YEMEN ARAB REPUBLIC

SURVEY REPORT ON ECONOMIC DEVELOPMENT

JAPANESE SURVEY TEAM

Organized by

OVERSEAS TECHNICAL COOPERATION AGENCY

GOVERNMENT OF JAPAN

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PREFACE

In 1970 the Government of Yemen Arab Republic, having terminated the nation's 8-year long civil strife and succeeded in the unification of its domestic affairs, established diplomatic relations with Japan and at the same time sought economic and technical cooperation from Japan.

In compliance with the request of the Government of the Yemen Arab Republic, the Government of Japan decided to dispatch a survey team to the country to carry out basic surveys in the fields of economic development, agriculture and mineral resources and also to study the method by which Japan's technical cooperation could best be extended to that nation. Implementation of this survey program was entrusted to the Overseas Technical Cooperation Agency.

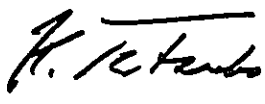
The said Agency, for its part, organized a survey team comprising four experts headed by Mr. Tsuneharu Someya and sent it to the Yemen Arab Republic for a period of 14 days from April 7 to 20, 1972.

Although the period set for the survey was thus limited, the team was able to exchange views with H. E. Prime Minister Mohsin Al Ainy and other government officials concerned, as well as to carry out field surveys in the areas centering around the cities of Sanaa, Taizz and Hodaydah.

It is our sincere hope and desire that this report, prepared by the survey team upon its return to Japan, will contribute to the economic development of the Yemen Arab Republic, and in turn help promote the friendly relations between the two countries.

Finally, I wish to avail myself of this opportunity to express my deep appreciation to the Government of the Yemen Arab Republic for the friendly and positive cooperation extended to the survey team.

October 1972



Keiichi Tatsuke
Director General
Overseas Technical Cooperation Agency

Composition of Survey Team

Listed below are the members of the survey team appointed by the Overseas Technical Cooperation Agency, with the responsibility indicated in parenthesis.

Head : Tsuneharu Someya (Overall responsibility, economic development planning)
Director, Japanese Marine Science and Technology Center

Member : Kenkichi Sakai (Agriculture)
Chief, Chiba Branch, Central Agricultural Experiment Station, Ministry of Agriculture and Forestry

Member : Toshio Igarashi (Mineral Resources)
Senior Geologist, Mineral Resources Department, Geological Survey of Japan, Agency of Industrial Science and Technology, Ministry of International Trade and Industry

Member : Keiji Iimura (Overall Coordination, technical cooperation)
Development Survey Division, Overseas Technical Cooperation Agency

In addition, the survey team was given the maximum assistance by Mr. Nobu Ebina, a staff of the Middle East Division, Middle Eastern and African Affairs Bureau, Ministry of Foreign Affairs, who accompanied the team throughout the survey and extended every possible convenience.

Survey Schedule

The survey team left Tokyo on April 7, arrived in Sanaa, the capital of the Yemen Arab Republic, on April 12, and after spending about two weeks there for field surveys and collecting the data concerned, returned to Japan on April 26. Details of the survey schedule are as follows.

Item No.	Date	Destination	Activities
1	Apr. 7 (Fri)	Tokyo -	Travel day
2	Apr. 8 (Sat)	Jeddah	(The Kingdom of Saudi Arabia)
3	Apr. 9 (Sun)		Consultations with the Japanese Embassy staff on details of the survey. Collection of data at the Ministry of Oil Resource of K.S.A.
4	Apr. 10 (Mon)		Collection of data and information at the office of the Japan Geological Survey Team and other places.
5	Apr. 11 (Tue)		Collection of data and information at the Applied Geology Center and the Agriculture Department of Abdul Aziz University.
6	Apr. 12 (Wed)	Jeddah - Hodaydah Hodaydah - Sanaa (by land route)	(Yemen Arab Republic)
7	Apr. 13 (Thu)		Call on H. E. Mr. Al-Ghales, Chairman of CPO (Central Planning Organization) and consultations on the details of the survey. Collection of data and information through meetings with Mr. H. Al Ainy, President of the Yemen Salt Corporation,

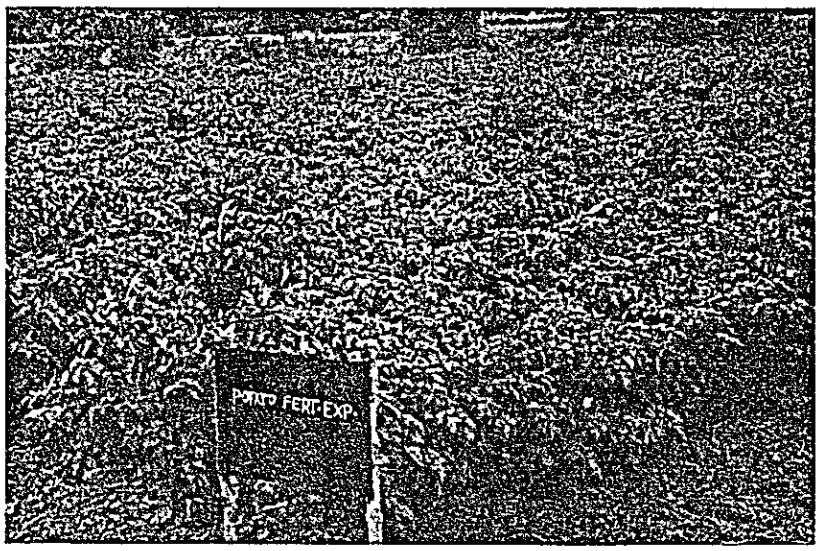
			Mr. Mohamed Al-Khader, Vice Minister of the Ministry of External Affairs, Mr. A. Abdul Ghany, President of the Central Bank of Yemen, Mr. A. Al-Taawr, Chairman of the Bank of Yemen.
8	Apr. 14 (Fri)	Sanaa -	
		Bany Hoshysh (by return trip)	(Suburbs of Sanaa)
			Field survey of coal mines and other mines and also of agriculture in the Bany Hoshysh district.
9	Apr. 15 (Sat)		Call on H. E. Mr. A. Asnag, Minister of the Ministry of Economy. Call on Vice Minister in charge of agriculture at the Ministry of Agriculture. Visit to the West Germany's pilot firm and the textile factory of Y. A. R.
10	Apr. 16 (Sun)		Call on H. E. Mr. Mohamed Al-Ghunaid, Deputy Premier, Minister of State in charge of development. Consultation with CPO on survey schedule. Call on H. E. Mr. Mohsin Al-Ainy, Premier of Y. A. R., and H. E. Mr. H. Al-Ainy, of the Ministry of Public Works, Mr. Ahamad Al-Rucayni, Vice Minister of the Ministry of Communications. President of the Yemen Salt Corporation, Mr. Ali Abu Alrigal, Vice Minister of the Ministry of Public Works, Mr. Ahamad Al-Rucayni, Vice Minister of the Ministry of Communications.

11	Apr. 17 (Mon)	Sanaa - Taizz	Field survey of Al-Lasi mine and agriculture in the Thamar district.
12	Apr. 18 (Tue)	Taizz - Hamura (by return trip)	Call on the governor of Taizz Province and Mr. M. H. Sirry, Chairman of YOMICO. Field survey of UNDP Midland project and the copper deposits in the Hamura district.
13	Apr. 19 (Wed)	Taizz - Ibb (by return trip)	Field survey of UNDP Highland project and the magnetic zone in the Hamura district.
14	Apr. 20 (Thu)	Taizz - Hodaydah	Field survey of Mukha harbor and UNDP Wadj Zabro project.
15	Apr. 21 (Fri)	Hodaydah - Salif (by return trip of A group)	Field survey of Salif rock salt mine.
		Hodaydah - Bajil (by return trip of B group)	Field survey of the U.S.S.R. model firm.
16	Apr. 22 (Sat)	(A group)	Courtesy call on the governor of Hodaydah Province and field survey of Hodaydah harbor.
		Hodaydah - Jumaisha (by return trip of B group)	Field survey of UNDP Lowland project and the East Germany's model firm.
17	Apr. 23 (Sun)	Hodaydah - Jeddah	Consultation with CPO.
18	Apr. 24 (Mon)		Report on the findings of survey at the Japanese Embassy, and visit to the Yemen Embassy in Jedda. Preparation of an interim report of the survey.
19	Apr. 25 (Tue)	Jedda -	
20	Apr. 26 (Wed)	Tokyo	

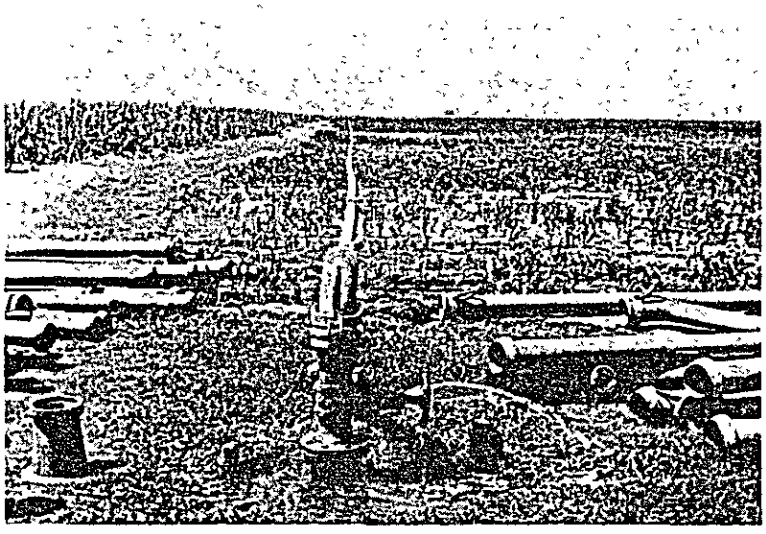
Panoramic view of West Germany's model farm is Sanaa

Farmland in the Thamar plateau district located between Sanaa and Taizz
(puddles formed after a rainfall are observed)

Terraced farm (Teracea) in the district between Hodaydah and Sanaa
(Puddles formed after a rainfall are observed)

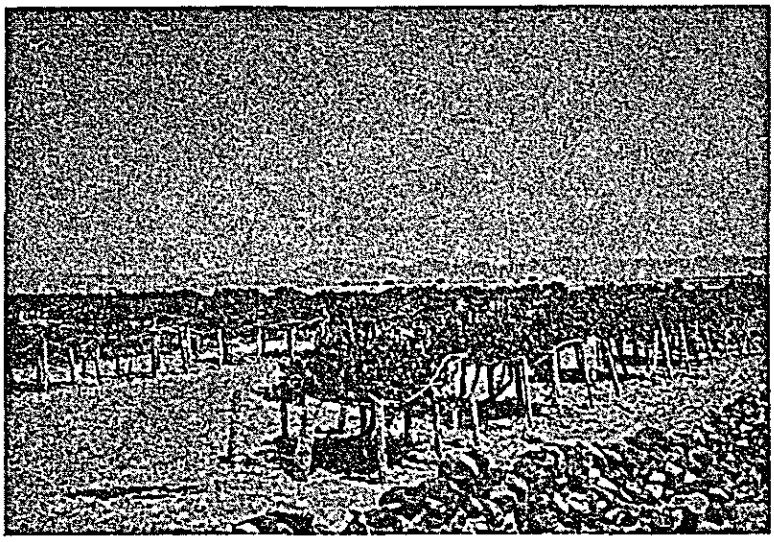


U.N. model potato farm in Ibb

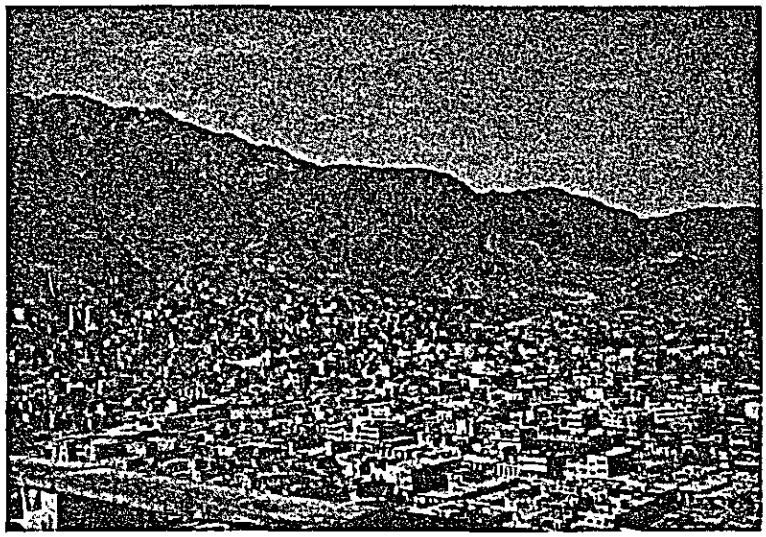


Irrigation at East Germany's model farm in the Hodaydah district

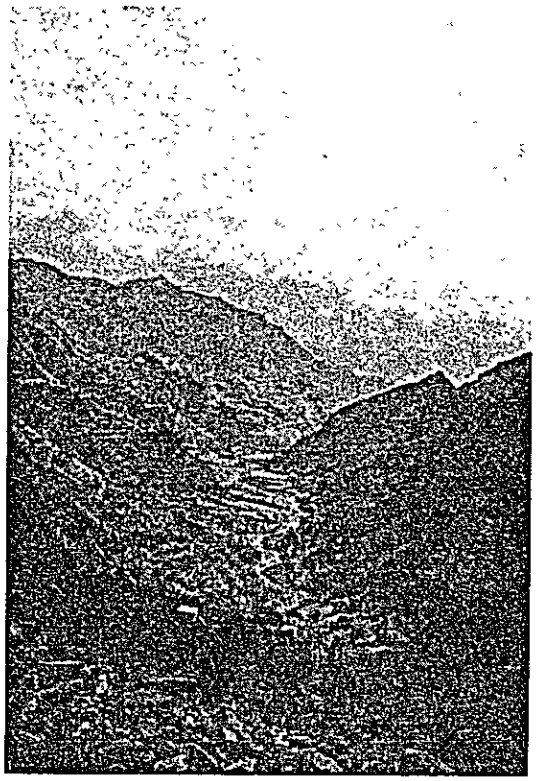
Irrigation at U.S.S.R.'s model farm in Sardud



