NATIONAL MUSEUMS OF SCOTLAND

SAQQARA PROJECT 1991

David Jeffreys, Ian Mathieson, Ana Tavares

National Museums of Scotland
Chambers Street Edinburgh EH1 1JF

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An interim report on one season of survey, field-walking and research into previous records of archaeological work at the Saqqara Necropolis of Memphis, Egypt.

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The findings of this project will enable the National Museums of Scotland to produce a map with archaeological commentary of the described area. It will show the results of remote sensing work combined with field inspection and the plotting and recording of previous excavations and surveys. The programme of work will cover several seasons and consist of:

1. The basic framework of resistivity surveys and research into previous records.

2. Further resistivity surveys consisting of cross-sections over the valley floor and the preparation of the base map. Detailed study of major anomalies appearing on the cross-sections.

3. Completion of the cross-sections and further study of particular anomalies using proton-magnetometer, sonic and perhaps ground penetrating radar.

4. Preparation of the final publication with interpretations, comments and recommendations.

The 1991 field season ran from the 16th November to the 5th of December, the staff being David Jeffreys (archaeological adviser), Ian Mathieson (geo-archaeological surveys), Ana Tavares (survey and archaeological project research). Prof. H. S. Smith advised on previous work in the area of the animal galleries.

The National Museums of Scotland acknowledge with gratitude the help and cooperation of the Egyptian Antiquities Organization with whose permission the Museum's work is carried out; especially the Officers at Abassiya, Chairman Prof Dr Mohd Ibrahim Bakr, the members of the Committee and the Secretariat, Mr Ahmed M Moussa and Mme Samia; at Giza Dr Zahie Hawass; at Saqqara, the Director of Antiquities Mr Yehia Eid and the EAO representative Mr Ahmed Mohd Shaaban, all of whom have been most willing to give assistance at all times.

Financial assistance from the British Academy, the Wainwright Fund and map reproduction by Survey and Development Services, Bo'ness, West Lothian, are gratefully acknowledged.

As permission to use the electrical remote-sensing equipment in the concession area was not granted by the Government Security Department which deals with the Egyptian Antiquities Organization, it was decided to reverse the normal approach to this type of work and to carry out the location surveys of existing tombs, recognisable structures, proposed remote-sensing lines and archaeological field walking of the concession area.

During the 1990 Season resistivity work was completed along the length of the concession area and four of the proposed cross-sections covering the large enclosure known as the Gisr el Mudir were surveyed. Work began in 1991, therefore, on surface observation of this same area.

FIELDWORK

Resistivity Survey (Ian Mathieson, Ana Tavares)

Methodology: The electrical resistivity method for sub-surface study was first developed by Schlumberger in France in 1912 as part of geophysical development in the pursuit of oil exploration. Since that time the method has proved itself to be among the most effective ways of remote sensing for shallow sub-surface investigation.

Resistivity surveys can distinguish types of sub-surface materials, determine the composition of an overburden and the depth to the rock-head. Any intervening material or void gives an anomaly which can be plotted in depth and linear position. Resistance to an electric current is a physical property that characterizes a material almost as definitely as its density and magnetic susceptibility.

The procedure relies on the principle that separate material deposits beneath the surface offer different resistances to the passage of an electric current, depending largely on the amount of moisture present in the material. A damp midden pit-fill will offer less resistance than the surrounding soil, a brick or stone structure a much higher resistance. The measuring device used consists of a source of electric current and a meter to measure the resistance. The instrument used for this project is a Strata-Scout analogue resistance meter connected to a linear array of 24 copper rods by a multi-core cable addressed by a multi-selection switching device. The copper rods are driven into the ground at two metre intervals and the current is passed through the pins in paired sequences, the configuration being called the Wenner method, (Wenner,1916) which provides a measure of the depth and position at which the resistance is being measured (Plates 5 & 6).

The profiles are overlapped to give continuous depth recording down to 8m depth. Readings can be taken at 10, 12, and 14 metres to gain further information when a structure is observed. The data is computerized for smoothing and removal of background "noise" and then plotted in the form of crude cross-sections or pseudo-sections by software which gives maximum flexibility in scale and notation. As the resistivity data can range from zero to infinity within the space of a few metres the ability to plot natural scales as well as logarithmic is greatly appreciated for clarity of presentation in graphic form.

It is regretted that due to the withholding of permission for the use of electrical remote-sensing equipment in the 1991 season the work started in 1990 could not be continued. It is sincerely hoped that permission will granted for the 1992 season to allow the survey to continue as great interest has been shown by Egyptian and International archaeological missions in this form of non-destructive archaeology and in the results produced.

The pseudo-sections for the main traverses and the cross-sections completed in 1990 are shown on Plates 1 - 4.

Location surveys

The location of tombs, structures and survey lines are based on local triangulation schemes laid out by the Survey of Egypt, Cairo University Engineering Department and the Egypt Exploration Society, all of which have been reduced to the UTM Grid (Universal Transverse Mercator Grid Projection - Hayford 1909 Int. Ellipsoid) which is the base for the topographic map sheets produced in 1978 for the Ministry of Housing and Reconstruction (MHR 1978) at a scale of 1/5000. It is from these map sheets that the basic topographic features used by the authors are obtained.

The main traverses and cross-sections of the completed and proposed resistivity profiles along with the shafts, tombs and structures surveyed during the field-walking are shown on Map Sheets 1 - 4.

Gisr-el-Mudir (Great Enclosure)

When completing cross-sections 1 to 4 in 1990 several clear exposures of the rough local limestone-built walls of the enclosure were observed. These, when plotted, showed that the width of the walls did not agree with the indicated size on the MHR1978 maps or with the widths given by N. Swelim (1991).

The average width of the three known walls, that is the North, East and West walls, appears to be 15m; this was observed at the North West corner and in sections of the East and West walls where both wall faces are partly exposed (see Map sheet 1 & Plate 7).

East Wall

Being the nearest wall to the rest of the Saqqara monuments, the East wall has suffered most from stone-robbing and perhaps for the same reason it appears to have a greater number of intrusive tomb structures. This condition has made the wall appear much wider than it really is with the line and width obscured by excavation cuts and dumps, which has led some scholars to say that it was a double wall and perhaps even showing crenellations (N.Swelim, 1983)). This is not proven when inspected in the field. From field observations we have been able to establish that the wall is 15m thick and is located as shown (Map sheets 1 & 2). These plotted positions of the wall also differ from that shown on the Ministry of Housing and Reconstruction maps.

Surface observation and anomalies of sub-surface structures seem to indicate that intrusive burials were cut into the East wall. An EAO archive photograph of A S Hussein's excavations carried out in 1947 confirms this observation. It shows an intrusive burial within the East wall consisting of a wrapped body, somewhat disturbed, laid East-West with no cut or burial goods apparent. Along the East wall limestone blocks with reliefs and pottery are also present particularly in the area of Cross-section 4. These remains seem to be robbed from Old Kingdom mastabas, probably positioned against both sides of the wall. However a clear chronological and stratigraphical relationship between the mastabas in the area and the Gisr el Mudir has not yet been established.

West Wall

The width and orientation of the West wall has also been ascertained, as both faces of the wall are visible in several places. Construction techniques are still visible on exposed sections of both the West and North Walls. These show sections of roughly-built, coursed rubble masonry with thick mortar in both bedding and rising joints. EAO archive photographs show, in the West face of the West wall near the North-West corner, masonry in two tiers with courses sloping inwards. The same stepped construction is apparent on the North Wall but on a larger scale so that the wall line is altered in places (Map sheet 2).

These sections seem to resemble the masonry at the corners of the unfinished pyramid of Sekhemkhet and Zawiyet el-Aryan to the North. However in this case the building technique is on a smaller scale and less regular.

Other construction devices are visible; on the West wall a small ramp of rough masonry runs up to the West face and the internal angle of the North West corner shows irregularly laid brick and limestone rubble forming a small wall pushed against the East face of the West end of the wall. The internal angle then seems to be roughly covered with coarse mud-plaster (EAO archive photograph).

During the field-walking this season it was found that an area of limestone fragments and chippings situated to the West of the "South-West corner" and assumed to be a stone-mason's work area is duplicated in the North-West corner in a similar position. There are no indications of tombs to the West of the enclosure, however on the inside of the enclosure in the North-West quadrant and extending over a considerable area there are limestone fragments, red quartzite and some fragments of red granite and black basalt which suggest the existence of a built structure in this area.

North Wall

Although greatly disturbed, the North wall has sections of exposed masonry often surviving to a considerable height (see Map sheet 2). The outer and inner faces of the North-West corner are visible confirming the wall thickness to be 15m (Plate 7).

The evidence seems to suggest that walls were built of roughly coursed masonry with rubble core but the corners show solid masonry construction. Sections of the stepped construction of the wall are visible in a cutting which may have been A S Hussein's attempts at finding a gateway/access to the enclosure. The proposed line of cross-section 7 will allow some clarification of the layout in this case (Plate 8).

South Wall

Although the South wall is indicated both on archaeological maps (De Morgan 1897, Lepsius 1849, Vyse & Perring 1842) and on the MHR78 map, there are no surface indications of this wall. The apparent natural desert ridge along which cross-section C1 was observed in 1990, showed no sub-surface data which could be interpreted as the South wall. The line of the wall as shown on the MHR78 map corresponds to a photogrammetric interpretation of a shallow trench/ditch now filled with fine wind-blown sand. Further resistivity cross-sections will be required to establish the existence and exact position of a South wall.

