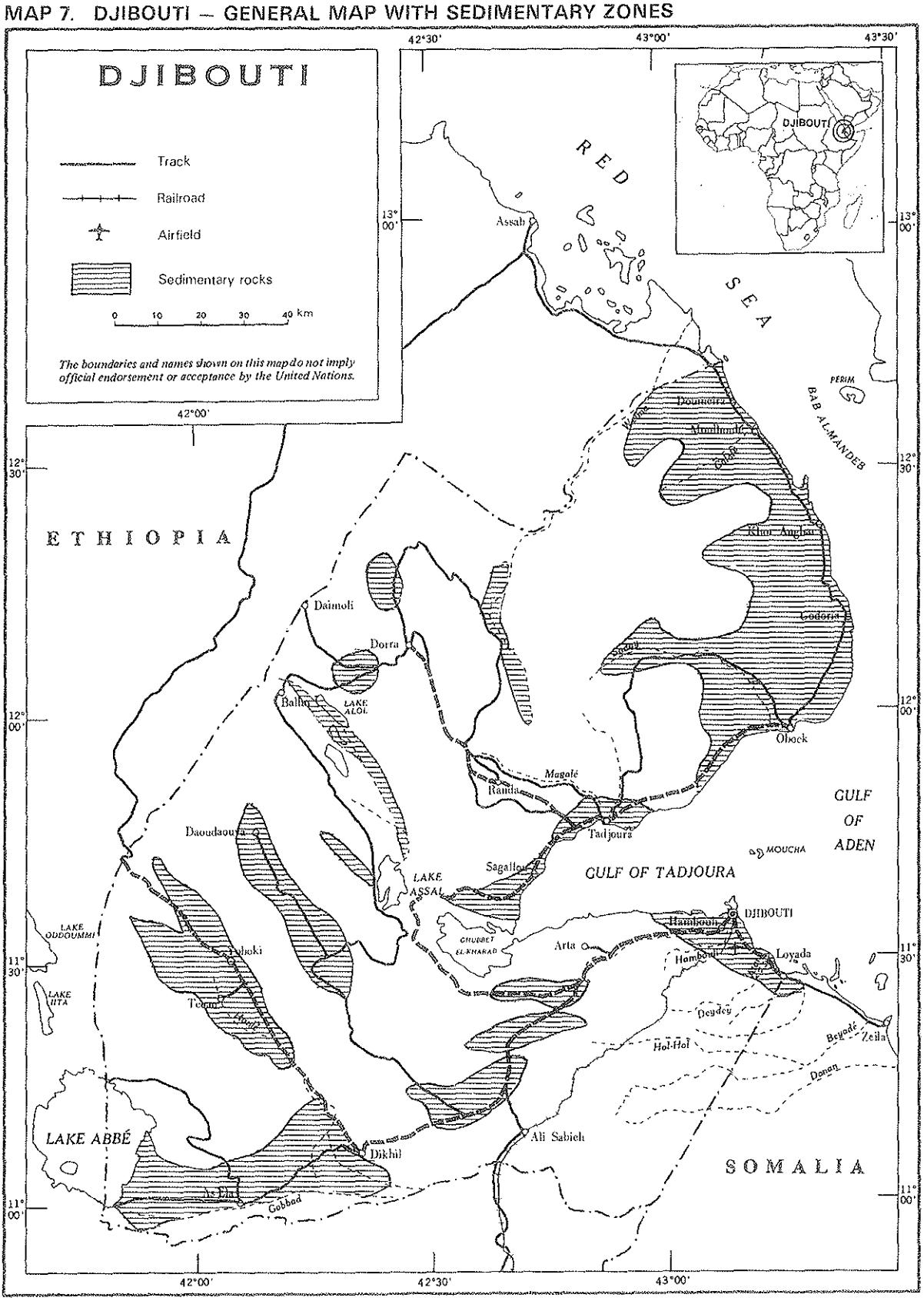
MAP 7. DJIBOUTI – GENERAL MAP WITH SEDIMENTARY ZONES



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DJIBOUTI

Area: 23,000 km^2
Population: 350,000

I. BACKGROUND

The Republic of Djibouti is situated in the arid zone of Eastern Africa. Bordered by the Red Sea and the Gulf of Aden, it lies between Ethiopia and Somalia, with 250 km of land frontier and 370 km of coastline.