Vineyard in the Bany Hoshysh area located in the suburbs of Sanaa

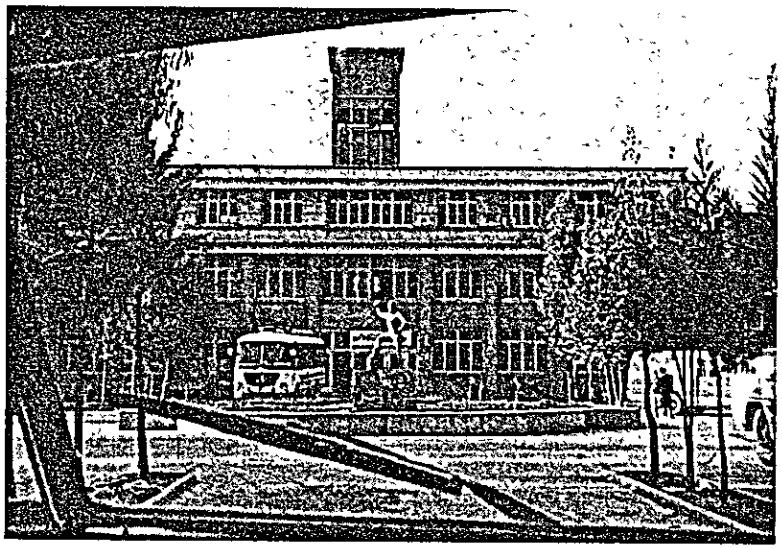


Taizz, the city built on the rock and the second largest in Y.A. R., is a well known tourist site

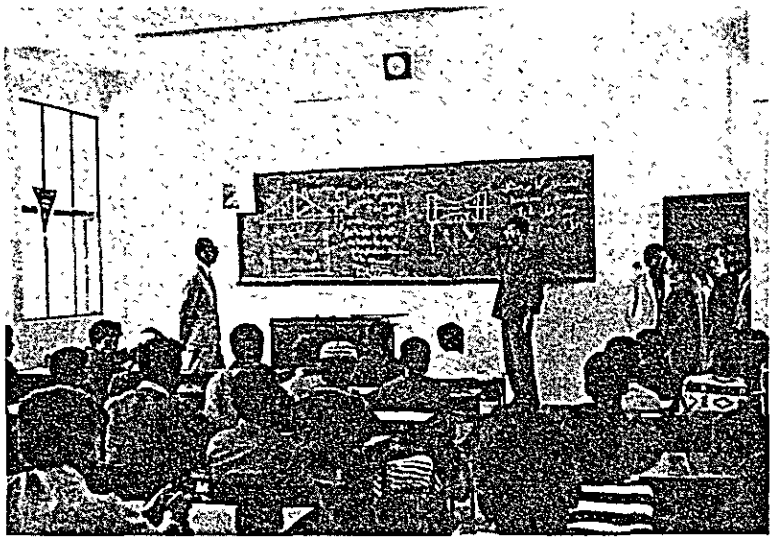


Dry river (Wadi) between Sanaa and Taizz

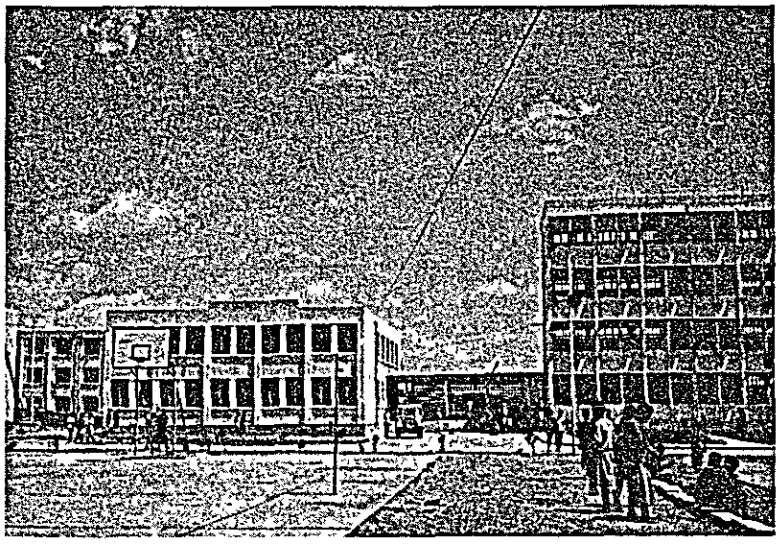
Mukha harbor (requires constant dredging because of drift sand).



Modern textile factory in Sanaa, only one of its kind in Y. A. R., and constructed with the aid of the People's Republic of China.



Class given in the vocational training school.
A Chinese teacher lecturing in the Arabic language



Vocational training school established with the aid of the People's Republic of China

CONTENTS

INTRODUCTION

The economic development survey for the Yemen Arab Republic conducted by a survey team comprise four members, headed by Mr. Someya, extended over twenty days beginning April 7, 1972. While this survey was limited in time, the team made utmost efforts to attain its objective. As a result, the following report was compiled for the economic development of the Yemen Arab Republic.

As regards the agricultural and mining sectors, specialists in these two fields worked separately from the team. Their findings are therefore presented in two separate reports.

I. PRESENT STATE OF ECONOMIC DEVELOPMENT

I-I Present State of Economic Development in the Yemen Arab Republic

The present economic development in the Yemen Arab Republic is lagging considerably. The national income in 1970 is estimated to have been about 300,000,000 dollars, with the per capita income being about 50 dollars. While the economy of the Yemen Arab Republic is characterized by constant shortages of essentials, the most serious problem is a shortage of foodstuffs. The staple food in this country are wheat, barley and the like, but they are always in short supply. Agriculture there is dependant solely on rainfalls, which fluctuate greatly from year to year. One long spell of dry weather will immediately bring about a drought, which in turn will result in a serious decrease in crop production.

When, for example, the drought continued through 1968, 1969 and 1970, the government made an urgent appeal to the UN for emergency shipments of food supplies.

Another problem in this country is a shortage of foreign currency. The principal export items are coffee, leather, rock salt, cotton seed, qat, but the quantity is small. As for imports, even such daily necessities as soap, matches, etc., have to be imported and as a result, the balance of trade is always in the red with every country except Switzerland and R.O.K. The trade deficit for 1970 is estimated to have amounted to about 30,000,000 dollars. While the remittance by the Yemen people who have emigrated abroad can probably make up part of this deficit, it certainly is not enough to cover the country's shortage of foreign currency as a whole.

Moreover, the country's natural resources are not sufficient to cover the shortage of provisions and foreign currency. In order to solve the problem of food shortage, it is essential to increase agricultural production by all means. For this purpose, water is the first requisite, but that is also in short supply. It is true that in mountain regions as much as 500 mm of rainfall per year has been recorded, but little has been done to make use of this rainfall. If mineral resources such as oil and copper and iron ores

are exploited in this country, export of these items would increase country's foreign currency reserve and that, in turn, would solve the problem of food shortage through imports. Regarding mineral resources, however, the only surveys made were that by a team from Sweden in the area centering around the northern region for about four months in 1961 and that made by a team from Czechoslovakia for about three months in 1968. Since no promising resources have been found yet, it may be said at this stage that no mineral resources exist in the country.

Deficiency is also seen in human resources and funds. Education is not diffused and 90% of the people are said to be illiterate. The number of elementary school children in 1970 is said to have been around 70,000, and there certainly are not enough trained personnel. Funds are not readily available either. Capital investments seem to be limited mostly to construction projects and most of them are dependent on foreign aid. The capital formation is estimated to have been about 20,000,000 dollars in 1970.

As regards economic aids to such a country as Yemen, a country extending the aid does not necessarily receive direct economic advantage therefrom. Notwithstanding, many countries are extending positive aids for the economic development of this country.

For example, West Germany has provided about 30,000,000 dollars for construction of a road between Sanaa and Taizz, an airfield in Sanaa, an experimental farm and communication facilities. East Germany has provided about 5,000,000 dollars for construction of an experimental farm and communication facilities. Besides, Yugoslavia has given about 2,000,000 dollars for a power plant, and from the Kuwait Fund about 3,000,000 dollars has been provided for construction of a hospital and other facilities. Notable as these aid efforts are, they fall far short of the aids from the U.S.S.R. and the aids extended by the People's Republic of China. The U.S.S.R. has provided 19,000,000 dollars for an experimental farm, 10,000,000 dollars for a cement plant, 15,000,000 dollars for the Hodaydah harbor and 34,000,000 dollars for the road between Taizz and Hodaydah. Among these grateful aids, the one that has touched the hearts of the Yemen people most seems to be that from the People's Republic of China.

The People's Republic of China has provided 15,000,000 dollars for the construction of a mountain road between Hodaydah and Sanaa, 24,000,000 dollars for a similar

road between Sanaa and Sadah, 2,400,000 dollars for a spinning factory and 4,000,000 dollars for a technical training school. The mountain road between Hodaydah and Sanaa is 230 km. in length and most of it runs through mountain regions having the highest peak 3,700 m. above sea level. Therefore, the construction work which was completed only in 2 years must have been carried out under most difficult conditions. The mountain road between Sanaa and Sadah is about 240 km. in length and runs mostly through mountain regions where the highest mountain rises more than 3,700 m. above sea level and where construction work is very difficult. This project began in 1971 under a 2-year program and the progress made to date is such that one more year will probably see its completion. When this road is completed, it will make a great contribution to the development of the northern regions. The spinning mill constructed in Sanaa has 10,000 spindles and while it is small in scale by the international standard, it is the only modern mill now operating in the Yemen Arab Republic (Completion of the cement plant under construction with the aid of the U.S.S.R. is delaying considerably for some unknown reason and therefore the plant is not in operation). In this mill domestically produced raw cotton is used as raw material to manufacture cotton goods in the integrated production system all the way to the dyeing stage and materials for military uniforms are also produced here. In that sense, it is a national factory which is indispensable for the nation's economy. The fact that of the 4,500 workers employed by the mill, 350 are women is an indication of the trend toward modernization though very small in the percentage and is considered unusual in a country with stern Mohammedan traditions like the Yemen Arab Republic. Besides, as far as the construction and operation of the vocational training school is concerned, it is no exaggeration to say that the People's Republic of China is literally contributing toward the establishment of the Yemen Arab Republic as a nation. This school effers a four year course and at present has a student enrollment of 180, with a staff of 17 instructors and 25 training personnel dispatched from the People's Republic of China. The school facilities consists of a four-story building for classrooms, four three-story buildings for dormitories, two one-story buildings for experimental stations, and three one-story building for work shop and such subjects as the Chinese language, moral science, science and technology are being taught. These contributions of the People's Republic of China seem to have captivated the Yemen Arab people.

I-2 Aids from Japan

Such are the cases of aid from foreign countries, Japan should give serious consideration to the necessity of extending aid to the Yemen Arab Republic. Taking a long view, it will behoove Japan to cooperate with the Yemen Arab Republic in earnest and good faith for its establishment as a nation.

II. CONCLUSIONS

In the Yemen Arab Rebublic economic development just got under way and as already mentioned, such important questions as improvement of administrative structures, diffusion of education, assurance of food supply, increase of exports are awaiting urgent solution. However, whether these problems are solved through its own efforts or through the aid from foreign countries or international organizations, it is the conclusion of this survey mission that the following should be given top priority in the economic development.

II-1 Construction of Underground Water Storage Facilities

Since the Yemen Arab Republic's most urgent need in an increase in food production, it is essential to secure water supply by constructing irrigation facilities to overcome the principal obstacle to the nation's agriculture.

If the relatively abundant rain water in the highland is drawn to the underground reservoirs for storage and used for irrigation as need arises, it is obvious that agricultural production will be greatly increased.

Most of the rivers originating in the mountain regions are dry rivers called "Wadi", which are the result of less rainfalls which are concentrated to a short period of 2 to 3 months. Because of the high evaporation rate in this country, mere construction of ordinary dams cannot be the answer. It is recommended therefore that a survey be made to find suitable locations along Wadi where underground reservoirs could be built to store rain water for use as irrigation water.

II-2 Preparation of Topographical Maps

Topographical maps are indispensable not only for the development of national land as a whole but also for the exploration of underground resources. They are also useful for the construction of the abovementioned underground reservoirs. To that end,

immediate preparation of topographical maps is greatly desired.

According to the information received by the survey team at the time of its visit to the Yemen Arab Republic, a survey team from England was to take aerial photos in the autumn of 1972. That should be followed by such surveys as tidal observations, water leveling, astronomical survey. As a step toward the preparation of topograhical maps. The most effective means to accomplish this objective is to start from the regions which the Yemen government consideres most important.

II-3 Establishment of Agriculture Junior College

As regards the training of agricultural experts, it is obvious from the actual experiences in Japan that crop selection and improvement of cultivation technique will greatly contribute to the increase in the yield. For this purpose, the most important thing is to assign native experts to all farm villages. And the quickest way to achieve that end would be to establish agricultural training institutes in the existing experimental farms of the UN and other countries for the purpose of training local people in agricultural techniques. If, however, there is any difficulty in the realization of the above objective, the establishment of a agricultural junior college may be considered as a parent institution of the agricultural college which is envisioned in the Yemen government's agricultural policy.

In the proposed agricultural junior college consideration should also be given to the level-up of education standard in the Yemen Arab Republic as a whole. It is therefore advisable that general cultural courses as well as instructions and trainings in agriculture be given in this college and the length of the course should be about 4 years. For the time being, enrollment will be limitted to local people and it may be necessary to invite specialists in various fields from foreign countries as instructors. The important point to be considered in this connection is how to make efficient use of the graduates of this college. They might, for instance, be employed as the nucleus of various organizations that are to be set up under the policies being considered by the Yemen government and meanwhile they may be given a tract of land which would serve as a basis of agricultural extension work throughout the country.

II-4 Promotion of Rock Salt Industry

Beginning in 1962, Yemen exported 30,000 to 100,000 tons of rock salt to Japan annually. But its export to Japan has recently become increasingly difficult for various reasons, especially because Japan has liberalized import of various items including rock salt. In order to promote export of rock salt and reactivate other rock salt industries, it is necessary to take the following measures.

1) Opening of new markets.
2) Reduction of production cost through mechanization.
3) Institution of tax reduction and exemption for exporters, and adoption of the bonus system (Granting special import right on goods of large profit margin).
4) Prompt study of the possibility for the establishment of chemical industries for production of caustic soda, ammonium chloride, etc. by making use of rock salt.

II-5 Promotion of Small and Medium-Sized Manufacturing Industries

The Yemen Arab Republic is heavily dependant on imports for many of its daily necessities. In order to make the efficient use of its limited foreign currency, it is necessary to encourage and promote small and medium-sized manufacturing industries centering those producing articles of daily use, especially the goods processed from agricultural products. For this purpose, it may be necessary to introduce technology from foreign countries, and to induce foreign capital if necessary. Besides, it is necessary to give due consideration to the import control measures in order to protect domestic industries.

