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A SUMMARY OF NIOBIUM AND RARE EARTH LOCALITIES FROM HA'IL AND OTHER AREAS IN WESTERN SAUDI ARABIA

A PRELIMINARY STUDY

By

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ABSTRACT

Investigations in 1965 located veins containing radioactive material in the Halaban Group on the east side of a granite pluton at Jabal Aja near Ha'il. Later study extended the known area of radioactivity to a total length of about 30 km. Mineralogic studies indicated that the samples were low in uranium and that the radioactivity was due principally to thorium in niobium-bearing minerals.

Two samples were reexamined to identify the sources of radioactivity, but X-ray and alpha plate studies did not reveal the radioactive minerals, even though uranium mineralization was indicated by the alpha plates. Further sampling is suggested to isolate the sources of radioactivity. This study indicates that niobium occurrences are related to alkaline intrusives in many areas of western Saudi Arabia. These areas should be investigated for their possible niobium and rare earth contents; their uranium content is apparently too low to be of economic interest.

INTRODUCTION

Location and previous work

The Ha'il area (fig. 1) is in the northeastern Hijaz quadrangle (Brown and others, 1963) about in the center of an area sampled by Hummel and Hakim (1972) and Meissner and Petty (written commun., 1970). In their mineral reconnaissance survey Hummel and Hakim collected two samples (2334d and 2335a) about 10 km north of Ha'il and just east of Jabal Aja (fig. 2) that contained as much as 0.29 percent Nb_2O_5. These samples were collected from veins that measured as much as 1 m wide. V.J. Flanigan (written commun.) stated that an aerial scintillation survey made in 1966-67 showed an anomaly of twice background over the Ha'il sample localities and other anomalies over the granite pluton at Jabal Aja.

Meissner and Petty (written commun., 1970) further investigated these niobium-rich localities in the Ha'il area and other anomalous radioactive sites. They determined that the many aeroradiometric anomalies over the granite are caused by the large volume of slightly radioactive granite to give a large mass effect and that localized radiation on the ground is only slightly above background. The radioactive material is confined to veins and plugs. Other veins of about the same size as those sampled by Hummel and Hakim were discovered and sampled by Meissner and Petty 9 km south of the sample 2335a locality and also 17 km northwest; the approximate length of an anomalously radioactive zone is thus about 30 km.

