GEOLOGICAL SURVEY OF PAKISTAN
MINISTRY OF INDUSTRIES
GOVERNMENT OF PAKISTAN

NOT FOR ISSUE

INFORMATION RELEASE NO. 11

AN INVESTIGATION OF ALLUVIAL SANDS FOR URANIUM AND MINERALS OF ECONOMIC IMPORTANCE: THE INDUS, GILGIT, NAGAR AND HUNZA RIVERS, GILGIT AGENCY, WEST PAKISTAN.

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Issued by the Director, Geological Survey of Pakistan
September, 1959
Price Rs. 2.00

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AN INVESTIGATION OF ALLUVIAL SANDS FOR URANIUM AND MINERALS OF ECONOMIC IMPORTANCE; THE INDUS, GILGIT, NAGAR AND HUNZA RIVERS, GILGIT AGENCY, WEST PAKISTAN

- BY -

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Issued by the Director, Geological Survey of Pakistan.

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ABSTRACT

Uniformly low uranium content of 18 samples from widely distributed sample locations on the Indus, Gilgit and Hunza Rivers suggests that economically significant concentrations of uranium are not likely to be found in the alluvium of the upper Indus watercourses. Sands collected from boulder and cobble gravels in terraces and river beds contain 0.001 percent uranium or less. Wind-and water-deposited mantle sands contain 0.001 to 0.006 percent uranium. Spectrographic analyses of sand and heavy mineral concentrates show no unusual or economically-significant concentration of rare or valuable elements.

INTRODUCTION

Purpose and scope of the report

Reports of highly-radioactive alluvium along the upper part of the Indus River were widely circulated in Pakistan in 1957 and 1958, causing many inquiries and much speculation about the economic possibilities of developing the alluvium as a source of radioactive minerals. Subsequent sampling and examination of the alluvium by Tahirkheli (1959) resulted in the identification of uraninite within the heavy mineral suite in the Indus River sand. His work was confirmed by chemical analyses of heavy mineral concentrates in the laboratories of the U.S. Geological Survey, which showed that the concentrates are rich in uranium.

In order to evaluate the sands of the Indus and its tributaries as a possible source of uranium, samples of sand were collected by the writers at selected sites during December, 1958. This report describes the sampling and gives the results of chemical analyses for uranium in samples of these sands.

Sample localities

All the samples of sand were collected from the valley floors and alluvial terraces of the Indus, Gilgit and Hunza Rivers in Gilgit Agency, West Pakistan (see Fig. 1). Most of the samples were collected at points along the rivers where deposits of gravel and sand appear to be ample for large-scale placer mining. Many of the samples are from localities where the alluvium is reworked and concentrated on a small scale to obtain gold.

Previous work

Other than a mineralogic study of the heavy minerals by Tahirkheli (1959) no reports on Indus sand have been available. The geology of the area is described in a reconnaissance report by Ivanac, Traves and King (1956).

Acknowledgements

The writers are grateful to Mr. H. Rahman, Political Agent, Gilgit, for his co-operation in providing lodging and local transportation. Analytical work was done at the U.S.Geological Survey laboratory in Washington D.C. by Joseph Budinsky, Helen Worthing, and Katherine Hazel. Shipment of samples was facilitated by the U.S. Operations Mission to Pakistan. In addition to the mineralogic work done by Tahirkheli, petrographic and mineralogic analyses were done by Zaki Ahmad in the laboratories of the Geological Survey of Pakistan.

GEOLOGY

Topography and distribution of alluvium

The Gilgit and Hunza Rivers drain the meltwater of snow and glaciers from the slopes of the Karakoram and Haramosh Ranges across a terrain of exceptionally high relief. Peaks in these mountains are 16,000 to more than 25,000 feet high and rising 10,000 to 19,000 feet above river level within distances as little as 6 miles from the river.

The river valleys are steep-sided and gorge-like throughout most of their extent in the area. The gradient of the valley floors is 35 to 40 feet per mile. The floor of the Hunza valley, approximately 4,500 feet above sea level at its junction with the Gilgit Valley, rises to an altitude of 7,000 feet above sea level within a distance of 70 miles.

Low terraces, less than 50 feet above river level and as much as one mile wide, locally occupy the valley floors. These terraces, as well as terraces of intermediate elevations, 50 to 100 feet above river level, are underlain by thick deposits of stream-laid cobble and boulder gravel and sand substantially the same in composition as the alluvium in the river bed. High terraces, as much as 500 feet above river level, are locally present along the sides of the valleys. Some of these terraces are underlain by finely-ground rock and angular boulders of glacial origin; some are truncated alluvial fans and some are remnants of terminal moraines of glaciers that formerly occupied valleys of some of the tributaries.