The South-West corner of the enclosure was not found during the 1990 season and there are no surface indications of any construction. The location of the large anomaly (1990 A7, Map sheet 1) recorded 600m along C1 precludes it from being the South-West corner of the enclosure (Plate 8).

Further field searches for the "South-East corner" fail to show its existence although some large limestone fragments are present on the surface along with many small (2m dia.) grave pits in the area.

Although it has often been assumed that any remains of a pyramid in this enclosure would be found in the centre or towards the South end where the ground rises to form a high knoll or platform, no such indications, other than two small trial-pits, were found on the surface. The sub-surface cross-section C2 taken in 1990 only produced a small anomaly on the East slope which had no surface exposure. The area covered by cross-sections C3 & C4 within the enclosure walls crosses two zones of shallow pittings with a scattering of bones and fine limestone fragments which combined with the sub-surface data suggest these may be from shafts.

The excavations of three tombs shown by De Morgan are clearly seen and have been surveyed (MT6, 12, 13) but at present no independent dating or comment on layout is possible. The small anomaly (A8, Map sheet 1) shown in the 1990 survey had no surface exposure.

Southern Limit of the Valley

Between the Gisr el-Mudir and the Sekhemkhet enclosure, along the West-East slope of the desert plateau just North of cross-section C1, there are surface indications of a mud-brick wall or structure which extends eastwards over the anomaly recorded on Traverse 3 in 1990 (A6, Map 1).

Parallel to this structure and North of the area of small pittings surveyed in 1990 are traces of disturbed tomb shafts. These extend over the North-South desert track and East towards the Sekhemkhet enclosure (Map sheet 1).

Moving to the valley or wadi between the Gisr-el-Mudir and the Sekhemkhet enclosure a close inspection was made of the two North-South gravel mounds which have been suggested in the past as possible enclosure walls. There are no indications of man-made structures on either mound; geologically speaking they appear to be homogeneous sand and gravel deposited over limestone intrusions on the valley floor.

As shown on Map sheets 1 & 2 there are many previously delineated tomb structures and robbed shafts on both sides of the North-South desert track. Three Old Kingdom mastabas are shown by De Morgan and where clear indications of other features have survived they have been incorporated to provide a more complete map of the area.

Continuing beyond the proposed cross-section 7 at the North-East corner of the Gisr-el-Mudir there are some surface indications of tombs or shafts on the West side of Traverse 3. De Morgan places three mastabas here, which have been dated to the New Kingdom. No independent dating is possible at present. The results of 1992 resistivity work will be required in order to show any sub-surface anomalies. However on the East side between Traverse 3 and the Zoser enclosure, research into existing published material and the surface survey both show many tombs and shafts.

A few metres North of the junction of the proposed cross-section 7 and Traverse 3 there is a large anomaly (A5-1990) with traces of mud-brick on the surface. This anomaly could be connected with an L-shaped mound some 25m to the North-East. The mound extends North for 140m and there are anomalies and tomb indications for some 400m on the West side of this feature. Extending the Southern arm of the L-shape to the East (MT41), it continues for some 200m with many tombs and shafts located within the enclosed quarter of the feature. Field study indicates the composition of the L-shaped mound to be gravel and sand with mud-brick and limestone traces on the surface. This feature can be seen on aerial photographs and the South-West corner is indicated on maps of De Morgan, Lepsius, Vyse & Perring. If reconstructed as a rectangular enclosure the North East corner would coincide with the Ptahhotep tomb group.

De Morgan's map also indicates a ridge forming a North-East corner enclosing a roughly square area. He positions a large number of tombs within this area as well as to the South and North. Some of these "shafts" are dated to the Greek period while the other structures shown (mastabas) are dated to the Old Kingdom. Within the enclosure De Morgan names the mastabas of Sem-nefer (VI Dyn.), Ra hont and Ank Ten Sekhet.

He also places a small "Greek" shaft within a large crater near the North end of the enclosure. This circular feature is seen very clearly on the ground and lies in the centre of a large mud-brick structure (MT80), where there are also fragments of limestone. The mud-brick extends to the North and West of the main feature (MT80).

To the North of this enclosure De Morgan shows various clusters of tombs and names the Old Kingdom mastabas of Pepitat-a, Hap-dua, Ankh-hapy V Dyn., Ptahhotep (V Dyn. excavated by Wild 1939). To the North-West of the L-Shaped ridge and just South of the Serapeum enclosure wall De Morgan places the isolated V Dyn. mastaba of Khyat-hotep-her. The distribution and grouping of tombs indicated by De Morgan seems to correspond roughly with those surveyed this season.

Resistivity profiles are planned for the future to see if a signature (a plotted graph form of data repeated by each profile) for the enclosure wall can be derived and then traced round the boundary to confirm the hypothesis. Profiles will also be taken of the main central mound to delineate the extent of the mud-brick sub-surface structure.

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Serapeum

In the 1930s R. Macramallah (1940) partly excavated an Early Dynastic cemetery in the Serapeum area. Several small depressions in the desert surface are now the only indication of part of this cemetery, which consisted mostly of shallow cist burials cut in the gravel surface. In 1852-4, while excavating the Apis bull catacombs A. Mariette (1856, 1882) partly cleared the Serapeum enclosure walls. Late Period buildings have also been excavated in the area, some of which may have been disturbed by the construction of the large EAO resthouse.

To the North West of the resthouse (Map sheet 3) there are traces of mud-brick and limestone masonry which are often considered to be part of the North gateway of the Serapeum. This would alter the positiion of the Nothern enclosure wall and gate to 50m further North and the gate further West than indicated in A. Mariette and De Morgan's plans. Resistivity profiles in the area may make it possible to establish the actual location of the North enclosure wall and therefore correctly position the North gate and define its relationship to the Sacred Animal Necropolis (SAN).

Field observations in the area where anomalies MT3 and MT4 were recorded in 1990 confirm the existence of mud-brick traces on the surface. The overall surface of the Serapeum area is very disturbed and excavations have revealed intensive use throughout Egyptian history, therefore a detailed discussion will require further sub-surface information from resistivity profiles.

The Old Kingdom Mastaba Field

The Old Kingdom mastaba field excavated so far extends across the wadi in a crescent shape to the North of the Serapeum. In the 1850s A. Mariette (1884), excavated some of these mastabas. In subsequent maps De Morgan (1897), Stevenson-Smith (1936), they are noted though few were ever relocated or re-excavated. To the West, the discovery of the 19th Dyn. tomb of Khaemwaset, by the Japanese Mission has been reported early in 1992.

Indications of shafts, excavation craters with surface debris, articulated mud-brick and limestone walls or corners were surveyed and plotted. Some of these coincide with the positions for tombs B15, 19, 20 and 21, while tomb 24 and the older mastaba to the East (recleared by W Stevenson-Smith) actually shows exposed limestone walls and corners. Tombs 1 to 4 are likely to be on the East edge of the Ka-aper/T11 mound where traces of a structure are visible. However no positive identification can be made without exposing part of the chapel or finding inscriptional evidence.

De Morgan alters somewhat the positions of the tombs excavated by A Marette and adds a large number of Old kingdom mastabas across the wadi and in the area East and North-West of T11. No name or date is given for these which perhaps indicates that most were not even partially cleared but inferred from surface finds.

Our observations confirm that the mastaba field seems to extend in a crescent shape across the wadi and around the tomb of Ka-aper (recently excavated by the EAO (OR 1990) and by the Czechoslovakian archaeological mission in 1990). The density of tombs is comparable to other areas of the Necropolis and they extend further North and North-West than indicated in previous maps. In the vicinity of the anomalies A1 & A2 and in the area where De Morgan shows a "Greek Tomb" traces of a structure were surveyed.

Some of the areas shown as "empty" even on the De Morgan maps, show clear traces of structures:

East of anomaly A1 there is a cluster of excavation craters and debris which coincides with a "New Kingdom" tomb indicated in De Morgan's map.

Located on a gravel mound in the centre of the valley to the South-West of the tomb of Ka-Aper there are surface indications of four shafts surrounded by a considerable amount of animal bones. The appearance of the bone deposit is very similar to that on the South-East side of the main wadi excavated by WB Emery beneath the Sacred Animal Necropolis (SAN) temple platform (WB Emery 1965. HS Smith 1976).

The mastaba field extends further North than previously thought, with shafts and structures across the valley from the Ka-aper mound to the West of the SAN temple platform, where WB Emery cleared some 3rd Dyn. mastabas (WB Emery 1967).

On the slopes of the valley sides leading from the tomb of Ka-Aper to the North-East and down towards the edge of the old Lake of Abusir surface deposits which might indicate the existence of stone and mud-brick mastabas and shafts have been surveyed. This indicates that the mastaba field extends across the wadi even this far North(Map sheet 4).

Abusir remanent lake (Birket Mukhtar Pasha)

From the junction of Traverses 1 & 2 an area of mud-brick on the East side of Traverse 1 extends Northwards down to the assumed edge of the Lake. On both the East and West side of the lake edge sloping deposits of fresh water bi-valve shells in a compact mud matrix may indicate old water level or more probably lake-side inhabitation (midden layer).