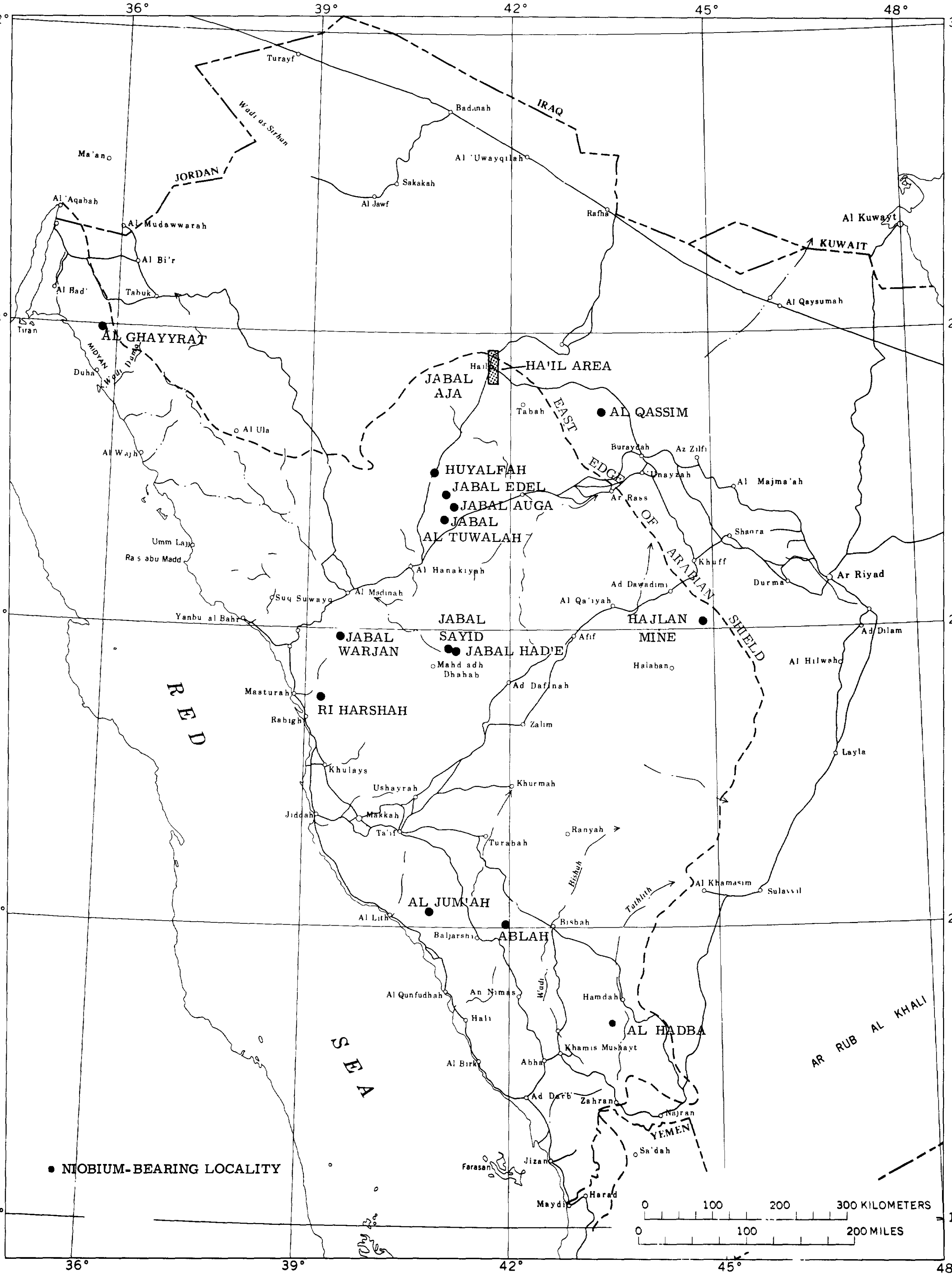

Figure 1.- Index map of western Saudi Arabia showing the Ha'il area and all known niobium-bearing localities.

