International Atomic Energy Agency

IUREP N.F.S No. 90
September 1977
Distr. LIMITED
Original: ENGLISH

INTERNATIONAL URANIUM RESOURCES EVALUATION PROJECT

I U R E P

NATIONAL FAVOURABILITY STUDIES

SAUDI ARABIA

77-9195

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FIGURES No. 1 Index map for Arabian Shield Area

S U M M A R Y

Saudi Arabia occupies most of the Arabian Peninsula and has an area of 872,722 sq miles, or 2,260,350 sq km. The ancient Arabian Shield of igneous and metamorphic rocks comprises most of the western third of the country. The shield contains many extinct volcanoes surrounded by lava beds. Sloping eastwards are the newer sedimentary areas in which rich oil fields are found. In Saudi Arabia oil is paramount and less effort has been put into searching for mineral deposits than in other countries of similar size and geology. Four aerial radiometric surveys have been undertaken and some of the anomalies discovered in the earlier ones were ground checked by an IAEA expert in 1963-64. Two anomalies warranted more detailed work, these were the Jabal Said anomaly in the Central Shield area and the Al Ghrayyat in Wadi Sawawin about 70 miles from the Jordan border. The Jabal Said anomaly consists of a zone of altered rocks consisting largely of pegmatite and pegmatized granite.

Allanite, pyrochlore, cyrtolite, xenotime and monazite are the ore minerals. The deposit was estimated to have 2.2 million tons of ore grading 0.2 - 0.3 percent Nb_2O_5 and 0.03 - 0.05% U_3O_8. The other occurrence at Al Ghrayyat is similar but with much lower grade uranium content. In view of the huge size of Saudi Arabia, the existence of many geologically favourable rock types and the poor coverage by sophisticated uranium exploration techniques, the Sepculative Potential is placed between 10,000 and 50,000 Tonnes uranium.

A. INTRODUCTION AND GENERAL GEOGRAPHY

Saudi Arabia a kingdom of southwest Asia, occupies most of the Arabian peninsula. The kingdom is bounded north by Jordan, Iraq and Kuwait with two areas of neutral territory west and south of Kuwait; west by the Gulf of Aqaba and the Red Sea; south by Yemen, South Arabia and Dhofar (Dhufar); east by Muscat and Oman, Trucial States, Qatar and the Persian gulf. Its boundaries with Jordan and Yemen in part and with its southern and eastern neighbours have never been fixed. The total area is 872,722 sq miles (2,260,350 sq km).

Physical Geography

Saudi Arabia's coastline on the Gulf of Aqaba and the Red sea is more than 1,100 miles long; its Persian gulf coastline, though of undetermined length, is somewhat shorter. Neither side has deep natural harbours. Islands and coral reefs in the Red sea are numerous, particularly in the Farasan bank, which runs along Saudi Arabia's coast for over 300 miles. In the Persian gulf the ownership of various islands is in dispute between Saudi Arabia on one hand and Kuwait, Iran or Abu Dhabi (one of the Trucial states) on the other. A treaty signed in 1958 established a water boundary between Saudi Arabia and Bahrain.

Saudi Arabia's highest mountains are in Asir where peaks rise to over 9,000 ft. The mountains of Al Tubayq dominate the undefined border between Jordan and Saudi Arabia east of Aqaba. Southeast of Jabsl Shammer escarpments parallel the bulge of the shield, the most prominent being Jabal Tuwayq, 800 miles long from north to south. The Red Sea coast plains are narrow, whereas plains in the central and eastern regions sometimes stretch over great distances. In the north the Syrian desert reaches down into Saudi Arabia. The largest sand deserts lie east of the shield; the Great Nafud in the north and the Rub' al Khali (the Empty Quarter) in the south, connected by the Ad Dahna sand belt.

Climate

The Asir mountains constitute the only area in the kingdom receiving adequate rainfall. Virtually all the rest of the country is desert, apart from scattered oases fed by underground water sources or flash floods. Winters are cool, and spring and fall days are often agreeable, but spells of good weather are interspersed with gusts or storms of swirling dust and sand. The fierce summer heat, tempered by aridity in the higher regions of the interior, is aggravated along the coast by high humidity.