II-6 Training of Technicians

Despite the vigorous efforts of the Yemen government, a serious shortage of technicians still exists in all industries including agriculture and mining. To improve this situation, it is necessary to invite foreign experts to train native technicians, as well as to dispatch personnel for training abroad by making the most of technical assistance by advanced countries.

III. AGRICULTURE

As the objective of the survey team was to obtain every possible information concerning the Yemen Arab Republic within a relatively short period of time through concerted efforts, all the member of the team acted together throughout the period except for the last day in Hodaydah. The time alloted for the field survey therefore was quite limited,the team was able to observe farm villages along the main road between Hodaydah - Sanaa - Taizz - Hodaydah and survey a considerably large number of experimental farms and farm villages on the way to the mining stations.

Although the overall data on agriculture were obtained through the courtesy of the Ministry of Foreign Affairs and some data were also obtained in the field, it is regrettable that no reliable data related to the pilot farms or model farms run with the aid of foreign countries were obtained except for West Germany's farm. Moreover, the figures of statistic data obtained show great variations and even the answers to the questionnaire sent in by the CPO contained many unknown factors.

This report has been prepared on the findings of the survey conducted by the team with reference to the data and answeres to the questionnaire mentioned above.

III-1 Natural Environments Surrounding Agriculture

III-1-1 Topography and geology

As the topography and geology are explained in detail in the section dealing with mineral resources, only the items related to agriculture will be described hereinafter. The Yemen Arab Republic is situated in the southwestern end of the Arabian Plateau which extends between the 42nd and 46th degrees east longitude and between the 13th and 18th degrees north latitude and occupies the highest portion thereof. Details of the geological features are not known, but it seems that there is little defference in the geology between north and south and that there is a big difference in the east-westward direction due to the altitude. As shown in the topographical map of Yemen in Fig. 1, there are a number of mountains and the national land may be topographically divided

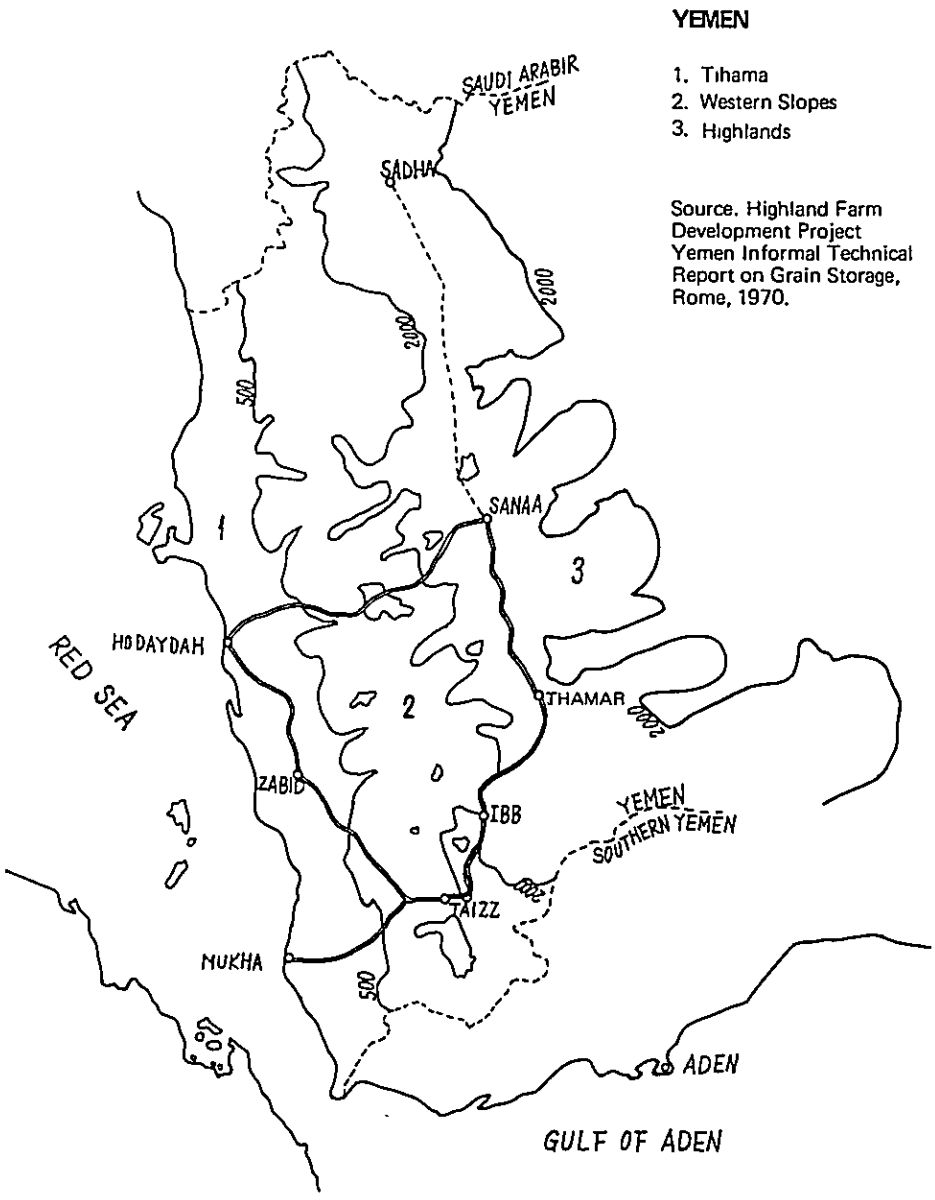


Fig. 1 Topographical Map of Y.A.R.

into the following four regions according to the altitude.

1) Tihama (Coastal plain facing the Red Sea)

There are many Tertiary stratum in this region and approximately one fourth of the area consists of marine deposits on which drainage areas of the principal Wadi and thick layers of delta and fan deposits in the mouth of river have been formed, and water is found between the rock-bed of Tertiary stratum and the piled-up alluvium.

2) Central mountain region

The western slope of the Arabian Peninsula facing the Red Sea where the highest point of the mountain range is more than 3,000 m. above sea level and appears to be very sharp in contour with the erosion of its mature period.

3) Plateau

A highland of 2,000 m. or so in height is formed with many hills. This region is mainly a distribution area of volcanics.

4) Desert

This is a desert and the westernmost region of Al Rub Al Khaly.

This division of the land does not necessarily conform with the boundaries of Tihama, Western slopes and Highlands shown in the topographical map, because the division shown in the map is somewhat different from the division by the altitudes. Tihama has a width of 30 to 60 km. extending from the seashore to the hinterland and stretches for 500 km. in the north-south direction along the coast of the Red Sea, and the altitude of the hinterland appears to be about 300 m. above sea level. The area in and around Hodaydah was selected as a representative survey area. The central mountain region lying east of Tihama is over 200 m. in height and the ground is becoming higher and steeper toward the hinterland until it reaches the highest peak called Mt. Nabi Shuaib which is located about 50 km. west of Sanaa and the highest mountain (height is

estimated to be 4,308 m. above sea level) in the Arabian Peninsula. This region is a vast area and is said to occupy about one fifth of the whole national land. The area in and around Taizz was selected as a main survey area. The plateau is a tableland with a hight of 2,000 m. or over and does not form steep mountains but forms a gentle hilly land dotted with fairly wide basins here and there. The Plateau is also said to be a vast area which occupies about one fifth of the whole national land, and the soil is composed of fertile lava deposits suitable for farming. Ibb in particular is said to be the most suitable place for farming in Yemen. In this region Sanaa and Ibb were selected as survey areas.

III-1-2 Soil and water quality

No official soil data were available and moreover the report from CPO contained spaces as shown in Table 1 below.

Table 1 Soil Conditions

Site	P.H.	Soil constitution (mg/100g)			Organism	Degree of Fertility
		N	P_2O_5	K_2O		
Sanaa	7.2 - 7.4	-	36	38	-	-
Taizz	7.6 - 7.8	-	-	-	-	-
Hodaydah	7.8 - 8 0	-	40	32	-	-

Note Report from CPO (April, 1972)

Therefore, it is difficult to say anything definite about the soil in Yemen, but the content of phosphoric acid and potassium in the soil appears to be of no small quantity. In fact, the yield of farm products seems to be fairly good when adequate water supply is provided and for fertilizer, it is said that nitrogen fertilizer alone is sufficient to obtain good results. PH of the soil is generally high and such crops as upland rice and sweet potaots which have less resistivity against alkalinity are not suitable.

Except in the rainy season, only the well water is used as irrigation water. Table 2 shows the results of a survey of underground water in various sampling stations in Yemen shown in Fig. 2. As compared with the test-results of the underground water in Japan (survey conductd at the Agricultural Experiment Station, Konosu city, Saitama Prefecture), all items show very high values, indicating that the water in Yement is extremely high in hardness.

Table 2 Water Quality

Sampling No.	Hardness	SiO_2 mg/l	Cl mg/l	Total solid mg/l
1	331	42.5	102	610
2	407	72 5	264	1,168
3	270	65.0	141	854
4	579	75.0	399	1,340
5	636	58.8	368	1,290
6	244	47.5	65	518
7	377	52.5	104	718
8	368	47.5	84	680
9	446	105 0	433	1,954
10	248	97.5	173	1,166
11	342	53.8	40	548
12	230	35.0	40	434
13	308	66 3	60	674
14	302	72 5	60	520
15	337	72.5	73	618
Japan (Konosu)	72 - 144	45.3	15.5	300

Note · Determined by the USGS laboratory, Jeddah
20 June, 1971

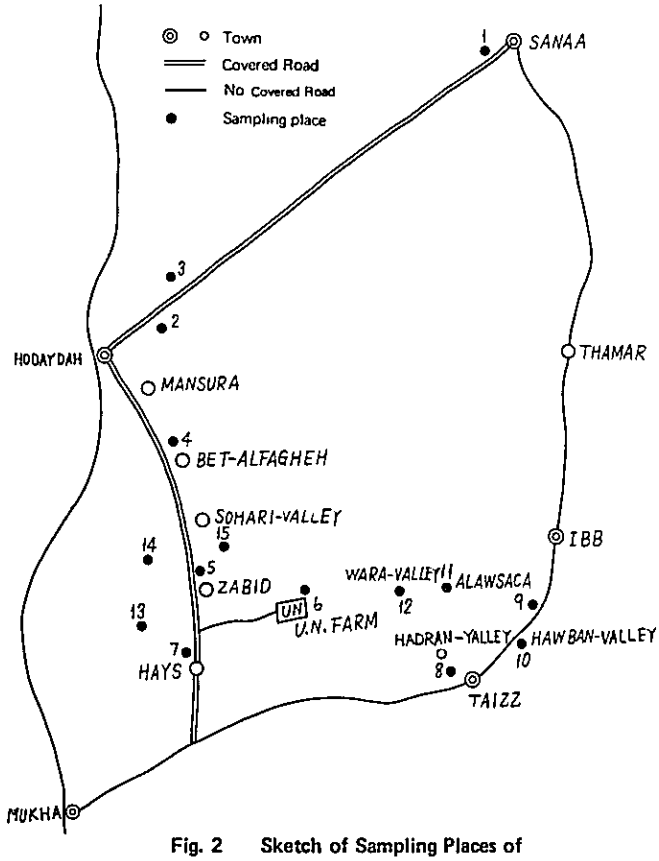


Fig. 2 Sketch of Sampling Places of Underground Water of Y.A.R.

III-1-3 Climate

Main features of climate in the typical districts may be summarized as shown in Table 3. As the greatest part of the national land is within the tropics, the temperature is high in general. However, regional differences due to the altitude are remarkably great and while the coastal region suffers from constant hot weather, the mountain areas enjoy moderate and cool climate. Like India and South Africa, this country also sees the rainy season brought about by the monsoon, but the precipitation is relatively small. Riding on the west wind, the humid air from the Red Sea hits the ridge of the central mountain region and causes a rainfall there. Therefore, the rainfall is highest in the Taizz and Ibb district, followed by the plateau region. In the coastal plain area and the eastern slope area, the rainfall is not high. There is a difference in the length of the rainy season between Sanaa and Taizz with the former has a longer rainy season than the latter. The monthly rainfall in the two regions is shown in Tabel 4 and the distribution of rainfall is shown in Fig. 3.

In general farming is carried out under high-temperature, little rain and plenty sunshine, a condition which is inconceivable in Japan. In most of the region sowing or transplantation is made at the beginning of the rainy season and thereafter the growth of crops is entirely dependent upon rainfalls. During the survey period in the middle and latter part of April, just before the rainy season, the farmlands along the road between Hodaydah - Sanaa - Taizz - Hodaydah were just completing their tilling and ploughing, and in the central mountain region and the plateau a number of fields looked just like paddy fields with puddles caused by occasional rainfalls. Wind is fairly strong and atmospheric pressure varies greatly between regions due to variations in the altitude.

III-2 Division of Agricultural Zones and Characteristics of Each Zone

As described previously, the agricultural zone in Yemen may be divided into the following four regions according to the topographical variations of altitude.

Table 3 Weather Conditions

Item \ Place	SANAA	TAIZZ	HODAYDAH
1. Temperature (C)			
Yearly average	16 5	24 3	29 0
Max. montly aver	24.7	30 8	32 9
Min. montly aver.	7 6	18 8	24.7
Max.	31.0	37.6	40.7
Min.	- 5.6	10.2	15.5
2. Humidity (%)			
Yearly aver (0800hr.)	39 0	51 5	66 0
Yearly aver (1400hr.)	23 0	42 0	58.5
Average	31 0	46.3	62 3
3 Wind Speed (knot)			
Yearly aver. (0800hr.)	3.8	5.7	9 3
Yearly aver. (1400hr.)	8 7	10 6	16.5
Average	6.2	8 2	12.9
4. Atmos. Pressure (mb.)			
Yearly aver. (0800hr)	780 2	888.6	1008 9
Yearly aver. (1400hr.)	776 3	886.2	1005.9
Average	778.3	887 4	1007 4
5. Yearly Rainfall (mm)			
1963 - 1965 aver.	395		
1963 - 1968 aver.		540	
1963 - 1966 aver.			153
Yearly Rainy Days	75	88	24
6. Evaporation (mm)			
Monthly aver (Evaporimeter)	189	-	-
Montly aver. (Pich)	244	-	-

Source . Various reports submitted

Table 4 Montly Rainfall

Montly Rainfall in Taizz (mm.)

