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Natural Resources / Water Series No. 9

GROUND WATER IN THE EASTERN MEDITERRANEAN AND WESTERN ASIA

EGYPT.

UNITED NATIONS
New York, 1982

Area: 1,001,000 km^2

Population: 37,200,000 (United Nations estimate, 1975)

General

Egypt, occupying a part of the arid belt of north Africa and western Asia, is subdivided into the following physiographical provinces (see map 8):

(a) The Mediterranean coastal areas (20,000 km^2), characterized by low topographic relief (rarely exceeding 100 m). Mean annual precipitation is 125 mm; so there is adequate potential water for agriculture, watershed management and range development.

(b) The Red Sea-Gulf of Suez coastal areas (10,000 km^2) which have a complex relief pattern and arid climatic conditions (winter rain and rare summer showers; the average rainfall is less than 25 mm). The ground elevation is about 200 m above mean sea level. The province is crossed by the downstream parts of many dry river beds and wide tracts are occupied by mudflats, which are subject to salinization. The agricultural potential of this province is therefore limited.

(c) The Nile Valley between the delta and the High Dam Lake (20,000 km^2), which is dominated by the main cultivated area of Egypt (flood plain) by flat areas suitable for land reclamation (terraces) and the great artificial water reservoir. The ground elevation rarely exceeds 200 m above mean sea level.

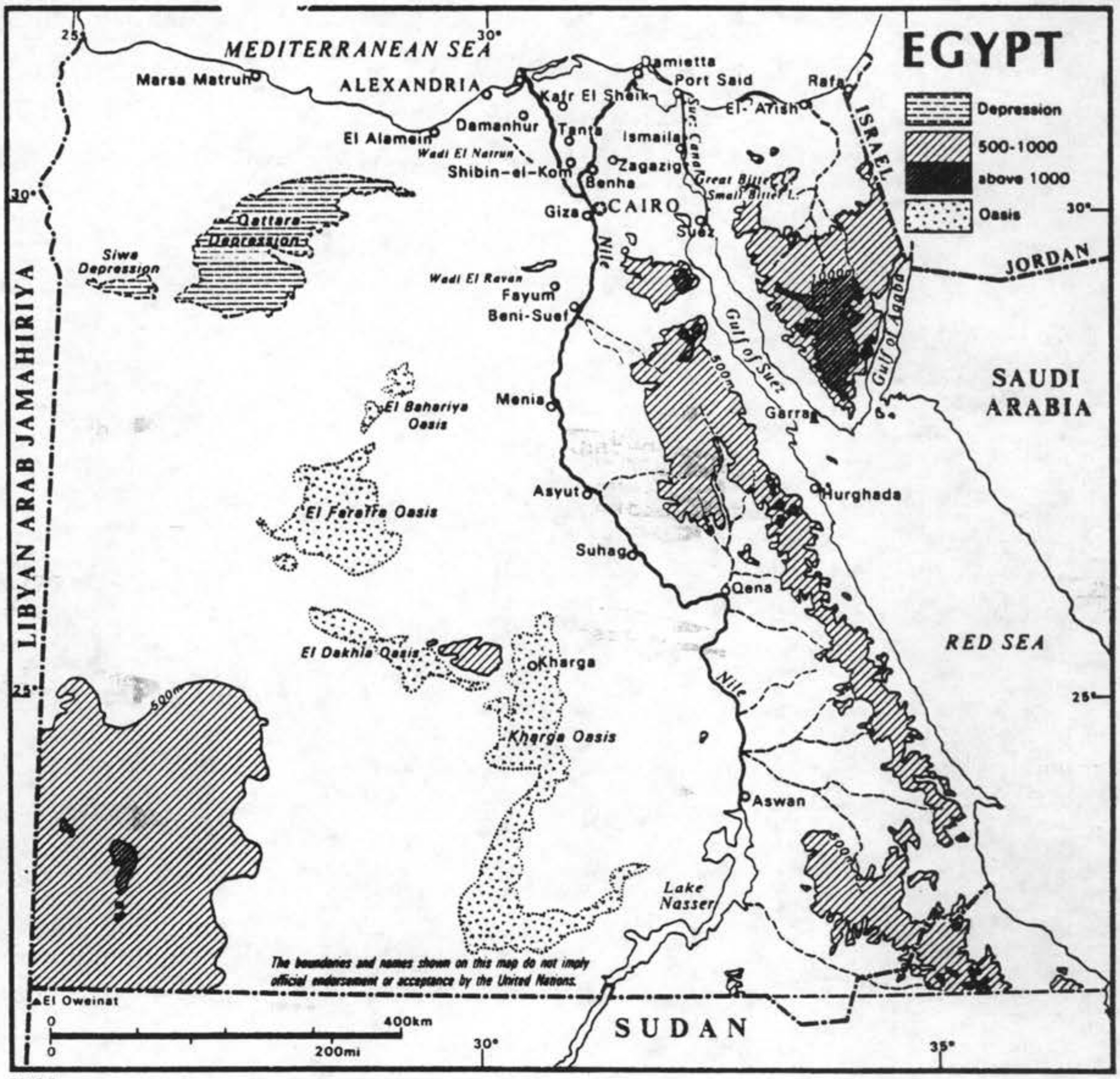
(d) The south Sinai-Red Sea granitic ridges (75,000 km^2), which form the backbone of the high mountain ranges of Egypt and rise to 2,600 m above mean sea level. This part of Egypt has very rugged topography and is dissected by many dry drainage valleys, which end at the Red Sea and Gulf of Suez or in the Nile Valley.

