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INVESTIGATION OF PLACER MINERAL DEPOSITS IN THE INDUS, GILGIT, HUNZA AND CHITRAL RIVERS OF PAKISTAN

By

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ABSTRACT

In October, 1973, the Geological Survey of Pakistan undertook a project on the directive of the Honourable Minister for Finance, Development & Planning, and the Ministry of Fuel, Power and Natural Resources. Under this project the placer mineral deposits of parts of the Indus, Gilgit, Hunza and Chitral Rivers were examined by spot sampling. A few high level terrace gravel deposits were also sampled. The sampling was carried out by employing local gold washers along with their equipment. A measured volume of sand and gravel was washed and whatever gold was recovered from any one sampling site was finally calculated as oz/l. ton for that site. The values have been determined at Rs. 575·00 per tola or Rs. 1,437 per ounce (taking 2·5 tola equal to one ounce).

The gold contents of the alluvium deposits, as determined during the present reconnaissance survey, are generally low. In the upper Indus Valley, between Thore and Sasi in Gilgit Agency, they range between the lowest of 0·0004 oz/l. ton (disregarding a single zero) to the highest of 0·011 oz/l. ton. On the high side there is only one exception ; one sample from a high terrace in the Bunji-Jaglot area was found to contain 0·05 oz/l. ton of gold. Among the lower Indus Valley deposits, the lowest and highest gold contents range between 0·002 oz/l. ton and 0·014 oz/l. ton. In the Gilgit and Hunza Valleys they range between 0·0021 and 0·0135 oz/l. ton, and in the Chitral and Mastuj Valleys the same are 0·003 and 0·0108 oz/l. ton, respectively.

Final values of the gravel deposits, taking all their constituents into account, can not be computed at the moment because the heavy mineral samples are under study. However, there is little doubt that most of the spots checked during the survey are very poor in terms of gold. Their values, in terms of other metals and minerals also, are not likely to increase much because the heavy minerals themselves constitute a very small fraction of one percent. Nevertheless, a few deposits are being recommended for a second look to see if any portion of them contain values higher than the ones recorded during this survey.

3.	Lower Indus	(Darband-Attock-Tarbela) party October 13, 1973 to January 4, 1974.
4.	Gilgit-Hunza party	October 10 to December 22, 1973.
5.	Chitral party	October 21 to December 24, 1973.

The constitution of the geological field parties that carried out the investigations in the five different areas was as follows :—

1.	Chilas	Ghulam Sarwar Alam, G. S. P., Geologist.
		Sharjeel Ahmad, NDVP, Geologist.
2.	Gilgit-Hunza	Basher A. Saleemi, G.S.P., Geologist.
		Rafiullah Khan, G. S. P. Geologist & Shaukat A. Qureshi, N. D. V. P., Geologist.
3.	Partab Pul-Sasi	Rab Nawaz Khan, G. S. P. Geologist & Sahibdad Khan, N. D. V. P. Geologist.
4.	Darband-Tarbela-Attock ..	Ahmad Hussain, G.S.P. Geologist.
		Mohd. Saleem, G.S.P. Geologist & Sajid Hussain Shah, G. S. P. Geologist.
5.	Chitral	Ashraf K. Khattak, G. S. P. Geologist.
		Sikandar Khan, G. S. P. Geologist & Shafiq Ahmad, G.S.P. Geologist.

Method of investigation

The investigations of the river alluvium of the Indus, Gilgit, Hunza and Chitral rivers were carried out by employing local sand-washers along with their equipments. Three to five persons, generally belonging to one family worked in a party on one sluice or "Nava" as it is locally called. This number depended on the nature of the site and its distance from water. The number of parties and the number of total labour varied from time to time and from place to place. In good warm weather, they generally worked for eight hours a day.

