the data for most surveys are useful and important and should be assembled and compiled at a scale consistent with the geological mapping of Egypt (as noted in another section of this report).

A brief description of the various airborne surveys is given in the following section.

Aeromagnetic surveys

Aswan Region.--A survey by Lockwood of Canada, Ltd. (1968) for the United Nations Development Project (UNDP), one of the earlier airborne surveys, was flown in 1968 over two areas in the Aswan Region of the Eastern Desert (see fig. 1). The purpose of the survey was the application of geophysical studies in the assessment of mineral potential. Principal elements of the survey are shown in table 1. The magnetic data were compiled as total intensity magnetic anomaly maps at three scales: 1:50,000, 1:100,000, and 1:1,000,000 (10 gamma contour interval). A summary interpretation map was compiled at 1:500,000. The International Geometric Reference Field (IGRF) has not been removed from the data, nor has any arbitrary regional gradient. The data were adjusted to a datum of 34,500 gammas, which represents the approximate intensity of the earth's field in this area.

Table 1 -- Principal elements of the Lockwood (UNDP) airborne survey, Aswan Region, Egypt.

	SW Zone	NE Zone
Survey area in sq.km.	5,000	15,000
Line -kilometres flown	10,000	15,000
Flight line direction	N 25° E	N 60° E
Flight line spacing	0.5 km.	1.12 km.
Flight elevation	130 m..	150 m.
Instrumentation:		
Magnetics	fluxgate ($\pm$ 18)	fluxgate ($\pm$ 18)
Radiation (TC)	Yes	None
Electromagnetics	None	Dual freq. (400 & 2300 Hz)

The data have provided much valuable information that is the subject of three reports (Lockwood, 1968; Huntec, 1969, UNDP 1973). The magnetic anomalies over this part of the Nubian Shield, like those observed across the Red Sea in the Arabian Shield, clearly delineate such features as ring structure, plutons, dike systems, and zones of "quiet" magnetics. In a quantitative analysis of data in a part of the northeast area, called "Red Block," Huntec (1969) found two magnetic sources: (1) regional sources at average depths of 1 km below observation level; and (2) near-surface features at average depths of 0.3 km below observation level. Much attention was given to the study of the systems of magnetic lineations caused by dikes, some of which were reversely polarized. Surprisingly, none of the dike systems are related to the development of the Red Sea rift zone.

Airborne electromagnetic survey

Aswan Region.--The only airborne electromagnetic (AEM) data were recorded in the southwest zone of the Aswan Region in 1968 by Lockwood Survey (see above). The axis of the transmitting coil was vertical and the axis of the receiving coil was horizontal, trailing 165 ft below and 455 ft aft of the DC-3 aircraft. Of the anomalies observed, seven were judged worthy of further study in a ground follow-up investigation.

Delta Area (GSE survey).--During 1962 and 1963, the GSE flew more than 20,000 line-kilometers in the Nile Delta area along north-south flight lines spaced 1 km apart (see fig. 1 and 2). The survey was flown at 200 m

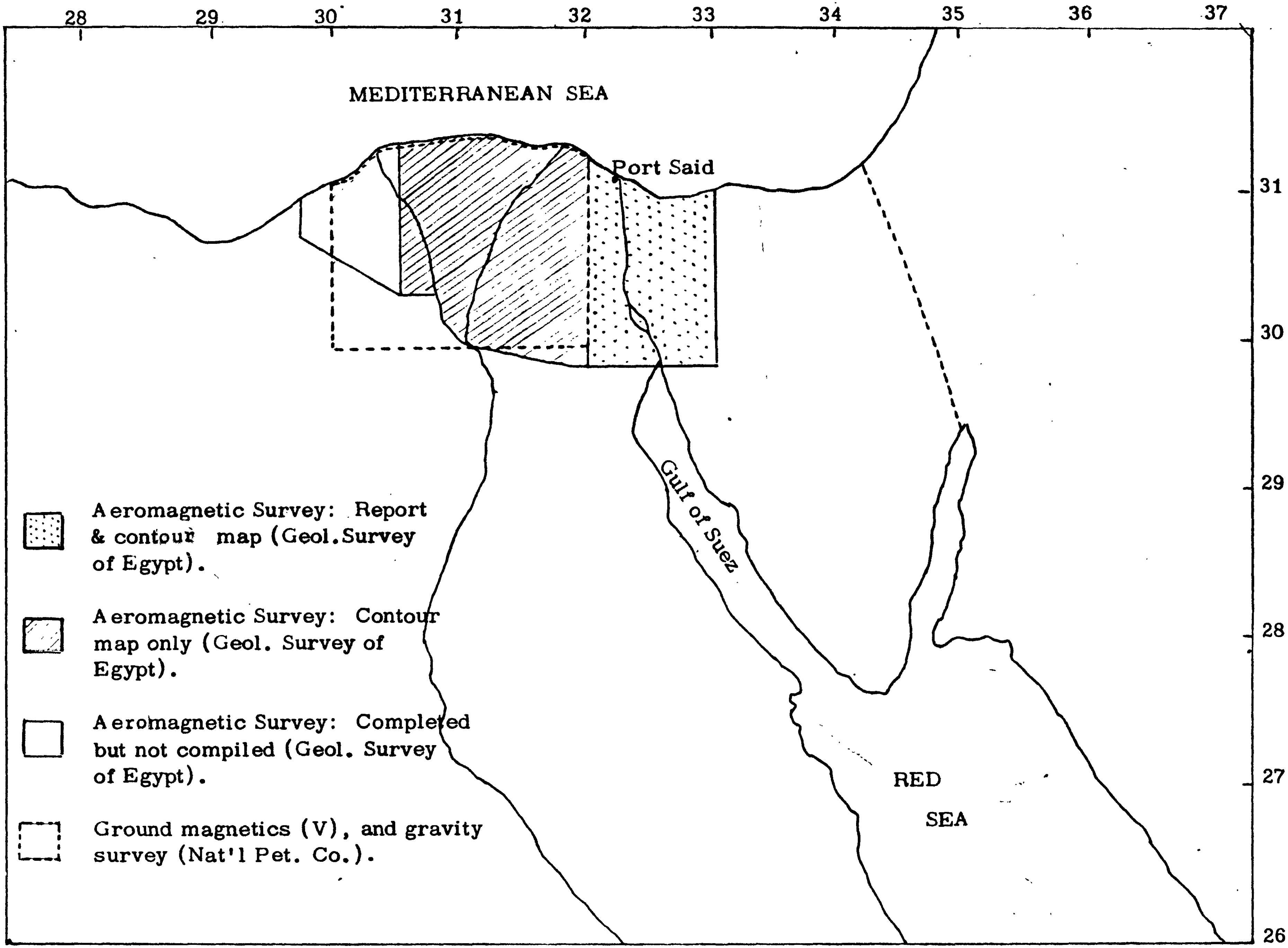


Figure 2.-- INDEX MAP SHOWING LOCATION OF GEOPHYSICAL SURVEYS IN THE DELTA REGION, EGYPT

above land surface in a Russian AN-2 (single engine) aircraft, using an AM-13 fluxgate magnetometer. The resulting data was compiled and contoured at a 10 gamma interval at a map scale of 1:100,000. Actual locations of individual magnetic anomalies or lineations are in doubt as there were seldom more than two documentation points per flight line. A report on the interpretation of the magnetic data has been prepared by El-Diasty (1960). In general, the southern part of the survey area is characterized by east-trending, high frequency, short-wave-length anomalies indicating shallow depths to the upper surface of the anomaly-producing bodies. These anomalies lie adjacent to the low-amplitude, long-wave-length anomalies that characterize the northern part of the area. The east-west contact between the two anomaly groups suggests faulting or abrupt down-warping to the north of the anomaly-producing rocks.

Previous ground geophysical studies were carried out in this area by Standard Oil of Egypt for the EGPC. Both gravity and vertical component magnetics were recorded in the 1947-48 surveys. These surveys are described in another section of this report.

Western Desert (Aero Service Survey).--This survey was flown in 1961 under AID contract ICA c1775 for the Desert Research Institute (DRI) by Aero Service Co. (1961). It was the purpose of the survey to assist in the definition of possible aquifer thickness by calculating depth to the Precambrian surface from magnetic anomalies. Most of this survey was reconnaissance in nature, because the flight lines along which data were recorded are too far apart to be contoured (see fig. 3.).