The gravel and compacted sand mound leading Eastwards up to the Islamic cemetery shows shallow pits and small mud-brick structures. The Early Dynastic cemetery partly excavated by Bonnet (1928) and by the EAO (Leclant 1990), is cut into the same type of strata. The present extent of the Islamic cemetery was surveyed and the edge of the most recent cultivation delineating the probable boundary of the Lake was located.

The relationship between the Lake, the surrounding deposits and the ancient use of the area needs further and urgent attention.

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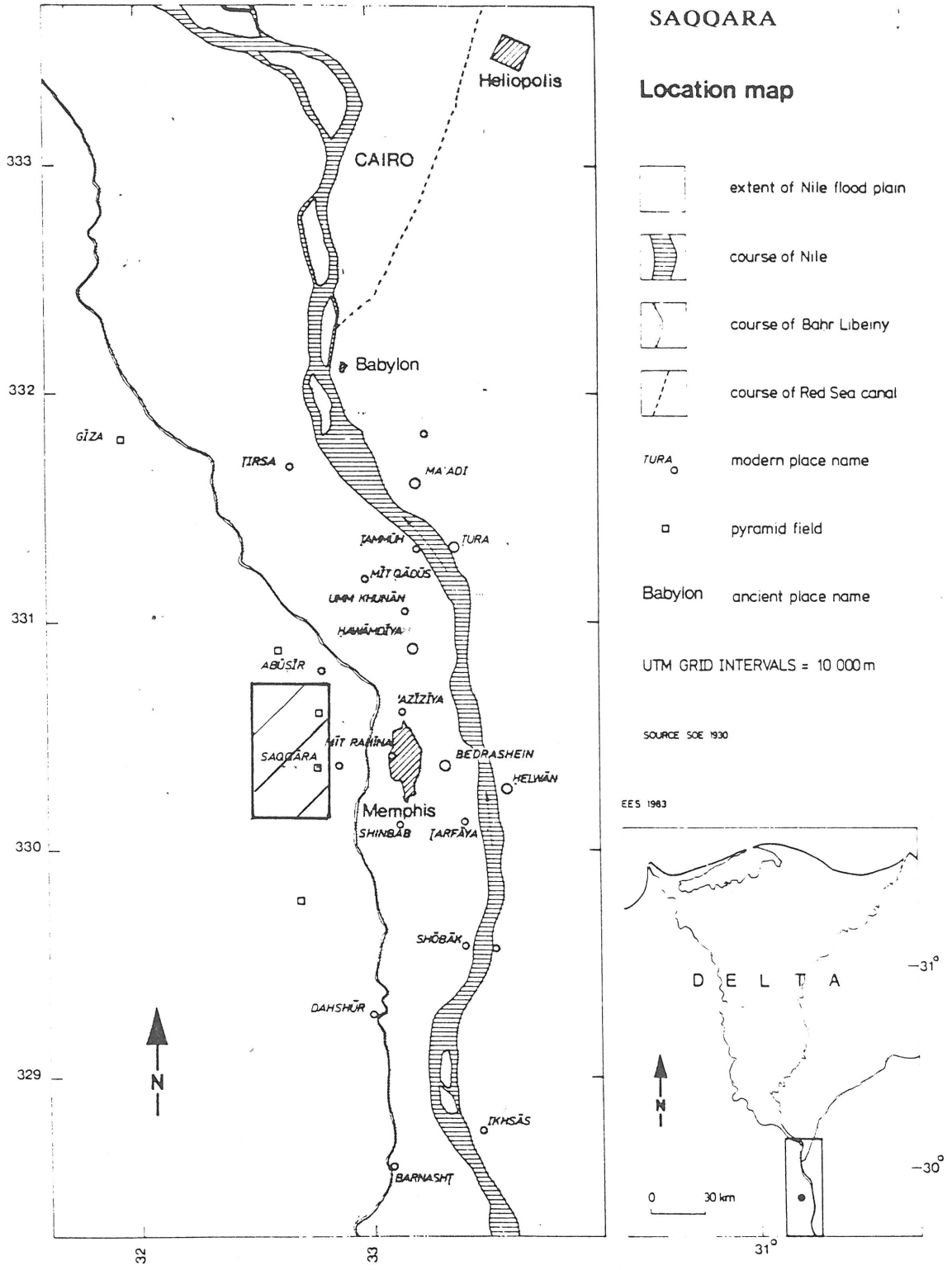
SAQQARA
Location map
Heliopolis
CAIRO
Babylon
GĪZA
ṬIRSA
MA'ADI
ṬAMMŪH
TURA
MĪT QĀOŪS
UMM KHUNĀN
ḤAMĀMĪYA
ABŪSĪR
'AZĪZĪYA
SAQQĀRA
MĪT RAHĪNA
BEDRASHEIN
HELWĀN
Memphis
SHINBĀB
ṬARFĀYA
SHŌBĀK
DAHSHŪR
IKHSĀS
BARNASHṬ
333
332
331
330
329
32
33
N
extent of Nile flood plain
course of Nile
course of Bahr Libeiny
course of Red Sea canal
TURA modern place name
pyramid field
Babylon ancient place name
UTM GRID INTERVALS = 10 000 m
SOURCE SOE 1930
EES 1983
D E L T A
−31°
−30°
31°
0 30 km
N

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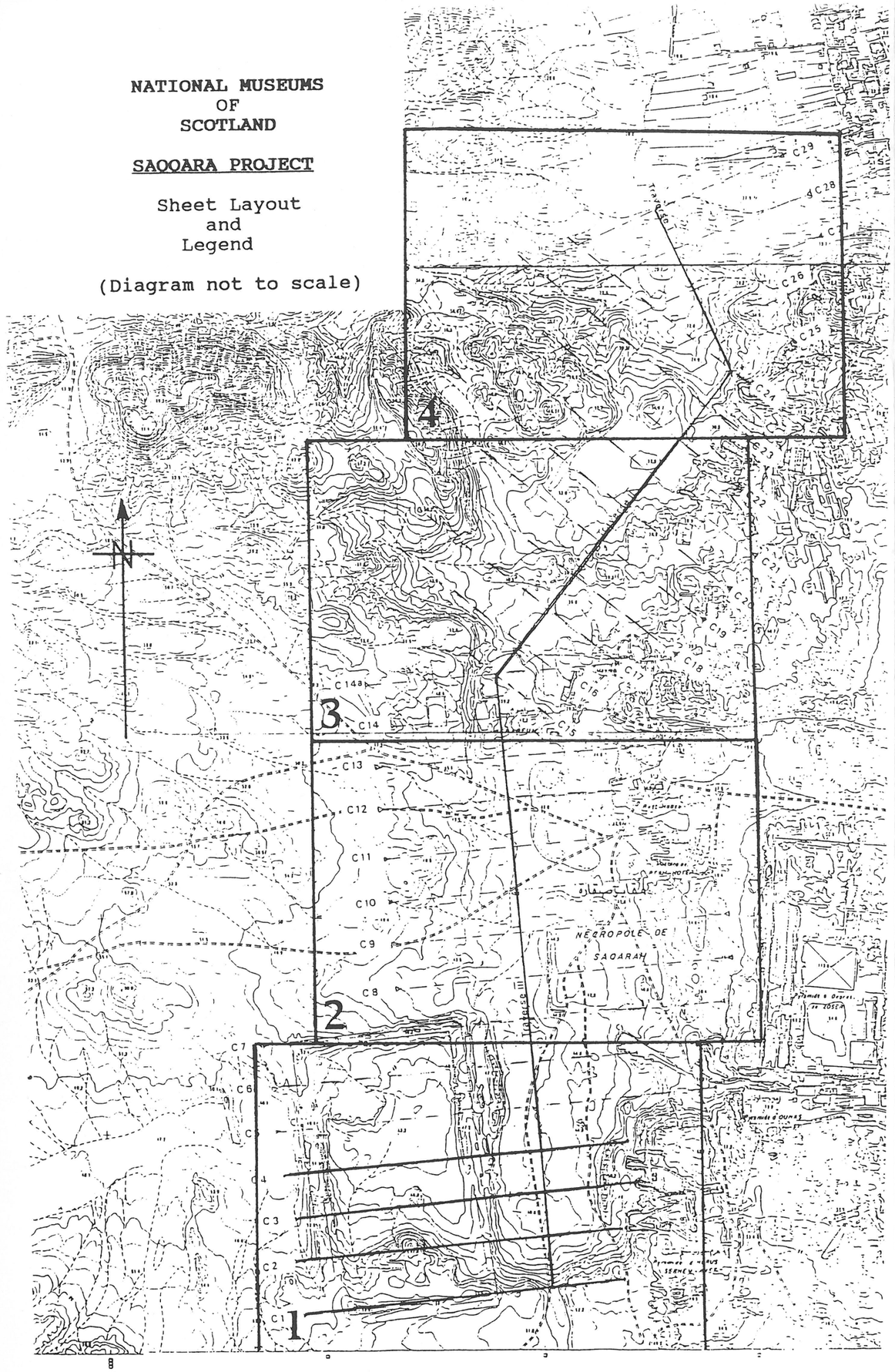
Sheet Layout
and
Legend

(Diagram not to scale)



LEGEND

Topographic

Contour	35
Spot Height	.29
Triangulation Point	△
Building (modern)	
Track	==========

Remote Sensing

Resistivity Line	————
Proton-magnetometer Line	-----/-----/---
Ground Radar Line	---- ---- ---
Acoustic Line	---)|(---)|(---
Thermal Image Site	*****
High Reading	——··——·———
Anomaly	——:::——— A2

Archaeological

Mariette's numbered mastabas	39
Old Kingdom mastabas	
Probable shafts	○
Probable shafts/structures surveyed and numbered (Mathieson-Tavares)	○ 46
Exposed limestone/articulated brick surveyed and numbered	+ 99
Animal Galleries	
Shallow pits-probable cemetery	
Shell deposits	

Scale

1/2500 — 0 — 100 — 200

Elevations in metres above Mean Sea Level.