Source of alluvium

The alluvium sampled and examined for the purpose of this report is derived largely from granodiorite and metamorphosed basic volcanic rocks that extensively underlie the drainage areas of the Gilgit and Hunza Rivers. Diorite, schist, quartzite, marble and several kinds of pegmatite are also abundant in the area (Ivanac, Traves and King, 1956 , Pl. I), contributing to the large variety of crystalline rocks present as pebbles and cobbles of the river alluvium. The sand, mostly quartz, also contains pyrite, chalcopyrite, calcite, uraninite and other easily decomposed minerals that were produced from rocks disintegrated under alpine conditions of glaciation and rigorous weathering and were rapidly transported by fast-moving floodwaters.

Nature and composition of alluvium

Mantle deposits

The floors of the valleys are extensively mantled with broad patches of sand that has been deposited and winnowed by wind and water. These mantle deposits of sand, though extensive, are thin and constitute only a small part of the alluvium.

Samples of the sand are mostly light gray to medium gray, but viewed in the field the sand appears pink in broad streaks and irregular patches. The sand consists mostly of fine (1/8 to 1/4 mm) subangular to subrounded grains, including abundant quartz and mica, rock fragments, and subordinate amounts of heavy minerals. Most samples of the sand contain quartz, biotite, dolomite, garnet and scheelite, listed in estimated order of decreasing abundance. Scheelite grains are very scarce.

Gravel deposits

Some of the gravel deposits, especially those that underlie the low terraces, contain boulders as much as 6 feet in diameter, but most of the boulders range from 1 to 3 feet in diameter. The boulders and cobbles are closely packed; the interstices are filled with intimately mixed sand and pebbles which constitute 5 to 50 percent of the total volume of the deposit.

Sand forming the matrix of the gravels is estimated to constitute less than 15 percent of the gravel because of the general prevalance of small pebbles less than ¼ inch in diamter. The sand is medium dark gray; it is mostly coarse grained, but the grain size ranges from very fine to coarse. Quartz is the most abundant mineral. Heavy minerals, prodominantly biotite, constitute approximately 25 percent of the sand. Other minerals, listed in the order of their abundance, are as follows; calcite, dolomite, garnet, chalcopyrite and magnetite. The size of the heavy minerals ranges from very fine to coarse. The fine-grained sand generally contains the highest proportion of heavy minerals.

A sample of sand from Amb, Hazara District, that was analysed earlier by Tahirkheli contains a heavy mineral suite as follows: abundant magnetite and lesser amounts of ilmenite, zircon, monazite, garnet, uraninite, uranothorite, amphibole and scheelite. The uranium minerals were verified by X-ray diffraction analyses of a selected mineral concentrate made in the laboratories of the U.S. Geological Survey.

COLLECTION OF SAMPLES

Sand samples were collected from three kinds of deposits: mantle sand from the valley floors; sandy matrices from gravel deposits of the present stream level; and sandy matrices from gravel deposits that underlies the terraces.

Samples from the mantle deposits were taken from the first few inches below the surface. Samples from the gravel deposits were collected from between boulders and cobbles from the surface to as much as one foot below the surface. Many of the samples were collected from gravels that have been worked by gold washers who inadvertantly provided the rich unranium-mineral concentrates mentioned earlier; some were collected near the edge of the water, along white-water rapids, in locations similar to goldwasher's digging grounds. In some areas, sampling points were spaced to provide data on horizontal distribution of uranium within gravel bars and terraces. Channel samples were taken along several alluvial terraces to give data on vertical distribution of uranium within the terraces. Exact positions of samples are given in Table 1.

The samples were collected in cloth bags and were carefully handled to avoid loss of the fine constituents during transport. The samples remained wet between collection points and the Geological Survey office; they were dried, coned quartered and repacked into paper envelopes for shipment to the laboratory. Samples from the gravel deposits were sieved with a 3 mm mesh screen to remove pebbles and very coarse sand. Splits were retained for physical and petrographic examination.