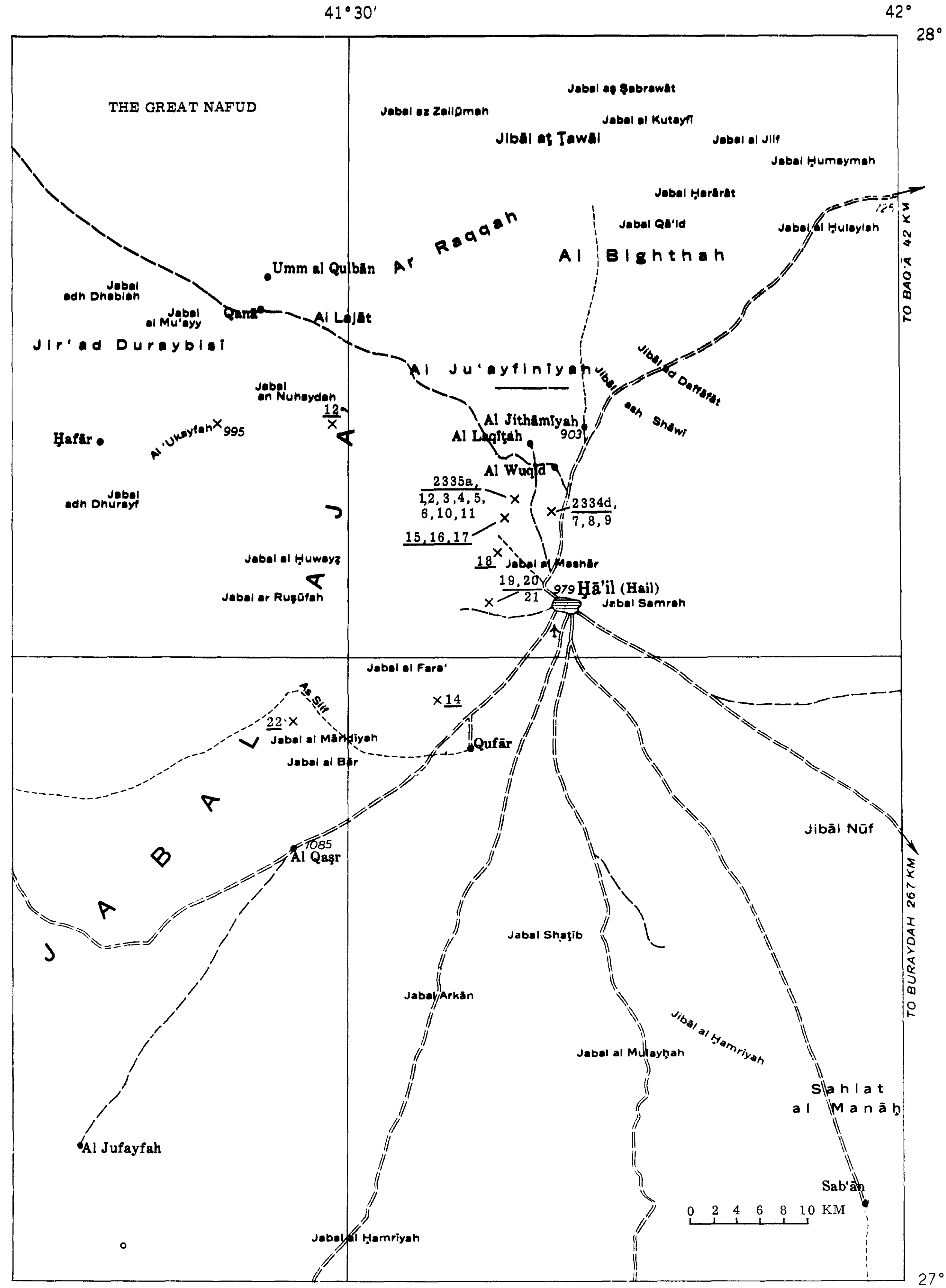

Figure 2.-Sketch map of Ha'il area showing sample localities

Analyses and descriptions of all samples referred to above are given in table 1. D.J. Johnson, U.S. Geol. Survey, studied the mineralogy of the more niobium-rich samples collected by Meissner and Petty, but was unable to identify any radioactive minerals because the material was too fine-grained and intensely altered. Johnson prepared heavy mineral separates of the samples for chemical analyses by the DGMR-USGS laboratory in Jiddah, the results of which are shown in table 2.

General geologic setting

Hummel and Hakim (1972) reported that veins in granitic bodies and in rocks of the Halaban Group contain copper, lead, iron sulfides, and fluorite. They also reported high-grade magnesite deposits in the Zarghat area (fig. 1) north-northwest of Hulayfah and gravel terrace deposits of probable Pleistocene age that may contain gold derived from nearby gold-bearing quartz veins.

The lower part of the Tabuk Formation (Powers and others, 1966) crops out about 50 km northeast of Ha'il. The underlying Saq Sandstone crops out further south. In the Tabuk Formation of the Al Qassim area, radioactive anomalies were found by airborne gamma radiation survey (Matzko and others, 1978). The principal sources of the radioactivity were identified as monazite and allanite.

Table 1. Partial analyses and descriptions of rock samples from samples from Jabal Aja-Ha'il area. (Adapted from Meissner and Petty, 1970)