Topographic information from 1978 Map Sheets for Ministry of Housing and Reconstruction.
UTM Projection - Hayford 1909 Int.Ellipsoid.

N

Ramp

Gisr el Mudir

Sekhemkhet enclosure

T III

C1 C2 C3 C4

A6 A7 A8

40,5 44,8 46,1 47,1 50,2 43,2 47,2 44,9 40,6 50,2 48,8 40,8 52,8 51,7 51,5 55,5 55 52,2 51,0 60,5 63 1

Pyramide d'HOR
SEKHEM-KH

Sheet 1

SERAPEUM

Apis Tombs

Tombs

44,8

55,1

51,1

Rest-House

استراحة

41,6

42,9

T III

مصطبة بتاح حتب

Mastaba de PTAH-HOTEP

مقابر صقارة

42,6

NÉCROPOLE DE SAQQARAH

44,3

46,6

42,8

44,9

Sheet 2

Gisr el Mudir

47,2

50,2

45,1

48,7

43,5

48,8

49,5

54,3

49,4

43,5

40,6

54,6

N

S.A.N.

III Dyn. mastabas

galleries

Ibis galleries

TII

A2

A3

A4

Early Dynastic cemetery

Serapeum

Mastaba de Ti

56,7

36,4

52,1

50,2

33,9

35

30,5

30,9

39,8

53,9

38,1

38,8

36,2

39,3

43,6

40,5

35,9

52,6

48,4

39,2

42,2

39,5

41,1

39,7