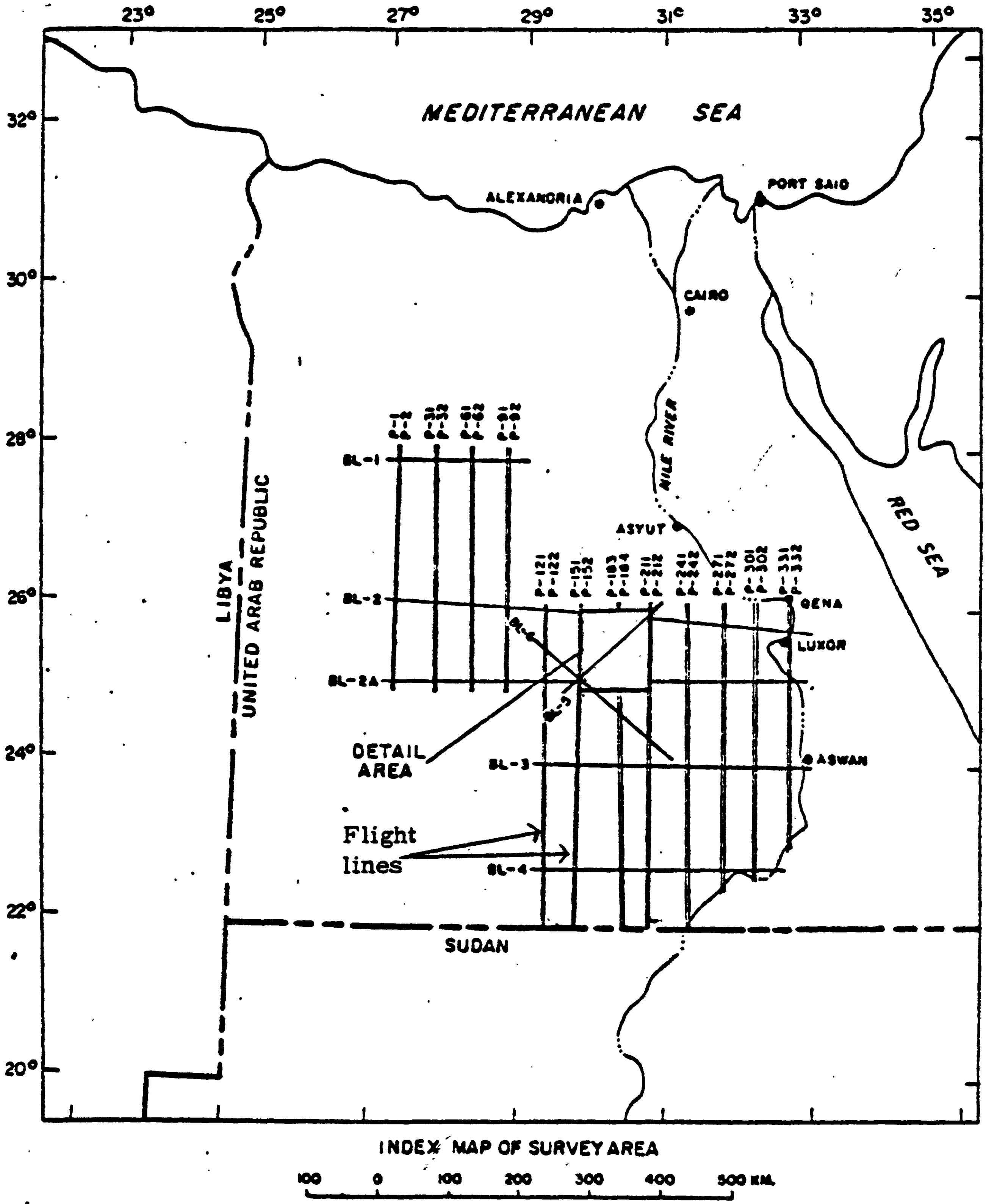


Figure 3 -- Detailed index map of the Aero Service survey for the Desert Development Organization.

More closely spaced flight lines were flown in the Kharga Oasis area to provide greater magnetic detail. The principal elements of the reconnaissance survey and the Kharga Oasis survey are given in table 2. Flight line locations were compiled on 1:500,000 scale topographic maps from the on-board Doppler Navigation system. The magnetic data were compiled at 1:100,000 (six sheets). A 1:500,000 aeromagnetic compilation was also prepared. The datum for the magnetic data was chosen to be 3,700 gammas.

The results of the survey indicated that the magnetic method could provide depth-to-basement estimates, and, thus, aid in the estimation of thickness of the overlying beds (possible ground water aquifers). A regional aeromagnetic survey of this area was recommended.

Qena-Safaga strip.--A strip was flown for magnetics from about Safaga and Quseir, on the Red Sea approximately southwest to the Nile river (see fig. 1). This project was flown with the same aircraft and instrumentation as the Delta Area (described above). The area of the strip is about 20,000 km^2. Flight line direction was normal to the axis of the Red Sea (about N. 60° E.), the spacing 2 km (?), and the altitude above ground, 150m (?).

The major problem confronting the interpreter of results of this magnetic survey is lack of documentation points necessary for adequate spatial representation of the data. The data for the northern half of this strip were interpreted by El-Hákim (1978). The magnetic data for the southern half of the strip were compiled at a scale of 1:100,000 and contoured at 10 gamma intervals.

Table 2 -- Principal elements of the aeromagnetic survey of the Western Desert (including Kharga, Dakhla, and Farafra Oases), Egypt.

	Reconnaissance Survey	Kharga Oasis Detail
Survey area (sq.km.)	N.A.	12,000
Line-kms. flown	11,500 (?)	5,000 (?)
Flight direction	North-South	North-South
Line spacing (km.)	50 (pairs)	3.3
Flight elevation	2,000 BAR	2,000 BAR
Instrumentation	Gulf Mark III fluxgate mag.	Gulf Mark III fluxgate mag.
Map scales	1:100,000 1:500,000	1:100,000

Aeromagnetic surveys for petroleum exploration.--Very little information is available at the GSE regarding magnetic surveys flown for petroleum companies.

Of those areas shown on the index map (fig. 1), a part of the contour map was available for the large area in northwest Egypt (bounded by the Nile on the east, the Libyan Desert on the west, the Mediterranean on the north, and 28° latitude on the south). Flight line direction was north-south and the lines were spaced 2 km apart. Beyond this, no other information was available at the GSE, and it was not feasible to make arrangements with the EGPC to obtain additional information within the time available to the writer. Therefore, the index map of airborne magnetic survey areas in Egypt must be considered incomplete.

Airborne radiation surveys

A major mineral resources survey of natural gamma radiations was made by the GSE (through UNDP) in 1968, as a part of the Lockwood aeromagnetic survey in the Aswan Region (see above). Three thallium crystals were used for total count recording only. The data were compensated for deviations from the nominal flight altitude of 130 m, for cosmic radiation, and for instrument drift. The data were compiled as profiles and as contour maps (1:50,000 and 1:100,000 scales).

The total count gamma-radiation data yielded much information useful in prospecting for silicic mineral deposits. The data are compiled as contour maps (same scale as the magnetic maps) that have been interpreted qualitatively. The maps have been especially useful in ground follow-up geophysical and geochemical investigations.

The Lockwood airborne radiation survey was the only such survey the writer was made aware of by GSE geophysicists and for which documentation was available. It is likely that total count radiation was recorded both for the Qena-Safaga strip and for the Delta area.

Some additional information regarding radiation surveys was obtained from E. M. El Shazly, Director of the Nuclear Materials Corporation (NMC). At some point, NMC inherited the single-engined AN-2 together with its geophysical instrumentation. Figure 4 shows an index map of airborne radiometric surveys prepared by NMC. From an inspection of this map, it is not possible to determine which areas were flown by NMC, but certainly the areas in the Eastern Desert (Aswan Region), south of Idfu, were flown by Lockwood.

According to El-Shazly (oral communication, 1979) the NMC plans a country-wide aeromagnetic and gamma-ray spectrometry survey, to be done with a twin-engined Islander, equipped with Geometrics magnetometer and an Exploranium gamma-ray Spectrometer. Surprisingly, no Doppler navigation is planned. And although on-board recording equipment is both analog and digital, data reduction will be by manual methods.

Ground surveys

Ground geophysical surveys of a regional character include gravity and magnetics (total field or vertical component). In most surveys in Egypt, both gravity and magnetic measurements were made. Figure 5 is a recent index map of gravity surveys conducted by or for the GSE or the

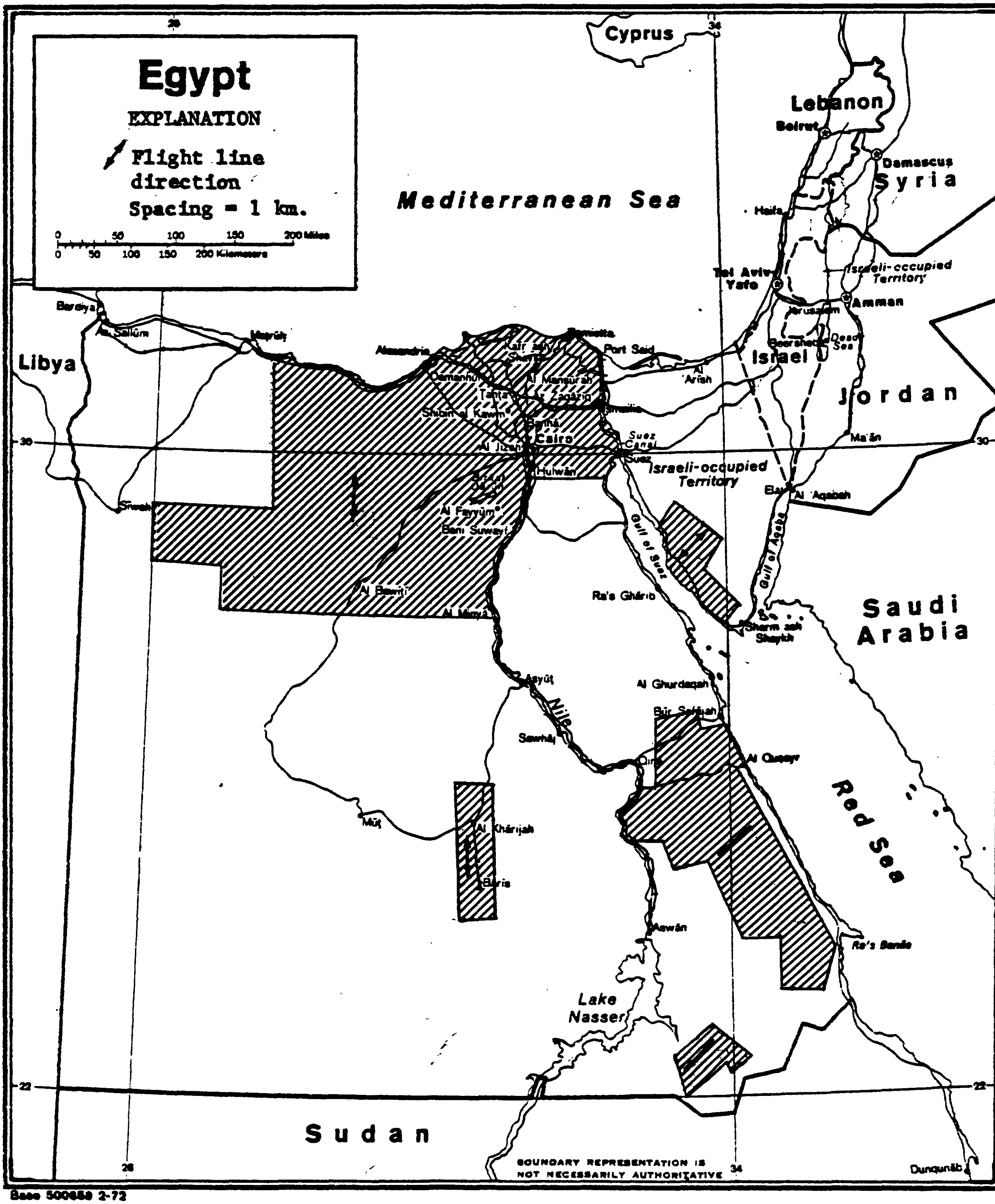


Figure 4 -- Areas covered by airborne radiometric surveys, Egypt. (from Nuclear Materials Corporation, 1979.)