Sample No.	Radioactivity Outcrop	Equivalent U_3O_8	Percent Nb_2O_5	Description
2334d	2 X 1/	0.028	0.15	Chem. U = 0.004%.
2335a	2 X	.068	.20	Chem. U = 0.008%.
1	2 X	.012	.14	Vein, 2 inch wide.
2	BG 2/	.002	nd 3/	Pink granite that encloses sample 1.
3	BG	.003	nd	Gray granite.
4	BG	.003	nd	Lense in gray granite of samples.
5	BG	.002	nd	Pod in gray granite.
6	BG	.003	nd	Gray granite.
7	1-1/2 X	.007	.06	"Plug" at locality 2334d.
8	1-1/2 X	.005	.04	"Plug" at locality 2334d.
9	3 X	.005	.10	Center of plug at locality 2334d; eU_3O_8 appears too low.
10	7 X	.01	.06	Discrepancy between outcrop and hand sample.
11	4 X	.022	.29	Vein, about 1-1/2 ft. wide.
12	2 X	.02	.10	Vein, 2 inches wide.
13a	BG	.003	nd	Gray granite, Jabal Aja.
13b	1-1/2 X	nd	.02	Dike rock in gray granite, not located.
14	1-1/2 X	.002	nd	Gray granite.
15	1-1/2 X	.003	.01	Dike in Haliban Group.
16	BG	.001	nd	Dike in Haliban Group.

Table 1. Partial analyses and descriptions of rock samples from samples from Jabal Aja-Ha'il area. (Adapated from Meissner and Petty, 1970) Cont'd.

Sample No.	Radioactivity Outcrop	Equivalent U_3O_8	Percent Nb_2O_5	Description
17	BG	.001	nd	Pink granite in Haliban Group.
18	1-1/2 X	.001	.04	Veins and dikes in pink granite.
19	15 X	.008	.02	Vein, 3 feet wide.
20	9 X	.012	.14	Another vein, 3 ft. wide.
21	4-1/2 X	.005	.04	Rock that encloses samples 19 and 20.
22	BG	.002	nd	Jabal Aja, pink granite.

Note: Normal counts per second on outcrop = 1600

Normal counts per second on hand sample removed from area equal 600. Sample locations shown on fig. 2; n.d. = not detected.

1/ Two times normal

2/ BG, normal background

3/ nd, not detected.

(Samples 2334d and 2335a collected by C. L. Hummel, 1965; other samples collected by Meissner and Petty in 1970.)

Table 2. Partial chemical analyses of concentrated samples from Ha'il area. (Analyses by U.S. Geological Survey-DGMR laboratories, Jiddah)

Heavy Liquid and Frantz Isodynamic Separates

	g <2.9					g >2.9 <3.3				
Sample No.	1	9	11	12	20	1	9	11	12	20
Nb	0.015	0.08	0.03	0.03	0.03	0.02	0.3	0.12	0.03	0.03
Nb_2O_5	.021	.1	.04	.04	.04	.03	.4	.17	.4	.4
Ce	.01	.03	.03	.03	.07	.03	.3	.2	.7	.7
La	<.01	.02	.01	.01	.07	.02	.2	.1	.7	.7
Y	.01	.03	.01	.02	.03	.03	.3	.3	.3	.3
Th	nd	nd	nd	nd	nd	nd	.03	.02	.05	.04
U	<.001	.001	<.001	<.001	.001	<.001	.003	<.001	-	-
	g >.3, Non-mag.					g >3.3, Mag.				
Sample No.	1	9	11	12	20	1	9	11	12	20
Nb	0.012	0.015	.015	0.17	0.2	<0.005	0.02	0.005	0.005	0.005
Nb_2O_5	.017	.21	.21	.26	.3	<.007	.03	.007	.007	.001
Ce	.1	.7	.5	1.	1.	nd	.05	nd	nd	.05
La	.05	.5	.2	1	1	<.01	.02	0.1	.03	.02
Y	.02	.3	.2	.3	.3	<.01	.03	.01	.03	.01
Th	.02	.05	.02	.05	.03	nd	.03	.03	.01	.07
U	<.001	.006	.001	-	-	-	-	-	-	-

Table 2. Partial chemical analyses of concentrated samples from Ha'il area.

(Analyses by U.S. Geological Survey-DGMR laboratories, Jiddah)

Cont'd.