41,7

46,7

45

47,7

44,3

Sheet 3

N

Birkhet Mukhtar Pacha

Shell deposit

Shell deposit

Early Dynastic cemetery

Rock-cut tomb

Ibis galleries

Ka-aper

III Dyn. mastaba

TI

TII

34.9

31.2

27.1

22.5

30.7

38.7

40.6

37.7

20.7

22.6

30.7

24.9

34.6

27.9

33.7

26.2

34.5

38.8

42.2

47.8

50.7

41.5

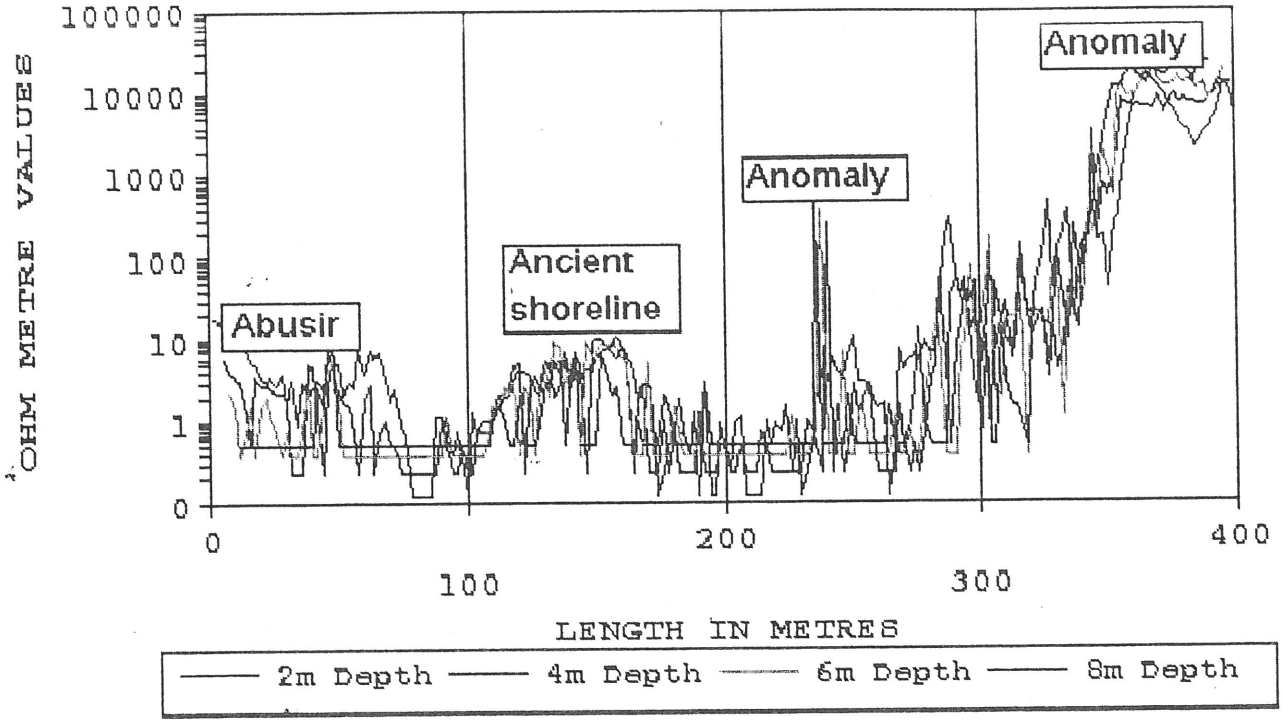
49.2

55.8

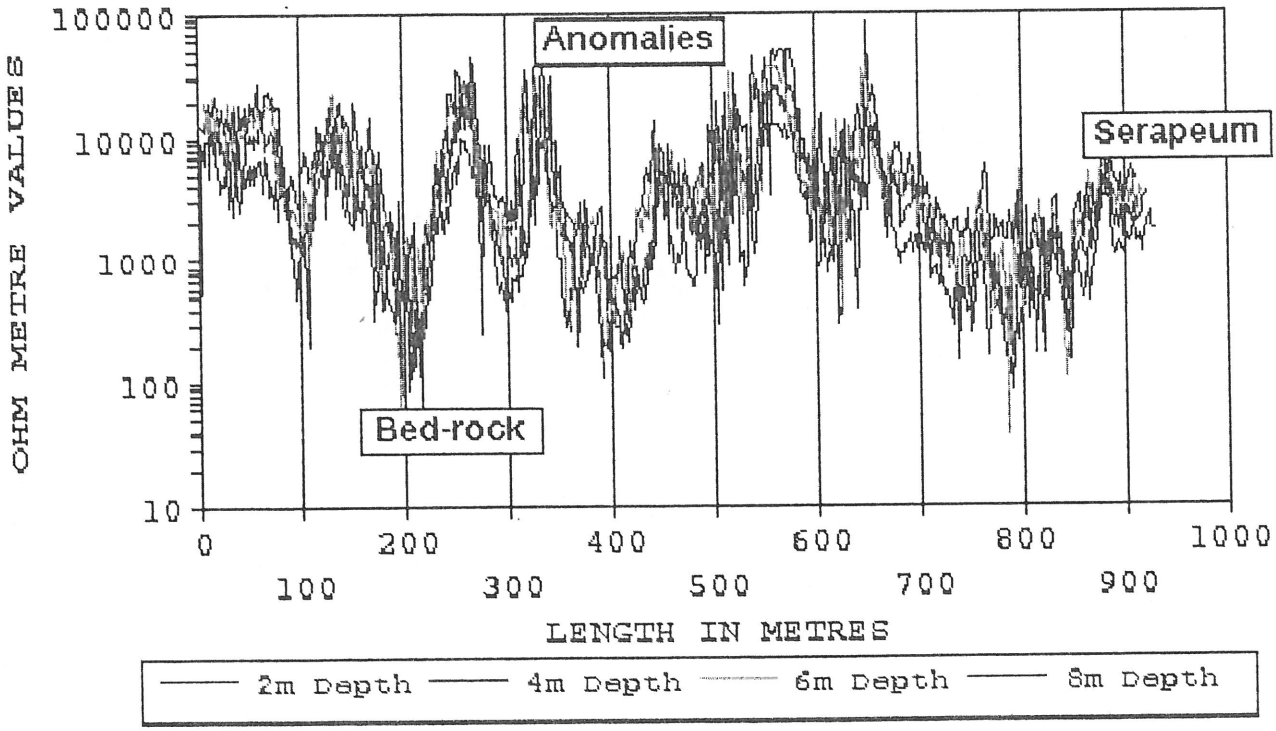
19.6

Sheet 4

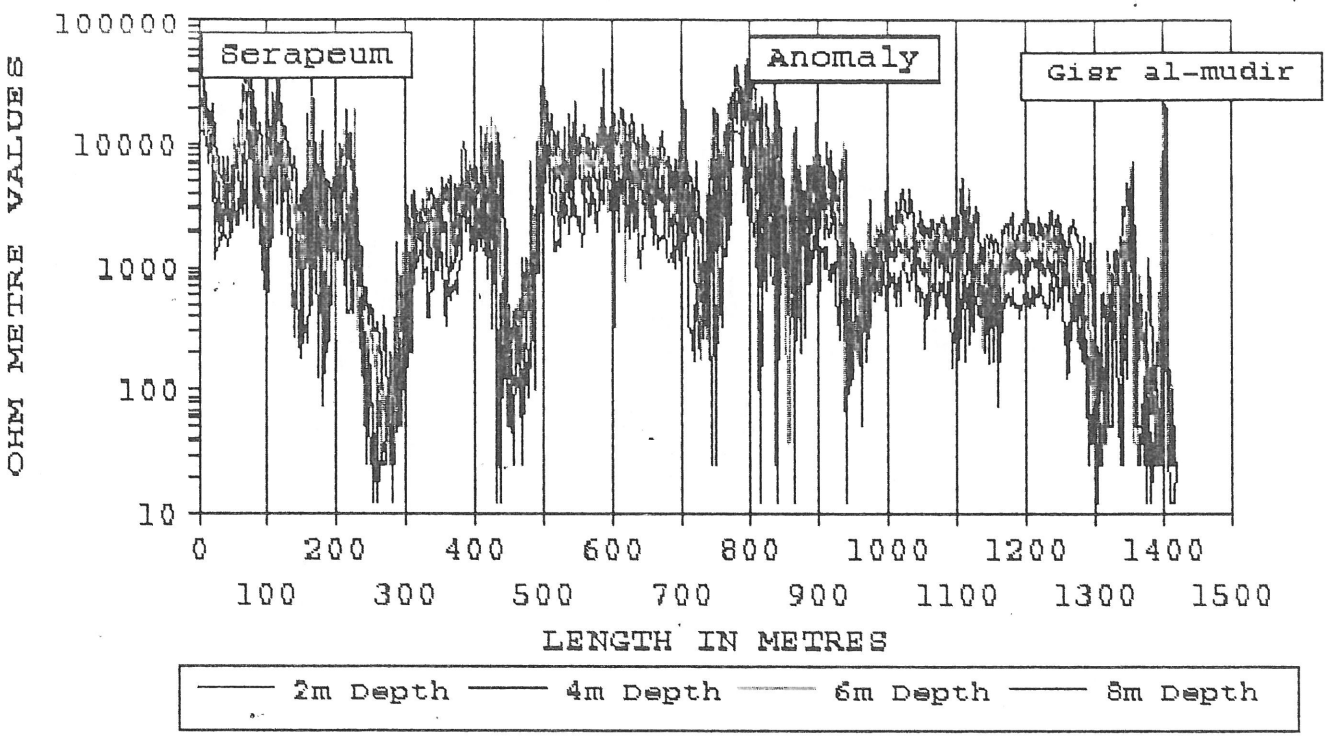
NATIONAL MUSEUMS OF SCOTLAND SAQQARA
Pseudo-section of Traverse 1 (Dec 1990)



NATIONAL MUSEUMS OF SCOTLAND SAQQARA
Pseudo-section of Traverse II(Dec 1990)



NATIONAL MUSEUMS OF SCOTLAND SAQQARA
Pseudo-section of Traverse III(Dec1990)



NATIONAL MUSEUMS OF SCOTLAND SAQQARA
Pseudo-section of T3/C1 (1990)

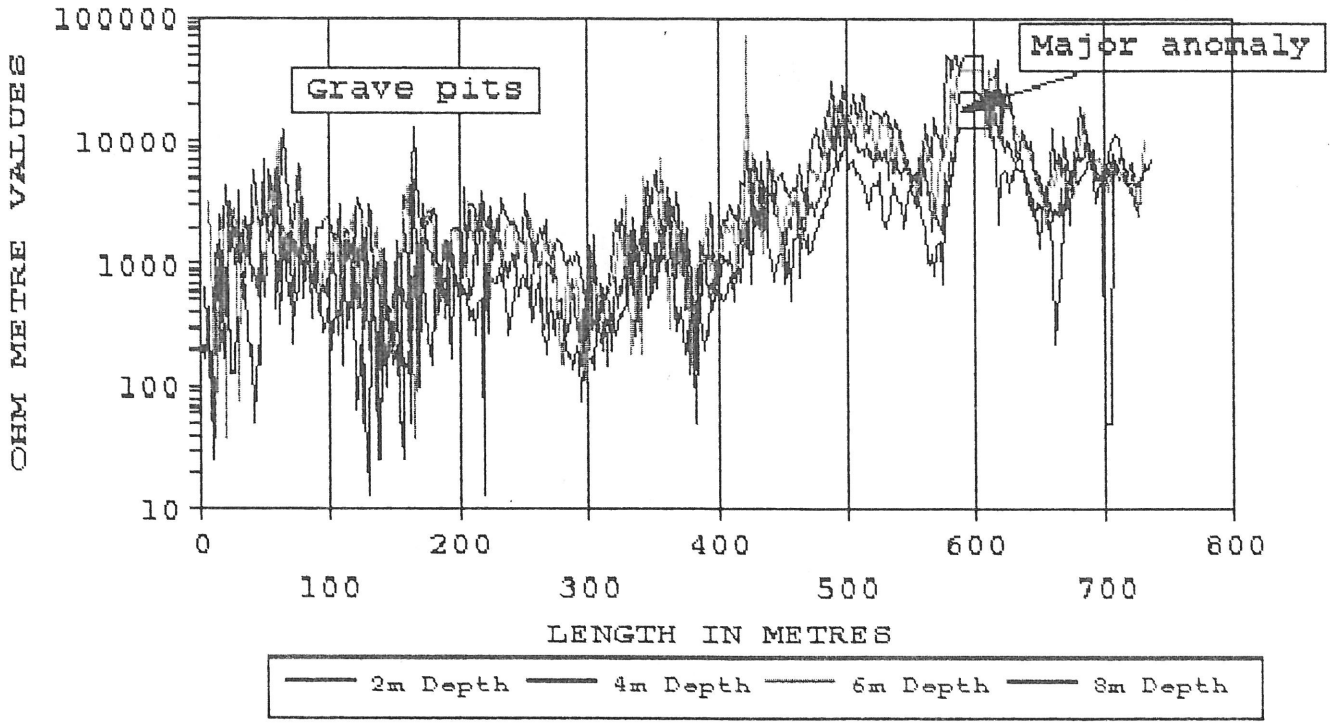
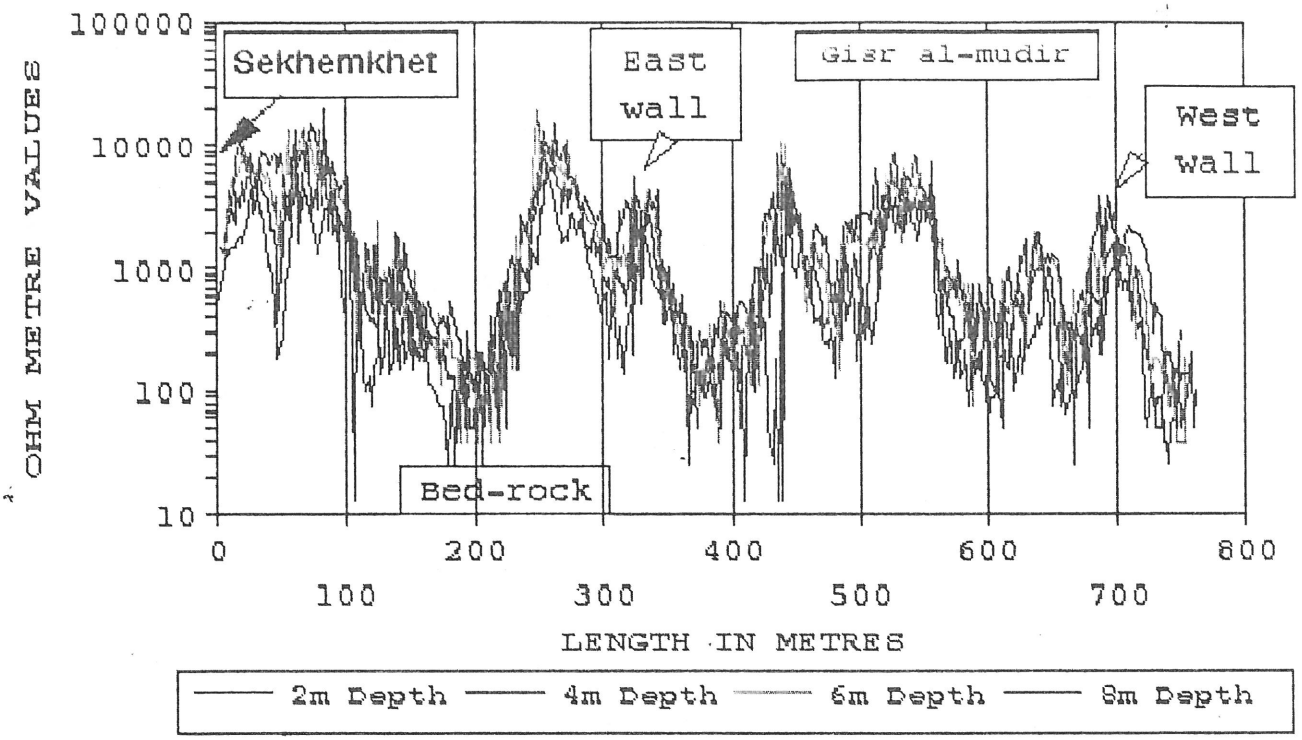
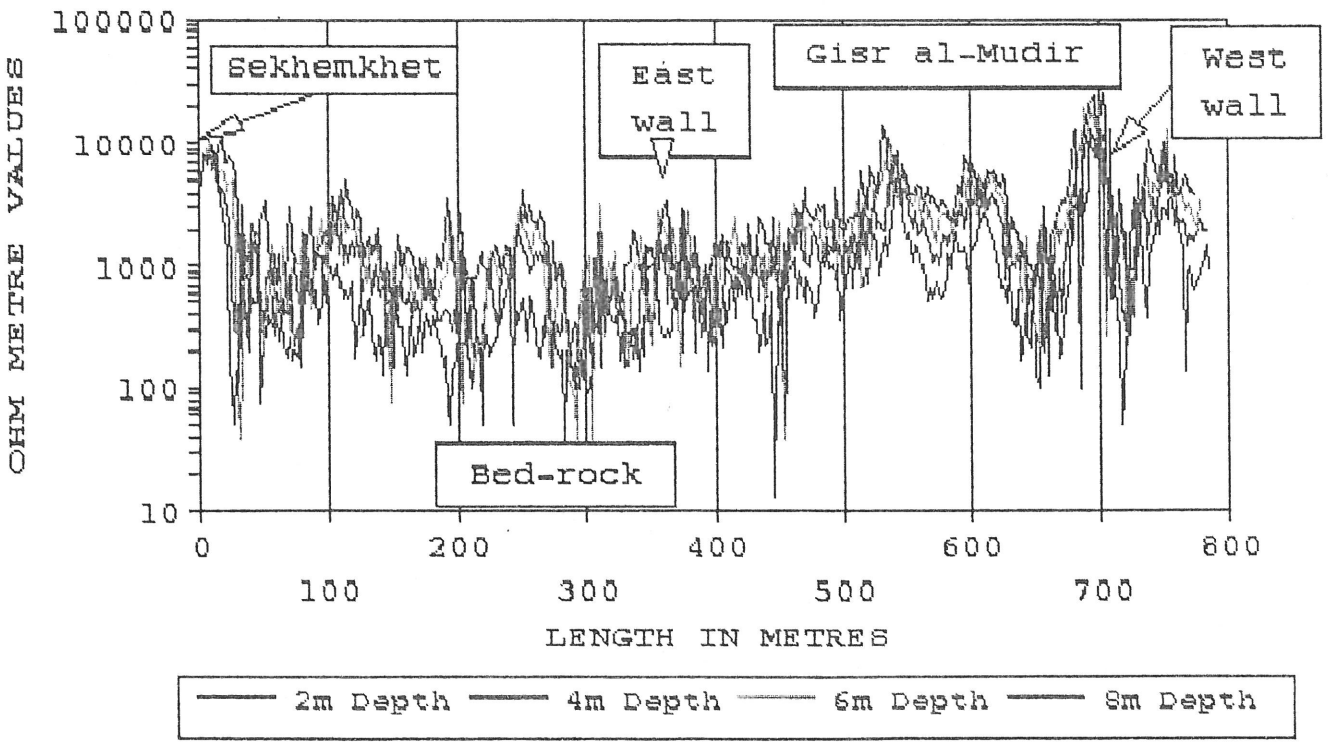