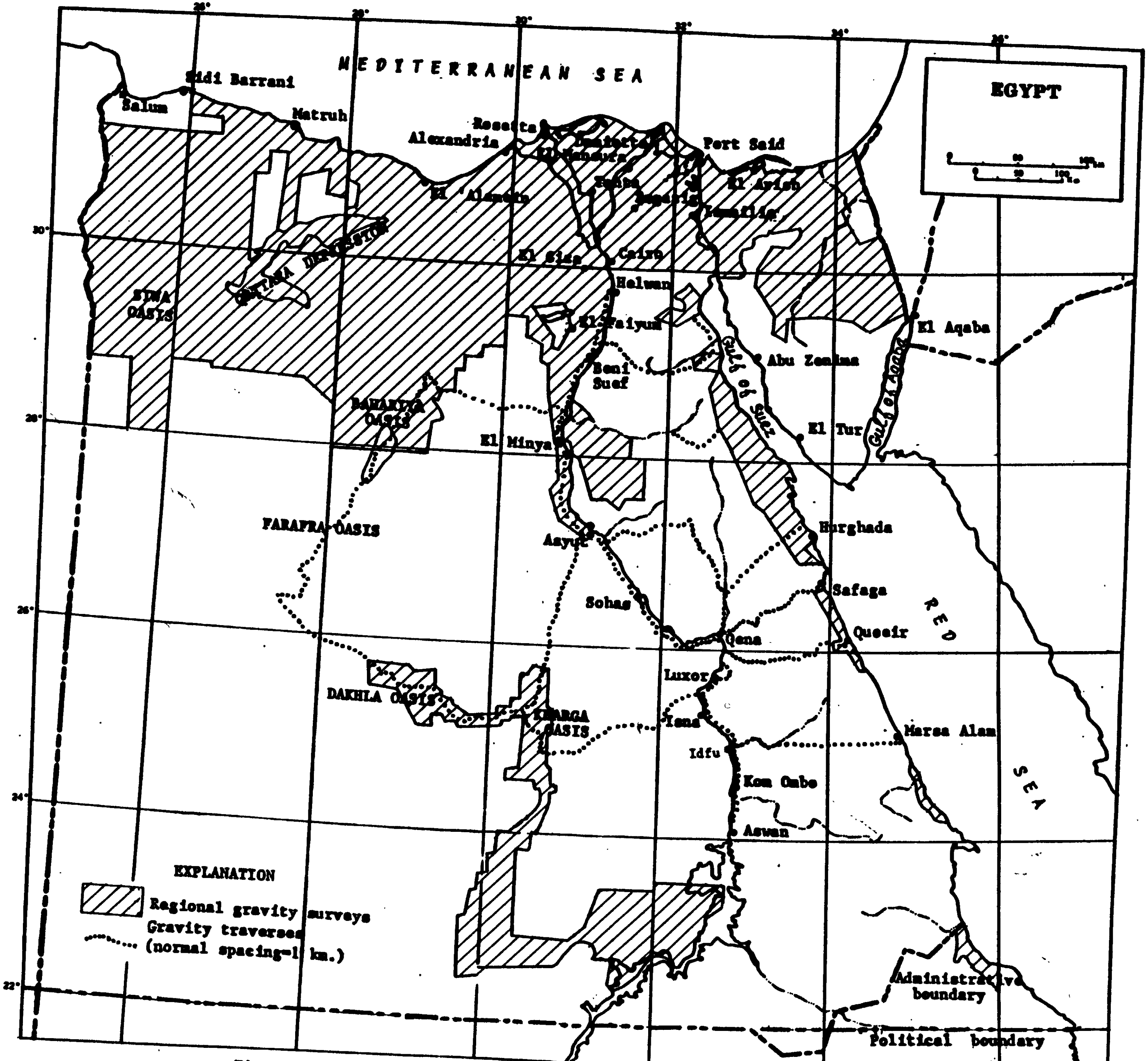


Figure 5 -- Index map of Egypt showing gravity survey area and traverses, after F. K. Boulos (written communication 1979)

EGPC (no index map was available for magnetics only). It may be noted that most of the northern one-third of Egypt has been covered by gravity measurements, principally for petroleum exploration. Much of the work in this area was completed and a report written by the USSR for the General Petroleum Co. of Egypt under Contract 1500 (Gas and Oil Prospect). This report has not yet been evaluated.

During 1947-48, Standard Oil of Egypt completed a gravity survey of 7,000 km^2 in the Delta area (fig. 2) at an average station density of one per 4.4 km^2. Bouguer gravity anomaly maps were compiled at 1:100,000 and contoured at a 10 mgal. interval. The anomaly map shows gravity maximum-minimum values of 1750 and 850 mgals, respectively. A broad east-trending high is contoured on the coastal margin whereas the southern border of the area is characterized by numerous short-wave-length anomalies. This correlates well with the aeromagnetic anomaly pattern. From these anomalies, depths to basement were calculated.

In 1960-61 Geofizika Enterprises (1966), in cooperation with the DRI, completed a regional gravity and magnetic survey (total field) of the South Kharga and Aswan-Tushka areas--called the New Valley project area (see fig. 6). Station spacing for both measurments was 0.5 km along lines spaced 10 km apart. The total area surveyed was 23,000 km^2. A Worden gravimeter (no. 387) was used and the resulting data compiled as Bouguer anomaly maps (scale 1:100,000). In some areas, terrain corrections (to 22 km) were calculated. The magnetic measurements were made with an Elsec Proton Magnetometer. Data compilation included removing a regional field (5.88/km N, 1.58/km E).

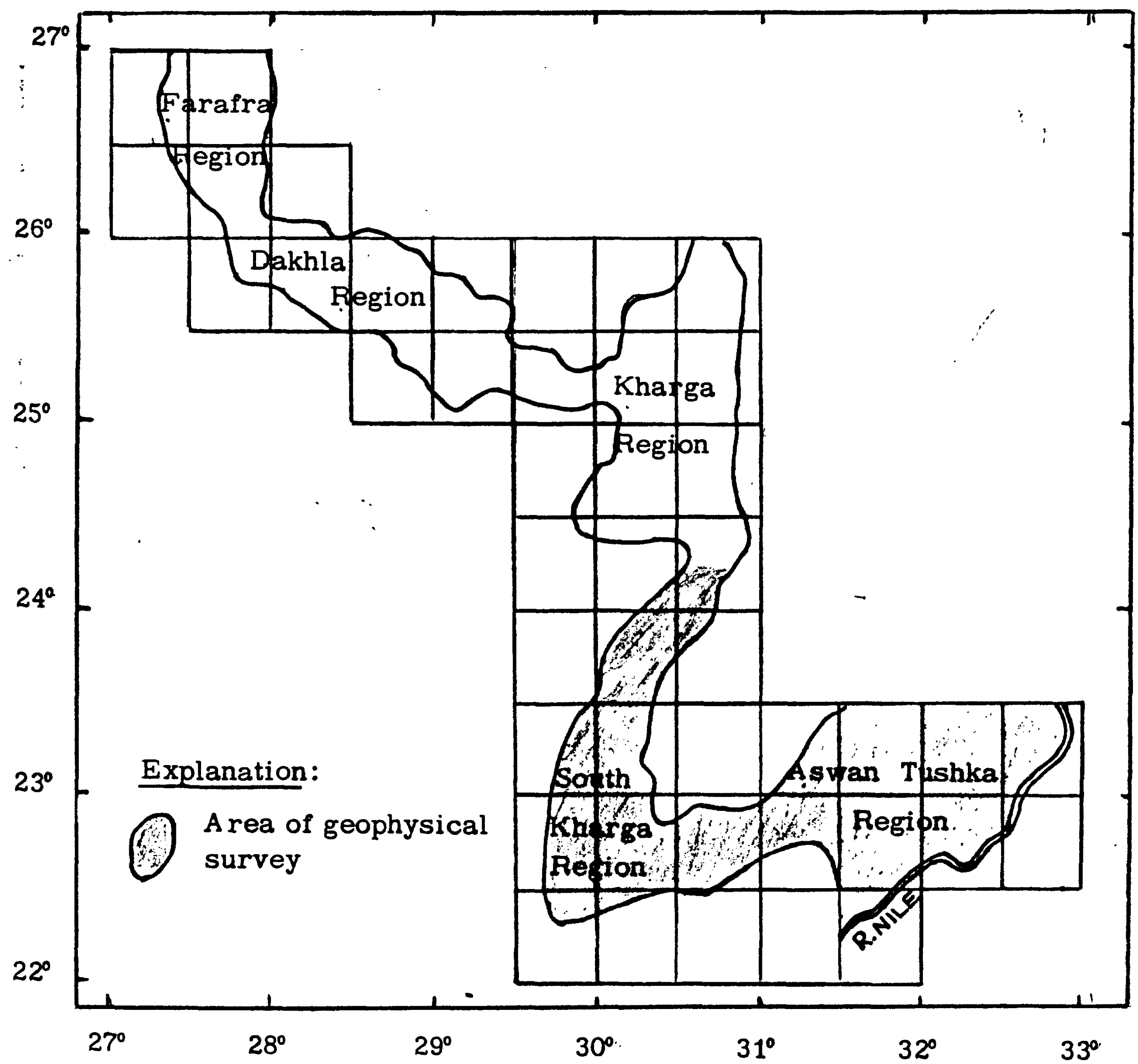


Figure 6 -- Index map of the New Valley Project, Eastern Desert

A principal product of the surveys was a basement contour map based on depth analyses of the anomalies. In this area, Precambrian crystalline rocks are overlain by the Nubian Sandstone which ranges from very thin or absent to more than 600 m. As the Nubian Sandstone is a possible groundwater aquifer, it is important to know its thickness and the relief on the basement rocks.

The GSE has measured the gravity along several profiles that are generally normal to the axes of the Red Sea and the Gulf of Suez (see fig. 5). The measurements were made with a La Coste-Romberg Gravimeter (model G) and the reduced data interpreted in terms of structural significance (Fahim and Hennin, 1978; Boulos, and others, 1979; Riad, 1977).

<u>Mining geophysics (electrical methods)</u>

Much of the effort of the Geophysics section of the GSE has been directed to the application of electrical methods to specific mineral target areas, not only in the Eastern Desert, but countrywide, including the Sinai (see fig. 7). The list of GSE geophysical technical reports (unpublished) appended to this report attests to the continuing high level of activity in the use of electromagnetics, resistivity, induced polarization, self potential, electric logging, etc., in mineral exploration. Non-electrical methods--gravity, magnetics, gamma-ray spectrometry--are also employed in specific cases. An excellent example of several geophysical techniques being brought to bear on iron ore exploration at Bahariya may be found in Awad, and others (1979).