The very flat coastal plain consists of coral reefs and is 30 km wide in the north, between Doumeira and Obock. It is 8 km wide south of the town of Djibouti and extends into Somalia.

The Gulf of Tadjourah and its extension, the Goubet-al-Karab, divides two groups of steep-sided mountains: Arrhé and Arta to the south and the Mabla mountains, the Dahla massif, the Goda mountains and the Day massif to the north.

The plateaus in the south of Djibouti are either horizontal or tilted slightly eastwards. In the west, the big subsidence plains (Gobaad, Hanlé, Gaggadé, Harralol, Sakalol) separate the tablelands (Daka, Gamaré, Yaguer, Babaolou, Siarou, Garbi). Lake Asal lies north-west of the Goubet in a deep depression, about 153 m below sea level. Lastly, there is Lake Abhé in the south-west, famous for its series of limestone chimneys.

Climate

The climate is of the arid to hyperarid type, with little and irregular rainfall, very high temperatures and intense evaporation.

The maximum annual rainfall (300 mm) occurs in the area west of Tadjourah (Goda massif). Here the annual rainfall is in the order of 100 to 150 mm. There are periods of drought lasting several years, with rainfall below 50 mm/year. The average temperature is high throughout the country (35 °C).

The sunshine is intense. Evaporation is therefore high, around 1,849 mm/year (5.1 mm/day).

Table*. Climatological data (station: Djibouti-Serpent)

Surface water

The hydrographic system of the Republic of Djibouti has no permanent watercourses. It is divided into two clearly defined parts:

- A system draining the surface water towards the sea (wadis Weima and Sadai in the north, and wadis Ambouli, Atar and Wahayi in the south);
- A system draining the water towards the plains in the west of the country (wadis Andaba and Alol north of Lake Assal, and wadis Galafi, Shekheyti, Gobaad, Dagadle and Eroli south of Lake Assal).

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* See table - Annex I.

The surface water has never been studied in detail. The few observations made in some wadis (Ambouli) indicate in approximate terms a minimum annual flow of 0.5 % of the total annual precipitation, with a large sediment charge. This flow is in the form of short-lived flood waters (five to seven floods a year). The country has several salt-water lakes, including Lake Assaf which is below sea level.

II. GEOLOGY

The country is situated at the intersection of three tectonic systems of Eastern Africa: the Great African Rift, the Red Sea Rift, and the Gulf of Aden trench. This can be seen from the vast diffusions of lava and the marks of Recent fault tectonics. This is why many geologists have taken an interest in this part of Africa. The following are the main geological units:

- The epimetamorphic basement rock

  This heading includes the sandstones and limestones of Jurassic to Cretaceous age which are the oldest formations in the country. They are found in the Ali-Sabieh region.

- The volcanic effusions

  Volcanic activity probably began 25 million years ago, at the same time as the tectonic movements. The groups are:

  - The Ancient fissured basalts;
  - The Mabla rhyolites;
  - The Dalha basalts;
  - The Afar stratoid series, a large, mainly basaltic formation covering 60 to 70 % of the country.

- The sedimentary deposits

  In addition to the reef formations, these deposits include fluviatile, fluvio-lacustral or piedmont formations of varied facies (silts, clays, diatomites) which are often thick and extensive. The fine deposits alternating with coarse detritic sediments are of fluviatile origin.

  The distribution of the sediments in time and space is determined by the volcano-tectonic and climatic factors.

III. GROUND WATER

In an arid country like Djibouti, where there is no permanent watercourse, the relatively rare episodes of rainfall are of enormous importance. On the one hand this rain produces short-lived pasturage in the nomadic areas. On the other hand it recharges the ground-water aquifers which are the only permanent water resource. It thus determines the very survival of the people and their livestock.