Item \ Month	1	2	3	4	5	6	7	8	9	10	11	12	Total
1944 - 1953 (Average)	1.4	8.3	16 8	87 3	115.9	85.6	63 5	46 9	82 6	83.3	5 5	12 8	610 0
Year of Max. (1950)	0.8	20 0	11.8	130.0	125 9	150.0	96 8	71.0	102.0	110.0	0 1	2 9	821.3
Year of Min.	0.5	0.8	11.2	-	95 3	23 5	45.5	61.7	33.2	95.2	18 0	35.4	403 6

Montly Rainfall in Sanaa (mm)

Item \ month	1	2	3	4	5	6	7	8	9	10	11	12	Total
1938 - 1947 (Average)	1.9	4	27.2	42.1	33.3	4 2	66 0	89.1	13.3	2.2	8 1	4 6	295 3
Year of Max. (1946)	0.5	-	25.8	56.1	72 5	7.2	58.8	273 6	-	-	-	-	494 5
Year of Min (1939)	-	-	19.6	30 1	50.5	2.2	-	20 7	16 9	14 0	-	-	154 0

Source CPO (Apnl 1972), and no data of rainfall in Hodaydah

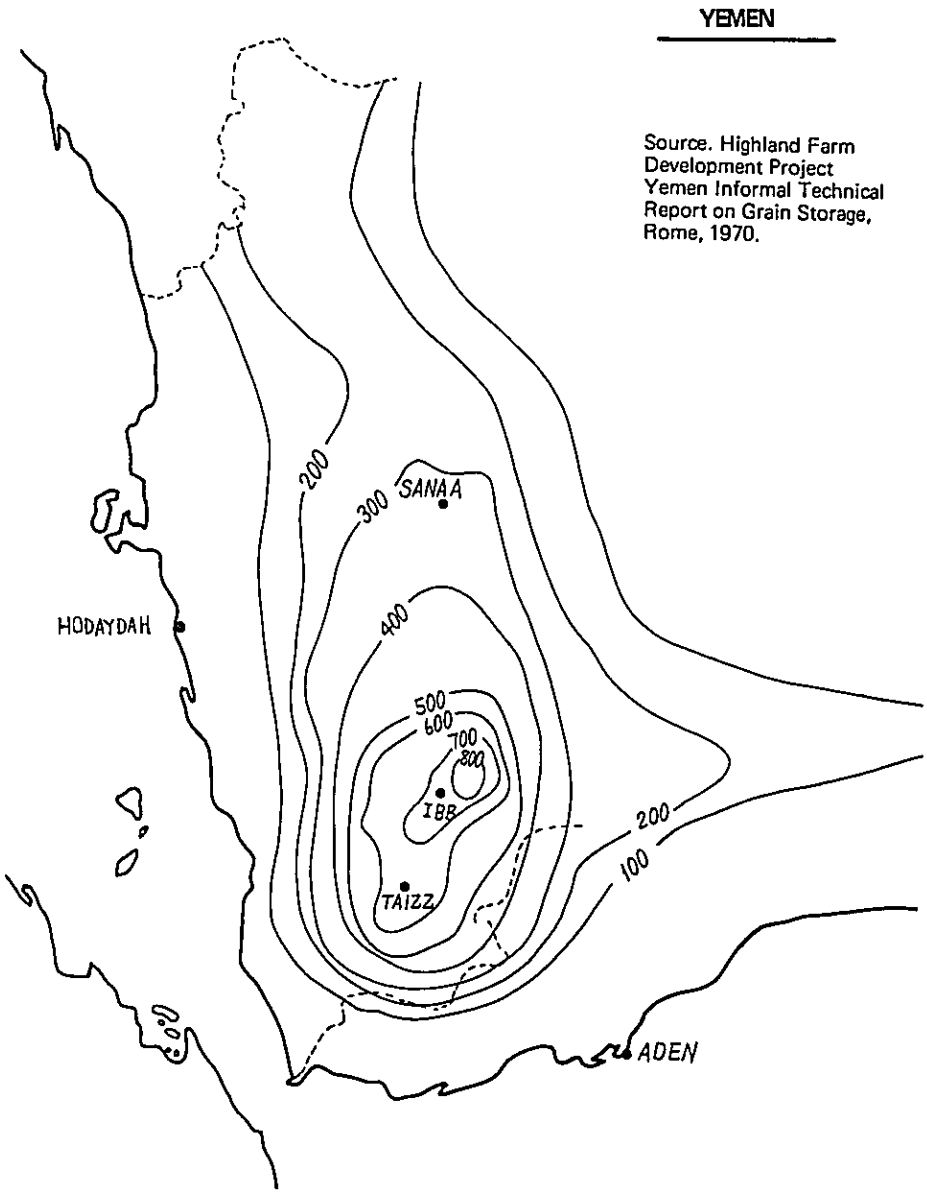


Fig. 3 Distribution Chart of Rainfall

1) Tihama (also called as Lowlands)

This is a region of sandy soil extending from the coast to the hilly land about 200 m. in altitude in the hinterland. Because of little rain, agriculture in this region depends largely on the water from wadis and wells. There are a number of farmers engaged in large scale agriculture and on the average the area under cultivation is about 3.5 ha per farm household. The principal crops in this region are cotton, Indian corn, tabacco, sesame and olive.

2) Central mountain region (Middle lands)

This region is about 600 to 1,500 m. in altitude and includes some steep mountains, some of which reach 2,000 m or more in hight. The region is favored by abundant rainfall and the soil is comparatively fertile with a small content of clayey soil. Terraced farm (teracea) is well developed and cultivation is dependent on rainfall. In this region, farming is generally small in scale and the area under cultivation is about 0.75 ha. on the average. The principal crops are grains (Indian corn, sorghum), coffee, gat, banana and vegetables.

3) Plateau (also called as Central highlands)

The altitude of this region is about 1,500 to 3,500 m. but mountains are not so steep with fairly wide basins scattered here and there. The east slope of the region, is said to be characterized by extensive undulations of the ground. The area under cultivation per farm household is small on the average in the southern part but fairly large in the northern district. The principal crops grains (wheat, barley), coffee, grape and alfalfa.

4) Desert

This is a barren land or a deserted land.

In some of the literatures the agricultural zone of Yemen is divided into five regions of Tihama, Western slopes, Central highlands Middle heights, Eastern slopes

(Desert) by further dividing the two regions mentioned in paragraphs 2) and 3) into three regions.

Characteristics of each region are shown in Table 5.

Table 5 Characteristics of Farming in Each Region

Region	Topographic features	Weather conditions in main area	Characteristics of agricultural location	Principal crops
1) Tihama	Tertiary 1/4 part : marine deposits Drainage of principal wadi and delta in mouth of rivers Water flows between marine deposits and delta and fan deposits	HODAYDAH Yearly aver. temp. 29.0°C Max. (Montly aver.) 32.9°C Min. (Montly aver.) 24.7°C Yearly aver. atmos. pressure (mb.) 1009 Yearly rainfall (mm.) 153 Yearly rainy days 24	Light rain; irrigational farming A number of large-scale farmers (aver. 3.5 ha. per farmer) P.H. 7.8 - 8.0 (water in Hodaydah)	Cotton Maize Tobacco Sesame Olives
2) Central Mountainous Region	Weatern slope facing the Red Sea Highest spot : more than 3,000 m. above sea level Steep contour of the ground in the mature period	TAIZZ Yearly aver. temp. 24.3°C Max (Montly aver.) 30 8°C Min. (Montly aver.) 18.8°C Yearly aver. atmos. pressure (mb) 889 Yearly rainfall (mm.) 540 Yearly rainy days 88	Blessed in rainfall Fertile soil Terraced farms (teracea) developed Many small-scale farmers (aver. 0.75 ha. per farmer) P.H. 7.8 - 8.0 (water in Taizz)	Cereals (maize and sorghum) Coffee Qat Fruits (banana) Vegetables
3) Plateau	Highlands of 1,500 - 2,500 m. above sea level Many hills, mainly volcanics	SANAA Yearly aver temp. 16.5°C Max. (Montly aver.) 24.7°C Min. (Montly aver.) 7.6°C Yearly aver. atmos. pressure (mb) 780 Yearly rainfall (mm.) 395 Yearly rainy days 75	Frequent showers Relatively fertile soil Relatively large-scale farming P.H. 7.2 - 7.4 (water in Sanaa)	Cereals (wheat and barley) Coffee Fruits (grape) Alfalfa
4) Desert	Western skirt of Alrus Al Khaly Desert	–	Barren lands	–

III-3 Crop Production

Area under cultivation, yield per ha. and production of principal crops in recent years are shown in Table 6. It is noteworthy that the production of grains which are the staple food in the country was remarkably small in 1969. This is due to the fact that the yield of agricultural products began to decline in 1966 and hit the lowest level in 1969 as a result of continuous drought and the civil war, thus dealing the hardest blow to the production of grain crops. Apart from the effect of the civil war, the chronic shortage of grains sustained by the farmers who depend solely on the rainfall for cultivation is said to amount from 200,000 to 300,000 tons annually. Grains including dura and dukhn (both belong to sorghum group) account for 90% of the total agricultural production and the remainders are wheat, Indian corn, pulses, barley and alfalfa. Production of principal crops totals about 1,150,000 tons consisting of about 970,000 tons of sorghum, millet, Italian millet and Indian corn, about 25,000 tons of wheat, about 145,000 tons of barley, and about 10,000 tons of Indian corn. As the production

Table 6 Area under Cultivation, Yield per ha. and Principal Crops

Farm product	Out put (unit : 1,000 t)		Area under cultivation (per 1,000 ha)			
			1965 - '69 aver.		1969	
	1965 - '69 aver.	1969	Area	Yield (t/ha)	Area	Yield (t/ha)
Grain	1,150.0	849.0	1,434.0		1,380.0	
Sorghum and millet	970 0	680.0	1,260.0	0.8	1,200.0	0.6
Wheat	25.0	160 0	25.0	1.0	25.0	-
Barley	145.0		145.0	1.0	145.0	-
Indian corn	10 0	9.0	4.0	2.5	4.0	2.2
Pulse	40.0	50.0	40.0	1.0	40.0	1.2
Potato	20.0	20.0	4.0	5.0	4.0	5.0
Vegetables	40.0	39.0	8.0	5.0	8.0	4.8
Fruit	-	23.0	63.0	-	63.0	0.4
Date (100,000 tr.)	-	60.0	0.5	-	0.5	-
Grape	12.0	10.0	4.0	3.0	4.1	2.4
Coffee (300,000 tr.)	4.5	4.0	4.5	1.0	5.0	0.8
Cotton	5.0	4.5	12.0	0.4	12.0	0.4
Sugar cane	5.0	4.0	0.5	10.0	0.6	6.6
Tobacco	2.0	2.0	3.4	0.6	3.6	0.6

Source : From "Recent Economic Developments" issued on October 21, 1970 in Y. A R.

of these crops is insufficient for the domestic need, about 120,000 to 130,000 tons of wheat and barley are said to have been imported for the past few years. Dura and dukhn are grown in most of the farm land. They are tough and highly resistant against drought and most stable in productivity. Wheat and barley are grown mostly in the Central highlands, but they are said to be very poor in quality. Cotton is produced mostly in the Tihama region where irrigation water is available, so the area under cultivation is said to vary depending on the availability of water supply. The total area under cultivation is about 10,000 ha. The key point of cotton raising is said to provide a favorable condition in the early stage of its growth: While various techniques may be required for that purpose, the most important thing is the provision of irrigation facilities that will make irrigation possible in all seasons.

Coffee is grown mostly in mountain regions in the shade of trees such as acacias. Before World War II, annual production of coffee was as high as 12,000 tons, but the production in recent years has declined to about 5,000 tons, of which about 3,500 tons are said to be exported. This decrease in coffee production is said to be due to the old plants which are not being replaced by young plants, low yield resulting from inproper cultivation techniques, insufficient irrigation facilities making crops more subject to drought damage and also a smaller share for the tenant farmers in profit distribution. As a result, many farmers seem to turn to the cultivation of qat. Most of them operate on a very small scale, growing only 200 to 300 plants. Qat (chewing of its sprout is said to produce narcotic effect) is cultivated in an area covering some 8,000 ha. in the mountain region of 1,000 - 2,400 m in altitude and is more resistant to drought than coffee. As cash income from qat is greater than that from coffee, cultivation of qat is increasing constantly and the authorities are now attempting to find measures to counter this trend. Other crops include peanuts, various kinds of beans, potatoes, sugar cane, tomatoes, and such fruits as grapes, figs, bananas, papayas, dates, apples and oranges. Various kinds of vegetables are also grown around oasis and in areas where irrigation is available. In short, a variety of crops can be raised in Yemen because of a wide variety of topographical and meteorological conditions.

Of these crops, what appeared to be the finest crops in the farmers' plots were the grapes in and around Sanaa, potatoes in Ibb and cotton in the individual farmlands. The grape vines, as shown in the photos, were widely spaced and were showing excellent growth. The greater part of grapes are shipped as raisins which, however, lack uni-

formity in grade and quality because of insufficient irrigation. Alcoholic beverages are prohibited in Yemen, but if the production of wine for export purpose is authorized under the government supervision, production of grapes will be greatly expanded. Although potatoes seemed to be cultivated from home-grown seed, they showed a very good growth condition with practically no signs of virus infection: Therefore, the prospect of potato production is bright both for domestic consumption and export as seed. Probably because of adequate irrigation, cotton was excellent in its growth.

III-4 Outline of Cultivation Method

As regards the cultivation method, little is known beyond what is shown in Table 7. With the exception of cotton, most spermatophyte are raised from home-grown seed; and in areas where irrigation is not available sowing is made during the rainy season (April to July), and harvest begins with the start of the dry season (October and November). As regards fertilizer, use of droppings of domestic animals is in general practice, although in some exceptional cases use of nitrogenous commercial fertilizers was observed. Weeding is done by hand and the same seemed to be true of harvesting, because there were not even foot-threshing machines seen around.

When a farmer near Taizz was asked whether sorghum was fed to their livestock, the answer was that only the dried stalks were fet to the animal. And at a farm household in Hodaydah the farmer said that the first crop (fully grown) of sorghum was used for human food, while the second crop (half grown) was fed to livestock and the remaining stalks were used as fodder and litter for livestock.