(e) The tableland areas (350,000 km^2), which are covered by carbonate rocks and recognized in central and northern Sinai, in the area between the Nile and the Gulf of Suez and in almost all the area west of the Nile from about the latitude of Aswan. In the Sinai and in the area to the east of the Nile, the surface elevation of the tableland rises to about 1,000 m above sea level, whereas in the area west of the Nile, the elevation averages 350 m above mean sea level. The surface of the tableland area is dissected by a dry hydrographical network, which ends either in the inland depressions or in the Nile Valley or in the sea. In the area west of the Nile Valley, the surface of the tableland shows the following different physical features:

Map 8

Egypt

MAP 8



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(i) Natural depressions, some of which are below sea level. Such depressions include, from north to south:

Wadi El Natrun	(- 20 m);
Qattara depression	(-134 m);
Siwa oasis	(- 18 m);
El Faiyum	(- 60 m);
El Bahariya oasis	(+100 m);
El Farafra oasis	(+100 m);
El Dakhla oasis	(+100 m);
El Kharga oasis	(+ 50 m);

(ii) Sand dune ridges and sand sheets, either in groups or in isolation;

(iii) Gravel plains south and east of the Quattara depression.

(f) The elevated sandy plains, which are located between the granitic slopes and the southern vertical edges of the carbonate tablelands (350,000 km^2). These extend southwards into the Sudan and westwards into the Libyan Arab Jamahiriya. The ground elevation is about 500 m above mean sea level, but locally it may rise to 1,000 m (El Gilf El Kebir). The surface of such elevated plains is dotted in places with volcanic cones, granitic ridges and ring dykes (El Oweinat, 1,600 m). The surface is also dotted with circular depressions filled with lacustrine deposits and is covered by sand sheets and Barkhan dunes.

In Egypt, cultivation is essentially restricted to the Nile Valley, the Mediterranean littoral, and to the oases in the depressions of the tableland area west of the Nile (3 per cent of the total area of the country). Attempts to reclaim the desertified areas of Egypt are under way and it is expected that by the end of the century the area cultivated will have increased to 5 per cent of the total area of the country (about 5 million hectares).

Geology

Egypt occupies a part of the "foreland structure" on the northern edge of the Arabian-Nubian shield. In south and south-eastern Egypt, Pre-Cambrian and Infra-Cambrian basement rocks are exposed or occur at shallow depths (south Sinai, Red Sea hills, Aswan and El Oweinat). They include igneous and metamorphic rocks and offer good prospects for mineral exploration.

Overlying the basement rocks is a predominantly sandstone sequence representing epicontinental environments of deposition. The thickness increases gradually from the south (500 m) to the north (in some bore-holes it is as much as 2,500 m) and locally marine facies can be observed. This section belongs to the Paleozoic and to the lower portion of the Mesozoic. The major ground-water aquifers of Egypt are associated with this complex, mostly known as the Nubian Sandstone.

Following the Paleozoic-Mesozoic sandstone section in a northward direction is a carbonate section (with interbeds of clay), which has an exposed thickness of about 2,500 m. This section, which belongs to the Upper Mesozoic (Jurassic and Cretaceous) and to the Lower Tertiary (Paleocene), displays classical examples of karst hydrology and occupies much of the tableland areas. The geographical distribution of this carbonate section in the subsurface and the variation in its lithology is controlled by the geological structure.

