25-07

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PROJECT TITLE:
The pre-seafloor spreading development of continental margins: A geophysical study of the northern Red Sea.

SHIP NAME:
R.V. Robert D. Conrad

OPERATING INSTITUTION:
Lamont-Doherty Geological Observatory

CLEARANCE COUNTRY:
Egypt

DATES:
May 24, 1984-July 3, 1984

SENIOR SCIENTIST:
Dr. James R. Cochran

PORT CALLS:
Piraeus, Greece, May 19-May 24, 1984
Piraeus, Greece, July 3-July 7, 1984

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DESCRIPTION OF SCIENTIFIC PROGRAM:

Background

Research cruise 25-07 of R.V. ROBERT D. CONRAD took place from May 24, 1984 to July 3, 1984, departing from Piraeus, Greece and returning to the same port. The main area of operations was the Gulf of Suez between 28°N and 29°15'N and the northern end of the Red Sea, north of about 26°N (see accompanying track charts, Fig. 1 and 2). Permission was sought and granted to work in Egyptian territorial waters and an Egyptian Navy Officer, Mr. Ahmed M. Mahar and an Egyptian student, Mr. Mohamed Fawzy El-Difrawy, from the Geophysics Department of Cairo University, participated in the cruise. Permission was also sought to work in Saudi Arabian territorial waters. This permission was granted, but so late that the details could not be worked out. It was, therefore, decided to work entirely outside Saudi Arabia's claimed maritime jurisdiction as defined in U.S. State Department's Notice to Research Vessel Operators #61 (Revision 4).

The main objective of the cruise was a geophysical study of the very early phases in the rifting of continental lithosphere to form a new ocean basin. Major rifting of the continental lithosphere at the present location of the Red Sea began near the Oligocene-Miocene boundary (about 25 million years before present) and seafloor spreading and the generation of oceanic crust can be documented only in the southern Red Sea and only for about the past 4 million years. The Red Sea is a particularly attractive laboratory to study the processes of lithospheric rifting and the early development of a continental margin because the available data suggest that organized seafloor spreading has not yet begun in the northern Red Sea, north of a transition area at 22°-25°N. This gives an opportunity to study a continental margin which is still in the pre-seafloor spreading stage of its development.

Narrative

Although the cruise lasted from May 24 to July 3, a fair amount of time was spent in transiting the Mediterranean Sea and Suez Canal and in waiting in Port Suez for the Egyptian participants. Thus, CONRAD sailed from Port Suez on the afternoon of May 29 and returned in the early morning of June 29, so that about 30 days were actually spent in the field area. The field program can be conveniently divided into three projects, each occupying about one third of the ship time. These are: 2) a program of heat flow measurements, 2) a seismic refraction experiment using ocean bottom seismometers and 3) surveying using the ship's underway geophysical equipment.

The geophysical survey consisted primarily of northeast-southwest oriented lines with some cross lines for control. There are fifteen lines completely across the Red Sea from near the Egyptian coast to the Saudi 12 mile limit and five shorter lines part way across the sea. The survey extended from about 26°N to 27°30'N, but was concentrated in a roughly 50 km wide corridor off of Port Safaga near 27°N.

The data collected during the underway surveying included depths (both conventional 3.5 KHz P.D.R. and Seabeam swath mapping), gravity, and magnetics. Single channel seismic reflection profiling was done on 11 of the NE-SE lines. It had been planned to conduct a large number of refraction experiments using expendable sonobouys. However, it was found that the water guns, which are by far the best sound source for high resolution seismic profiling, do not produce enough low frequency energy to penetrate the very thick sediments. Thus, it was decided to concentrate on seismic reflection profiling at the expense of sonobouys. A number of sonobouys, using air gun arrays were run in the Gulf of Suez entering and leaving the Red Sea with some success in determing sediment thickness.

The goal of the underway surveying was to determine the nature of the active tectonics through which motion between Arabia and Africa is accommodated, and to map the structures resulting from that motion. Although detailed analysis awaits preparation of final navigation, it seams that this part of the cruise was quite successful. It appears that we can define a central area of the Red Sea where extension is accomplished by intrusion and marginal areas where it is accommodated by faulting. We can also delineate a shift in the active rifting axis near 27°N from near the center of the Red Sea to closer to the Egyptian coast. We are hopeful that careful analysis of the data will reveal details of the rifting process and that the underway geophysical measurements when combined with the heat flow and refraction results will yield information on the deeper lithospheric structure and processes.