RADIOACTIVITY OF THE ALLUVIUM

A hand-borne scintillation counter and a Geiger-Muller counter were used to measure radioactivity of the sand at the sampling sites. Radioactivity of the samples was measured with a scaler counter at the U.S. Geological Survey laboratories. The results, listed in Table 1, show that in general the gravel deposits have a much lower level of radioactivity than the mantle deposits of sand. Relatively high values of radioactivity were noted locally in some gravel deposits, but these values are attributed to local sources of radioactivity issuing from boulders of relatively highly-radioactive pegmatite. This partly explains the lack of parallelism between values listed in Table 1 for radioactivity of gravel measured in the field and radioactivity of sieved sand measured in the laboratory

URANIUM CONTENT OF THE ALLUVIUM

Samples of sand from the terrace gravels generally contain less than 0.001 percent of uranium. Most samples of sand from the river-bed gravel contain 0.001 percent uranium. The low content of uranium is surprising, considering that some of these deposits have yielded uraninite grains from their heavy mineral concentrates. Recalculating to account for the pebbles, cobbles and boulders, the overall uranium content of the gravel is on the order of 0.0007 percent, assuming that the pebbles, cobbles and boulders, comprising more than half the gravel, contain 0.0004 percent uranium, the average content of uranium in granite (Rankama, 1954 p. 118).

Wind and wave-borne sand of the mantle deposits contains from 0.001 to 0.006 percent of uranium. Although the deposits are relatively rich in uranium, they comprise probably less than one tenth the volume of alluvium, thus contributing little to the total uranium content of the alluvium. The uranium minerals in these sands are probably uranothorite, thorianite or other uranium-bearing minerals that have a relatively low specific gravity.

OTHER ELEMENTS IN ALLUVIUM

Spectrographic analyses of three samples of sand and two samples of heavy mineral concentrates were made in the hope that the alluvium might be shown to contain appreciable amounts of rare or valuable elements. The results of semiquantitative spectrographic analyses (Table 2) show an assemblage and concentrations of elements that are not unusual, considering the suite of minerals known to be present in the sand. The detection of zirconium, rare earths and other valuable elements in these samples merely reflects the presence of zircon, monazite, and the uranium and thorium-bearing minerals. These minerals, though rich in valuable elements, as seen in the analyses of the concentrates, (samples 1-c and 19-c, Table 2) are in the gravels and sands in amounts too small to be of present economic value.

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Ivanac, J.F., Traves, D.M. and King, D. 1956, The geology of the northwest portion of the Gilgit Agency: Records, Geol. Survey of Pakistan, Vol. VIII, Pt. 2, p. 1-27.

Rankama, K., 1954, Isotope geology : Pergamon Press Ltd., London.

Tahirkheli, R.A., 1959, Preliminary report on heavy minerals from Indus River alluvium: Geological Survey of Pakistan (in preparation).

Table 1. Uranium and radioactivity analyses and field information on samples of sand from the Indus, Gilgit, Nagar and Hunza Rivers.

(Chemical analysis by Joseph Budinsky)

Sample No.	Percent uranium	Radioactivity: Measured in laboratory; in % equivalent uranium	Radioactivity: Measured in the field; in milliroentgens per hour	Description of sample locality, material sampled, and type of sample.
		Hunza River, gravel deposits		
1.	0.001	0.003	0.010	Approximately ½ mile above confluence with Gilgit R. 1-foot pit in cobble gravel 10 feet from water's edge, 2 feet above water level; sand collected from sites worked by goldwashers.
1c.	28.6	24.4	---	Concentrate of heavy minerals.
2.	0.001	0.003	0.009	200 feet west (shoreward) of No.1, approximately 12 feet above water level; fine sand matrix in boulder gravel.
3.	0.001	0.002	0.010	180 feet west (shoreward) of No.2. 1-foot pit in cobble gravel on bottom of a flood-water channel.
		Hunza River, mantle sand		
4.	0.001	0.003	0.010	1-foot channel sample, middle part of 12 feet deep canal in terrace; 25 feet south of water's edge.
5.	0.002	0.005	0.090	1-foot channel sample of dark pinkish-gray sand near edge of water.
6.	0.001	0.001	0.025	A grab sample of medium-gray, fine grained, angular sand mantling a deposit of gneiss, granite and quartz pegmatite boulders.
		Channel sample of a 20-foot terrace deposit, Hunza River		
7.	0.001	0.001	0.020	2.8-foot channel sample of light-gray, coarse-grained, thinly-laminated sand at base of deposit; approx. 15 feet above water level.