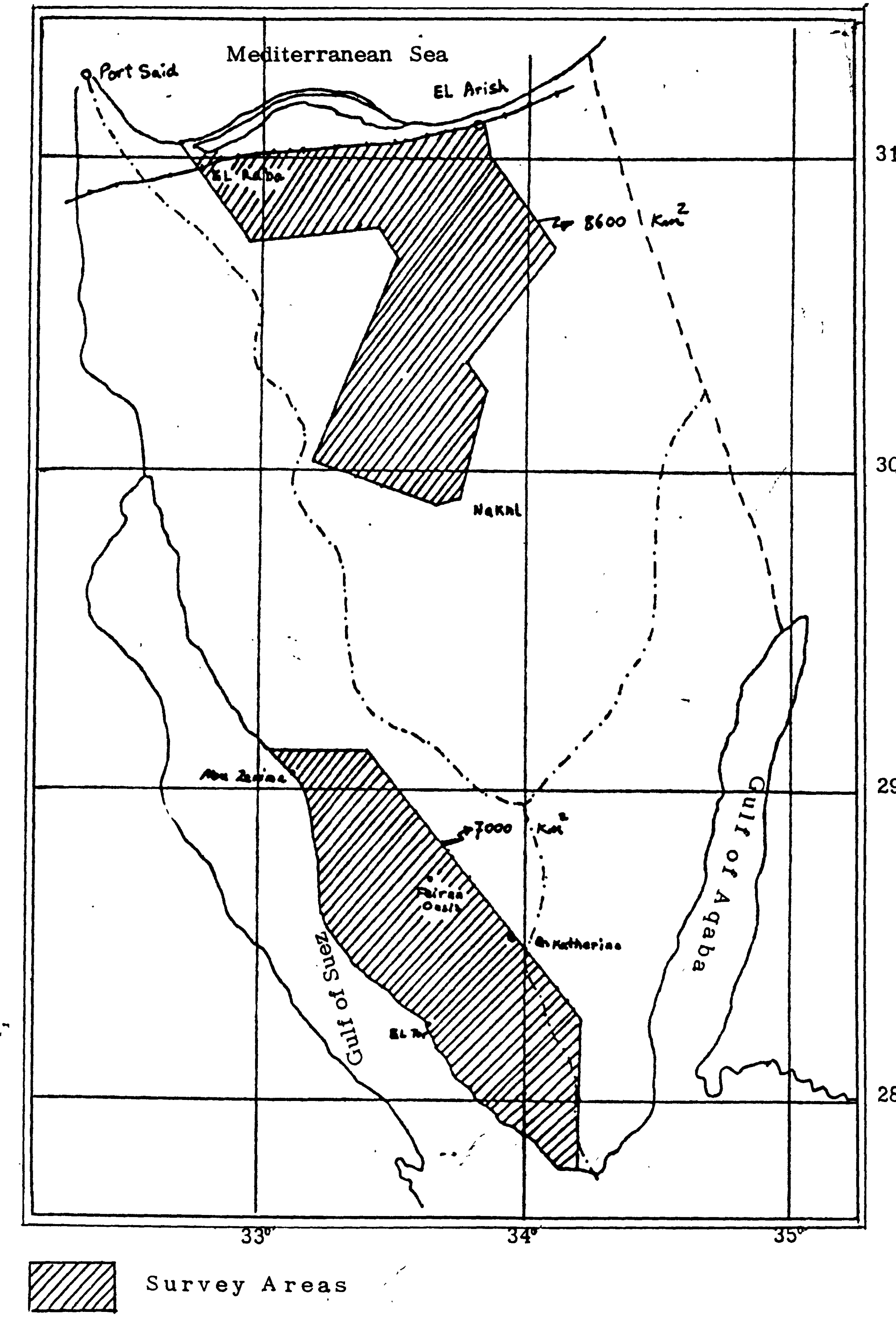


Figure 7 — Index map of Sinai Peninsula showing areas of hydrological, geophysical, and soil studies, by Geogizika, 1963.

An index map of the survey areas was not available, but most of the field work is presently concentrated in the Precambrian Shield complex of the Eastern Desert, where mineral deposits of iron, manganese, gold, coal, ilmenite, copper, and zinc are known, as shown in figure 8.

Until recently, the work of those involved in electrical methods has been limited to the use of outdated instruments of USSR origin and for which spare parts are difficult or impossible to obtain. This situation is now being remedied by the purchase of current instrument models and spares, as may be seen from the instrument list elsewhere in this report.

Topical studies

At present there are three on-going geophysical studies of a topical nature: microseismicity, geothermal (heat flow), and paleomagnetics. All three studies contribute fundamental information on the structure of the earth's crust, and on the geologic framework within which mineralization may occur. Such studies are especially significant here in view of the fact that Egypt is bounded on the north by a zone of compression and is situated adjacent to a major fracture zone in the earth's crust that continues south along the axis of the Red Sea, joining the East African Rift at the Afar triangle. Both the Red Sea and the Gulf of Suez are active seafloor spreading centers, and the associated transform faults likely have landward extensions. That the region is geologically active is manifested by the high frequency of microseismic events and high heat flow values (Daggett and others 1979; Morgan and others, 1976).

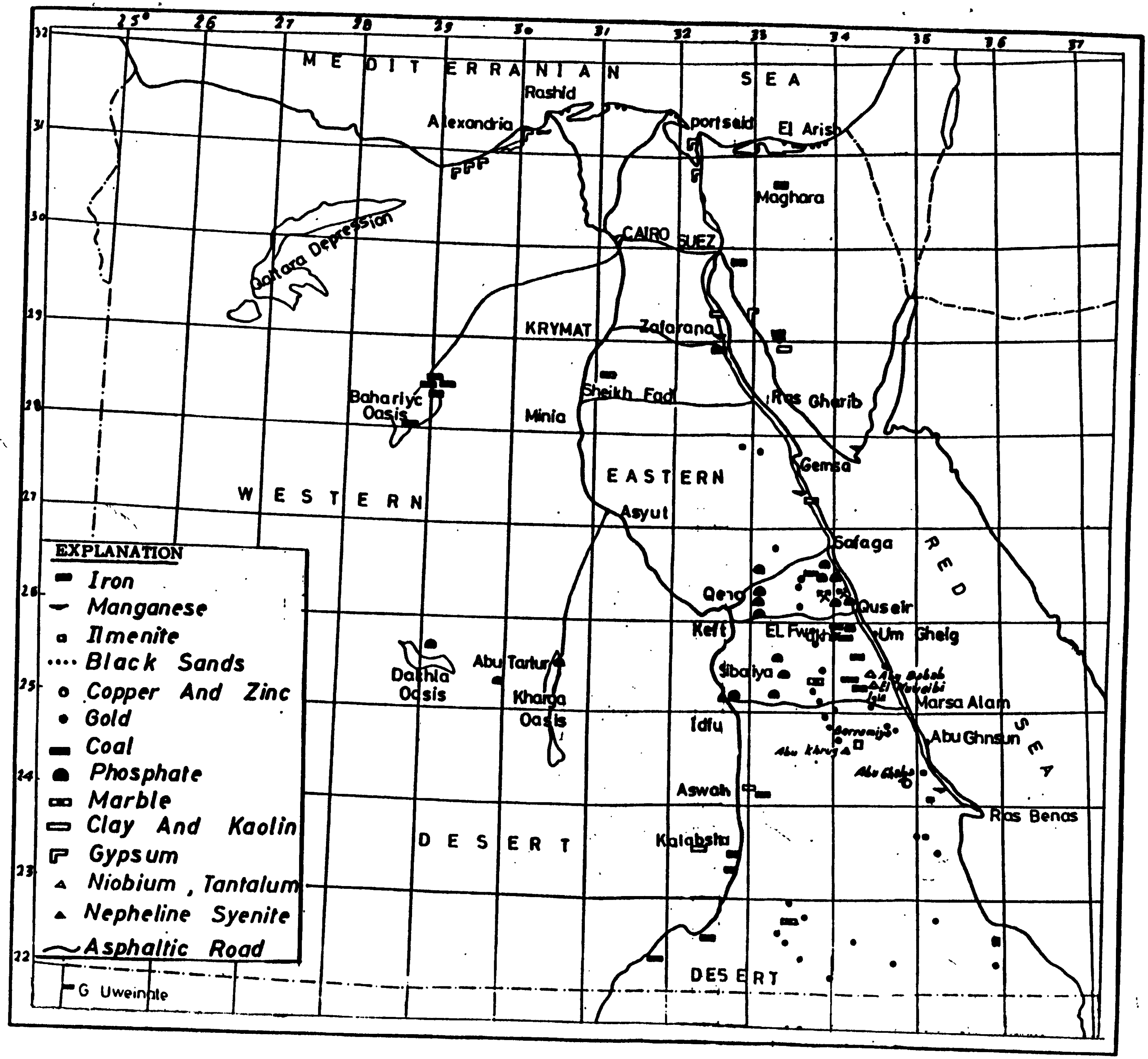
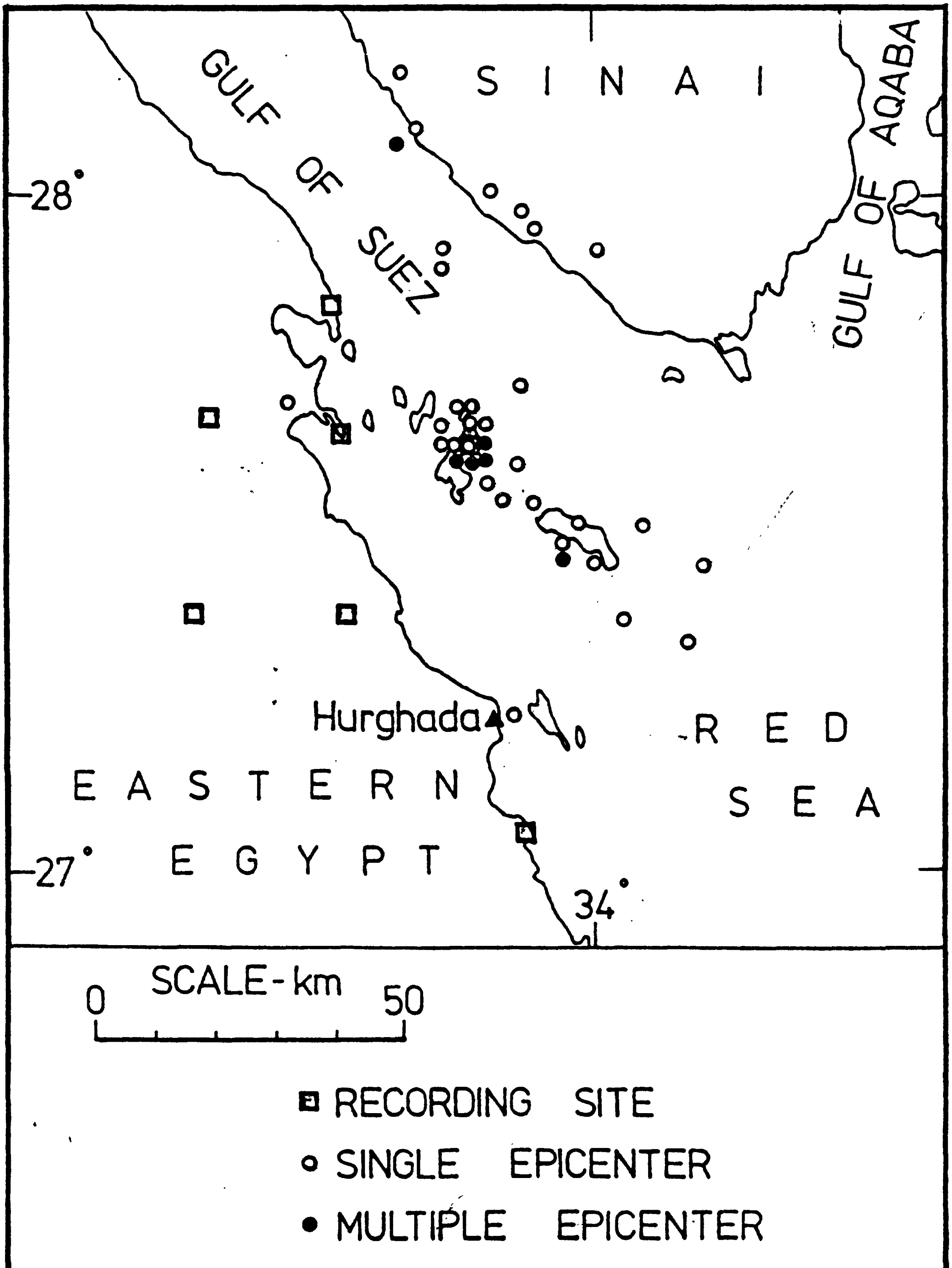