The equipment used by the gold washers consists mainly of a 'Nava' or wooden sluice, about 1-1/2 feet wide and 3 feet long, nearly half of which is covered by a removable wooden "grizzly" of roughly 1/4 inch mesh. The procedure commonly adopted by the washers is to set this tray, somewhat

sloping, just beside a stream, place the wooden "grizzly" on top near the head, pour sand and gravel (everything less than 1-1/2 inch in diameter) on the "grizzly" and wash it down with water. The gravel remaining on the "grizzly" is removed from time to time. When the tray is full of sand after washing about 1/2 ton of material, it is further washed with water and simultaneously moved upslope and downslope of the sluice by hand or a flat wooden spoon. The last process is to hasten the outflow of light material. When only 10—20 pounds of material is left on the sluice, the characteristic gold 'colour' appears near the head. At this stage, further washing and pushing the sand by hand higher toward the head of the sluice results in the formation of a 'golden apex' which is made up of gold and some heavy minerals which are then collected. After collecting this gold-bearing apex material from a number of washes at any one site, they are mixed together and the gold is recovered by the mercury amalgam method. The amalgam is then heated to evaporate mercury and obtain gold. During the present investigation, the heavy mineral fractions, besides the gold-bearing apex material, have also been collected. After the extraction of gold from the apex material, the remaining part has been termed gold tailing in the field reports. In the present report, however, the gold tailing and the heavy mineral fraction has been taken to mean one and the same thing. To determine the gold tenor, the recovered metal has been weighed in the field in the local weight measure of tola, ratti and masha, later converted into ounce per ton.

The field data was gathered strictly according to the proforma devised by the Project Advisor, Dr. R. A. Khan Tahirkheli of the Peshawar University and approved by the project's Advisory Committee. The field parties were instructed to collect data accordingly and report them daily and weekly on the same format. These forms defined and more or less confined the sphere of field activity. Separation of the metal using the mercury amalgam method in the field was also carried out on the advice of Dr. Tahirkheli.

Sampling sites were marked on 1 : 40,000 Pakistan Air Force aerial photographs obtained from the Survey of Pakistan. Subsequently a simple planimetric base map was prepared from these photos and photographically reduced to accompany this report. Where Survey of Pakistan topographic maps at the scale of 1 : 50,000 were available, they were used in place of aerial photographs. These maps too were reduced for presentation with this report. Besides, this report also carries graphs showing the gold contents in the alluvium at different sites, a frequency diagram and scatter diargrams of (1) material washed against expenses on labour, and (2) of gold contents against percentages of the heavy mineral in the bulk material.

22.4 cubic feet has been taken to equal one long ton of gravel-sand for the purpose of conversion from field measurements in cubic feet into long tons. In case of gold, 2.5 tola has been taken to equal one ounce and its values have been calculated at the then prevalent price of Rs. 575.00 per tola or Rs. 1,437.00 per ounce (as of Karachi, 10th February 1974).

Areas of present investigation

The five field parties covered the following area :

1. Upper Indus (Chilas) party : The section between Thore (20 miles down-stream of Chilas) and Jaglot ; a stretch of about 100 miles.

2. Upper Indus (Gilgit-Hunza) party :	From the confluence of Indus-Gilgit Rivers to Chalt, a stretch of about 70 miles. Confined mainly on the right bank of Gilgit and left bank of Hunza.
3. Upper Indus (Partab Pul-Sasi) party ..	From Sasi in the Indus Velley on the road to Skardu, to a point a few miles down-stream of Partab Pul on the Indus , a stretch of about 50 miles.
4. Lower Indus (Darband-Tarbela-Attock) party :	In the Darband area, from Tirbat to Kirpalian along the Indus ; and in the Tarbela-Attock area, again along the Indus mostly on the left bank.
5. Chitral party :	From Ishtan Lasht about 20 miles north of Chitral town, southward to Khair-abad along the Chitral River a stretch of about 40 miles.

For the purpose of the present report, the investigated areas have been described under (1) Upper Indus Valley, (2) Lower Indus valley, (3) Gilgit and Hunza Valleys, and (4) Chitral and Mastuj Valleys.

The areas of the upper Indus, Gilgit and Hunza Valleys in Gilgit Agency are served by the Karakoram Highway. The road is wide enough for 5-ton trucks and is partly metalled and partly gravelled. The areas are approachable through Rawalpindi. They are also linked by truckable gravel road with Swat District. The Chitral area is reached from Dir across the eleven thousand-feet Lowari Pass through a fair-weather jeep road. Most parts of the Indus Valley in Durband-Tarbella-Attock area is connected with Rawalpindi by all-weather roads.