Average

Sample No.	1	9	11	12	20	Total
Nb	.013	.104	.076	.126	.134	.091
Nb_2O_5	.019	.092	.107	.177	.185	.116
Ce	.035	.270	.182	.432	.455	.275
La	.022	.135	.080	.502	.447	.237
Y	.017	.165	.130	.162	.160	.127
Th	.005	.028	.018	.028	.038	.023
U						.001

PRESENT INVESTIGATION

Two samples from the Ha'il area were available for the present study, a pulverized sample (2334a) collected by Hummel and a weathered rock from a radioactive dike collected by Meissner and Petty. The samples were analyzed spectrographically and mineralogic studies were made on various fractions. Alpha plates were used to locate the radioactive grains, which were then examined microscopically and by X-ray diffraction.

A thin section of the dike rock shows it to be a highly altered dacitic type rock probably hydrothermally altered and containing abundant well-crystallized goethite. Microcline is more abundant than perthite; hypersthene is strongly corroded and appears to be replaced in large part by goethite; irregular grains of quartz show complete extinction without strain and replace microcline that shows straining; zircon is clear and doubly terminated; and biotite occurs in trace amounts. A magnetic opaque mineral that is deep red in condensed transmitted light may be maghemite.

Strong alpha radiation was emitted by colorless to white fragile grains and brown to red grains in both samples. X-ray analyses of these minerals gave very poor patterns and the minerals could not be identified.

The content of Nb_2O_5 is related to that of equivalent U_3O_8 as is shown on figure 3. High niobium content may thus be detected indirectly in the field by radiometric traverses.

Chemical analyses show the uranium content to be very low. Potassium would also contribute to the overall radioactivity, but chemical analyses for potassium are not available; however, potassium feldspar is abundant in the dike rock.

Figure 4 shows the relationships between Nb and Ce, La, Y, and Th. This plot shows a direct relationship between the content of niobium and those of cerium, yttrium, and thorium.

The relationship between niobium and lanthanum is more complex, as samples containing 0.1-0.2 percent Nb contain amounts of La that range from .12 to .45 percent. As shown for these samples the relationship between La and Nb is consistent up to 0.12 percent Nb, after which concentration the curve is not valid.

DISCUSSION

Samples from the Ha'il area contain only minor amounts of uranium and somewhat more thorium. Semiquantitative spectrographic analyses were made on various splits from sample 2335a (table 3). Niobium, thorium, uranium, and zirconium concentrate in the fraction denser than bromoform (2.89 sp. g.), and less dense than methylene iodide (3.3 sp. g.). Material denser than 3.3 sp. g. was insufficient for analysis and this density fraction could not be compared with previous data by Johnson, Meissner and Petty. Radioactivity is associated with niobium mineralization known to extend over 2 30-km strike length. As cerium and lanthanum are more highly concentrated in some samples than the niobium, the locality should probably be studied for the rare earth content as well as for niobium.