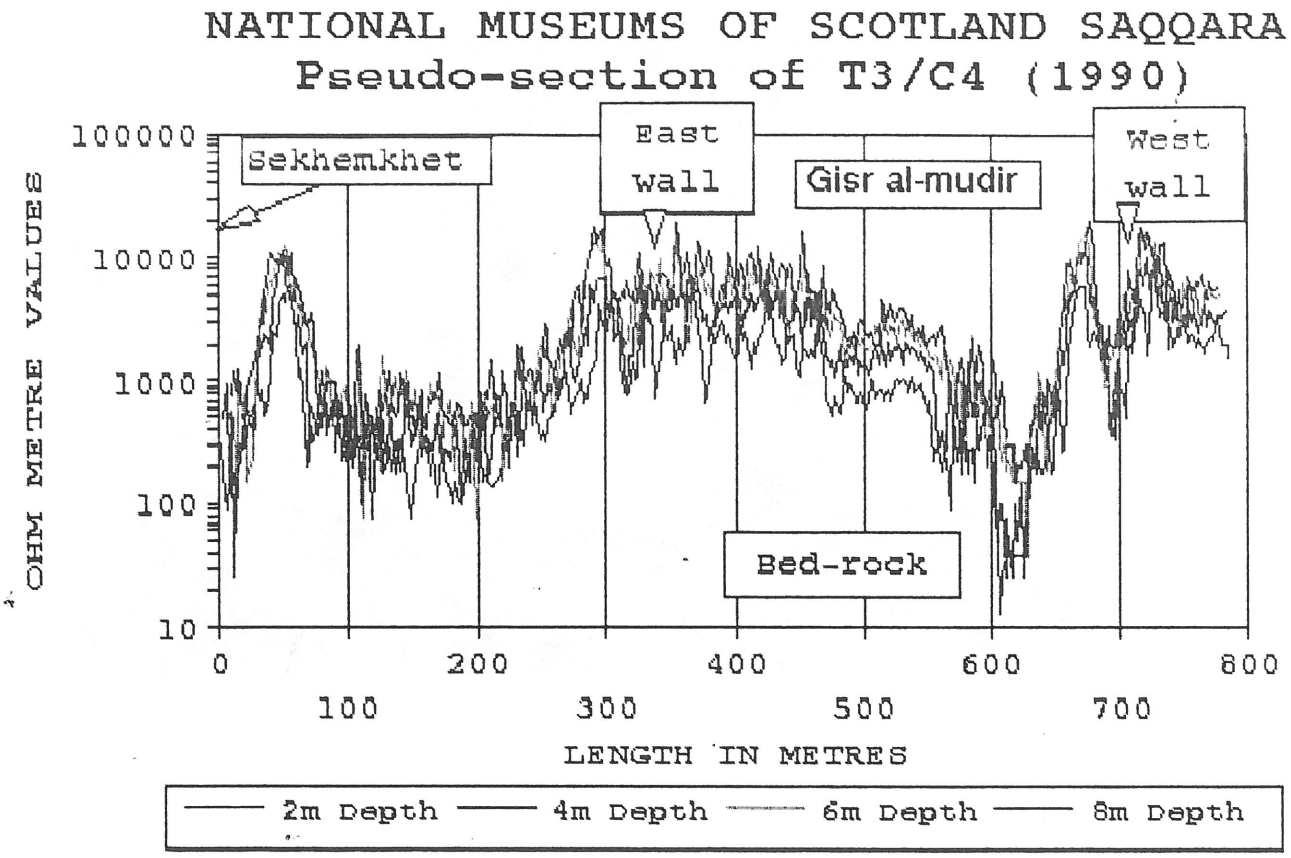
Plate 2

NATIONAL MUSEUMS OF SCOTLAND SAQQARA
Pseudo-section of T3/C2 (1990)



NATIONAL MUSEUMS OF SCOTLAND SAQQARA
Pseudo-section of T3/C3 (1990)




NATIONAL MUSEUMS OF SCOTLAND SAQQARA
Pseudo-section of T3/C4 (1990)
OHM METRE VALUES
100000
10000
1000
100
10
Sekhemkhet
East wall
Gisr al-mudir
West wall
Bed-rock
0
200
400
600
800
100
300
500
700
LENGTH IN METRES
2m Depth
4m Depth
6m Depth
8m Depth