An unexpected result of the survey was the discovery of two new "deeps", Conrad deep near 27°03'N, 35°43'E and Barbecue deep near 27°16'N, 34°26'E. Their locations are noted by large dots on figure 1. A number of deeps are known further south in the Red Sea where they form an extremely discontinuous northward extension of the southern Red Sea spreading axis. These deeps represent the very first stage in the development of a mid-ocean ridge in the central and northern Red Sea and generally become smaller and shallower to the north. The significance of the two deeps discovered on the CONRAD cruise is that they are at the very northern end of the Red Sea about 100 km north of any previously reported.

The heat flow program was undertaken with the goal of understanding the lithospheric thermal structure during rifting prior to seafloor spreading. This information places strong constraints on models of the rifting process which have been developed by us as well as by other groups.

The heat flow field program consisted of three transects completely across the Red Sea and one across the Gulf of Suez. Measurements were taken at roughly one mile intervals along each transect. The total number of measurements was 209; 73 on the southern traverse, 58 on the central traverse, 64 on the northern traverse and 14 on the Gulf of Suez traverse. The Gulf of Suez measurements must be examined carefully because the shallow water depths will result in the mantle heat flow signal being affected by seasonal water temperature variations. The three traverses in the main Red Sea appear to be mainly high quality measurements. These traverses represent the first heat flow measurements in the northern Red Sea by an academic institution and are the first systematic study of the variation in heat flow across the Red Sea. These data will be used to investigate the temperature regime in the mantle beneath the Red Sea rift.

Heat flow measurements were taken in each of the two deeps discovered on the cruise. Clear evidence of hydrothermal circulation was found in Conrad deep in the form of variations by a factor of ten in the heat flow over very short distances. Less conclusive evidence of hydrothermal circulation was found at Barbecue deep. This means that metalogenesis and the deposition of metal rich sediments may be presently occurring in the deep.

The seismic refraction program was done in cooperation with the Institut für Geophysik, Universität Hamburg, Federal Republic of Germany and was carried out by scientists from that institution who participated in the cruise. The plan was to use a series of ocean bottom seismometers as receivers and to run each line twice, once with an array of airguns firing at one minute intervals, and once with 20Kg charges fired on a five minute schedule to give strong arrivals at large distances. Unfortunately the blasting caps for the explosives proved to be defective. Therefore, the lines

could only be run with the airgun array. Thus, although we are optimistic, it is uncertain at this time whether the seismic experiment succeeded in its goal of determining the crustal structure and thickness and the structure of the upper mantle.

Four seismic lines were conducted. The first started just south of Ras Muhammed and extended south for about 100 km down the center of the Red Sea. It was designed to tie into previous work in Sinai and to determine both the crustal structure beneath the central portion of the northern Red Sea and how that structure changes as the Sinai Peninsula is approached. A second line extended out from the Egyptian coast near Port Safaga. It was designed to start over what is known from oil company drilling to be continental crust and to determine how the crustal structure varies from the margin to the center of the Red Sea. Two additional profiles were obtained from the eastern side of the Red Sea, just outside of Saudi territorial waters. These are designed to compliment the central Red Sea profile and previous work by the Institut für Geophysik along the Egyptian coast to give a picture of the crustal structure completely across the Red Sea.