In 1979 the Water Resources Organization (ORE) was established in order to co-ordinate the water research and development programmes and solve the problems of water use. It is presided over by the Ministry of Agriculture and Rural Development and has the following three permanent members:

(i) The Ministry of Agriculture, with the Agricultural Engineering Service, the Livestock and Fisheries Service, the Agriculture and Forests Service, and the Laboratories Service for analysis of soils and water;

(ii) The National Water Office of Djibouti (ONED) which is responsible for the supply and distribution of water in urban areas;

(iii) The Higher institute for Scientific and Technical Research Studies (ISERT); also involved are: the Ministry of Public Health (Planning Office); the Department of Public Works.

The Agricultural Engineering Service of the Ministry of Agriculture and Rural Development operates in the areas of water resources, (study, evaluation, research, programming and planning) and rural development works.

ISERT, which is concerned primarily with research, is making a considerable effort to acquire the material and human necessary for full participation in research work on water resources.

Djibouti's hydrogeological research work is very dispersed and is carried out mainly by research companies.

It should be noted that each of the bodies listed above (Agricultural Engineering, ONED and ISERT) has a hydrogeologist who is a national of Djibouti. The most recent hydrogeological study was carried out by the Federal Agency for Geosciences and Mineral Resources (BGR) as part of German hydrogeological co-operation (1979-1982). It covers the whole of the country.

At the present stage of knowledge about water resources it is usual to distinguish two types of aquifer which have different exploitation capacities:

- The consolidated rocks of the volcanic systems with fissure porosity;

- The unconsolidated or partially consolidated rocks of the depression fills (graben) and alluvial sediments with interstitial porosity.

The volcanic systems

The possibility of ground-water movement in the volcanic rocks depends on the tectonic dislocations of the rocks which manifest themselves on the surface in areas of lineation which may correspond to fractures and/or fissures. These gaps in a relatively large catchment basin allow considerable movement of water. The small extent of the Ancient fissured basalts and the considerable hydrothermal alteration of the Mabla rhyolites reduce the movement of ground water and thus the possibility of exploiting this formation.

The intensity of the tectonic dislocation of the Dalha basalts and the degree of clogging of the fissures with silica or calcite are the factors which determine their water-bearing potential.

The stratoid series is the largest volcanic unit. There are good prospects of exploiting the ground water owing to the frequent intercalations of scoriaceous strata or detritic sediments (pebbles, sands) and the presence of numerous fissure faults.

Lastly, the basalts of the Gulf of Tadjourah in the vicinity of the capital constitute the aquifer which supplies the town of Djibouti. There seems little possibility of exploiting them north of the Gulf owing to their small extent.

Unconsolidated formations

The exploitation of the ground water of the sedimentary fills depends on the thickness of the sediments and their type (fluviatile or lacustral deposits, and evolution of their tectonics). The Ancient alluviums are of interest for ground-water exploitation owing to their piedmont location, thickness and extent. The most interesting sediments are those of the Tadjourah region (dejection cone of wadis Dariyyou and Magalé), the Soublali region (dejection cone of wadi Sadai) and the Bissidirou region, and the deposits of wadis Didjan Der and Oueha.

The consistency of the present alluviums depends mainly on the drainage basin and the slope of the wadis concerned.

The volume of exploitable ground water is determined by the thickness of the sediments, while the number of floods and their duration determine the recharge properties.

The chemical and physical properties of the water vary according to the nature and frequency of leaching. Generally speaking, the aquifers of Ancient and Recent alluviums and the continuous aquifers of the volcanic formations (mainly the stratoid series) contain water which can be classified as "acceptable" to "excellent" for drinking purposes.

Present hydrogeological knowledge consists mainly of estimates. It is sufficient for the determination of the large regional systems in terms of type of aquifer.

In order to substantiate the hypotheses which have been put forward, it is necessary to continue the research work and carry out reconnaissance drilling. This will provide a better picture of other tapping areas (Djibouti aquifer), indicate the country's hydraulic potential, and make it possible to implement a "rational water policy".

IV. EXPLOITATION OF THE GROUND WATER

The water supplies of the town of Djibouti and the four urban centres of Ali-Sabieh, Dikhil, Tadjourah and Obock and the responsibility of the National Water Office of Djibouti, which operates under the Ministry of Industry and Industrial Development. The existing national personnel and foreign technical assistants are not sufficient for the performance of the various technical and administrative tasks which are their responsibility. The senior officials of the Office have therefore been giving increasing attention to staff training and the acquisition of equipment.