The landscape of Egypt attained much of its present shape in post-Paleocene times. Reference to the following geological events may be made:

(a) General rising of the land surface, retreat of the sea, development of terrestrial conditions with volcanic and hydrothermal activities in Oligocene and Lower Miocene times;

(b) Formation of the Red sea graben;

(c) Local ingressions of the sea from the north during Oligocene, Miocene and Pliocene (successive oscillations of the Mediterranean level);

(d) Development of the Nile basin, initially as a marine gulf during Pliocene time and then as a fresh water way flowing from south to north during Pleistocene time;

(e) Gradual changes in climatic conditions, ending with the development of aridity, which at present is indicated by sand-dune accumulation, degradation of most of the surface area with regard to soil and vegetation, domination of salinization processes, and lack of precipitation.

Ground water

The main aquifers are as follows (in decreasing order of productivity):

(a) The basal clastics (commonly referred to as the Nubian Sandstone portion of the basement rocks and the base of the carbonate rocks. This sandstone aquifer has a thickness varying between 100 m or less and 2,500 m, and water occurs generally under artesian conditions. Within the limits of Egypt, the piezometric level of this aquifer declines from 500 m in the south-western part of the vast area west of the Nile. This part of Egypt has developed into a common ground-water reservoir (or basis), which is hydraulically connected with other basins in north Sudan and in the south-eastern part of the Libyan Arab Jamahiriya, all of which form parts of what are known as the northeast-east African artesian basins. The chemistry of the water obtained from such basins shows a great similarity and the salinity of the water is generally less than 500 ppm (meteoric water). Dating of the water by means of the carbon 14 method, as well as by means of other radio isotopes, shows that, for the most part, the water accumulated <u>in situ</u>, during one or several pluvial periods. Its age ranges from 20,000 to 40,000 years (fossil water). It is accepted among hydrogeologists that the water is possibly recharged (at present) by small amounts from other sources located outside Egypt, including precipitation in equatorial Africa and the Nile in northern Sudan. The water is discharged, either naturally or artificially, into several locations in the vast region west of the Nile, which include the following:

(i) The Qattara-Siwa depressions in north Egypt (natural outlets), where the amount of water discharged exceeds 3 million m^3/day. The fresh-saline water interphase is located to the north of this depression area.

(ii) The El Kharga and El Dakhla oases, which are located in the south-eastern portion of the area (natural and artificial discharging area). In these two oases, some 400 relatively shallow bore-holes (not exceeding 100 m in depth) and deep wells (500-1,000 m) have been drilled. The amount of water extracted from El Kharga and El Dakhla exceeds, at present, 1 million m^3/day and it is expected that this amount will increase to 3 million m^3/day during the five-year period, 1979-1983. The water will be used for land reclamation, and it is expected that misuse of the water will not be permitted. The five-year plan includes improvements in well design and spacing as well as improvements in irrigation techniques. The total area to be reclaimed for cultivation during this period will be about 40,000 hectares;

(iii) The El Farafra and El Bahariya oases, located in the central part of the vast area west of the Nile Valley where natural and artificial discharge occurs. The amount of water discharged in this vast area is about 400,000 m^3/day; the number of deep wells is rather limited, but some are as much as 2,500 m deep. In the five-year plan, 1979-1983, the amount discharged will be increased to 1 million m^3/day and the area to be reclaimed will be increased to 15,000 hectares.

Very little is known about the amount of water seeping by vertical leakage into the fissured carbonate mantle from the underlying artesian sandstone aquifer. One can refer only to Siwa oasis, where there are about 200 natural springs in the Miocene carbonate rocks, with a daily output of about 200,000 m^3.

With regard to the area east of the Nile (excluding the Sinai Peninsula) the basal clastics also act as an aquifer, but the capacity is rather limited because of unfavourable topographical conditions on the western side of the high granitic ridges and because the sandstone section is rather thin compared with the area west of the Nile (many details are lacking). Some hot natural springs (Ain Sokhna) are reported to occur along the edge of the Gulf of Suez and are associated with block faulting. The water from these springs indicates a high amount of mineralization and is discharged as hot brines.

With regard to the Sinai Peninsula, during oil-drilling operations, high pressure water was encountered in the sandstone aquifer, which has a thickness of about 500 m. In some wells in central Sinai (for example, Nakhl well No. 1 of Esso), the water rises to about 200 m above mean sea level and the salinity is about 1,500 ppm. In western Sinai, the water in the sandstone aquifer flows to the surface at Ayoun Mosa to the south of Suez. Fewer than 20 wells tap the sandstone aquifer in Sinai. It is expected, however, that the aquifer can make an important contribution to the water supply of the Sinai. Water samples collected from the aquifer were analysed using the carbon 14 method, which revealed similarities with waters occurring in areas west of the Nile. On the other hand, it is generally considered that the sandstone aquifer of the Sinai is recharged from the vast watershed area located to the east of the Mediterranean (in Lebanon, the Syrian Arab Republic and Israel). Detailed studies, however, would be necessary to determine the pattern of ground-water flow.