Figure 8--Index map showing locations of principal mineral deposits of Egypt. (after the Egyptian Geological Survey 1979)

Microseismicity studies

Recent microseismic events have been systematically recorded under a program of the New Mexico State University (NMSU) and the Southern Methodist University (SMU) in cooperation with the Egyptian Geological Survey and Mining Authority (GSE). The work has been supported by funds from the Earth Science Program of the U.S. National Science Foundation (NSF) and from U.S. Public Law Fund 480. The new seismic data and preliminary interpretation are presented in a report by the investigators (Daggett and others, 1979) that is now in press. Figure 9, taken from their report, shows the spring 1977 activity in the Hurghada area. The hypocenters for these earthquakes are especially related to the major normal faults of the Gulf. The events recorded just south of lat. 26° N. (not shown) tentatively define an active tectonic zone that extends from from the mouth of the Gulf of Suez into the median zone of the Red Sea; the investigators interpret it to be an active zone related to the opening of the Red Sea.

In the present program, two or three high-sensitivity portable seismograph stations are used in a reconnaissance mode to locate areas of micro-earthquake (microseismicity) activity. An array of five or more instruments is then installed around the epicenters to locate individual events. The instruments used are the Sprengnether (USA) model MEQ-800, high gain, single channel, in conjunction with Teledyne-Geotech (USA) model S-13 seismometers with vertical component natural frequency of 1 Hz.



from Daggett, et al (1979)

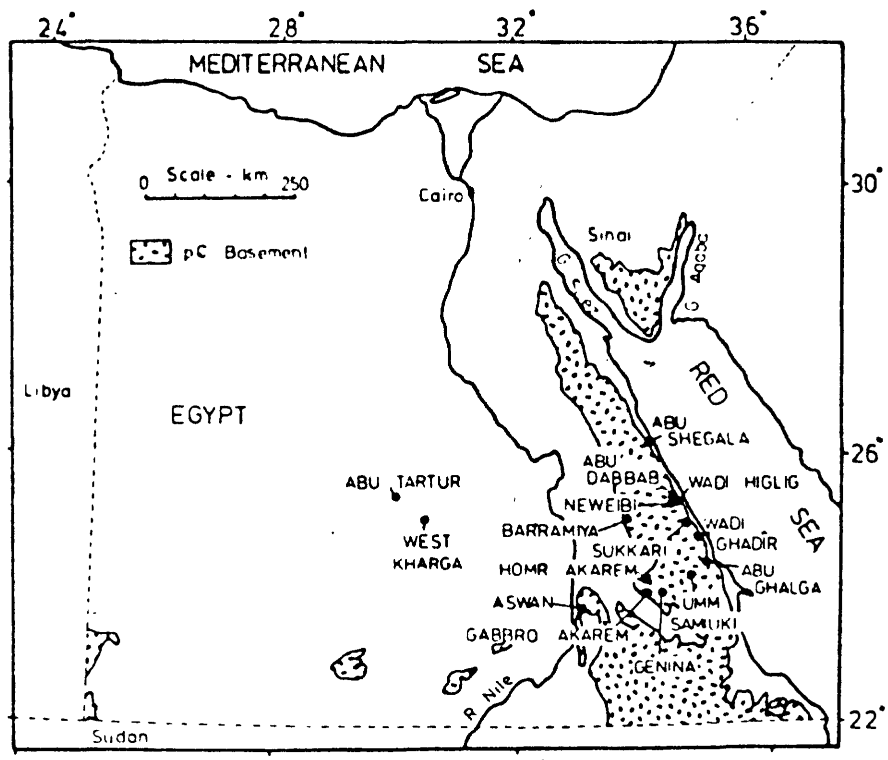
Figure 9 — Map showing microearthquake activity in the Hurghada area, Spring, 1977.

Geothermal studies

The geothermal studies have been carried out by personnel of the same institutions involved in the microseismicity studies, namely, GSE, NMSU, and SMU, and financed from grants from the Earth Science Program of NSF and the Science Research Centre of NMSU.

Analyses of temperature gradients and heat flow values measured during 1976-77 (see fig. 10) are the subject of two reports by the investigators (Morgan and others, 1977 and 1979). They point out that geothermal processes are closely related to seismically active plate margins, as is shown by a close spatial relationship between volcanoes and plate margins. As noted above, Egypt is located in a complex transition between two plate types—a zone of compression on the north and a seafloor spreading centre in the Red Sea. The following is taken from the 1979 report:

"New heat flow data from Egypt indicate that the high heat flow anomaly extends approximately 30 km inland from the coast in the Precambrian rocks bordering the Red Sea. Preliminary heat flow values ranging from 42 to 175 mWm^{-2} (1.0 to 4.2 ucal $cm^{-2}s^{-1}$, HFU) have been estimated for Egypt from numerous geothermal gradient determinations with a reasonably good geographic distribution, and a limited number of thermal conductivity determinations. Generally, heat flow west of the Nile and in northern Egypt is estimated to be low, 40 - 45mWm^{-2} (1.0 - 1.1 HFU), typical of a Precambrian Platform province. East of the Nile, however, including the Gulf of Suez, elevated heat flow is indicated at several sites, with a high of 175 mWm^{-2} (4.2 HFU) measured in a Precambrian granitic gneiss



from Morgan et al (1979)

Figure 10 -- Location of bore hole temperature-logging sites in Egypt, excluding oil well data sites.

approximately 2 km from the Red Sea coast. Water geochemistry data confirm the high heat flow values, but do not indicate any deep hot water circulation systems. Heat flow values from the Kenya section of the East African rift system and from the lakes in the western rift and extending south in Zambia are also high, but all other heat flow data from Africa indicate a regionally low to normal heat flow. The high heat flow values therefore appear to be closely related to the active tectonic sections of the African plate, the East African rift system, and the Red Sea spreading centre."

Paleomagnetic studies

The GSE has been studying the magnetic and paleomagnetic properties of rock samples since 1969 when F. K. Boulos prepared Technical Report No. TR-39 (see Appendix) on densities and magnetic susceptibilities of Precambrian rocks in the Eastern Desert. In 1971, Boulos completed Technical Reports Nos. TR-54 and TR-56 (see Appendix) on paleomagnetic studies in the Igla area and Fawaklir area, respectively. In 1972, Boulos and others completed five technical reports on physical properties of rocks (including magnetic susceptibility). These are TR-3, TR-8, TR-13A, TR-25, and TR-30 (see Appendix). A systematic program of paleomagnetic studies is scheduled to begin in 1980 when the recently ordered Schoenstedt Spinner Magnetometer system is installed. This laboratory is described in greater detail elsewhere in this report. The program has received USAID funds for laboratory equipment purchases, but, to ensure a successful operation, the technical assistance of a paleomagnetic specialist is required.

Geophysical laboratories

There are three geophysical laboratories at the Egyptian Geological Survey in Abassia, Cairo: (1) the largest site (approximately 150 m^2 is on the ground level and houses the general electronics maintenance and repair facility for all geophysical instruments; (2) a second laboratory (about 25 m^2) is located on the fourth floor and is principally a magnetics laboratory; and (3) the third and smallest laboratory is located on the third floor and is currently used as a storage room for geophysical equipment no longer in use.

Figure 11 shows the floor plan of the first and largest laboratory. This space is poorly insulated from the outside environment (dust, temperature, humidity) and therefore would be unacceptable as a viable electronics facility. However, with some alterations this site would be suitable now and for some time to come. Necessary alterations should include the following:

(1) Permanently closed and sealed windows (if any).

(2) Air-conditioning throughout the laboratory.

(3) Dropped, acoustical ceilings (to improve AC efficiency): Present ceilings are 3.5 m--suggest 2.5 m or less.

(4) Humidity control.

(5) New electronics work benches, etc.

(6) High-capacity voltage stabilizers to insure even power. Adequate power outlets throughout the laboratory.