Sampling

The sampling technique employed during the present survey has already been described in the previous pages. As mentioned earlier, the sampling sites were generally selected by the sand washers and confined to the apparently enriched zones in the flood-plain gravel deposits.

It may be stated that where the alluvium is confined to a narrow channel in the bed of a contemporary stream, systematic methods can seldom be applied. Deposits of alluvium in the Gilgit and Chitral areas are generally both narrow and patchy. In case of older alluvium in the higher terraces, however, larger areas are present at a few places. But to investigate them systematically by grid or semi-grid sampling from the surface down to the bedrock by pitting and trenching would have required much longer time per unit area in comparison to the time taken for the present reconnaisance survey. Hence, during the present

brief investigations, spot sampling of the meander gravel and sand bar deposits from the surface and, in some cases, up to a few feet depth, was carried out to determine the general grade. The older alluvium was also examined at a few places.

A total of 63 sites in the upper Indus Valley, 54 in the lower Indus Valley, 71 in the Gilgit and Hunza Valleys, and seven in the Chitral and Mastuj Valleys were sampled. Some of the sites have been sampled more than once. Also, some of the sampling sites were located so close to each other that they could not be plotted separately on the maps and, therefore, have been combined and plotted as one sample location. In both the above mentioned cases, the samples have also been combined for study and analysis.

PREVIOUS INVESTIGATIONS

The regional geology and structure of the Gilgit-Hunza area have been described and discussed by Baker (1965), Stauffer (1968) and Danilchick (1959). Tahirkheli (1960) , carried out regional survey of the Indus alluvium in various parts of the Indus, Gilgit and Hunza Valleys

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GEOGRAPHICAL AND GEOLOGICAL SETTING

The areas in Gilgit Agency are mostly overlain by a wide variety of igneous and metamorphic rocks, mostly of Paleozoic (?) age. Extrusive and sedimentary rocks of younger age are also present. Besides, there are large and small outcrops of intrusive, acid and intermediate and ultramafic rocks. In the eastern part, near Chilas and Besham the ultramafic rocks are exposed.

The common rock types in the area are granite, granodiorite, diorite, small outcrops of dunite and harzburgite, amphibolite, granite gneiss and various types of schists and phyllites. In places, these rocks have been intruded by younger dykes of dolerite, pegmatite and quartz vein. Several quartz veins at many localities are known to contain showings of sulphide ore minerals. In Gilgit Agency, no *insitu* deposit or showing of metallic or combined gold has yet been reported.

The situation with regard to the general rock types present in the Chitral area is not very much different from the one described for the Gilgit Agency. The only seemingly significant difference lies in the fact that in the area north of Chitral town a small deposit of antimony sulphide mineral contains a fair amount of combined gold, and there are other small antimony deposits in the same general area containing small amounts of gold.

A sequence of regionally metamorphosed slates, intruded in several places by quartz veins, is predominant rock type in the Darband-Attock area.

In all the above regions examined during the present survey, rocks favourable to serve as hosts for native gold, are present. These are the acid and intermediate igneous rocks, mica schists and younger quartz veins, particularly those that carry some sulphide minerals.

It may be mentioned that the presence of rich and minable gold lode in the drainage area of stream, contemporary or old, is not at all necessary to produce minable concentrations of the metal in its gravel deposits. Conversely, absence of minable gold concentration in recent or old gravel deposits does not preclude the presence of minable gold lode in the drainage area of that stream. In fact, the streams draining some of the rich gold country of Western Australia and elsewhere have not caused the formation of rich placer gold deposits.

The Gilgit, Hunza, Skardu and Chitral areas are characterised by rugged high mountains and deep v-shaped valleys. The only existing flatlands are the minor terraces and narrow flood plains along the main rivers. The flood plain gravel deposits are generally narrow and patchy.

Generally a relief of 5,000 feet is common and one of 10,000 feet or more is not rare. The sheer enormity of the topography is perhaps the major reason why no detailed mapping has ever been done in this area.