(b) The sand and gravel section deposited in the Nile and delta depression (Pleistocene Nilotic deposits). This aquifer has a thickness of about 350 m and is underlain by Pliocene clays which may be considered as an aquiclude. This section is amlost saturated with water (salinity is in the range of 500 ppm) and depends for its recharge on the surface water of the Nile as well as on the complex of irrigation canals. It has been determined that in this part of Egypt, the water table is continuous and declines gradually from south to north. After the construction of the High Dam, the water table in the Nilotic deposits began rising, presumably as a result of the pronounced difference in head of the water in the High Dam Lake (+178 m) and the surface water in the river to the north (maximum level about +90 m). Because the deposits in the Nile Valley are not homogeneous from the lithological standpoint, disconnected clay lenses have been observed and account for the local development of subartesian conditions. The amount of water stored in this aquifer as a renewable resource is probably about 600 million m^3, and the discharging area comprises the following:

(i) Wadi El Natrun (-20 m) and possibly also the Qattara depression (-134 m) on the western side;

(ii) Wadi El Tumeilat, the Bitter Lakes and the Suez Canal on the eastern side;

(iii) The peripheral lakes along the Mediterranean coast on the northern side;

(iv) The large number of wells drilled in this long and narrow area. The water is used both for supplementary irrigation and for municipal purposes. The staff of the Groundwater Institute is making an inventory of the wells and carrying out a study of their yields.

At the northern edge of the delta, severe intrusions of saline water from the sea have been observed, which can be related to the overpumping of ground water. Again, mounds of saline water are locally developed in the new reclaimed areas (the west El Nubaria project) and are obviously related to the overuse of water for irrigation and to the lack of efficiency of the drainage systems.

(c) Fissured limestone aquifers have a broad geographical distribution in Egypt and are good examples of karstic features. Reference may be made to some important water sources tapping this limestone, which have not yet been studied:

(i) In the area west of the Nile, almost all the natural springs in El Farafra, El Kharga, Sitra, Arag, El Bahrein, Garra, Siwa, wadi El Rayan, etc. and almost all the wells in the calcareous plateau to the north of the Qattara depression;

(ii) In the area east of the Nile (including Sinai), a large number of natural springs along the Red Sea hills, at Helwan and adjacent localities to the east of Cairo (highly mineralized water); in the faulted area of west Sinai (Hammam Faraun sulphurous springs; hot brines); and at the edge of the carbonate tableland of east Sinai.

(d) The Mediterranean calcarenites which have developed in the coastal plain in the form of stranded ridges. Such deposits, of both shallow marine and terrestrial origin, form an important water-table aquifer all along 1,000 km of coastline at an elevation close to sea level. This body of water, the salinity of which is about 1,000 ppm floats on a saline water wedge resulting from the intrusion of sea water. Locally, however, subartesian and perched conditions occur and are attributed both to change in facies and to the geological structure. This aquifer is replenished through direct infiltration of local precipitation (winter rainfall averages 125 mm). The water is extracted from this aquifer by different types of wells:

(i) Drilled wells, to a depth of about 30 m, and use of centrifugal pumps (north-east Sinai). More than 100 wells of this type have been installed;

(ii) Wide-mouth open wells. These are hand-dug wells, lined, and equipped with ordinary suction pumps. Many wells of this type are also to be found in north-east Sinai;

(iii) Shallow hand-dug wells equipped with windmills. Depths range from 5 to 20 m. Such wells are to be found in large numbers in the coastal area west of the Nile delta;

(iv) Extra-wide open wells (diameter about 5 m), and having radial trenches excavated to the water table (galleries). A small number of such wells are located to the west of Alexandria;

(v) Horizontal wells (galleries), excavated to less than 1 m below the water table. Such horizontal wells are located at Mersa Matruh and between El Arish and Rafa in Sinai.

(e) The wadi fillings act as aquifers of limited importance in Sinai and along the Red Sea coast. Hundreds of shallow hand-dug wells are known to exist. The water of the wadi fillings depends on local precipitation and on surface run-off.

Ground-water investigations

Detailed studies of the different aquifers are now under way, both by means of traditional methods and by the application of modern techniques. These include the use of different types of models (analogue and mathematical), radio isotopes and remote sensing techniques. The ultimate goal will be the evaluation of the potential of such aquifers since the possibilities for exploitation have received much attention. The Desert Institute is involved in all activities of exploration and exploitation of ground water in Egypt.