Transport and Communications

Difficulties of terrain kept the various regions largely isolated, with the camel as the chief means of transportation, until mechanical transport was introduced in the 20th century. The Hejaz railway, completed from Syria to Medina in 1908, was damaged during World War I and its Hejaz stretch abandoned in 1924.

After the unification of the kingdom, all areas were linked together by radio communications. Penetration of the interior by airplane became common after World War II; the principal cities were equipped with airports, and airlines brought the country closer to the rest of the world. In 1951 a railroad, 350 miles long, was completed to the capital Riyadh from the new port of Ad Dammam on the Persian gulf just south of the oil-shipping port of Ras Tanura. The government also built a modern port on the Red sea at Jiuda, the gateway to Mecca. Asphalt roads now speed pilgrims from Jidda to Mecca (45 mi.) and Medina (280 mi.), and other roads have been finished in the plan for a network of first-class arteries, which includes a transpeninsular highway. Even where asphalt is not laid, passable motor roads traverse the desert wherever necessary. A road paralleling Tapline leads to the neighbouring northern states of Jordan and Syria. There are still only 7,767 miles of road, only 1,560 miles of which are paved in this vast land. A pair of roads cross the peninsula and ring the northern third of the nations. No roads serve the south nor approach the "empty quarter" which occupies about the south third of the nation.

B. GEOLOGY OF SAUDI ARABIA IN REAATION TO POTENTIALLY FAVOURABLE URANIUM BEARING AREAS

The ancient Arabian shield of igneous and metamorphic rocks protrudes eastward from the Hejaz (Al Hijaz) into Najd (Nejd) as a bulge curving round from the Gulf of Aqaba to a point less than 125 miles W of Riyadh and then receding toward the southern Red Sea. The shield contains many extinct volcanoes surrounded by lava beds. Sloping eastward are the newer sedimentary areas in which rich oil field are found. The shield gives symmetry to Saudi Arabia's geography, as many escarpments and sand deserts follow its contour.

The Arabian shield acted as a cratonic stable block through most of geologic time. Today it crops out of, or is buried under sands and comprises most of the western third of the country. Marine platform deposits occupy much of the north while geosynclinal marine accumulations of over 20,000 feet occupy narrow troughs paralleling the Persian Gulf and Red Sea. Recent volcanic flows and cinder cones are superimposed upon the older rocks and attest to the affects of plate tectonics as the continents rift apart.

The physiographic character the country has been determined by recent rifting and tilting of the western portion of the peninsula acting as a deicrete block as explained by plate tectonics. The Red Sea coast has been tilted up so that the west coast is a high plateau 5000 feet above the Red Sea approaching 10,000 feet in places. This plateau slopes east to the Persian Gulf but even here scraps front the gulf.

Theepossibilities of finding new deposits in Saudi Arabia are considered good because of its sheer size. Deposits if found are likely to be veins or related discordant type, phosphorites or calcrete type.

C. PAST EXPLORATION

In Saudi Arabia, oil is paramount; and there is little likelihood of revenues from metalliferous deposits over equalling those derived from petroleum production. However, the Government of Saudi Arabia has, wisely decided to diversify its interests by seeking for mineral deposits in the Precambrian massif overlying the oil-bearing sediments.

Search by mining engineers in the years before World War 2 resulted in the opening of the gold mine of Mahad Dhahad (lat 23° 30 N, long 40° 52 E), and approximately one million ounces of gold were won before the mine closed down in 1954. Systematic geological investigations have been hampered by lack of suitably trained Saudi scientists, and by difficulties of recruitment of foreign staff; but the plan of evaluation of the mineral resources has been well conceived. Aerial photos on a scale of 1: 60,000 have been taken of the whole of the Western Shield; and mosaics prepared on scales of 1: 50,000 and 1: 100,000.

Mapping was undertaken by the geologists of the Arabian American Oil Company ("Aramco"), in post-war years, in collaboration with a team from the U.S., Geological Survey, and reconnaissance geographical and geological maps of the whole of Saudi Arabiaon a scale of 1: 2,000,000were published in 1963.