The climate of Gilgit Agency is arid. The weather is extreme, especially in winter. Rainfall is very meagre, a mere 1-1/2 to 5 inches annually. Due to very steep slopes, scanty rainfall and extreme climate, there has been very little soil formation. Consequently, the vegetation in the valleys and on the mountains is very sparse. The Chitral area gets more rainfall than Gilgit and, therefore has more natural vegetation. Similarly the area of the lower Indus Valley is also a moderate rainfall area and has relatively more natural vegetation than the Gilgit area.

EXPLORATION, MINING AND PROCESSING OF PLACER DEPOSITS

Although the present survey has not established an immediately minable ore body, it will not be out of place if the major steps of evaluation, common methods of placer mining and their processing are briefly mentioned. It is hoped that they will help the readers in visualising as to how much effort, technical knowledge and expenditure are really needed to evaluate, mine and process a placer.

Firstly a prospect is located and examined in a general way to determine if advanced exploration is needed. At this stage the deposit need not be economic, but it should not be too far off the mark, either from the point of grade or reserves. Like other deposits, a placer deposits also explored in depth by trenching, pitting, drilling and finally adits, inclines and shafts are driven if necessary.

It is always advisable to proceed step by step, weighing *pros* and *cons* of each step well in advance. Once a prospect is located, the detailed exploration is taken up in stages. A decision to launch the next stage operation must be based on the results obtained from the first stage. Exploration is a high-risk gamble and common sense dictates that one should not gamble all his fortune in a single stage operation. Expenses should be proportional to the size of the ore body that is expected and the chances of success.

Disregarding other factors of mineral economics (and one or more of these may be determining factors), reserve, grade and configuration of a deposit must be quite accurately determined and these must be economic before a prospect can be classed as a deposit. Once this is done (and processing methods established), a deposit is ready to be opened up for mining.

Various methods employed for mining a placer deposit are mentioned briefly in the following paragraphs. The summary is taken from McKinstry (1968) and Popov (1971, p. 567).

Underground methods

Placer deposits occur close to the bedrock surface also. Underground mining is employed for placers occurring at a depth of 50 feet or more. Placer deposits are of several types but this report is concerned with alluvial or transported placers only. These are closely associated with river systems, present or past, and are generally richest close to the underlying bed-rock, often penetrating them through crevices.

In early development, once the reserves and grade are established, the sheet-like placer deposits are divided into mine fields. The size of the fields depend on the mining and sand transportation methods to be employed. Mine fields are then opened up through vertical shafts, underground drifts and adits.

Prior to mining a placer deposit, diversion of surface river water may be necessary. Diversion of groundwater is necessary and is carried out either through underground drainage or by pumps. Among the different underground methods only (1) long-piller mining along strike of placer, (2) long-piller mining across strike of placer, and (3) piller mining with worked out space supported by timbering and mine fills are employed where conditions are favourable.

Opencast methods

The present report is concerned with placer deposits therefore, only those methods will be briefly mentioned which are employed in mining horizontally occurring ore bodies in placers. Such ore bodies are generally mined by stripping of overburden.

The basic mining operations in opencast are drilling and blasting (not always necessary), loading of mined bulk and its haulage and disposal of waste. In working friable and soft ground, excavation and loading at the face are combined in one operation; otherwise, drilling and blasting should precede loading. Mechanical methods of loading are usually used.

In mining placer deposits of gold and other metals and minerals, usually a surface mining method is employed. The thickness of the placer deposits mined by the surface methods may reach up to 150 feet.

The small content of gold and its non-uniform distribution necessitate thorough and regular assaying of the sands. Gold-bearing placers often carry other valuable metals and minerals also, and the commercial value of sands should be established on the basis of the total content of useful components.

The mining of placers is preceded by sinking pits and boring arranged with a definite spacing depending upon the nature of placer and the category of reserves under exploration. Some of the basic information needed in making a choice of mining method is : general geography, communications, sources of water and electricity, cross-section of each test pit and borehole showing contents of useful constituents, strength and toughness of the ground, size grading of individual constituents, characteristic of the underlying bed rock, nature of metal contained in the placer, specific weight and fineness, size grading, susceptibility to amalgamation in case of gold, and magnetic properties of magnetic and weakly magnetic minerals, etc.. metal reserves in each placer, monthly water discharge in the stream, stream velocity, its variation, its width and depth, monthly data on precipitation, topographic maps at a scale of 1:50,000 or larger, plan of the placer at a scale of 1:1,000 or 1:2,000 containing all geological and assaying informations and information on subsurface water table.