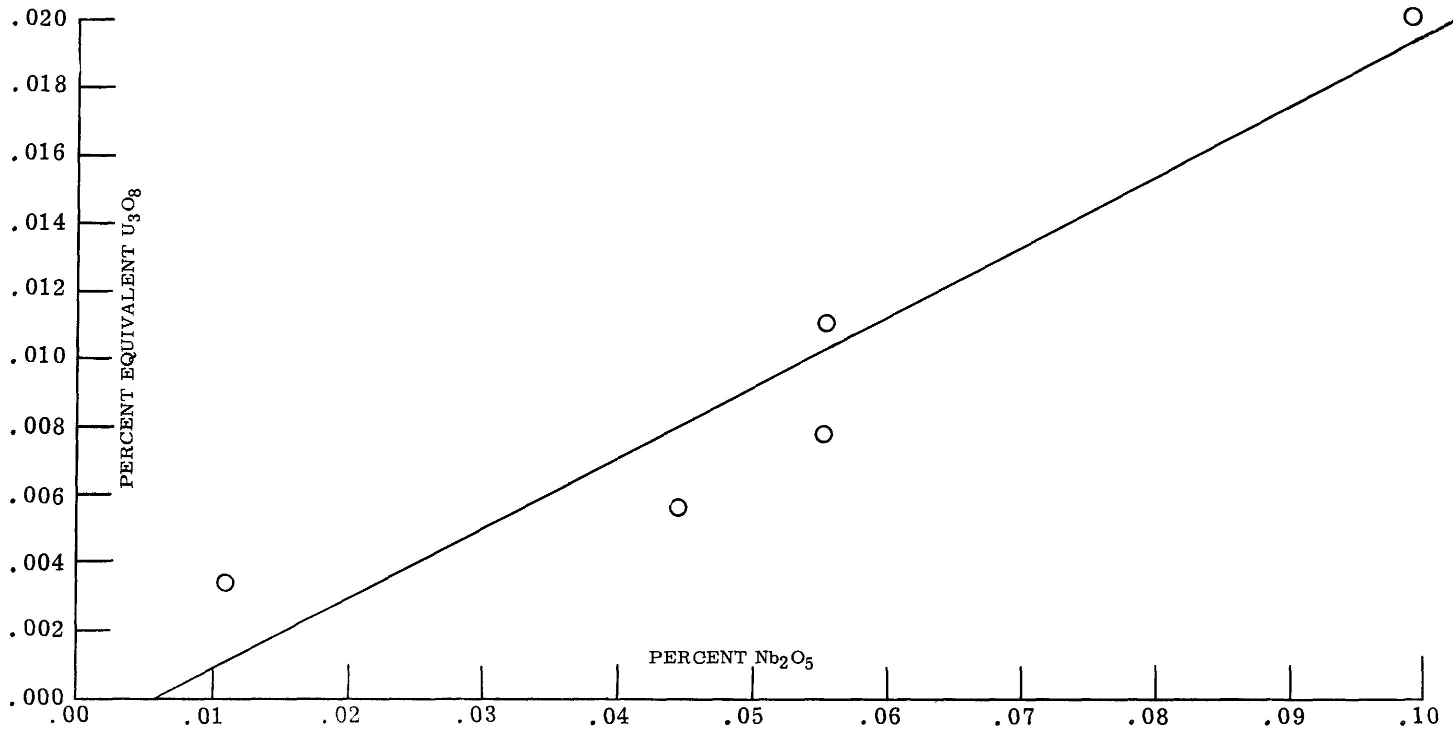

Figure 3. - Graph showing relationship between Nb_2O_5 and equivalent U_3O_8, Ha'il area samples.