The next step was detailed evaluation of mineral prospects. Some 42,000 square kilometers of air-borne geophsical survey (magnetometric and radiometric) was accomplished by a firm of geophysical consultants in 1961-2, and isorads, isogams and flight paths were plotted on the 1: 50,000 mosaics compiled from the contact prints. The area surveyed though comprising only a small proportion of the Precambrian shield (approx. 7 percent), is sufficient to provide a fair sample of what may be expected from scientific prospecting of favourable regions.

A team of expatriate geophysicists and geologists was hired under contract to the Directorate, and a programme of detailed mapping of the mining fields commenced.

A large team of U.S.G.S geologists has recently amplified the original mapping, compiled maps on the scale of 1: 100,000, and examined more closely the economic propsects.

An IAEA field expert assisted the Government in its investigations of nuclear raw materials from June 1963 to June 1964.

In the 1950s and early 1960s technical assistance in uranium exploration was also received from US and French sources. Two contract aerial surveys (1962) were made over part of the Pre Cambrian shield on the western side of the peninsula. A substantial number of anomalies were found and most of them checked by the IAEA expert. Later, in 1965-66, Huntings Geology and Geophysics Ltd were contracted to fly a major regional radiometric and magnetometer survey over a 300,000 sq km area. Still, later, in 1974 the same company were contracted for consultancy work on uranium exploration and follow-up of an airborne spectrometer survey over sandstones fringing the Arabian Shield. The results of this later work in 1965-66 and in 1974 are not known in the IAEA.

D. URANIUM OCCURRENCES AND RESOURCES

1. The radioactive anomalies checked by the IAEA expert all pertain to the 1962 aerial surveys' which only covered 7 percent of the PreCambiran Shield area. The expert examined 40 anomalies on the ground and classified them into two groups;

Group I	Eleven anomalies of possible economic importance
Group II	Twenty-nine anomalies found to be of no direct economic importance.

Within Group I two anomalies warranted more detailed work, these were the Jabal Said anomaly in the Central Shield area at Aqiq Um ad Damar and Al Ghrayyat in the Wadi Sawawin area about 70 miles from the Jordan border.

Radioactive deposits of Jebel Said Area

(1) Historical Survey

The Jebel Said deposit was discovered in 1956 by H.E. Dr F K Kabbani in company with geologist M.I. Ahmad of the Pakistan Geological Survey. The deposit was discovered on the ground before air survey work commenced.

The discovery was made during the period of inflated uranium prices, and the possible economic importance of the deposit was realised, and a programme of diamond-drilling was put in hand. Three holes were drilled with a combined footage of 960 feet.

The preliminary follow-up workd was undertaken by the Australian Mineral Development Laboratories who reported, among other minerals, the calcium and rare-earth niobate, pyrochlore. Interest in the prospect as a possible source of niobium revived.

(2) Geology of Jebel Said deposit

The regional setting, and lithology of the country rock

The deposit occurs as a zone of north dipping pegmatite, and pegmatised and altered granite to the north of a red or pink unmetamorphosed alkalic to per-alkalic granite containing accessory fluorite, riebeckite, and aegirine. Age 535 ± million years from Rb/Sr isotope ratios.

The Jebel Said granite is light grey in colour. It is difficult to obtain a fresh specimen, and extensive kaolinisation of the feldspars has occurred. In hand-specimen, the rock is coarse-grained with quartz constituting about 60 percent of its mass. Some quartz is white translucent, and some is glassy transparent.

The lode zone

This consists of a north-dipping zone of reddish and altered looking rocks consisting largely of pegmatite and pegmatised granite.

The footwall is sharply defined, but the hanging wall is not seen, so that tonnage limits cannot be precisely calculated.

At the surface, the pegmatite veins commonly dip at angles within the rangee40-45 degrees; but diamond drilling showed angles of dip of the footwall contact of 29, 70, and 74 degrees.

Lode genesis and ore-minerals

Field relationships clearly suggest that the lode zone is formed as a result of injection of a late liquid portion of the adjacent granitic mass. This is likewise the origin of the thin, fine-grained, radioactive dykes which may be manifestations of the concluding stages of pegmatitic activity.