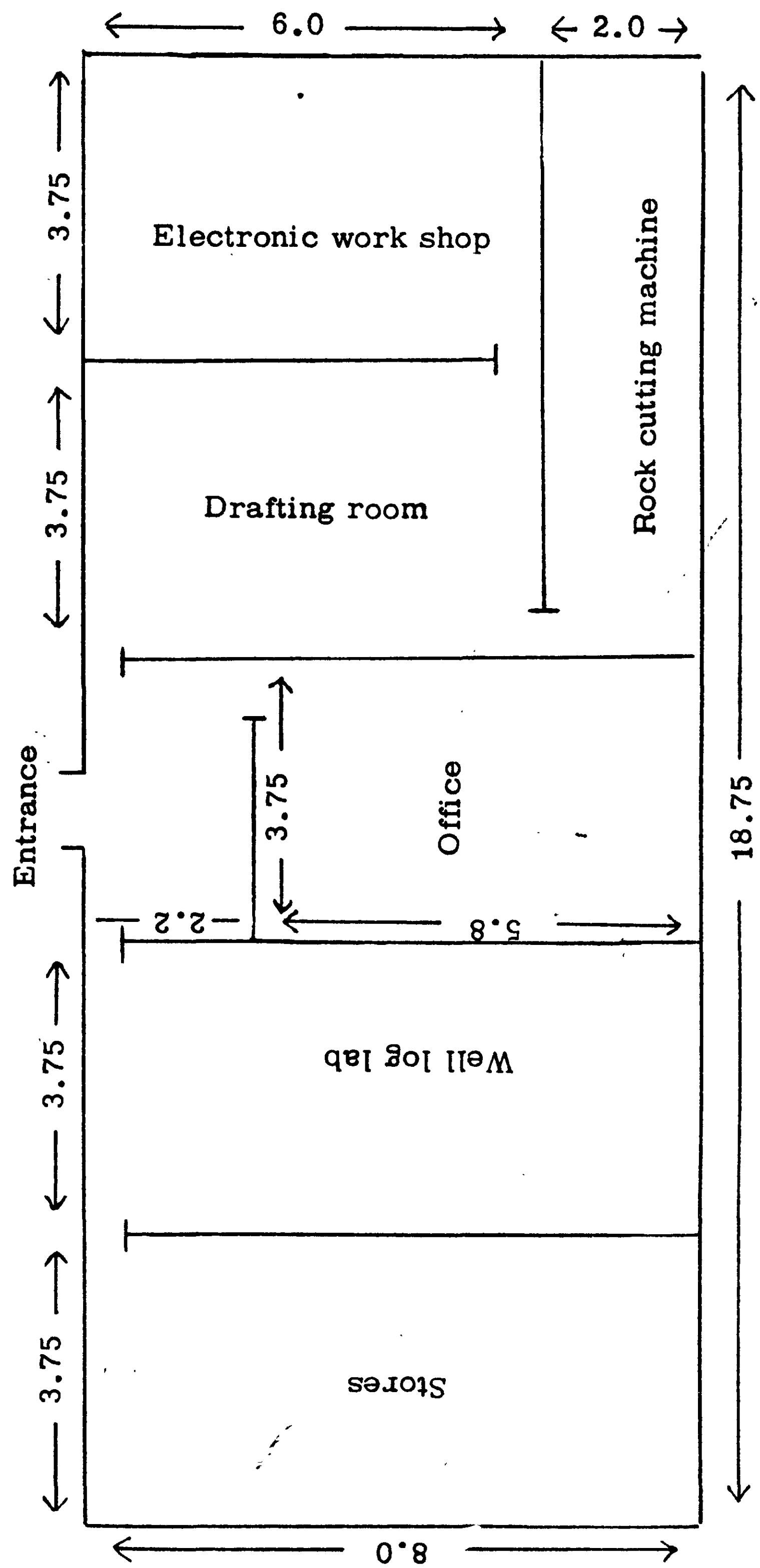


Figure 11. GSE Geophysics Laboratory present structure

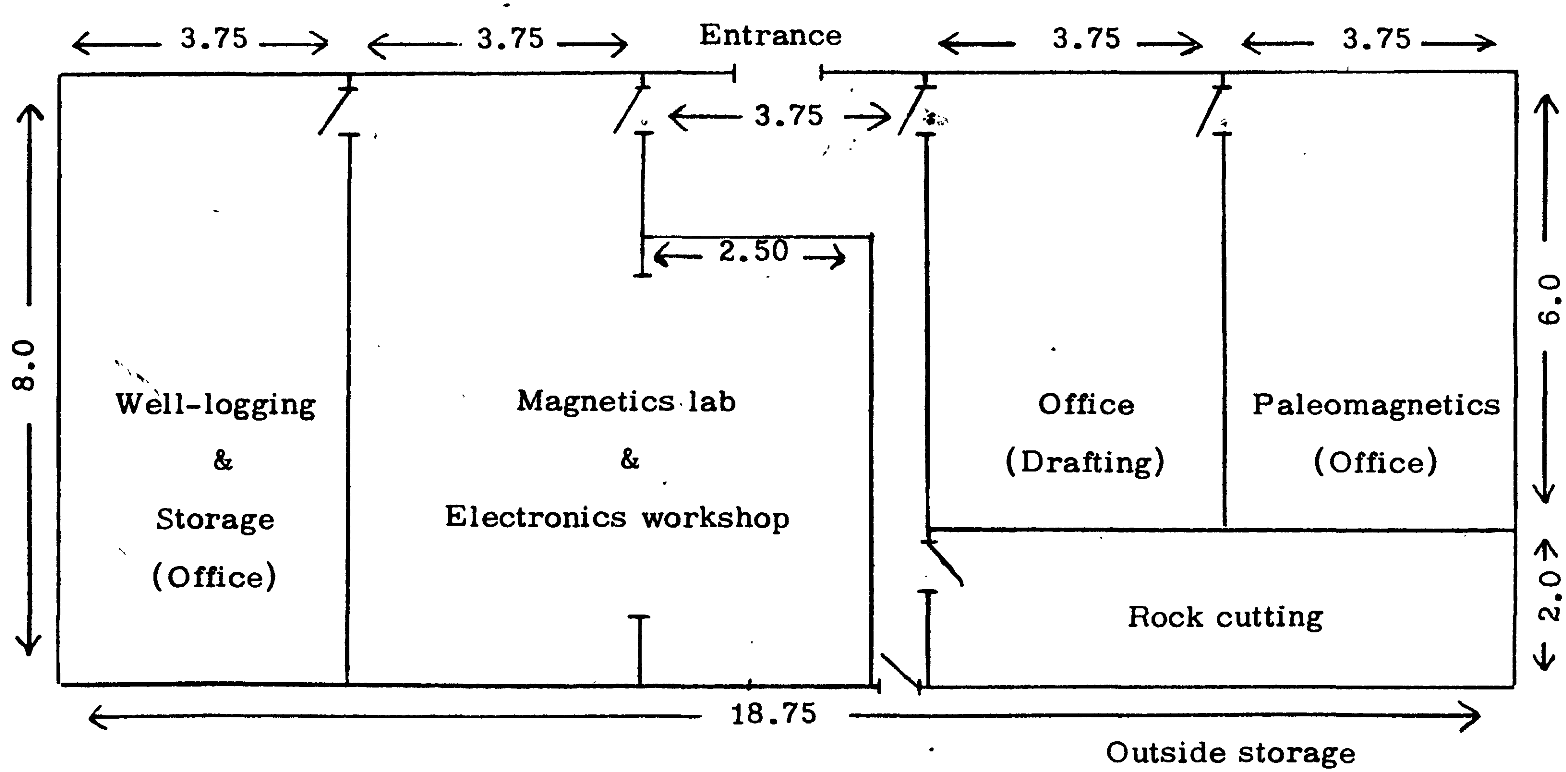
Scale = 1:100 (measurements in metres)

(7) Provision for sufficient built-in storage facilities for supplies, spare parts, field equipment not in use, etc.

(8) Adequate lighting throughout.

In addition to the above, the writer feels that this facility could house all the geophysical laboratories. One possible internal structural modification is suggested in figure 12. The main thrust of this design is to provide a proper environment for the paleomagnetic facility—with close access to the sample preparation room (rock cutting/drilling). A corridor was provided so that rock samples could be transported directly to outside storage (courtyard area) or to the sample preparation room, without disturbing the controlled environment areas of the laboratory. The office adjacent to the paleomagnetics room would serve as office space and provide some space for drafting. In order to accommodate the new Schoenstedt Spinner Magnetometer system, preparation of the paleomagnetic room should begin as soon as possible. Laboratory environment (including power) is the first priority; special equipment benches, cabinets, shelves, etc., should be carefully designed.

Figure 13 shows a possible scheme for the paleomagnetics laboratory. The actual layout should be supervised by a paleomagnetics specialist. The combined magnetics laboratory and electronics workshop occupies the largest area (approximately 45 m^2). With adequate built-in storage cabinets, etc., this should be excellent space. Wall-to-wall carpeting is recommended in the paleomagnetics room as it helps to keep down the



Scale = 1:100 (measurements in metres)

NOTE: All rooms sealed & airconditioned
Stable power
Carpet in Paleo room
New lighting
Numerous AC outlets

Figure 12--GSE Geophysics Laboratory proposed structural alterations.