Schedule for transmittal of Data

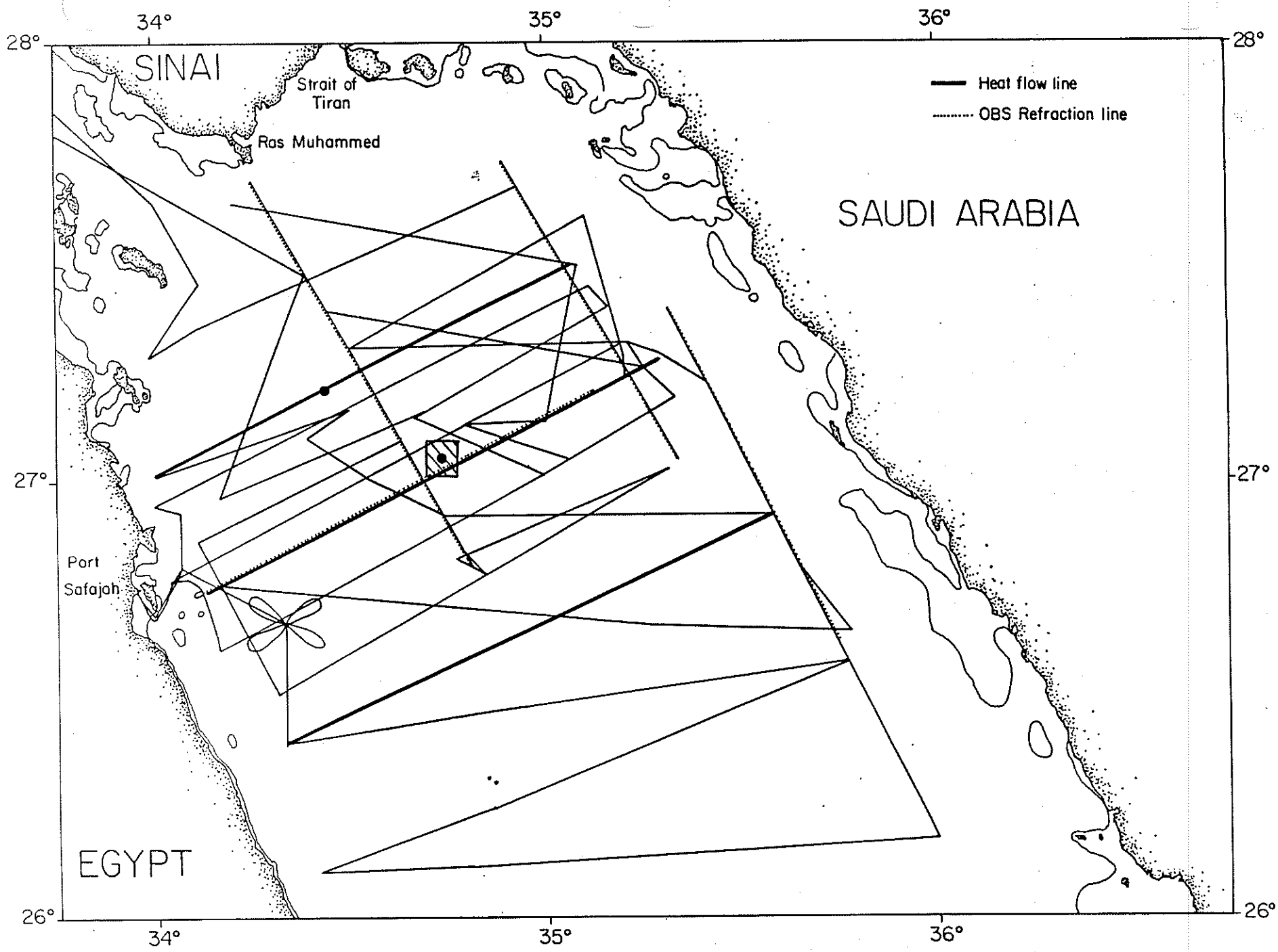
An obligation stated as a condition for conduct of research in Egyptian territorial waters is the provision of data results to the Government of Egypt. The raw data tapes were returned from the ship to Lamont-Doherty Geological Observatory during the first week in August with the exception of the seismic refraction data which is being processed by the Institut für Geophysik and was thus returned from the ship to Hamburg.

The factor controlling when the data will be ready to provide is the processing of the navigation data. The peculiar combination of Loran,

satellites and "dead reckoning" used on the cruise has required the writing of special computer programs to produce final smooth navigation. That process is well underway, and we estimate that we can provide the final navigation data by October 15, 1984. This is a somewhat conservative estimate and the data may actually be provided earlier. The October 15 date is designed to be certain that we have time to prepare the best possible navigation. Assuming that the navigation is ready by October 15, the following schedule is proposed.