As far as the temperature is concerned, there are many areas in which year-around cultivation is possible. As a matter of fact, there were farms in the suburbs of Sanaa where wheat and other grain crops were ripe in the middle and late April while wheat and other grain crops were being threshed near Thamar on the way to Taizz. In an oasis located along the road from Ibb and Taizz to Muhka corn was in flower, while on some farms cotton bolls were bursting. As for vegetables, it is said that cultivation is possible all year around in oasis and areas where there are wells from which water can be pumped for irrigation.

Table 7 Outline of Cultivation Methods

Farm product	Variety	Seeding (Month)	Row spacing (cm)	Irrigation interval (week)	Blight	Harvest season (Month)	Growth period (months)
Grain	Mostly local variety	Jan - Jul	25 - 30	-	-	-	-
Sorghum	Local variety	May	80 - 100	2 - 3	Pearl - moth (Vice - borer)	Oct - Nov	5 - 6
Millet	Local variety	All year in Tihama	60 - 100	3 - 4	-	-	-
Wheat	Local variety Mexican variety	-	-	2 - 3	-	Jun - Nov	-
Barley	Local variety	-	-	2 - 3	-	-	-
Indian corn	Local variety	Apr - May	40 - 60	2 - 3	Pearl - moth (Vice - borer)	Oct - Nov	6
Peanut	-	-	-	3 - 4	-	-	-
Potato	Egyptian variety	Mar - Apr Jul	50 - 70	2 - 3	Potato blight	Jun - Nov	-
Coffee	Local variety	-	-	Rain water	-	-	-
Cotton	American variety	-	40 - 60	2 - 3	Ballinurum	-	4 - 5 in Tihama
Sugar cane	-	-	-	2 - 3	-	-	-
Tobacco	-	-	-	-	-	-	-
Grapes	Local variety	-	200 - 400	3 - 4	Downy mildew	-	-
Water melon	Egyptian variety	Mar - May	100 - 200	2 - 3	-	-	-
Tomato	Egyptian variety	Apr - Jun	60 - 80	2	Tomato blight	-	-
Alfalfa	-	All year	-	2	-	-	-

Source : CPO April, 1972

III-5 Outline of Experimental Farms operated under Foreign Aid

Of the 8 experimental farms inspected, 4 were operated under the UN aid, 1 by East Germany, 1 by U.S.S.R., 1 by West Germany and 1 by foreign national. Cf. Table 8. Those operated by U.S.S.R. and East Germany were the largest in scale and were more like model farms than experimental stations. Others were experimental farms where comparative studies of various products other than fruit trees and fertilizer test were being conducted. They all had wells of varying sizes, and with the exception of the farm operated under the East German aid where pipes were used, all the others had open flumes for irrigation.

The team was informed at an individually operated farm in Tihama that 1 ha. of arable land in the neighborhood of the farm cost 7,000 riyals (about 420,000 yen) while the cost of digging of a well was 10,000 riyals (about 600,000 yen).

Table 8 General Conditions of Experimental Farms

Farm	Location	Year of establishment	Area (ha)	Number of experts (person)	Irrigation facilities	Description of research and tests
West Germany	SANAA	1964	4	5 (W. German)	Pump, open flume	Comparative study of various crops. Fertilizer test Rearing of vegetables
UN experimental farm (Middle Highland Project)	TAIZZ	-	27	1	Pump, open flume, wadi, reservoir	Test on the effect of irrigation on 50 farm products Comparative study of wheat crops
UN experimental farm (Plateau Project)	IBB	1969	7 5	6 (Experts in various fields)	Pump, open flume, wadi	Comparative study of various crops Fertilizer test Good results on raiging potatoes Highest production of wheat crops reaches 4t/ha Rearing of wood's trees
UN experimental farm (Wadi Zabid Project)	ZABID	1968	34 8	6 (Experts in various fields)	Pump, open flume, wadi	Irrigation of cotton fields, fertilizer test Comparative study of tobacco varieties (Good results by Virginia origin) Seasonal changes in water levels of 31 wells having different depths (150 - 200 - 300 - 400 - 500 m)
USSR model farm	HODAYDAH	1965	1,000 (existing) 800 (preparation) 10,000 (plan)	14 (Russian)	Pump, open flume, wadi (max scale in Y A R)	Large-scale cultivation of cotton Problem remains for irrigating method for such large units of farm fields as 50 - 75 ha. in area Rearing of vegetables in the field of 1 ha
East Germany experimental farm	HODAYDAH	-	300	5 (E. German including a managing expert)	Pump, water supply by pipe under ground with pressure	Large-scale cultivation of grains such as cotton, sorghum, Indian corn, etc Comparative study of crops and fertilizer test to some extent
UN experimental farm (Lowland project)	HODAYDAH	-	350 (25 at present)	5	Pump, open flume	Comparative study of various crops. Great emphasis is placed on cotton farming
Individual's farm	HODAYDAH	-	50	Amanager and many farmers	Pump, open flume (3 wells)	Cotton (3-crop raising) Tobacco (drying on the ground, domestic seed production) Vegetables (mostly water melon) Sorghum (3-crop raising)

Following is an outline of agricultural extension service with the aid from West Germany.

This program which started in 1961 was suspended in 1967 - 1969 because of the war and was resumed in September 1969. Its objective was to increase Yemen's agricultural production by 10%. Principal projects under this program are as follows:

A) Comparative test of variety of crops, with results as shown in Table 9.

Table 9 Comparative Test Result of Crop Variety

Product	Variety	Yield of local variety (kg/ha)	Yield of imported or selected (*) variety (kg/ha)	Increased yield ratio (%)
Indian corn	Kenyan Hybrid (KSCI)	4,100	8,100	97
Indian corn	Local variety	3,600	4,100*	12
Wheat	Mexpak variety (S216)	3,940	6,800	73
Potato	Grata	14,320	35,270	146
Potato	Wanda	14,320	29,960	109
Onion	Early Yellow	16,820	23,350	39

Source From Preliminary Project Report 9. 1971 of German Technical Assistance to Yemen Agricultural Extension Service in SANAA.

B) Fertilizer test on various crops, with results as shown in Table 10.

Table 10 Fertilizer Test-Result on Various Crops

Product	Variety	Yield with non-fertilizer (kg/ha)	Yield in fertilized area (kg/ha)	Kind of fertilizer N : P: K	Increased yield ratio (%)
Indian corn	Kenyan Hybrid (KSCI)	6,900	7,600	65/50/40	10
Onion	Early Yellow	15,900	23,350	80/80/50	47
Onion	Yemen Red	10,100	16,820	80/80/50	67
Barley	Local variety	3,360	5,300	60/50/60	58
Wheat	Mexpak variety (S216)	4,180	6,800	60/50/40	73
Wheat	Syrian variety	2,290	4,370	60/50/40	50

Source From Preliminary Project Report. 9. 1971 of German Technical Assistance to Yemen Agricultural Extension Service in SANAA.

C) Well drilling

Water is the first and most important element for Yemen's agriculture. By inviting a foreign expert and importing two machines, seven wells were dug beginning in March 1970.

D) Distribution of fertilizer.

Since the effect of fertilizer on the production is great, this program was launched in April 1970 with two experts assigned to take charge. Between March 1970 and May 1971, 4,500 tons of fertilizer was distributed in close cooperation with the UN's experimental farm.

E) Other activities.

Demonstration farm, improvement of seeds, extermination of blight and pests, mechanization of agriculture, compilation of meteorological data, cultivation of vegetable seedlings, distribution of seedlings. Total aid fund is 4,468,995 riyals (about 270,000,000 yen); and on the staff are 5 German nationals and 51 natives, for a total of 56 members.

III-6 Problems Related to Agriculture Development Program

III-6-1 Supply of food

There is a fundamental shortage of food in Yemen. It is estimated that there is an annual shortage ranging from 200,000 to 300,000 tons in the grain supply. The situation is worst in years of light rainfall; in 1969, for instance, there was a serious drop in the harvest because of drought. To meet this situation, 120,000 to 130,000 tons of wheat and wheat flour is imported each year. As a basic solution to the problem of food shortage, the overriding need is of course to secure sufficient irrigation water for farming. In addition, such measures as the reform of land ownership system, improvement of seed and cultivation techniques, establishment of agricultural extension centers, establishment of a distribution system for farm products, establishment of an agricultural college and training of students abroad under scholarships will also be necessary.

III-6-2 Promotion of agricultural production for export.

The Yemen Arab Republic is said to have a trade deficit of 30,000,000 dollars annually, most of which is covered by foreign aid and remittances from emigrants working abroad. As no promising mineral resources have been explored to date, there is an urgent need for promoting production of exportable farm products which account for a larger part of the income from exports. Such a measure, however, should be taken only after the domestic demand for food has been met satisfactorily.

Institutional reforms will probably have to be done through administrative measures, but securing irrigation water for farm land and training of agricultural experts are most urgent.

1) Water shortage is of course due to light rainfall in the country. In the mountain region, especially in the southwestern part of the country, however, the rainfall is said to be as much as 500 - 800 mm. and it is important to make effective use of this rain water. At present only about 50% of rain water is said to be in use. To improve this situation, construction of small dams and underground reservoirs should be considered. For this purpose, however, detailed surveys of topographical and geological conditions are indispensable, which will no doubt require a huge investment.

2) As regards the training of agricultural experts, it is obvious that the improvement of crop varieties and cultivation techniques through training of farmers can bring about tremendous increase of yield. The most effective means will be to station native agriculture experts widely in all farming villages. To that end, it is desirable to set up a training center at each experimental station.

III-7 Conclusions

The Yemen Arab Republic, situated in the part of the Arabian Peninsula which is blessed with fertile soil and warm climate, was known as Arabia Felix in ancient times. It is said that in the plateau region in the eastern part of the country, farming was practiced on a wide scale in the pre-Islam age when there was a large dam at Marib.

Agriculture is still the key to the nation's economy today. Nearly 90% of the population are farmers and they are said to be the most industrious and reputedly experts in making use of their limited land and water to their best advantage as exemplified by the terraced farms (Teracea) developed in the Central Mountain Region. Much to be regretted from the standpoint of the nation's agriculture is lack of adequate water and absence of an organization for adopting modern farming technique. If these two shortcomings are corrected, it is certain that Yemen's agriculture backed by the diligence of farmers will not only make the country self-sufficient in food supply but will also earn sufficient foreign currency through export of farm products. It is concluded therefore that there is every indication that agriculture will play a key role in the development of the Yemen Arab Republic as a modern nation.

IV. GEOLOGICAL FEATURES AND MINERAL RESOURCES

IV-1 Topography and Geology

The Yemen Arab Republic is situated in the south western part of the Arabian Peninsula, and according to its topography it may be divided into four main sections; namely, a coastal plain known as Tihama, a steep mountainous belt in the center, a high plateau to the east and a desert area that stretches farthest east.

Tihama, the coastal plain, faces the Red Sea and is the western rim of the Yemen Arab Republic; it is from 30 to 50 km. in width and stretches north-south for some 400 km. to the border of the Kingdom of Saudi Arabia. This section, geologically consisting of Red Sea graben covered by younger sediment, may further be divided into two parts: 1) this part is made up of Tertiary and Quartanary marine deposits, most of which is covered by earthly aeolian deposits and has the appearance of a desert; 2) the other part located along the mouth and drainage basin of the principal Wadi consists of thick layers of delta and fan deposits of the kind that is found along the border between the coastal plain and the mountainous belt.

There is virtually no surface water in the Tihama coastal plain. But along the border between the regions under paragraphs 1) and 2) there are numerous springs; and there is subterranian water along the principal Wadi and many wells exist there.

Central mountainous belt: While the western rim of the Arabian Peninsula faces the Red Sea, the mountain range located some 100 km. inward from the coast forms a watershed, with the principal rivers on the west side flowing into the Red Sea and those on the east side emptying into the distant Persian Gulf. The west wing of this mountainous belt facing the Red Sea is very sharp in contour and appears to be erosion of its mature period.

Plateau region: This region, lying east of the mountain range, is largely made up of gently sloping hills which get lower and lower toward east and finally transforms into a desert. The principal Wadi in this region are generally broad, and trees and shrubs are to be found in their basins.

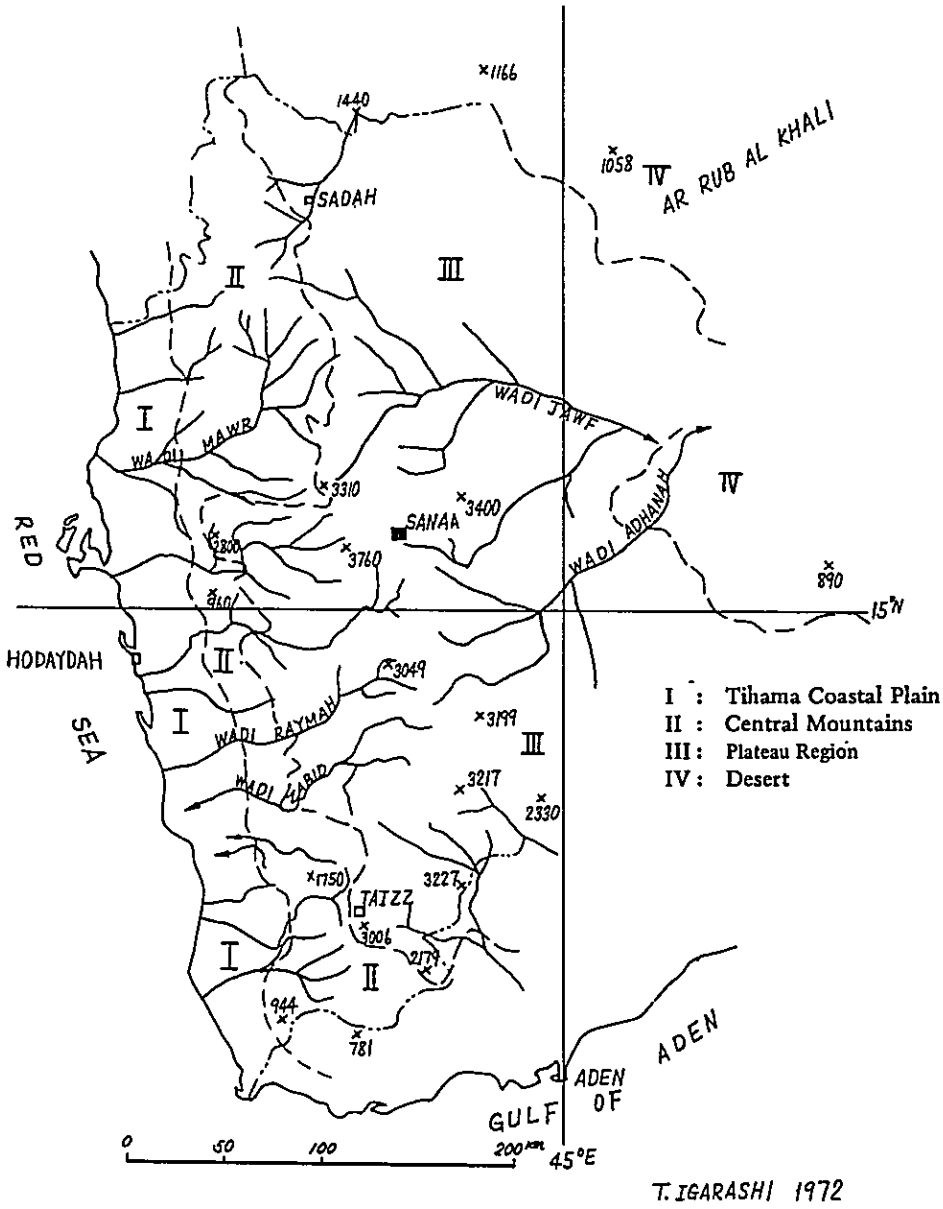


Fig. 4 Topographical Division and Principal Rivers of Y.A.R.