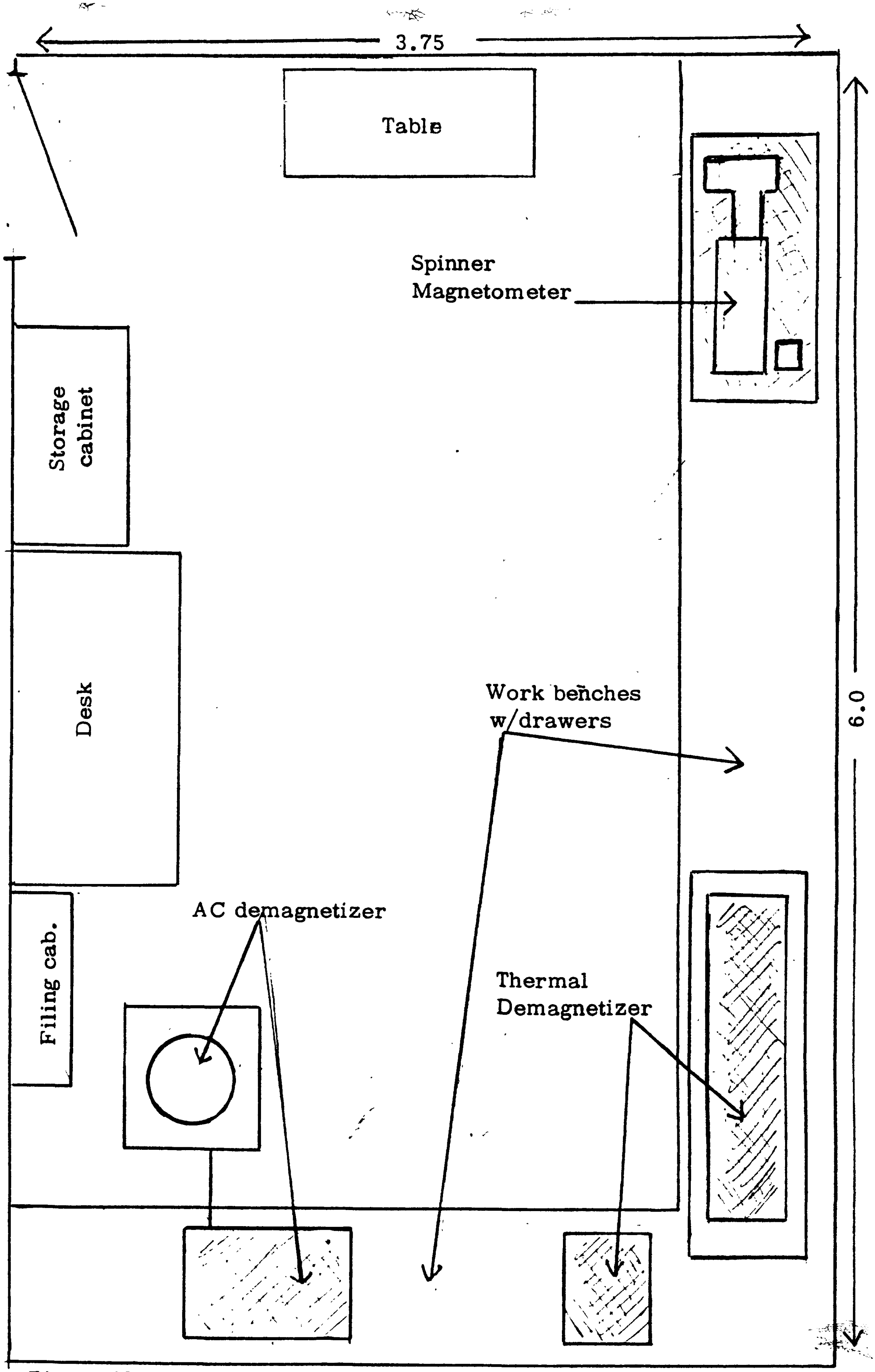


Figure 13--Schematic plan for paleomagnetics lab.

inevitable dust. Needless to say, constant and dedicated janitorial service is an absolute must, in order to maintain a "clean" laboratory if modern electronic equipment is to function.

Instrumentation (field laboratory)

One of the more critical situations within the Geophysics section is the present state of instrumentation--both laboratory and field. Except for a few new pieces that have recently been acquired, most items in the inventory are outdated and many are in a state of disrepair. Most of the equipment is of Russian origin and spare parts are difficult to obtain. Table 3 shows the current inventory of geophysical instruments, and table 4 lists the instruments that are on order. Table 5 is a list of proposed instruments. Acquisition of the ordered and proposed items will greatly help to bring the necessary equipment inventory to the desired level. Most of the antiquated equipment should be disposed of to make room for the new equipment.

Digital data processing

The Egyptian Geological Survey and Mining Authority has no internal capability for digital data processing. The geophysics section does some computer processing at one of the two University campuses or one of the governmental offices. Table 6 lists the computer centers available to the GSE.

Table 3 -- Current inventory of geophysical instruments

Type	Description	Quantity
Gravity	Gravimeter, L R model G (electronix read)	1
Magnetics	1) Proton magnetometer (Scintrex Co.)	1
	2) Proton magnetometer (Geometrix)	2
	3) Fluxgate magnetometer (Sharpe)	1
	4) Kappameter (SI) ABEM	2
	5) Kappameter (Cgs) USSR	1
	6) Proton magnetometer G-816 (Geometrex)	1
	7) Magnetic susceptibility bridge	1
Electrical		
A) Resistivity		
	1) SP5-RM (Scintrex)	1
	2) SP6-RM (Scintrex)	1
	3) RSP6 (Scintrex)	1
	4) ESK-1 (USSR)	2
	5) AE-72 (USSR)	6
	6) KS-50 (USSR)	1
	7) DC resistivity meter	1
	8) R & SP receiver (Heindrichs MK4C)	1
B) Self-potential		
	1) Mcphar (Canada)	2
	2) Mimi (Czechoslovakia)	2
C) Electromagnetics		
	1) VLF, SE-80 (Scintrex)	1
	2) VLF (Radem)	1
	3) Turam (ABEM)	1
	contd..	..

Table 3 -- contd.

Type	Description	Quantity
Radiation		
	1) Scintillometer, SPP-2NE (France)	2
	2) Scintillomter, (Scintrex)	6
	3) Gamma-ray spectrometer GAD-4 (Scintrex) less crystals	1
	4) Gamma-ray spectrometer, DISA 300 (GeoEX)	1
	5) Radon emanometer, ETR-1 (Scintrex)	2
Well-logging (self potential, resistivity, gamma, gamma-gamma) USSR		
	1) 900m. capacity	3
Seismic		
	1) Pocket seismometer, GISCO ES-1A	1

Table 4 -- Geophysical instruments on order

Type	Description
Paleomagnetics	1) Spinner magnetometer, Schonstedt DSM-1
	2) AC De-mag., Schonstedt DSM-1
	3) Thermal De-mag., Schonstedt TSD-1
	4) Portable specimen magnetometer, Schonstedt PSM-1
Electrical	1) Time domain IP receiver/transmitter, IPR-8, Heindrichs R10A

Table 5 -- Geophysical instruments requested from US AID

Type	Description
Electrical	1) 10-amp. Resistivity transmitter, Heindrichs MK7-PF 2) 20-amp. Resistivity transmitter, Heindrichs MK4B-PF 3) Analog chart recorders (2) 4) 12 volt DC to 220 volt AC converters (2) 5) Time domain IP transmitter, GISCO, IPC-7/25W.
Programmable Calculators	1) Pocket - HP67 2) Desk model similar to HP 9800 series or Tectronix 4000 series, (with peripherals)
Laboratory	1) Digital multimeter 2) Logic board tester
Seismic (controlled source)	1) Multi-channel seismometer (ES-2400) system with DMT-100 digital recorder; CRT-100 display.

Table 6--Computer Centers Available to the GSE

Computer Center	Location	Type of Computer
Ain Shams University	Abbassia	NOVA 830
Cairo University	Giza	ICL 1905
Central Agency for Mobilization and Statistics	Nasr City	ICL 1906 ICL 1904(?)

It was not possible in the time available to obtain an adequate description of the three computer systems. However, over and above possible problems centered on types of system and the inconvenience of off-site computer facilities, the most serious objection to use of other facilities is the lack of peripherals, generally regarded as essential: these include visual data display (automatic profiling and contouring via a data plotter) and digitizing capability.

A full mini-computer system is not recommended for the GSE at this time. However, it seems essential that the Survey acquire a substantial in-house digital data processing capability--not only for the geophysicists but for the geologists, geochemists, etc., as well. It is suggested that a viable system maybe the Tektronix Programmable Calculator (or similar). The complete system could include:

- 32K memory
- CRT with hard copy

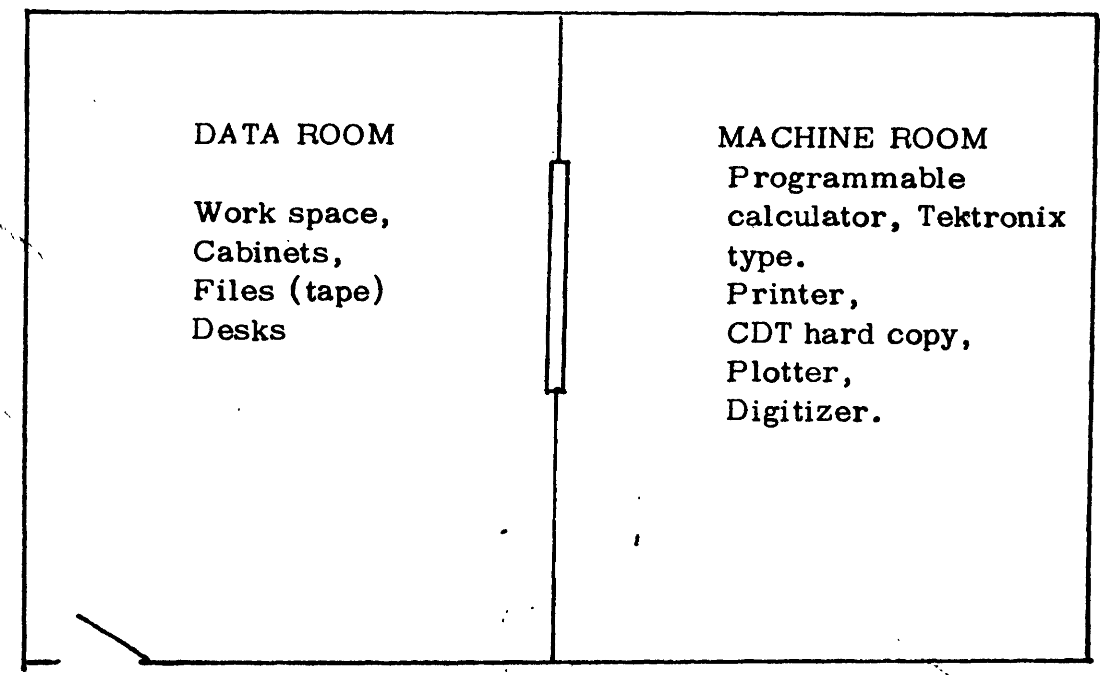
- 36" x 48" digitizer/CRT display
- Automatic data plotter
- Printer (132C)
- Cartridge tape drive (300K storage)
- Mass storage (600K, double density read/write)

The above system (or equivalent), at a purchase cost of about $75,000.00, could also serve as an intelligent terminal to a future main computer system and so would not become obsolete.

Figure 14 shows a schematic layout of a small data processing facility which, ideally would be located convenient to the majority of users. The rooms should be isolated from the outside environment and, in general, be prepared in the same way as the geophysical laboratories. A computer systems engineer should supervise the alterations.

Recommendations and cost estimates

The recommendations that follow represent a fairly comprehensive program designed to substantially upgrade the capabilities and facilities of the GSE, Department of Geophysics. Geophysical techniques applied to mineral assessment play a dominant role because large areas can be surveyed at much less cost and in a far shorter time frame than traditional methods. But this implies access to current instrumentation, highly trained geophysicists and technicians, computing facilities and the infrastructure for laboratory support, electronics maintenance and repair, etc. Airborne surveys, however, would be let out on bid to qualified contractors who would be responsible for all phases of data acquisition, compilation,



NOTE: Sealed rooms, air-conditioning, dropped tile ceiling, regulated power, humidity control, tables, files, desks, etc.