The Agricultural Engineering Service operates in two areas:

- Water-resources research and exploitation (boreholes for pastoral and village water supplies, water delivery systems, wells, small dams, etc.);
- Rural development works;
- The Service is also responsible for the maintenance of all the borehole installations supplying drinking water to the urban centres.

The studies and projects section, which for a long time existed only on paper, now has technical assistance provided by bilateral co-operation bodies (France, Germany) and international organizations (UNDP, UNICEF, FAO).

However, the numbers of national personnel are clearly insufficient. Since the creation of the Agricultural Engineering Service in 1975, the number of water points has shown a considerable increase (mainly boreholes of average depth - about 100 to 150 m).

Since Independence in 1984, the Agricultural Engineering Service has drilled 35 positive boreholes, 13 of which were required to maintain the water supply. In addition, 51 concrete wells have been installed in two districts (Ali-Sabieh and Dikhil).

The present exploitation of the various basalt and alluvial aquifers is designed mainly to satisfy the water needs of the people and their livestock, for the present level of farming is low. The largest demand comes from the country's capital, Djibouti. The current estimated consumption of 26,220 m^3/day is provided almost exclusively by 36 boreholes (26 of them in operation) located in a basalt aquifer. The consumption of the peripheral areas increases the total figure to 41,800 m^3/day.

The average consumption of the chief towns of the interior districts (Ali-Sabieh, Dikhil, Obock and Tadjourah) is between 400 and 500 m^3/day.

Rural water supplies are provided partly by boreholes and partly by concrete or traditional wells. About 30 boreholes are in use in the country to meet the water requirement in rural areas.

The studies on present water resources include the following components:

- Estimation of the hydraulic potential of the whole country;
- Study of the aquifer which supplies water to the capital; this study is to begin by tackling the problems of salt-water intrusion, after the construction of a model aquifer;
- Conservation of surface water and its development by means of artificial recharge (Djibouti aquifer).

The following hydrogeological studies are at present under way or planned for the near future:

- Study of the aquifer which supplies the town of Djibouti, including geophysical prospecting to determine the aquifer's geometry, a chemical analysis component, and the construction of a model aquifer to evaluate the risk of invasion of the aquifer by salt water;
- Study of the ground-water flows of the alluvial zones, with evaluation of the exploitable yields (including the fill formations of fluvio-lacustral origin in the Rift Valleys); this is a UNDP/DCTD project;
- Preparation of a water resources master plan, with particular reference to ground water, is envisaged under a UNDP/DCTD project (1987).

V. CONCLUSION

The economic and social development programme of the Republic of Djibouti indicates the routes to be taken in the attainment of the country's development goals, the most important of which are connected with its natural conditions.

Fighting poverty by establishing farming areas and feed crops to develop livestock in the pastoral sector; fighting thirst, and fighting hunger by means of irrigation of arable land to reduce food imports; and industrial development. The attainment of all these goals may depend largely on the availability of water of acceptable quality in sufficient quantities.

While the various development activities carried out so far have yielded encouraging results, it nevertheless remains true that in the years to come hydrogeological research accompanied by economic assessment of the hydraulic potential will remain Djibouti's principal concern.

The well-head cost of ground water is as follows:

- For yields in the order of 5 m^3/h and a lift of approximately 150 m: about 230 Djibouti francs;
- For yields between 10 and 30 m^3/h: 150 Djibouti francs;
- For yields of around 50 m^3/h: 30 Djibouti francs.