8.	0.001	0.002	0.020	Overlies No. 7; 1.8-foot channel sample of pebble and cobble gravel with a pebbly coarse sand matrix, Pebbles comprise 50 percent of matrix.
9.	0.001	0.002	0.015	Overlies No. 8; consists of sand 3 to 5 feet thick, similar to No. 7 but darker and contains more abundant heavy minerals.
10.	0.001	0.001	0.010	Overlies No. 9; boulder conglomerate, containing boulders to 7 feet in diameter. Pebbles comprise 30 percent of pebbly sand matrix.
		Nagar River, mantle sand and gravel		
11.	0.006	0.006	0.080	350 feet above confluence with Hunza River. Grab sample of gray medium-grained sand; contains chalcopyrite, pyrite and abundant garnet.
12.	0.001	0.002	0.020	3-foot channel sample of cobble gravel in a low terrace. Pebbles comprise 50 percent of pebbly sand matrix.
		Indus River gravel deposit		
13.	0.001	0.003	0.010	Pit sample, 3 inches below general surface of cobble and boulder gravel; pebbles comprise 50 per cent of pebbly sand matrix of gravel.
14.	0.001	0.002		200 feet downstream from No 13 and 100 feet from water's edge; 3 inches below general surface of cobble gravel; pebbles comprise 50 percent of pebbly sand matrix.
15.	0.001	0.003	0.012	200 feet downstream from No. 14, and 10 feet from water's edge; 3 inches below gravel surface of cobble gravel; sand in cobble gravel is coarse grained, contains abundant pebbles and grit.
16.	0.001	0.004	0.015	Approx. ½ mile above confluence with Gilgit R. Pit in foot below general surface of boulder gravel deposit. 10 feet from water's edge, 2 feet above water level. Pebbles comprise 60 percent of pebbly sand matrix.

Gilgit River gravel deposit

17.	0.001	0.002	0.010	500 feet below suspension bridge near confluence with Indus River; from pit 6 inches below general surface of cobble gravel deposit; 15 feet from water's edge and 4 feet above water level.
18.	0.001	0.003	0.020	180 feet west of No. 17, approx. 190 feet from water's edge and 10 feet above water level. Boulder gravel as above.

Indus River; Amb, Hazara District

19c.	2.6	2.1	---	Concentrate of heavy minerals in sand from cobble gravel; collected 25 feet from water's edge.

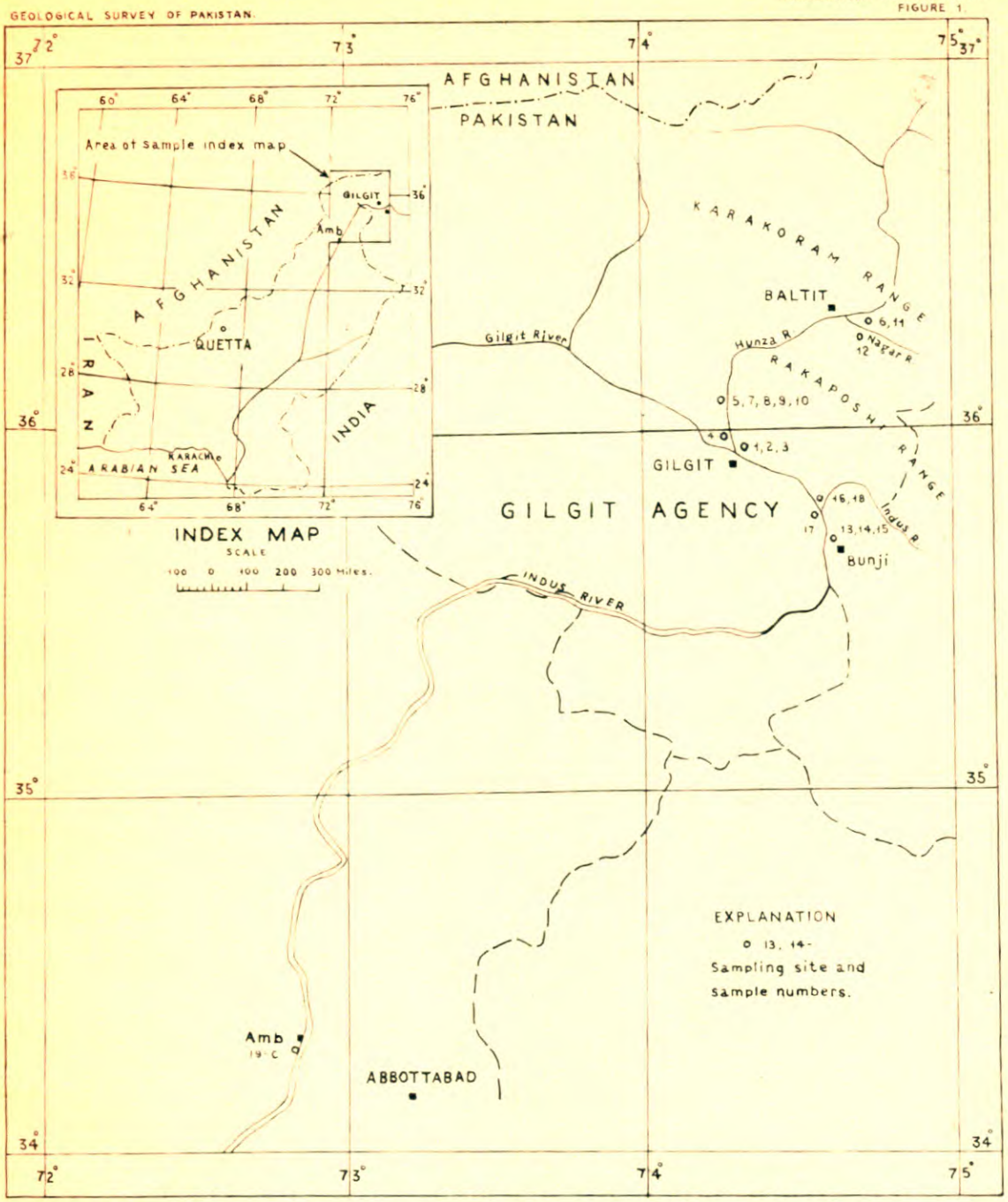
Table 2. Semiquantitative spectrographic analyses on samples of sand from the Indus, Nagar and Hunza Rivers