Type of Data	Date Provided	Form Provided
Navigation	October 15, 1984	magnetic tape
bathymetry magnetic anomalies	November 15, 1984	magnetic tape
seismic reflection records	November 15, 1984	paper copy
gravity anomalies	December 31, 1984	magnetic tape
seabeam bathymetry	December 31, 1984	maps at 1/50,000 or other convenient scale
heat flow measurements	December 31, 1984	paper listing

The seismic refraction data have not been included on the above list because it was gathered by the Institut für Geophysik and is not in our possession. In addition, Professor Makris, the head of the institute, and Dr. Dehgheni, their party chief on the cruise, are both presently at sea and cannot be reached. The Institut für Geophysik is, however, aware of the obligations as a condition for research and will make arrangements through the U.S. Embassy for transmittal of the seismic refraction data to the Government of Egypt.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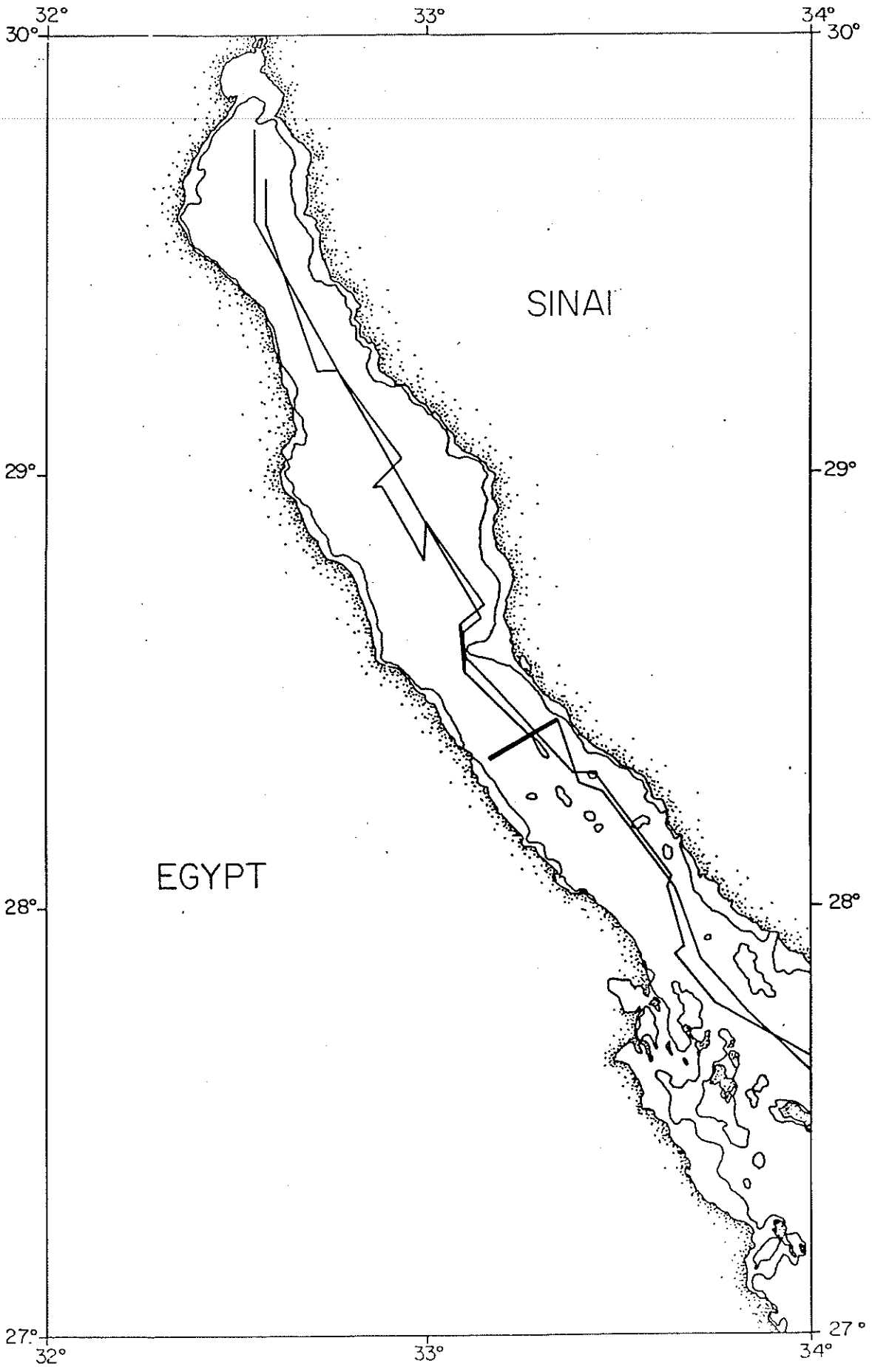
Ras Muhammed
SAUDI ARABIA
Heat flow line
OBS Refraction line
Port Safajah
EGYPT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