Figure 14. GSE Data Centre schematic lay-out.

and, possibly, data interpretation. A summary of cost estimates is shown on table 7.

Regional geophysics

The following are recommended for the regional geophysical program:

1. A national aeromagnetic map.

   Aeromagnetic data exist for approximately 65 percent of Egypt (though very little for the Eastern Desert). Compilation of these data--obtained from the many government agencies--should commence at once. No special funds are required for this phase of compilation, than manpower and technical assistance.

2. A national gravity map.

   Sufficient gravity data exist to begin compilation of all available data. Such a compilation would be of immediate benefit in planning future gravity investigation, avoid duplication of effort, and eventually result in valuable basic information. No special funds required, but technical assistance would be required, as would close access to a suitable computation facility.

3. Aeromagnetic/radiation survey, Eastern Desert.

   The Precambrian Shield of the Eastern Desert has been subjected to several airborne surveys in a patchwork fashion designed to achieve certain objectives in specific areas (targets) of interest. It now should be a principal objective to complete the aeromagnetic coverage over this broad area extending east from the Nile River.

Table 7 -- Summary of approximate cost profile (excluding costs of technical advisors).

	in thousands of US Dollars
Regional Geophysics	
Aeromagnetic/radiation survey (contract)	
Priority Area I	1,670
Priority Area II	2,130
Mining Geophysics	
Equipment purchase costs	70
Programmable calculator (e.g. Tectronix)	50
Misc. equipment purchase (electronics)	25
Training	80
Total	4025

Those areas already flown, in most cases, would be be reflown. A complete inventory of previous surveys including those by other agencies of the Government of Egypt, and data evaluation would be required. Figure 15 is an index map of the area of Egypt still in need of survey, divided into priority areas I and II. Area I extending from the Sudan border to lat 25° N., is an area of about 88,000 km^2 not previously flown. Area II extends from lat 25° N. to lat 30° N., and includes an area of about 112,000 km^2. The total of flight line-kilometers is approximately 200,000. At present prices, such a survey would cost approximately $3,800,000 and would require four months field work (assuming two aircraft). It is believed, however, that the actual survey area would be considerably less, following the recommended inventory of those areas already flown. Hence the above cost estimate represents an upper limit.

Mining geophysics

There are no specific field project recommendations for the various electrical methods employed in specific target areas. The Mining Geophysics Section would be fully qualified to obtain good quality data upon completion of additional training (as outlined in a following section) on the new instruments that are gradually arriving from the manufacturers. It is recommended that funds be made available for all instrument items proposed above. Recommendations on airborne electromagnetic surveys are delayed until possible mineralized zones already identified can be further evaluated.

Cost of proposed instruments: $70,000.

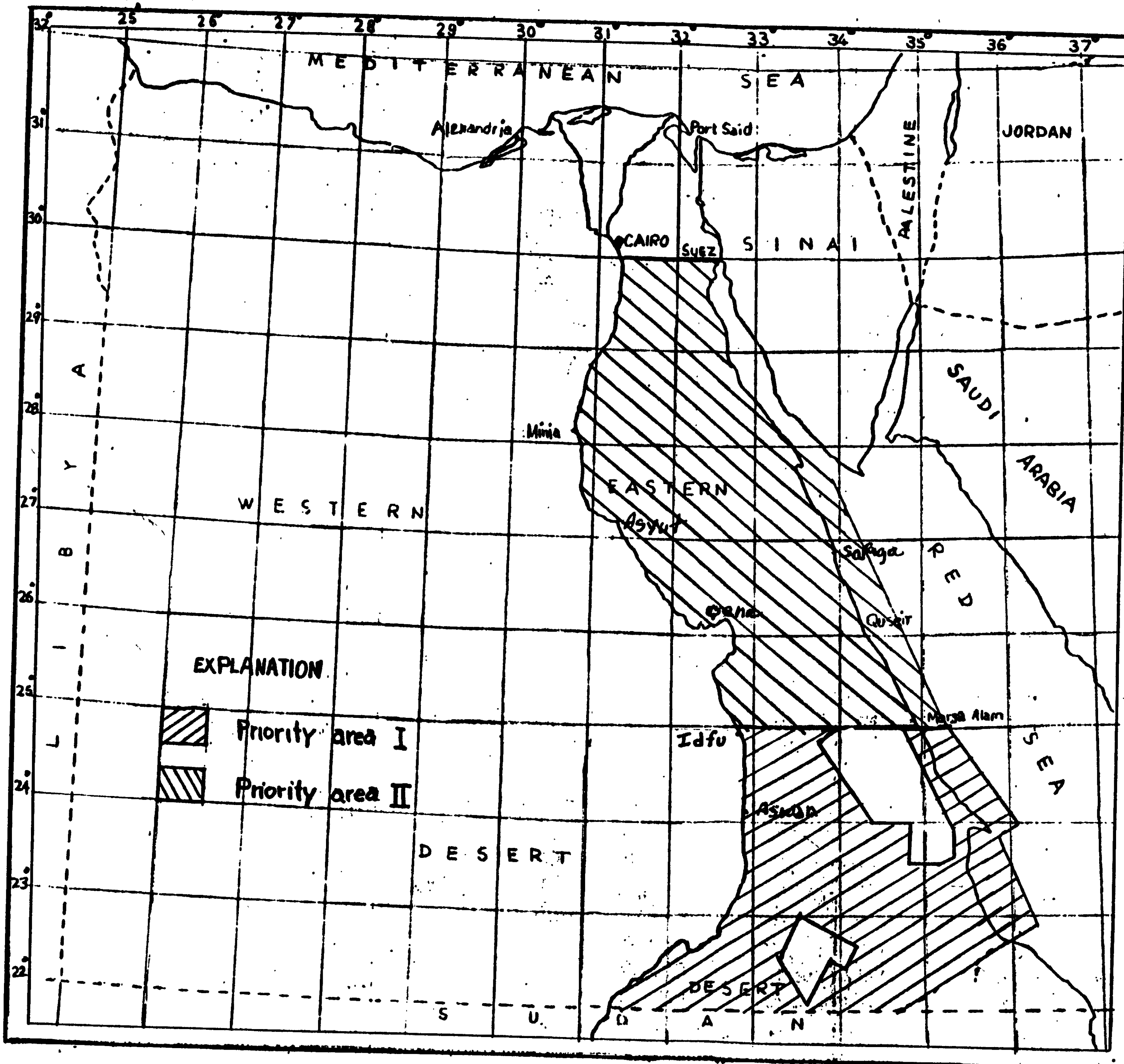


Figure 15 -- Index map showing approximate areas recommended for aeromagnetic and radiation surveys. 1979

Topical studies

Microseismicity studies

This program is at present a cooperative activity of the New Mexico State University, Southern Methodist University and the Egyptian Geological Survey. Financial support comes from the U.S. National Science Foundation. But if these funds should be withdrawn, other financial support should be arranged so that this important activity can continue.

Geothermal studies

This program is also on-going as a cooperative effort by the same participating groups as the Microseismicity program. Funding is also from NSF. As in the case of the above long-term program, should NSF funds be insufficient, other financial support should be sought.

Paleomagnetic studies

This program requires the technical assistance of a part-time resident specialist to set up the laboratory and help develop a viable science program directed toward mineral assessment.

Work on preparation of a suitable laboratory site should begin immediately and be supervised by a paleomagnetism specialist. At this writing, (December 1979) the laboratory instruments have not arrived.

The complete renovation of the paleomagnetics laboratory site, as well as the electronics laboratory should be the responsibility of the GSE. Training in the operation and maintenance of the sophisticated instruments of this section is essential.

Computation facilities

An adequate computation facility in a geophysical and geological environment is considered essential. The GSE has no such facility and of the three computer centers occasionally used by the GSE geophysics section, none has the peripheral equipment (auto-plotting, digitizing, etc.), necessary to produce visual display--only stacks of printout are produced.

A programmable calculator, similar to the Tektronix 4000 series, or HP 9800 series with accessories and peripherals described in another section of this report, is recommended. Approximate cost is $40,000 to $50,000.

Instrumentation (electronics laboratory)

Additional electronic test equipment, not yet completely identified, will also be required at a later date (e.g., dual-trace oscilloscope). Estimated cost: $25,000.

Training

The training of geophysicists in all phases of the GSE geophysics program is considered an important and necessary activity to up-grade levels of skills needed to deal with state-of-the-art instruments, data analyses, and field procedures. Table 8 shows a generalized training list prepared by the GSE and recommended by the author. Estimated cost: $80,000.

Table 8 -- Tentative list of training disciplines for Egyptian Geological Survey, number of participants, and approximate duration of training.

No. of Participants	Discipline	Duration
1 Senior	- Application of current geophysical methods to mineral exploration	3
1 Senior 2 Juniors	- Seismic prospecting methods for mineral exploration (controlled-source).	3
2 Juniors	- Deep resistivity sounding	3
1 Senior 1 Junior	- Paleomagnetism - sampling, measurements, data analyses.	2
1 Senior	- Well-logging techniques	2
1 Technician	- Electronics training	8
n.a.	- Computer training	n.a.

Finally, it is recommended that there be some level of USGS participation in Egypt--particularly in such fields as regional geophysics, paleomagnetism, and electronics. Initially, 1-year assignments would be desirable, followed by 1-3 month temporary duty assignments.

CONCLUDING OBSERVATIONS

The Geophysics Department of the Egyptian Geological Survey has developed quite a broad program of geophysical investigations - especially in electrical methods. Cooperative studies with universities in other earth science-orientated disciplines (e.g. microseismicity) seem very successful and productive. The department is handicapped by antiquated instruments--field and laboratory--but this is now being alleviated by recent purchases. Along with the need for up-dated equipment comes the need for training, not only on instrumentation (and its maintenance) but on data analysis. Analysis of geophysical data is largely computer-dependent and the GSE has no in-house facility, and only poor access to inadequate outside facilities. Of the three GOE agencies visited, the GSE geophysics department possesses by far the greatest depth and breadth of geophysical expertise, and should play a major role in the mineral assessment of Egypt. Lastly, the publication processes of the GSE, which is now quite slow (in many cases, more than five years) should be reorganized to develop a faster and more efficient publication system. It seems that this is being done, in part, by the development of part, by the development of a special cartographic and photo lab unit by Roger Shaff (USGS) and his staff. Publication in outside journals should also be encouraged.

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APPENDIX 1

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