(Analyses by Katherine V. Hazal and Helen W. Worthing)

Field No.	4	11	12	1-C	19-C
Sample type	Mantle Sand	Grab showing minerals	50 % Sand Matrix	Conc. of Heavy Min.	Conc. of Heavy Min.
Location	Hunza R.	Nagar R.	Nagar R.	Hunza R.	Indus R.
Silicon	10	10	10	1.5	1.5
Aluminum	7.0	7.0	7.0	0.3	0.7
Iron	3.0	3.0	3.0	10	10
Magnesium	1.5	1.5	1.5	0.3	0.15
Calcium	1.5	1.5	1.5	0.07	0.07
Sodium	1.5	1.5	1.5	0.7	0.015
Potassium	1.5	1.5	1.5	0.3	0.007
Titanium	0.7	0.7	0.7	1.5	3
Manganese	0.007	0	0.015	0.7	0.7
Silver	0	0	0	0.0007	0.0003
Arsenic	0	0	0	1.5	3
Boron	0.003	0.003	0.003	0	0
Barium	0.03	0.03	0.03	0.001	0.007
Beryllium	0.0003	0.0003	0.0003	0	0
Bismuth	0	0	0	0.07	0.003
Cerium	0	0	0	0.07	0.03
Cobalt	0.0015	0.003	0.0015	0.003	0.003
Chromium	0.003	0.003	0.003	0.007	0.015
Copper	0.007	0.003	0.0015	0.003	0.007
Dysprosium	0	0	0	0.007	0.007
Erbium	0	0	0	0.003	0.003
Europium	0	0	0	0.0015	0.0015
Gallium	0.0015	0.0015	0.0015	0	0
Gadolinium	0	0	0	0.015	0.07
Hafnium	0	0	0	0.003	0.007
Holmium	0	0	0	0.0015	0.0015
Lanthanum	0.007	0.015	0.007	0.07	0.15
Molybdenum	0.0015	0.0015	0	0.0007	0.0015
Neodymium	0	0	0	0.03	0.15

Niobium	0	0	0	0.03	0.03
Nickel	0.0015	0.0015	0.0015	0.07	0.07
Lead	0.0015	0.003	0.003	0.03	0.03
Praseodymium	0	0	0	0.015	0.03
Scandium	0.003	0.0015	0.0015	0.003	0.007
Tin	0.0015	0.0015	0.0015	0.03	0.03
Strontium	0.03	0.015	0.03	0.0003	0.0003
Samarium	0	0	0	0.015	0.015
Thorium	0	0	0	0.7	0.7
Uranium	0	0	0	10	3
Vanadium	0.007	0.007	0.007	0.015	0.03
Tungsten	0	0	0	0.07	0.07
Yttrium	0.007	0.003	0.003	0.03	0.03
Ytterbium	0.0007	0.0003	0.0003	0.003	0.003
Zirconium	0.03	0.03	0.03	3.	7.

Note ∠0.3 The figures in the analyses are reported in the nearest number of the series 7, 3, 1.5, 0.7, ∠0.15, etc., in percent. The figure 0 indicates that the element had been looked for but is either absent or is present in amounts too small to be detected. Elements looked for but not found include the following: P, Au, Cd, Cs, Ge, Hg, In, Ir, Li, Lu, Os, Pt, Rb, Re, Sb. Ta, Tb, Te, Tm, and Zn.



INDEX MAP OF RIVER-SAND SAMPLE LOCALITIES, GILGIT AGENCY, WEST PAKISTAN.

SCALE
32 24 16 8 0 32 Miles.