Ore-minerals are not macroscopically visible but the following have been determined by officers of the Australian Mineral Development Laboratories:

Allanite	-	rare earth epidote
Pyrochlore	-	niobate of calcium and rare earths
Cyrtolite	-	zircon with radioactive constituents
Xenotime	-	phosphate of yttrium and rare earths, trace only
Monazite	-	phosphate of cerium metals including thorium; trace only

Other introduced minerals of interest are fluorite and tourmaline, both of which indicate pneumatolytic introduction of material; rutile, sphene, and grossular garnet.

Assay Results of Surface Sampling 1957-8

The twenty samples assayed by U.S.G.S gave an arithmetical average of 0.048 percent U, or 0.057 percent U_3O_8. Weighting by sample widths gave 0.049 percent U.

(3) Economic appraisal and mining considerations

Present data indicate that bulk mining over at least the more radioactive bands could give about 2.2 million tons of 0.2 - 0.3 percent Nb_2O_5; .03- .05 percent U_3O_8; 0.5-1.0 percent Y_2O_3; 0.1-0.25 percent ThO_2; and 2.0-2.5 percent ZrO_2. This presumes a content of between 660 and 1100 tons U_3O_8, and presumably uranium would only be produced in association with rare earths. Many technical problems would have to be overcome.

2. Radioactive deposit at Al Ghrayyat

The deposit in the Wadi Sawawin area is located some 70 miles from the Jordan border.

The area is one where many ferruginous bands of interest as potential iron deposits, were reported by numerous geologists.

A great number of radiation anomalies are found in the region, and during a survey with a car-borne scintillometer, radioactivity of as much as five times background was detected.

The radioactive area is within a granite which is traversed by pegmatites. Basic dykes, devoid of radioactivity are also in the area.

One mineralogical investigation, zircon, thorite, columbite and cassiterite were identified as ore minerals but uranium assayed less than 0.001%.

A proved reserve of 12.5×10^6 long tons of lode material of grade 0.28 - 0.30 percent Nb_2O_5 is present but the uranium content is very low.

3. Other Areas

Some occurrences in other areas are reported such as at Hulayfah where veins of dark coloured amorphous material shows radioactivity up to 20x background.

Allanite was discovered in 1952 in a region near Hameltha.

E. PRESENT STATUS OF EXPLORATION

No information is available in the IAEA on the present status of uranium exploration in Saudi Arabia. No information has come available on the results of the 1965-66 and 1974 aerial surveys and evaluations by Huntings Geology and Geophysics Ltd.

F. POTENTIAL FOR NEW DISCOVERIES

Saudi Arabia was part of ancient Gondwanaland. The separation of Arabia from Africa is, geologically speaking, recent, and the chances of the occurrence of ore-deposits on the scale of Southern and Central Africa cannot be neglected. In fact, geological analogics between the two countries should be looked for; and deposits of characteristically African occurrence (eg. carbonatites, diamond pipes) may be expected. In geological detail, the conditions for ore-deposition are favourable, and ancient greenstones of mainly volcanic origin, and pierced by numerous granitic and granodioritic intrusions, have been rich in minerals (particulary gold) in other parts of the world.

With regard to the occurrence of uranium specifically, the chances are not so good. It is an empirical observation that high-thorium provinces, and those characterised by an assemblage of rare metals of the types commonly found in pegmatites, tend not to contain uranium of commercial grade.

Moreover, though granitic bosses which are so abundant in Saudi Arabia, are, in many places, the source of uranium mineralisation, deposits of ore-grade tend not to occur within granite masses; although many depoits are known within the effusive equivalents of granite.

The possibility of sedimentary-type radioactive deposits in Saudi Arabia should not be neglected, and any strongly developed conglomerate beds should be radiometrically scanned.

? ≡ Elliot Lake Type? or Sst. type? or both?

Calcrete deposits similar to those known in Australia and Somalia may exist. Conditions are very favourable for this type deposit. Closed interior drainage basins with long periods of no rain should be conducive to this type.

In view of the hugh size of Saudi Arabia, the existence of many geologically favourable rock types and the comparatively poor coverage by sophisticated uranium exploration techniques, the Speculative Potential is placed between 10,000 and 50,000 tonnes uranium.

Laws relating to exploration?