Desert region: The eastern part of the Yemen Arab Republic is a vast desert stretching as far as the border of Ar Rub Al Khali. Greater part of the coastal plain of Tihama also consists of earthly aeolian deposits and has the appearance of a desert.

Principal rivers: As the Yemen Arab Republic is largely made up of mountain ranges and plateau regions, the country abounds in numerous rivers. While most of them, called Wadi, have water running through them during the rainy season, their beds become dry during the dry season. The mountain range located approximately 100 km. to the east of the Red Sea forms a watershed. The Wadi on the west side of the watershed are fast flowing rivers that disappear in the Tihama coastal plain and reappear as wide rivers that empty into the Red Sea. The largest of these is Wadi Mawr. Its basin covers an area of approximately 7,650 sq. km., of which about 7,000 sq. km. is in the mountainous region. The annual rainfall in this basin is estimated at about 500 mm., so the total annual rainfall is expected to reach as high as 3,500,000,000 tons.

On the other hand, the principal rivers that flow eastward from the mountain range and disappear in Ar Rub Al Khali are Wadi Al Jawf and Wadi Adhanah. Another river, Wadi Bana, flows southward into the Gulf of Aden. As these three rivers all flow through highland areas, they have numerous tributaries; and the relatively wide canyons are being utilized for farming.

IV-1-1 History of Geological Studies in the Yemen Arab Republic

This Republic, located in the south western part of the Arabian Peninsula and known as "Arabia Felix (Happy Arabia)", was for a long time a land shrouded in geological mystery. Prior to this century, no geological observations had been made in this country.

The first geological survey is said to have been undertaken in 1912 during the Turkish occupation by George Botez along the Hodaydah-Sanaa road. Later in 1923, Pierre Lamare traveled through the central and southern sections of Yemen collecting topographical and geological data and formulated a provisional geological classification. Several years later Carl Rathjens and Herman Von Wissmann obtained permission to

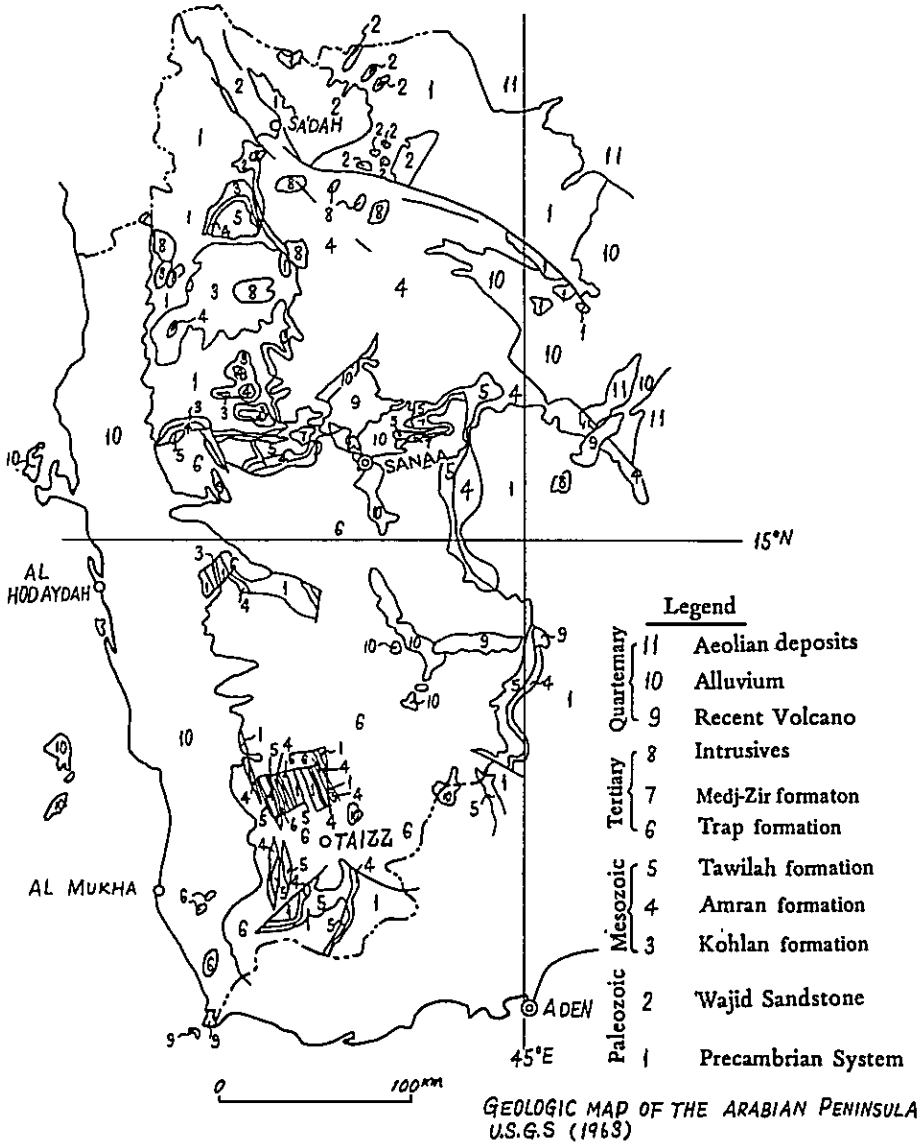
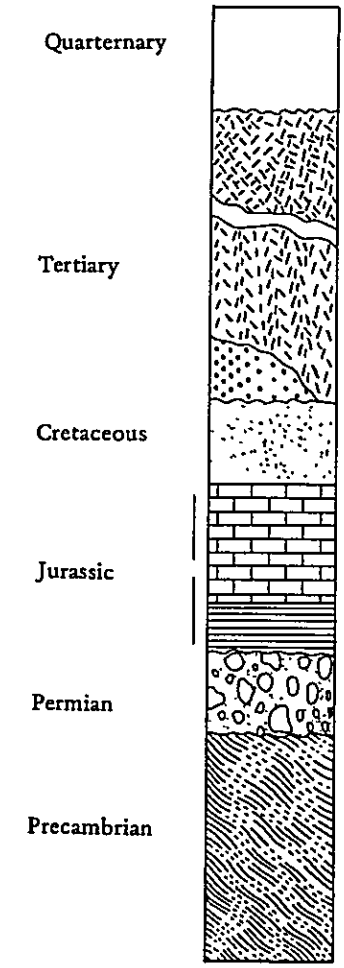


Fig. 5 Geologic Map of Y.A.R.



Geologic age	Gologic Formation	Mineral Resources
Quarternary	Alluvium Aeolian Deposits Recent volcano	Monazite sand Sulphur
Tertiary	Trap formation (1,200 m.) Andesite Basalt Rhyolite Tuff	Building stone Coal
	Medj-Zir formation (120 m.) Conglomerate Sandstone	Rock salt Gypsum (Sulphur)
Cretaceous	Tawilah formation (200 m.) Conglomerate Sandstone Shale	Iron Titunium
Jurassic	Amran formation (300 m.-) Shale l Limestone Sandstone	Limestone Gypsum (Petroleum)
	Kohlan formation (100 m.) Conglomerate Sandstone Shale	Hematite
Permian	Wajid sandstone (200 m.) Sandstone Conglomerate	
Precambrian	Precambrian rocks Gneiss Granites Crystalline Schist	Copper Zinc Gold Silver Graphite Mrble Iron sulfide

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Fig. 6 Geologic Column of Y.A.R.

conduct geological surveys which they carried out in 1927-28, 1931, 1934 and 1937-38; and in so doing, they completed the survey which was started by Lamare in the Hodaydah-Sanaa-Taizz region.

Still later, geological surveys in the triangular area of Hodaydah-Sanaa-Taizz were conducted by K. Fricke (1953), T. Lipparini (1954) and H. Karrenberg (1956). And as a part of the United Nation's technical aid program, F. Geukens (1966) conducted surveys in 1953-54 and 1954-55 not only of the abovementioned triangular area, but of other places as well.

The abovementioned surveys were concerned mainly with geological features and rocks and were made mostly along the routes traversing the triangular area. But in 1961, prior to the civil war, a six-men group headed by a geologist of Sweden's Bolden Mining Company conducted a survey centering on mineral resources over a period of five months. Unfortunately, that project had to be suspended because of the civil war. In 1966 U.S.S.R. sent a survey team to the Yemen Arab Republic, but nothing is known about the purpose or the results of the survey.

In August 1968 the Geological Research Center was set up in the Ministry of Public Works which gave impetus to the exploration of oil and mineral resources.

In April 1969 a visit to Yemen by a survey team from Algeria resulted in the establishment of a state policy company known as YOMICO (Yemen Oil and Industrial Company) whose object was to explore oil and mineral resources in Yemen; and its operations are still continuing today.

In 1969 the Technical and Scientific Development Corporation of the United Arab Republic despatched a survey team to study the Hamura copper deposit south of Taizz. In May of that year geological experts from the United Nations were also sent to Yemen for the same purpose. And a month later came an Italian survey team which surveyed the Bany Hoshysh area and is said to have shown keen interest in its coal and marble deposits.

In 1970 the Stroj Export Prague Geological Group of Czechoslovakia, under contract with YOMICO, sent an 8-men team (4 geologists, 4 investigators) for a period of three months to investigate mineral resources principally in the southern part of the Yemen Arab Republic. This team, too, attached the greatest importance to the copper deposit of Hamura.

In 1971, the geological survey station of France (B.R.G.M.) located in Jeddah had two of its geologists carry out a general survey of Yemen. However, the report they submitted to the Ministry of Petroleum and Mineral Resources (BRGM Report, JID 71-19) of the Kingdom of Saudi Arabia is little more than a summary of the report compiled by F. Geukens and hence contains nothing new.

All of the above surveys were fragmentary and general nature.

IV-1-2 Outline of Geology in the Yemen Arab Republic

The Yemen Arab Republic is situated in the southern part of the Arabian Peninsula, between the southern part of Saudi Arabia and the People's Republic of Southern Yemen, and as a result, it appears to have a combination of the geological features of these two neighboring countries.

The oldest stratum forming the foundation is made up of gneiss, crystalline schist and granite and is known as the Precambrian system; this stratum extends all the way from the south western edge of Saudi Arabia to Yemen. Distribution of this Precambrian system shows two major trends; it has intermittent exposures in the central mountainous region with the southern most part stretching from Taizz to southern Yemen, while to the east of Thamar it shows exposure in large areas.

Stratum overlaying the Precambrian system in the north is the Wajid Sandstone Bed which seems to be of the Permian system; and above that are found Kohlah formation of Lower Jurassic system, Amran formation of Upper Jurassic system, Cretaceous Tawilah group and Paleogene Tertiary Medj-Zir formation. In addition, the country is covered largely by the Trap formation which consists of rocks and other substances produced by volcanoes that were active from the end of the Cretaceous period to the

Tertiary. In the central and southern parts of the country there are many volcanoes that are still active today.

Violent volcanic activity that took place from the Tertiary period to the present day has formed a tremendous stratum of lava and tuff in the mountainous and plateau regions and therefore the geological characteristics of these regions are very similar to those of Southern Yemen. Plateau basalt, a product of volcanic activity that took place in Saudi Arabia from the Tertiary period to the present day, is different in nature from that found in the Yemen Arab Republic.

IV-1-3 Precambrian System

The oldest rocks found in the Yemen Arab Republic belong to the Precambrian system and are highly metamorphosed; but as the structure is very complicated, they have not yet been subdivided.

As indicated in the Geologic Map of the Yemen Arab Republic (Fig. 5), Precambrian system has intermittent outcrops along the central mountainous region and is in relatively wide distribution around Baydah to the east of Thamar.

In Wadi Akwam in the upper reaches of Wadi Najran near the border of Saudi Arabia, the Precambrian system interbeds a stratum of marble (limestone); and titanium ore is said to occure at points where this marble contacts gabbro intrusive.

In the north western area of Sanaa, there are large quantities of pyrite disseminated in the sericite schist, as well as dark colored quartzite.

Along the route from Rada to Al Bayda, there seems to be a layer of highly metamorphosed rocks (gneiss, mica schist, quartzite), a part of which consists of granite intrusive. In the Fadha area of this region, there are copper deposits that were mined more than 2,000 years ago. It is known, moreover, that there are signs of promising copper deposits in the metamorphosed rocks in the area south of Taizz.

IV-1-4 Sedimentary Rocks

A) Wajid sandstone: It is widely distributed throughout the Najran region of Saudi Arabia; and in the Yemen Arab Republic this stratum overlays the Precambrian system in the area northward from Sadah. In Saudi Arabia, limonite bed is frequently found underlying the Wajid sandstone. In the Yemen Arab Republic however, there has been no report on the discovery of such deposit.

B) Kohlan formation: This is a lower Jurassic stratum discovered P. Lamare and C.A. Carpentier (1932) which is distributed in the mountain region south west of Sanaa.

There has been a report to the effect that irregularly concentrated deposits of hematite have been discovered near Wadi Nasim in the upstream of Wadi Surdud.

C) Amran formation: The highland region of northern Yemen is made up of calcareous rocks which P. Lamare called as Amran formation in 1930. As a common feature it contains a thick layer of calcareous rocks and in some places, it also contains conglomerates at the base, as well as green and purple shale beds mixed in between. This formation is believed to be marine deposits formed by fossils of the Upper Jurassic period.

D) Tawilah formation: This formation which has a thickness of 180 m. was so named by Geukens in 1966; it is made up principally of white sandstone.