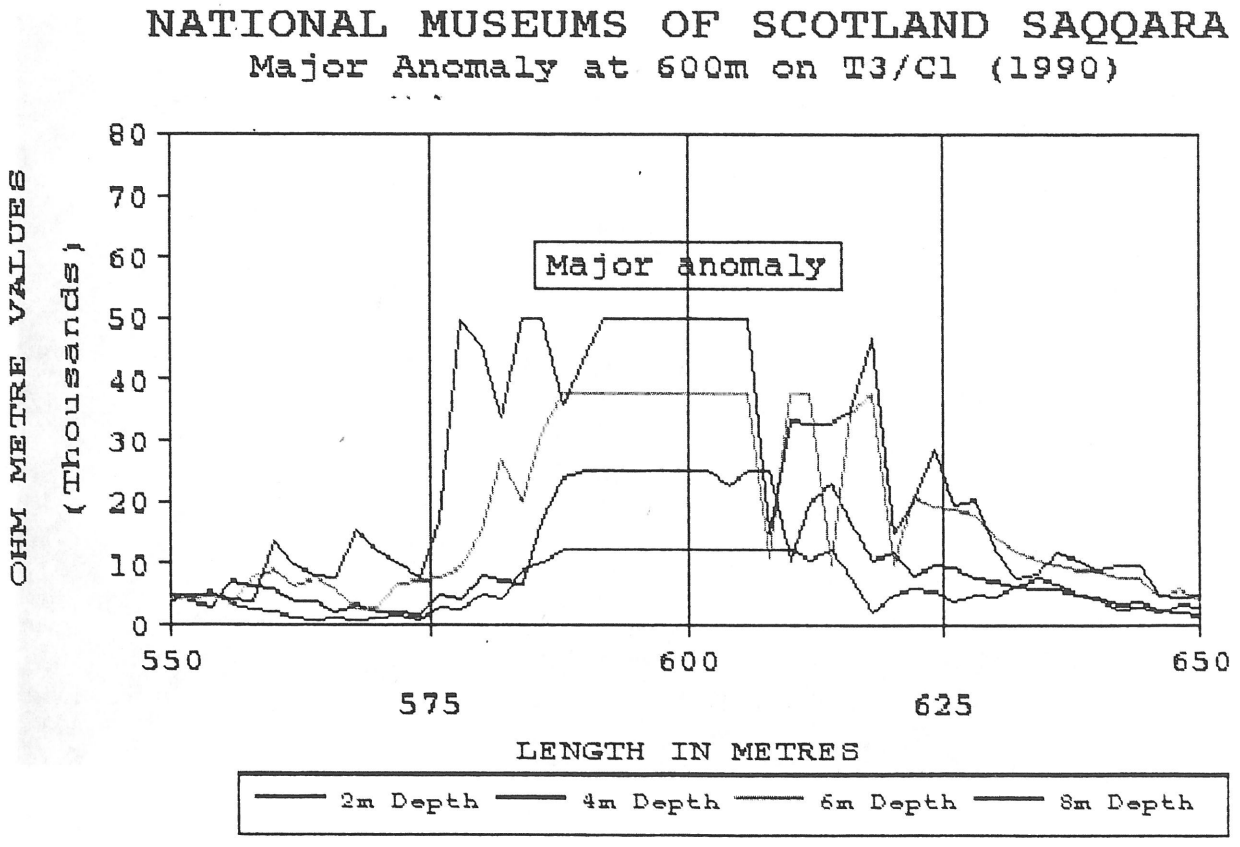
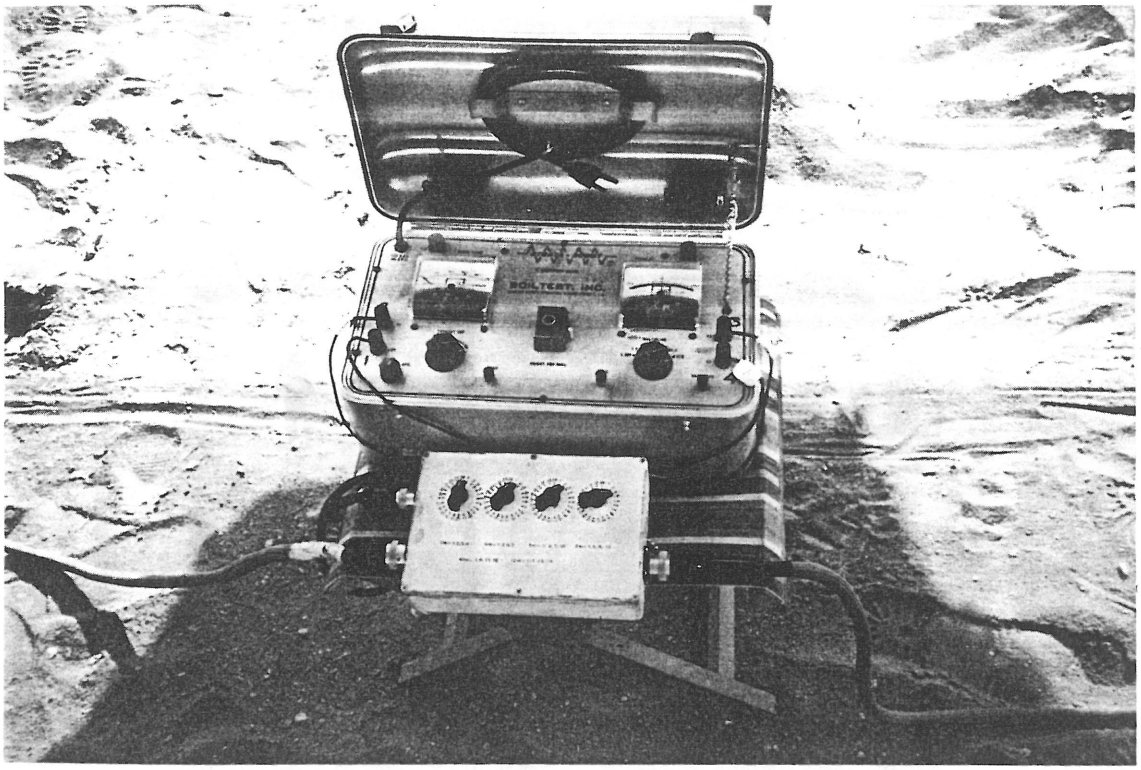
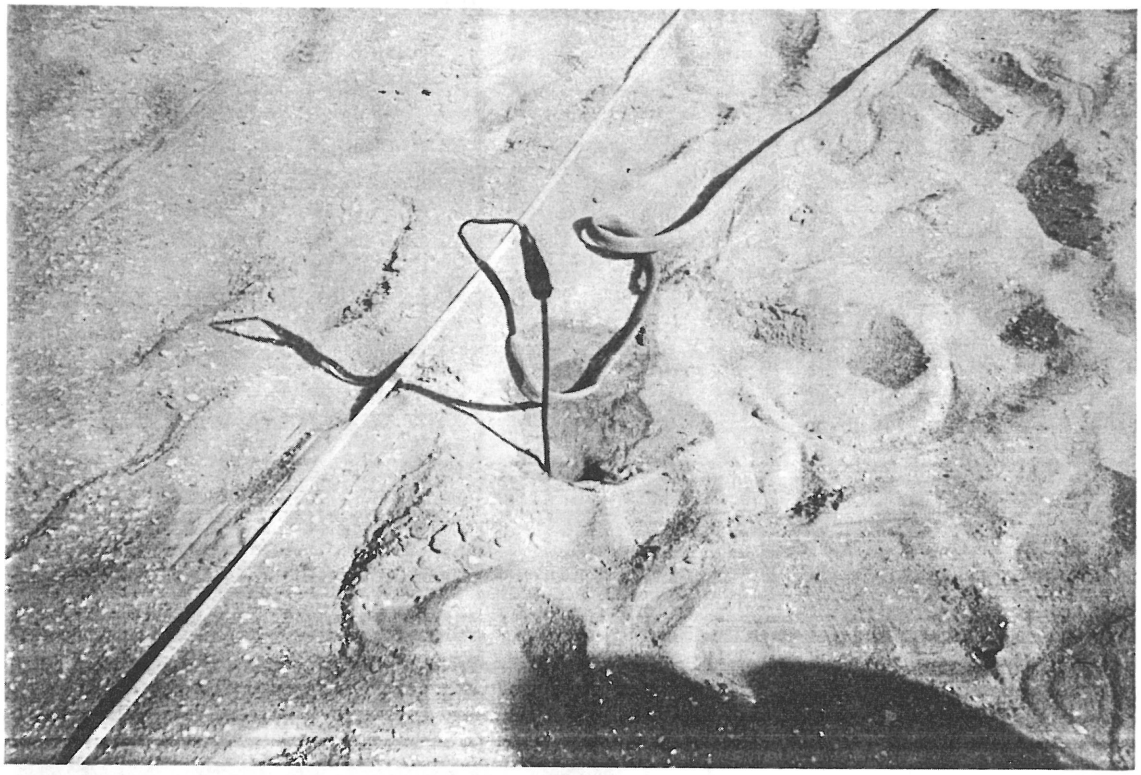

NATIONAL MUSEUMS OF SCOTLAND SAQQARA
Major Anomaly at 600m on T3/C1 (1990)
OHM METRE VALUES
(Thousands)
80
70
60
50
40
30
20
10
0
Major anomaly
550
600
650
575
625
LENGTH IN METRES
2m Depth
4m Depth
6m Depth
8m Depth