I think, in the light of the geological information given here, that the potential is a little optimistic. Additional geological data could however support this estimate

Compiled by J Cameron
IAEA Vienna
August 1977

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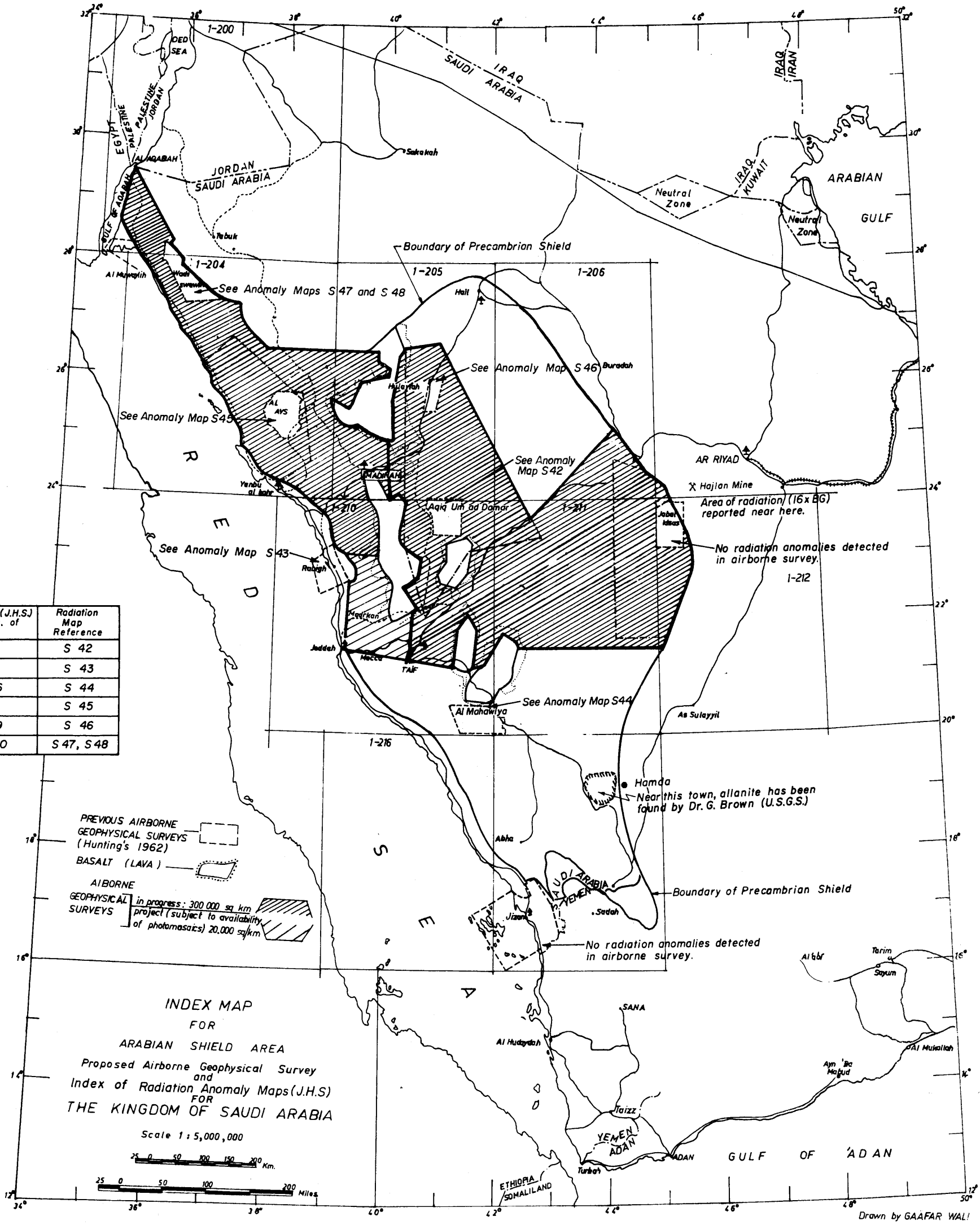
FIGURE 1: INDEX MAP FOR ARABIAN SHIELD AREA



M 34

Plan to accompany Annual Report July 64 — July 65 by J. Shepherd, I.A.E.A. Technical Cooperation Expert.

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