E) Medj-Zir formation: The stratum which has conglomerate at its base and overlays Tawilah formation is called Medj-Zir formation; it is about 120 m. in thickness. Fossils have been found in this stratum, and the fact of its having been formed in the old Tertiary period has been confirmed.

IV-1-5 Volcanics

A) Trap formation: South-western part of the Yemen Arab Republic which

constitutes nearly a quarter of the country's total area is overlayed by volcanics known as Trap formation. It is composed of such volcanics as basalt, andesite, trachyte, tuff and tuff breccia and is presumed to have a maximum thickness of 1,200 m.

In the early part of Trap volcanic activity there were periods in which the volcanes were inactive; during such periods non-volcanic deposits called Inter-Trap deposits which were characterized by terrestrial sediments containing large quantities of fossils were formed. In Jabal Rijam which is located 20 km. east of Sanaa, thin coal beds are found in the Trap formation; and as similar coal beds are said to exist near Taizz, the existence of such coal beds may be called a typical example of Inter-Trap deposits. Judging from the fossils found in these deposits it is presumed that the Inter-Trap deposits were formed between the Oligocen Age (from 37,000,000 to 25,000,000 years ago) and the Miocene Age (from 25,000,000 to 12,000,000 years ago).

B) Recent volcanoes: Volcanoes are still active in Yemen today. It is true that none of them is as large as those of the Trap period, but a few are of considerable size, like those found in Sanaa-Amran, Sirwah-Marib and Thamar-Rada areas. Besides, volcanoes of small scale are scattered throughout the contry.

In the course of the present survey the team was able to visit Jabal Al Lasi near Thamar-Rada where solfatara and hot springs were found in several location, which fact led to the conclusion that one of the latest volcanic activities in this country is to be found in this region.

IV-1-6 Geologic History of the Yemen Arab Republic

Precambrian rocks constitute the geological base of the Yemen Arab Republic. By comparison with Saudi Arabia, the Precambrian system of the Yemen Arab Republic has been subjected to a high degree of degenerative action and may be ranked with the Hali schist formation which is believed to be the oldest Precambrian system estimated to have been formed some 1,000,000,000 years ago. Later in the Permian Age (280,000,000 to 225,000 000 years ago) the northern Yemen was a shallow sea area which gradually transformed into a coastal plain where Wajid sandstone accumulated and again built up a land.

Northern part of Yemen began to sink again in the early part of the Jurassic Age and became a shallow sea accumulating Kohlan formation. Submergence of land expanded to the whole country, and because of the torrid climate limestone rocks began to accumulated, thus turning part of the country into bays or lagoons where evaporites were formed. This was the Amran formation of the Upper Jurassic period (from 190,000,000 to 135,000,000 years ago).

Coming into the Cretaceous period (135,000,000 to 65,000,000 years ago) most of the northern Yemen turned into land. Central and southern regions remained as shallow seas and accumulated Tawilah formation. Toward the end of the Cretaceous period, Alpine orgenic movement (Mediterranean, Himalaya, Circum Pacific area) was accompanied by the first stage of the formation of the Red Sea which separates Arabian Peninsula from the continent of Africa; and by that time volcanic activity around Yemen had started. However, there were no great movements of the earth crust prior to the Oligocene Age.

In the Miocene Age, vast changes were taking place. The Red Sea was formed, completely separating Continental Africa and the Arabian Peninsula. At the same time huge tectonic lines (fault) were formed about 40 km. to the east of what is now the Red Sea. Sudden upheavals took place on the east side of this fault, accompanied by a violent volcanic activity. As a result, volcanics of tremendous thickness called Trap formation covered the central and south Yemen forming the central mountain range, while the graben on the west side of the fault developed into the long and narrow coastal plain of Tihama.

IV-2 Mineral Resources

IV-2-1 History and Present State of Exploration

According to a legend, King Solomon is said to have explored mineral resources vigorously in various parts of Arabia and Africa. There still exist old mines in the Yemen Arab Republic which are said to have been worked more than 2,000 years ago.

With the sole exception of rock salt, however, no major attempts have been made since then to develop the underground resources of this country.

As stated previously, most of the geological surveys conducted in this century have been fragmentary and of basic nature. Even the survey made by F. Geukens in 1966, which is considered to be the most complete, made no reference to mineral resources.

Exploration carried out as a general survey of mineral resources was that conducted by the 6-men team of experts despatched by Boliden Mining Company of Sweden just before the civil war in 1961. Field studies were made principally of metalic mineral reources in areas where Precambrian system was distributed. No surveys were made during the period of the civil war.

In May 1969 Yemen and Algeria jointly set up a national policy corporation called Yemen Oil and Mineral Industrial Company (YOMICO) for the purpose of conducting joint exploitation of oil and mineral resources. This corporation is conducting extensive geological surveys in its search for mineral reources in areas of Precambrian system around Taizz, as well as the Precambrian system in and around Al Baydah and other regions that are of interest from a geological point of view.

In the coastal plain of Tihama, YOMICO is conducting a geological survey and drilling in an effort to explore oil resources. The above is a brief history of the mining industry in the Yemen Arab Republic. At present, the rock salt mine located in Salif is being developed but its future cannot be said to be very promising.

IV-2-2 Metallic Mineral Resources

The occurence of metallic minerals in the entire Arabian Peninsula is not known definitely yet. Discussion, therefore, will be limited to what has been known from the past survey reports and the findings of the survey team.

There are no accurate topographical maps of the Yemen Arab Republic available nor are the reliable data. In order to maintain up-to-date information and data, it is

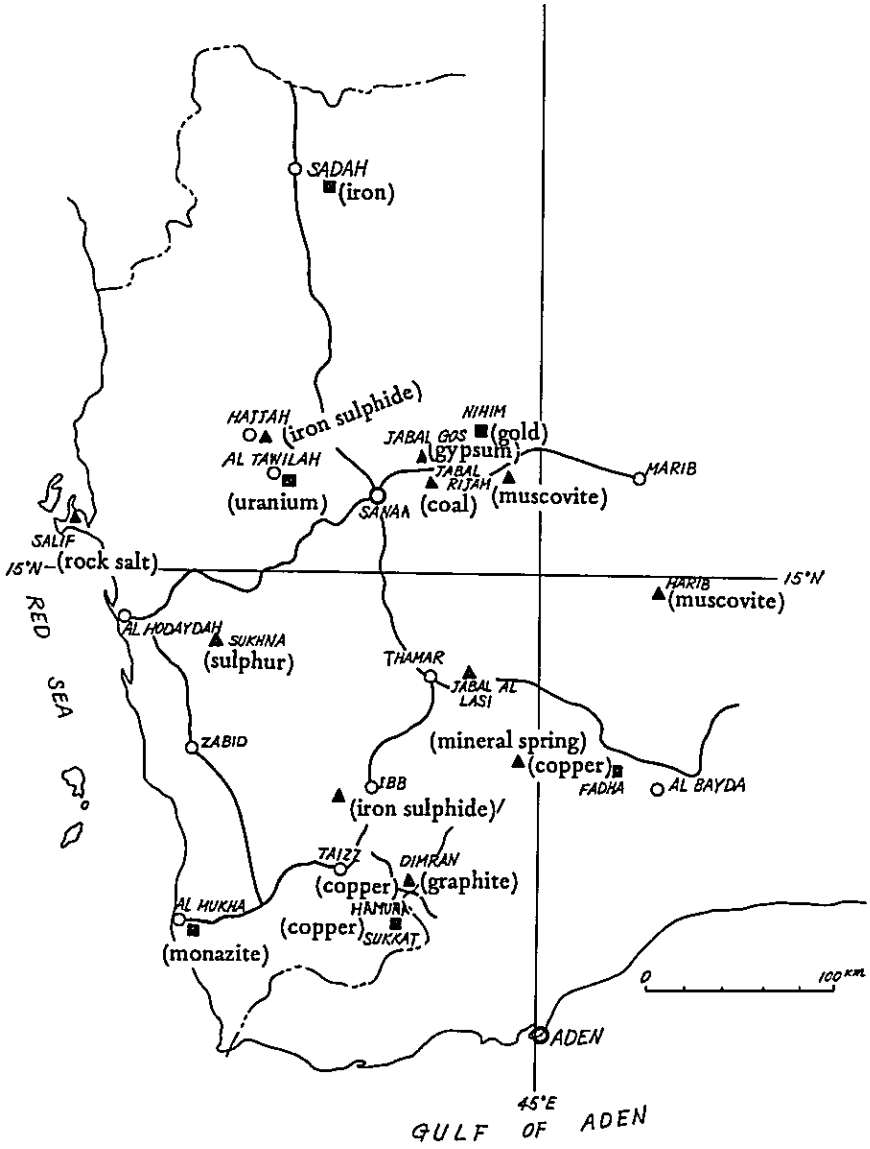

Fig. 7 Main Mineral Occurrences in Y.A.R.

advisable that a special agency composed of experts in various fields be set up within the government of Yemen for the purpose of constantly collecting data and updating the same.

A) Hamura copper deposit: Approximately 50 km. south of Taizz on the route to Aden is Rahedah (about 15 km. north of the border of south Yemen). Turning to right there and after traveling on the route leading to Hayfan over a distance of about 8 km, one reaches Jabal Hamura. From there the said mineral deposit is only one kilometer on foot.

The geology of this region consists of gneiss, biotite schist, amphibolite and migmalite, and has a general strike of N 30° E and dips southward.

The outcrop consists of limonite gossam, with strike of N 15-30° W and a dip of 60-75° SW. The veins are 10-12 m. wide with each extending 100-120 m. in length; they are exposed over a distance of 900 m. in north south direction.

The outcrop is made up of typical limonite gossam attended by such secondary oxide minerals of copper as malachite, azurite and chalcocite in the shape of dissemination or veinlet. In the joints of gneiss are found small quantities of chalcopyrite in the shape of dissemination.

Some scientific analysis of mineral ores have been made so far, but most of them, were concerned with spot samples of the secondary oxide minerals of copper. There have been no systematic samplings that covered mineral veins as a whole. Following are some of analysis examples.

Analysis in West Germany
Cu 15.27%, SiO_2 18 10%, Co_2 0.46% (June 4, 1970)

No.	Cu(%)	Soluble Cu(%)	Pb (ppm)	Zn	V(ppm)	Ni (ppm)	Co (ppm)	Cd (ppm)
1	13.0	0.65	20	-	400	300	100	70
2	17.1	0 60	20	-	100	300	100	-
3	17.4	' 9 40	10	-	60	300	100	30

(May, 1970)

Analysis in Ontario, Canada

2B 197,000 ppm (Total Cu)

3B 150,000

(April 7, 1969)

Analysis of the same sample in the United Arab Republic is said to have produced the following results.

2B 22.7% (Cu)

3B 22.8% (Cu)

At present the copper deposit of Hamura is the largest and most promising among the underground metal resources in the Yemen Arab Republic. Whether this can be mined economically at present, it is hard to say. It is considered essential to conduct the following on a continuous basis.

1) Field survey: Preparation of a topographic map (scale 1/2,000) and a geologic map based on detailed geological surveys; from these maps the occurrence and distribution of ore deposits should be determined.

2) Geochemical survey: On the basis of the above two maps, a traverse should be drawn and a geochemical prospecting should be attempted for Fe, Cu, Zn, Pb.

3) Drilling: By studying the consolidated results of the above detailed survey and of the geophysical and geochmical prospecting, occurrence of ore bodies should be confirmed by drilling at the most promising locations. For the estimate of grade and size of the workable ore body, the most effective means will probably be to begin drilling so as to encounter the occurrence at a depth of 50-100 m. from the surface.

4) Investigations should be conducted to determine whether the mining could be put on a paying basis after making studies of ore dressing and transportation route and confirming that the size and grade of the deposits are

economically justified.

B) Sukkat prospect: This is located 3.5 km. SSE of the Hamura copper deposit and is an extension of the Hamura mineralized zone. It is 100 m. in length and about 12 m. in width, with a strike of N 35° W and is contained in crystalline schist. As in the case of Hamura, outcrop is limonite gossam impregnated with malachite; no primary copper minerals were found there. The vein appers to be interrupted by basalt dike. Such outcrops of limonite gossam are found all the way from Hamura to Sukkat and therefore a systematic prospecting should be conducted in the future.

C) Copper in the Hadha area (Taffah--Al Ghelle): In the Hadha area which is not far from Al Bayda in the south eastern part of the Yemen Arab Republic, numerous copper-quartz veins are found in Precambrian system; a part of it is said to have been mined more than 2,000 years ago.

The quartz veins are found along a mineralized zone which extends over a distance of 25 km., but the individual veins vary greatly in both length and width. While most of them have a length of several hundred metres and a width of 1-1.5 m. in places, there are some veins that are only 1 cm. wide and 10-20 m. long. The largest vein was 700 m. long and 0.2-1.5 m. wide. While mineralization of copper is seen along the entire length of these veins, they vary greatly in copper content which ranges from less than 1% to more than 10%. The copper minerals in quartz veins are primary chalcocite and secondary mineral malachite.

A large vein between Fadha and Al Ghelle is said to have been mined over a distance of approximately 260 m. Part of the vein was mined by open cut method and pits of 20-30 m.deep are said to exist in part. At present, however, it is impossible to enter these pits which have a width of 1 to 2 m. The vein itself is only several tens cm. in width and it seems that no rich ores existed along its entire length of 260 m.

Although the copper containing veins were limited to copper-quartz veins, some were slightly of pegmatitic character.

In addition, there are calcareous veins (calcite, siderite) containing various skarn minerals. These calcareous veins were limited to areas within a radius of 400-600 m.from granite masses.

Some of the copper-quartz veins were rich in copper content, being as high as 15% Cu; but the grade was comparatively low. Below is a table of analysis.

Test No.	Cu (%)	Au (ppm)	Ag (ppm)	S (%)
1	2 70	0.3	19	1.3
2	2.58	0 6	4	0.2
3	2 93	0 2	20	0 9
4	1 09	0 1	2	0 6

For the deposits of this type, large ore reserves and high grade are the first requirement. Unfortunately the deposits found here were lacking both and therefore, the possibility of their being exploited commercially is very questionable.

D) Metallic resources in North and Central Yemen

1) Iron in Sadah area: There has been a report to the effect that concentrations of hematite often exist at the base of lower Jurassic-Kohlan formation. The iron deposits in south Sadah seem to be of the same kind but the report says the bed is irregular and thin and of little economic value.

It is also reported that there is a deposit of quartzite containing magnetite found in Precambrian rocks which are distributed in areas to the west of Sadah; but there is no definite information concerning its existance, not even as to its location.