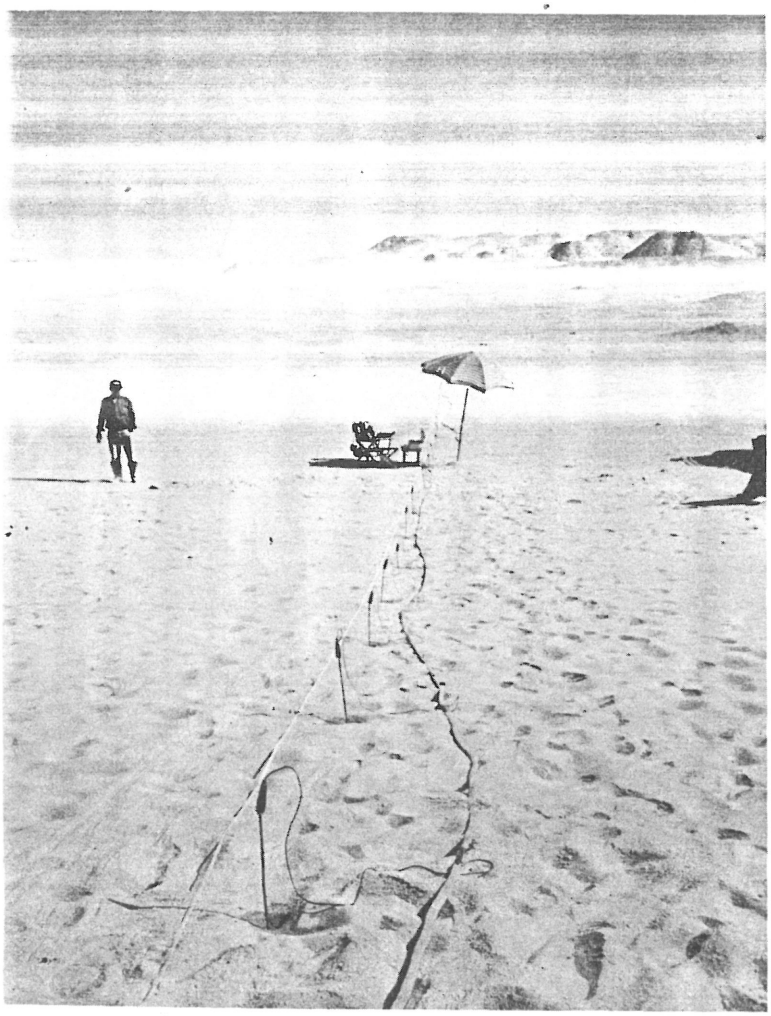
Plate 4



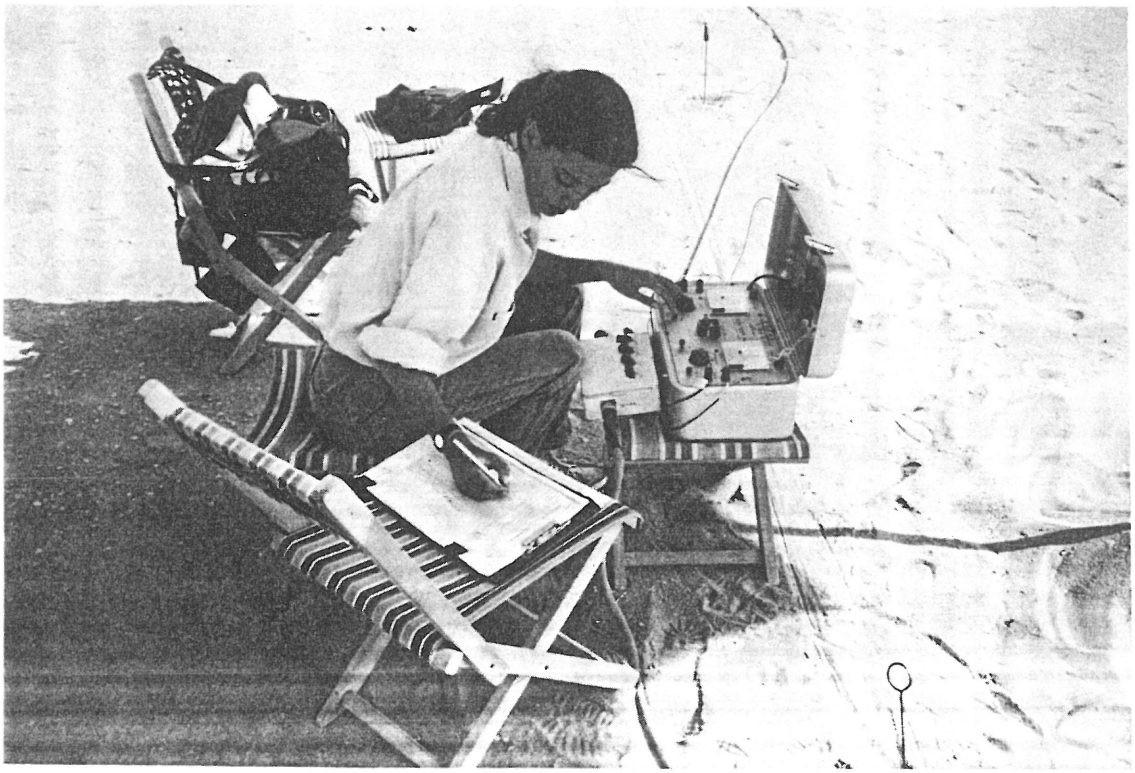
The Soiltest Stratascout Resistivity Meter



Copper Electrode in Position



24 Pin Electrode Layout



Analogue Recording of Data

Plate 6

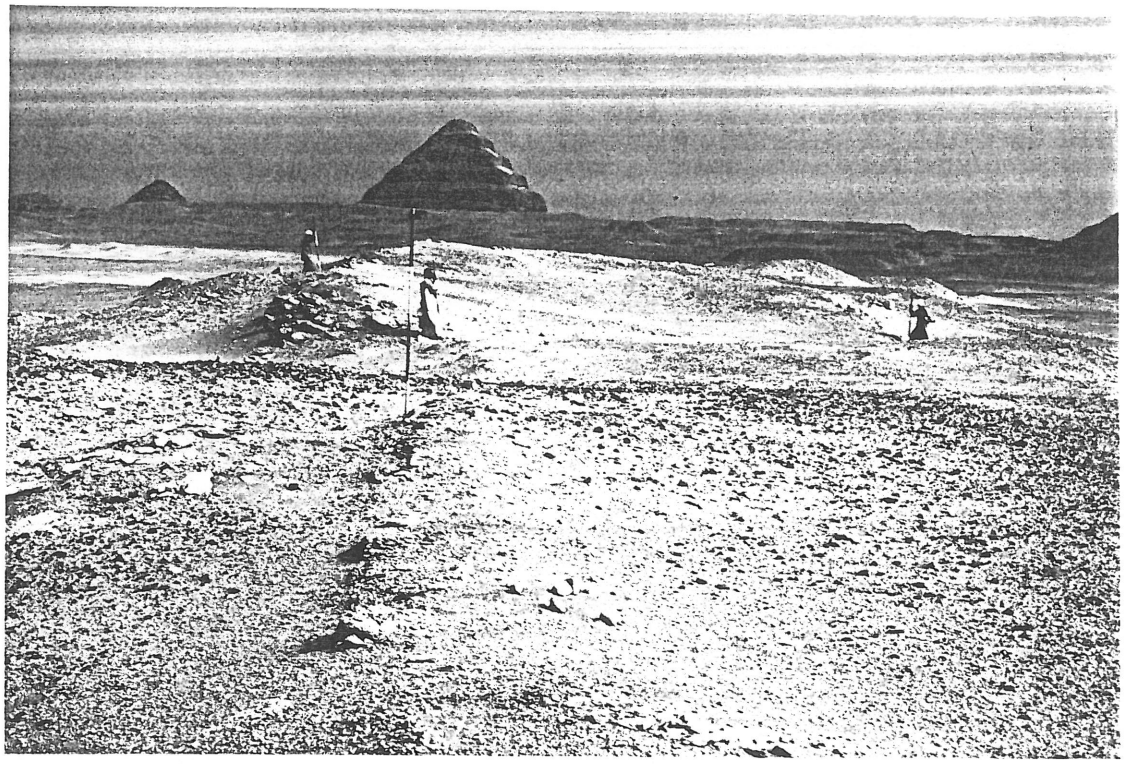
Gisr el-Mudir

West face of the West wall

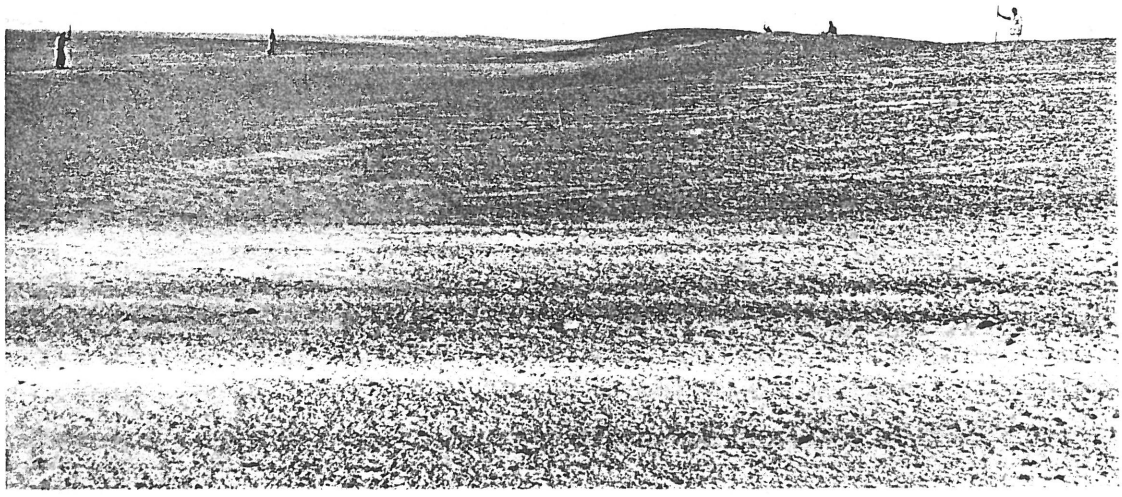
Gisr el-Mudir

Width of the walls at the North West Corner

Plate 7



Gisr el-Mudir
North wall showing stepped construction



Gisr el-Mudir

Major Anomaly site (A7) at 600m on cross-section C1

Plate 8