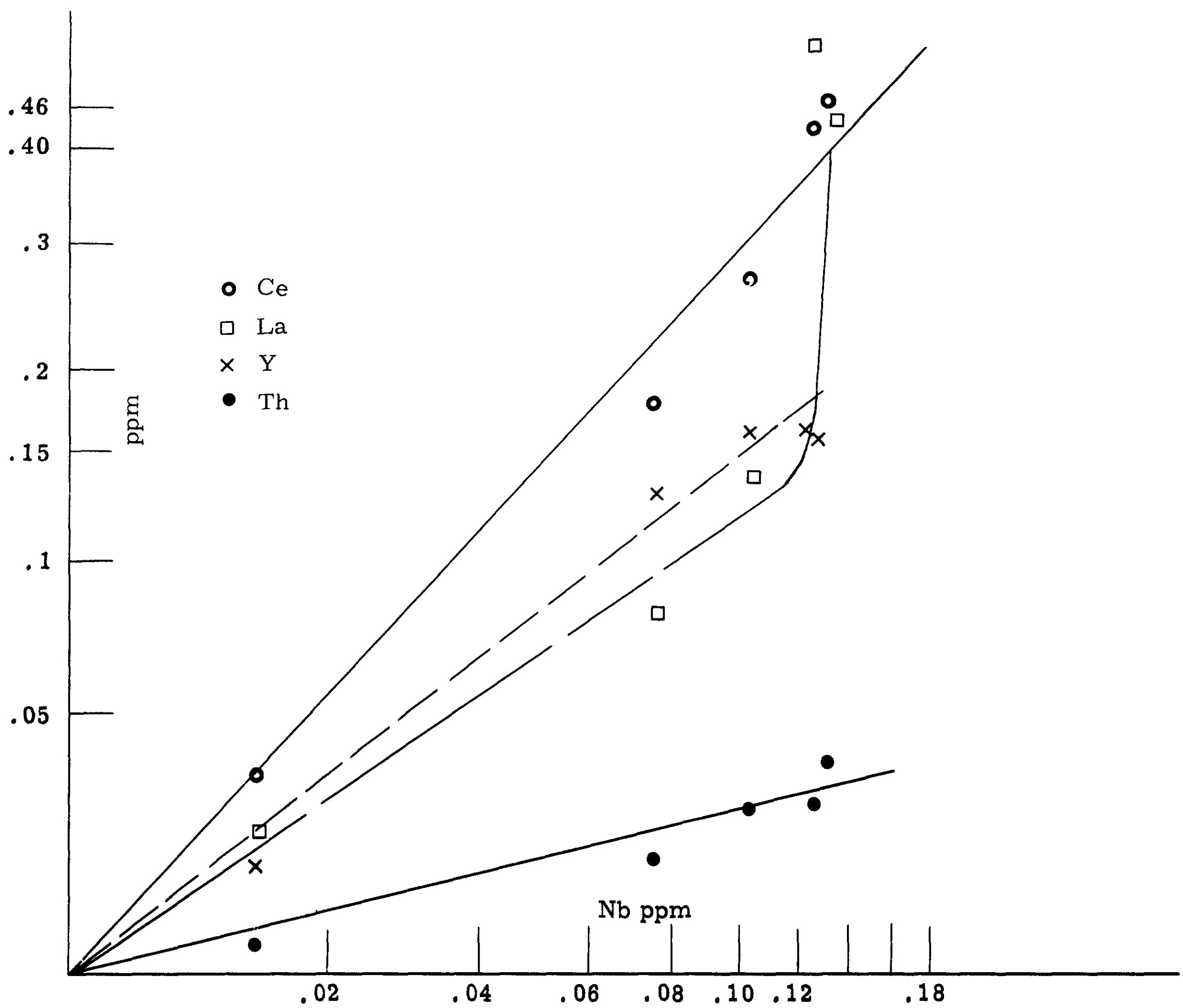

Figure 4. - Graph showing relationship between Nb and Ce, La, Y, and Th, Ha'il area samples.

Table 3. Semiquantitative spectrographic analyses of splits from sample 2335a, from Ha'il area. (Analyst: Mohd. Naqvi, Dec. 22, 1973, Film #1-81-A. USGS Geochemistry and Mineralogy Laboratories, Jiddah, Saudi Arabia).

	>2.89<3.3 spg.	0.3A magnetic Frantz Separate	0.7A Magnetic Frantz Separate	Unconcen-trated (-200)
		PERCENT		
Fe	>20	>20	>20	>20
Mg	.02	.02	.02	.02
Ca	1.5	.1	.3	.2
Ti	.5	.05	.1	.5
		PARTS PER MILLION		
Ag	3	2	3	3
Ba	30	20	20	20
Be	10	7	30	15
Bi	30	n.d.	n.d.	10
Cr	150	n.d.	n.d.	300
Cu	100	20	15	50
La	200	n.d.	50	>100
Mn	300	150	500	300
Mo	5	15	15	10
Nb	300	30	150	200
Pb	300	200	100	300
V	10	n.d.	n.d.	n.d.
Zn	n.d.	500	300	700
Y	200	50	100	150
Zr	>1000	300	700	>1000
Th	minor	n.d.	trace	trace

South of Ha'il and just southeast of Hulayfah, Brown and others (1963) mapped mineral localities containing copper, lead, zinc, iron, radioactive reddish zircon, and thorium. The radioactive minerals are associated with small pegmatites in the granite. Rocks of the area are andesitic Halaban, now called the Halaban Group (Schmidt and others, 1973) with associated granite and rhyolite. Southeast of Ha'il and east of Buraydah, Lambolez and Vincent (1967) reported radioactive anomalies in the Saq Sandstone.