There is also a report that there is a deposit of ilmenite ore in the Precambrian rocks found in the drainage basis of Wadi Akwan to the north of Sadah, where gabbro and limestone come in contact; but no definite information is available.

2) Gold and silver in Nihim region: There is a report to the effect that in Nihim located several tens km. to the north of Sanaa there are gold and silver deposits that were mined in ancient days.

3) Concerning uranium: In 1966 after the revolution the U.S.S.R. carried out geological surveys and are said to have detected traces of radiation. Nothing is known as to its exact location but it is believed to be somewhere near Tawilah. If such is the case, there is a strong possibility that it exists in the conglomerate or sandstone at the base of Kohlan formation (Jurassic) or Tawilah formation (Cretaceout) which accumulated unconformably in the upper part of Precambrian system.

Because of the limit of the field observation by the team both in area and time, it was impossible for the team to visit the said site. The degree of radiation based on the findings of the team is given in the following table; no unusual radioactivity anomaly is observed.

Medj-Zir F sandstone	0 02 - 0.025 mr/h
Amran F calcareous sandstone	0 01 - 0 015 mr/h
Jabal Rijam coal bed	0.02 - 0.025 mr/h
Trap F. andesite	0.003 - 0.005 mr/h
Trap F tuff	0.005 - 0.01 mr/h
Jabal al Lasi (rhyolite–obsidean lava)	0.02 - 0 03 mr/h

E) Monazite of Al Mukha: There is a report to the effect that there is a distribution of placer ore containing monazite in the area between the port of Al Mukha and Sheik Said. A survey was made of samples obtained from the dredging of the harbor and the result of analysis showed only a content of calcareous character with almost no trace of heavy minerals.

Analysis of sample placer ore which is rich in heavy minerals found near Salif showed that it contains some magnetite and ilmenite, with the rest being

mostly pyroxenes; no useful minerals were found. There is need to obtain more information concerning placer ore of this type.

IV-2-3 Non-metallic Mineral Resources (Industrial Minerals)

It seems that the Yemen Arab Republic is blessed with mineral resources as far as industrial mineral resources are concerned. They include rock salt which is its sole export mineral and such promising minerals as gypsum, sulphur, iron sulphide, graphite, limestone and coal. As it is the fate of industrial resources to be affected by ups and downs of domestic industry, their development as an export industry must be considered by providing it with specially favorable conditions.

A) Salif rock salt mine: Salif is located 60 km. NNW of Hodaydah along the coast of the Red Sea, opposite the island of Kamarane in Southern Yemen territory.

Near Salif are found sedimentary rocks which are believed to belong to the Oligocene age (in the central mountain region the Medj-Zir formation is also composed of sedimentary rocks of the same geologic age, but no accurate comparison has been made as yet) and are composed of limestone, dolomite, rock salt and gypsum which were accumulated in that order, and this is a typical formation made up of evaporite.

The rock salt deposit of Salif is too flat to be called a dome; and while its overall configuration is not known, it seems structurally to lie slightly below the surface along an anticline axis. While the thickness of the rock salt deposit has not been confirmed, it is said to be as great as 300 feet (about 90 m.) at its center. The area of rock salt confirmed to date extends at least 297,500 sq. m., but the future drilling should prove the area to be even more expansive.

Rock salt is being mined in three open pits in the north, central and south parts of the country. At present, however, mining is concentrated in the central pit where the product consists of coarse grained halite is white or light gray in color, and it appeared to have no impurities such as orgillaceous; the

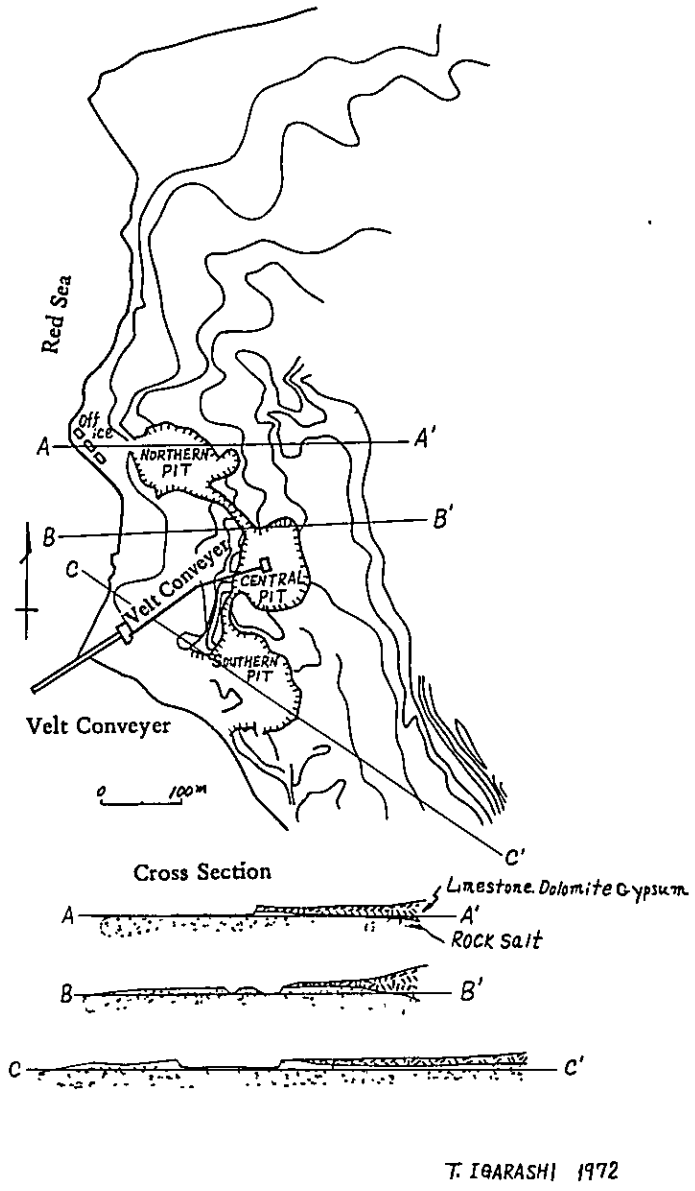

Fig. 8 Location Sketch of Salif Rock Salt Deposits

grade is uniform and stable.

No analysis table was available at the mining office; but the data provided by Lefond, S. J. (1969) show major and minor components shown in the table below:

NaCl	97.86%	$MgSo_4$	0.15%	$CaSO_4$	0.58%
KCl	0.33%	H O (-)	0.20%	H O (+)	0.79%
Total	99.91%				
Al	0.002% Ba Tr, Ca 0.2%, Cr Ti				
Cu	0.0001% Fe 0.006% Mn 0 0009%				
Ni	0 0002% Si 0.04%, Sr Tr, Ti 0.0003%				
V	0 0005%				

Mineralogically, the rock salt in question is made up almost entirely of halite (NaCl); and under the microscope the only impurity observed was anhydrite crystals which existed in small quantity.

While mining is being carried in the Salif region, no accurate estimate has been made on ore reserves. On the basis of available data, the reserves are estimated at about 40, 000, 000 tons. How much of it is workable reserves will depend entirely on the mining method employed.

The ore, after being run through the crusher and reduced to powder form, is carried by conveyor belt to the wharf and loaded on ships.

Present processing capacity of ores is 2, 000 tons per day, but the plant has never been operated at full capacity and was closed at the time of the visit by the team.

All the ore, with the exception of the portions for domestic consumption, is exported to Japan. Production to date following the resumption of mining in 1959 is as shown below.

Rock Salt Production

Year	Output (ton)	Year	Output (ton)
1959	100,000	1964	35,000
1960	100,000	1965	
1961	120,000	1966	85,000
1962	150,000	1967	100,000
1963	100,000	1968	85,000

The average annual production of rock salt from 1953 to 1957 was 100,000 tons (from Minerals Year-Book)

The Salif salt mine is operated by Salif Rock Salt Agency. This agency was established by joint investment by the governments of Yemen Arab and of United Arab with equal shares, but today it is 100% Yemen capital. During the past two years facilities were improved with loans from the World Bank and the Kuwait Government and productivity was greatly increased, but its operation is becoming more difficult by deterioation of market conditions.

Future questions will be : 1) development of markets and 2) reduction of production by cost increasing production through mechanization of operation. Mining problems are: 1) because of its proximity to the coast, mining operation will more further to below sea level as it progresses. The top of the deposit in the central pit is about 10 m. above sea level, and the deepest pit dug so far is located some 32 m. below surface. As the rainfall is very light in this area, there is no serious problem for drainage at present; but if production is to be increased further, drainage facilities will probably have to be provided. 2) Eastward from the open pit now being mined the over-burdened layer is gradually becoming thicker and mechanization of operation will be necessary.

B) Other rock salt deposits: Several rock salt domes are known to exist in the area bordering the Red Sea over a stretch of about 40 km. between Salif and Al Luhayyah. However, no study has ever been made as to their commercial value. Besides, test boring resulted in the discovery of a rock salt deposit in Az Zaydiyah about 40 km. west of Salif, but the deposit is said to have a very thin layer.

C) Gypsum deposit: As already mentioned, gypsum is found in mixture with the shale deposit in some portions of Amran formation in the upper Jurassic system. This gypsum in the form of fine crystalline granule and white in color is called Alabaster; gypsum of this type is found in several locations in Yemen. One such instance is the Alabaster observed in Jabal Al Gos (about 50 km. NE of Sanaa), which had a high grade exceeding 45% (chemical formula of gypsum is $CaSO_4 \cdot 2H_2O$; and grade is indicated as SO_3; and pure crystal is SO_3, 45%). Other known locations of gypsum deposits are in Anis, As Ser around Sanaa; and Wadi Djubey around Taizz.

Gypsum is used generally for manufacturing cement and building material in other countries. In Yemen it is commonly used as gypsum-plaster, and the full utilization of this high grade gypsum will probably be after the country's cement industry is fully developed.

D) Coal: Wadi Rijam is about 20 km. eastward from Sanaa, and Jabal Malah is located about 10 km. upstream. Geology in this neighborhood consists of andesite and tuff of the Trap formation; and in the mid-Trap formation located on the mountainside, there is a black shale bed accompanied by a thin coal bed. The coal bed here is 1-1.5 m. thick, but the size of this bed could not be confirmed. Similar coal beds are known to occur in Cherf of the Taizz region.

E) Sulphur: Jabal Al Lasi is a live volcano located about 22.5 km. east of Thamar. On the mountainside eastward from the village are many craters still exuding gas; and deposits of sulphur, gypsum and borates are found on the surface and in crevices. This sulphur deposit is very small in scale and is probably limited only to local use. Al Lasi volcano is made up mostly of

obsidian lava and pumice.

Sulphur occurs also in Sukhna located about 60 km. eastward from Hodaydah; it is presumed to be of sedimentary origin and has good quality.

F) Muscovite: At the Ministry of Public Works the team observed samples of muscovite 10-15 cm. in size which is believed to be pegmatite. The region where it occurred is near Harib located between Marib and Beida to the east of Sanaa and in Khawlan located halfway between Sanaa and Marib. As no survey data are available, details are not known.

G) Iron sulphide: Iron sulphide is a mineral from which sulphuric acid is produced; minerals used for this purpose are pyrrhotite (FeS) and pyrite (FeS_2). Exposure of Precambrian rocks occur along the Amran-Hajja-Taur route and along the Wadi east of Hajja (Wadi Shariss), quartzite and sericite schist with the dissemination of pyrite is distributed over a distance of several km. Judging from the high degree of dissemination and the size of the area, prospecting of this region is considered worthwhile. However, no useful mineral other than pyrite was observed.

H) Graphite: In Wadi Dimran about 8 km. SE of Raheda to the SE of Taizz, a paragneiss deposit containing flaky graphite has been discovered. This deposit has N-S strike with a 80° dip. The outcrop can be traced over a distance of more than 100 m., but the neighborhood is mainly farmland and the surface is covered with soil.

Graphite deposits of this type were observed in paragneiss deposits belonging to the Precambrian system in Yahni and Saueifa and further occurences will probably be observed in the future.

I) Other mineral resources of industrial use include raw material of cement, clay material and silica sand. While no survey data is available for these materials, surveys conducted as need arises will probably be sufficient to secure required production of these minerals. It should emphasised, however,

that these resources are of such nature that they can be developed only in keeping with the growth of domestic industry and that it is not practical to export them as primary products except in special cases.

IV-2-4 Petroleum and Natural Gas

Prospecting for petroleum and natural gas was being conducted by YOMICO at the time of the visit by the team, but neither petroleum nor natural gas fields that could be developed on a commercial basis had been discovered so far. The coastal plain of Tihama and the Ar Rub Al Khali desert show potentiality, but due to lack of basic survey data, considerable time will be required for prospecting.

IV-3 Conclusions

Discussion in this section will deal mainly with the present state of affairs related to the geology of the Yemen Arab Republic and various problems that must be tackled in the year to come.

IV-3-1 Analysis of present condition: It was in the latter half of the 18th century that geological science was separated from natural history and was established as an independent science. After experiencing a period which is represented by industrial revolution of England and in which society attached great importance to such underground resources as iron and coal, geological knowledge was accumulated and gradually came to be generally utilized. And today that knowledge has become indispensable as basic information in such fields as prospecting and mining of underground resources, city planning, water control, farmland development and civil engineering projects.

Since all surveys of the geological and mining conditions of the Yemen Arab Republic have been carried out by foreign experts so far, it is extremely difficult to make accurate evaluations of the situation of the Republic as a whole. Although the solution of the basic problems is indispensable, the two most important questions that should be given attention for the time being are as follows.

A) The Geological Research Center, Ministry of Public Works, which was established as a government agency, should be expanded so as to passess a combined function of the geological research agency and the ministry of mining like the ones which are found in other countries. The Center should be equipped with combined functions of geological research and mine administration and should be given responsibility for the palnning and implementation of projects. To that end, it will probably be necessary to invite a foreign expert of long experience as an advisor to the government, as well as several scientists to train native technicians.

B) Preparation of topographical maps: Such maps are basic materials which are indispensable not only for the study of the country's geology and mineral resources, but also for the country's overall development. No reliable topographical map has been prepared to date in this country it is said that English experts were to take air photos and analyze them in October of this year (1972). In order to make such topographical maps made from aerial all-purpose maps, it will be necessary to make tidal observations, leveling, astronomical survey, radio wave positioning and others.

The best results will probably be obtained by prompt implementation of the above two programs, followed by investigation and designation of key points and the planning of projects and their implementation.