VI. REFERENCES

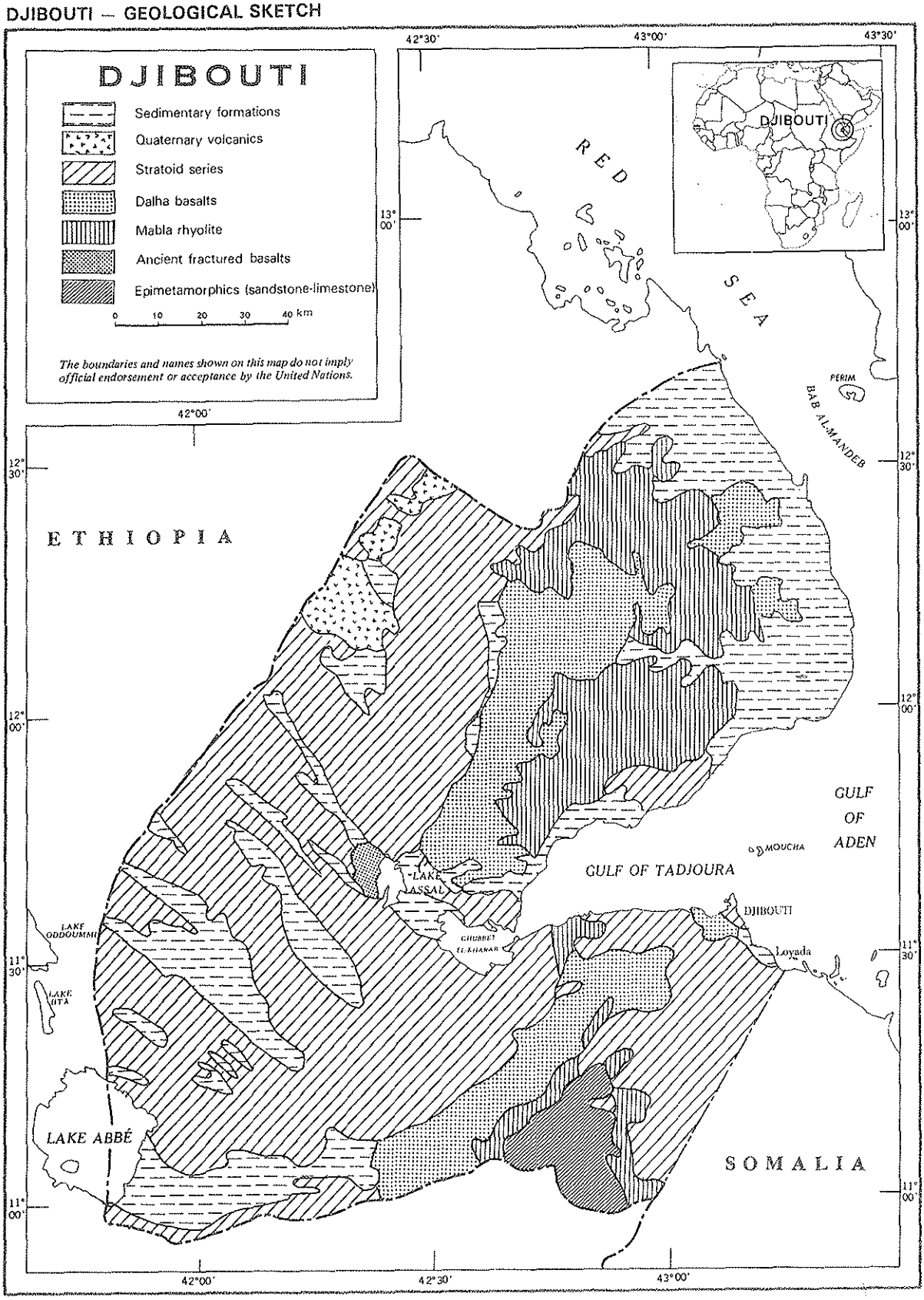
The documentation on hydrogeological research consists mainly of reports of missions and deals primarily with local studies. However, a co-operation project entitled "Inventory and development of ground water of the Republic of Djibouti" carried out by a German hydrogeological mission in 1979-1982 produced important reports on the state of hydrogeological knowledge in Djibouti. This considerable documentation base in considered reliable.

Annex I

Main climatological features (Djibouti-Serpent)

Month	Average temperature (°C)	Average monthly evaporation (mm)	Average annual precipitation (mm)
January	25.1	108.1	10.7
February	25.4	95.9	13.3
March	26.8	100.6	19.7
April	28.5	96.7	11.5
May	30.6	121.0	6.0
June	33.3	199.5	0.4
July	34.2	300.0	6.3
August	33.3	258.0	7.4
September	32.2	166.1	5.6
October	29.6	142.9	14.3
November	27.4	126.5	24.6
December	25.9	133.5	10.9

DJIBOUTI — GEOLOGICAL SKETCH



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