To the west of Ha'il, Shepherd (1965) reports an intensely radioactive deposit at Al Ghayyrat. Subsequent work by Matzko indicates niobium-rich mineralization in a sodic granite that contains more thorium than uranium. Columbite and thorite are the principal radioactive minerals. Analyses show as much as 0.51 percent Nb_2O_5, and analyses of bulk outcrop samples range between 0.26-0.30 percent Nb_2O_5, principally in columbite. The sodic granite is reportedly different in composition and appearance from others in the area. Shepherd described it as an albite-microcline granite and believed it to represent a late residual magmatic fraction; purple fluorite is common in the samples. Pegmatites in the granite are generally more radioactive than the granite, but represent only a small volume. Accessory minerals believed by Shepherd (1965) to be sufficiently abundant to recover as a byproduct along with columbite are zircon and cassiterite. The Tabuk Formation crops out in the area just northeast of Al Ghayyrat. This locality was not investigated by Shepherd, however thorium-bearing and rare earth minerals have been reported elsewhere in the Tabuk Formation (Matzko and Naqvi, 1978).

Shepherd (1965) also reports anomalies of about 2 times background in the Saq Sandstone east of the Wadi Sawawin area (fig. 1) which he was not able to inspect.

Shepherd (1965, p. 99) also describes the Jabal Sayid radioactive localities. These deposits are in highly kaolinized pegmatite and altered sodic granite, and are just south of the Jabal Sayid deposits of copper, zinc, silver, and gold. Black quartz is associated with the radioactive mineralization. The principal sources of radioactivity in the Jabal Sayid deposit are pyrochlore, allanite, and radioactive zircon. The presence of fluorite and tourmaline indicates pneumatolysis. The uranium content, over a 60 m width, averages 0.035 percent chemical U_3O_8 and surface sampling indicated a maximum of 0.24 percent Nb_2O_5. Analyses of drill hole DH 29 core from the surface of 77 m averaged 0.19 percent Nb_2O_5 (Shepherd, 1965). Shepherd (1965) reported radioactive zones smaller but similar to that at Jabal Sayid 35 km south-southeast in the Jabal Had'b area.

Northeast of Rabigh (fig. 1), near an area locally named Ri Harshah, Goldsmith (1971) reported niobium and tin. Shepherd (1965) reported an aeroradioactivity anomaly in the same Rabigh area and concluded that the anomaly was due principally to topographic highs. Ground traverses did not reveal any significant anomalies. About 130 km north-northeast of Rabigh, and east of Al Hamba at Jabal Warjan, Goldsmith (1971, plate 1) reported niobium occurring with tungsten.

Two other niobium localities are reported by Goldsmith (1971): one at Al Jum'ah (fig. 1) about 43 km east-northeast of Al Lith in an area of hot springs and the other at Ablah (fig. 1). The one at Abla is associated with zirconium and rare earths with 150 ppm niobium in a breccia and a syenite. Shepherd (1965) reported low radioactivity in rhyolite related to the granite at Ablah. No radioactivity was reported in the fluorite that occurs as a circular plug cutting a pegmatite breccia at Ablah.

Goldsmith (1971) reported allanite in minor amounts near Umm Thalathah. To the southeast at lat 19°02'N., long 43°35'E., allanite was reported from a pegmatitic vein at Al Hadba (fig. 1). Brown (1968) suggested that further studies should include niobium and rare earth minerals. In quadrangle I-206, in the area of the old Hajlan copper-silver mine at lat 24°05'N., long 44°50'E., radiation as high as 16 times background was recorded in brecciated rhyolite (Shepherd, p. 79). Lambolez and Vincent (1967) reported several anomalies in the Saq Sandstone in the general area north and northwest of an area from Ad Dawadimi to Buraydah. Ground checks by them revealed 4 to 5 times background in a calcareous sandstone. The source of the radioactivity was not determined, but possible radioactive source beds are nearby and these sandstones should be carefully studied.

Many data have been accumulated on the contents of U, Th, and Nb found at Al Ghayyrat and Jabal Sayid. Mineralogical studies, however, are incomplete, and further investigations to determine the sources of all the radioactivity seem warranted. The high contents of yttrium, lanthanum, and cerium reported in many samples suggests that a possibly valuable deposit of rare earths may be found.

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