In surface mining of placer deposits, two stages are distinguished. The first stage, preparatory to mining, includes removal of overburden, setting up of a water supply system for washing sand and dewatering of the ground where necessary. Sand washing plants are located near the stream or near outfall ditch which collects drained-out subsurface water.

After the necessary preparatory operations have been completed, sand placers are worked by excavators, dredges, hydraulic equipment and bull-dozers with hydraulic trailors. Only the first three are described briefly because these are the chief methods employed in placer mining. Bulldozing is common in case of other types of ore deposits.

The excavators used in open cast work are single-bucket and multibucket excavators. They may be crowler-mounted, rail-road type and walking type. The power shovel is the most commonly used single-bucket type. The multi-bucket (ladder and chain-and-bucket type) excavators are used in soft sandy ground where no drilling and blasting is required. The operation is usually combined with subsequent transportation of material by special conveyors. There are also rotary bucket excavators with several advantages over the multibucket type.

The dredge is a floating digger designed for mining sands and washing them to separate metals or minerals from waste. The basic parts of a dredge are a k pontoon, a dredging mechanism, supporting structures, concentration (washing) equipment and power plants. Dredges are classified as multibucket (continuous action) and single bucket (intermittant action). The multibucket dredges are of two types; in the first, buckets are directly coupled with each other, and in the second type they are separated by idler chain links. The first type is more extensively used. When in operation, dredges are moved along with the aid of spuds or lines.

Some of the definite mining conditions under which dredges are used are :—

1. The depth of placer occurrence should correspond to the digging depth of the dredge.

2. The presence of a water basin or the possibility of making a pond by construction of dam or by digging to set up the dredge should be there.

3. Reserve of pay sand should suffice for not less than 10 years.

4. The placer must not abound in big boulders exceeding one third of the dredge bucket in size. It may be mentioned that some of the dredges in common use have buckets sizes of approximately 5, 9, 13, and 21 cubic feet.

5. The top of the bedrock should be breakable by the bucket otherwise the losses of metal may be high.

6. For large and medium size dredges, water discharge in the placer valley should be 3.5 to 5.3 cubic feet/second.

In dredging, there are different ways of opening up a placer (by pits, with deep digging out of bedrock and with the aid of dams to provide sitting space for the dredge) and at least two basic systems of dredging (transverse and lengthwise) are practised. Then, there are various methods of extraction (straight face, oblique, face and under-digging).

Hydraulicking or ground sluicing means rendering the sand from its place in the ground by a strong water jet with subsequent transport of the dislodged material by the stream of water to the site of its treatment. The basic conditions for applying this type of mining are: (1) abundance of water which is consumed at the rate of 2,000 to 16,000 US gallons for every 35 cubic feet of mined ground, and (2) the possibility of unhindered removal of the tailings. Hydraulicking requires building up of a water supply line to the working face, a pressure tank or a centrifugal pump, hydraulicking giant & sluicing and disposal of waste. The efficiency of mining varies with the nozzle diameter and the type of ground. There are various methods of mining by hydraulicking. This method is most suited for mining placers in high ground.

Processing of sands

After the sand is mined, the run of mine ore has to undergo through various stages of screening and crushing (back and forth from one to the other), magnetic separation, classification and fine crushing, strake separation (for part of the gold content) and where necessary, through cyanidation processes. In some cases, straking is done in two stages and remaining portion may have to be treated in a post-cyanide plant for the recovery of left-over gold. After all this, the recovery is at best of the order of 90 percent of the total gold content. For recovering other minerals, several other processes have to be employed.

The above very brief rundown on the subject should enable the readers to visualize the problems and possible costs of detail exploration, mining and processing of the flood plain and boulder-strewn alluvial placer deposits, particularly in case of the upper Indus and Chitral Valleys.

DESCRIPTION OF THE PLACER DEPOSITS

Heavy mineral fraction

The heavy mineral fraction collected during the present survey is under physical and chemical examinations at the laboratories of the Engineering University and the Chemical Institute of the Punjab University at Lahore. The percentages of the heavy mineral fraction in the bulk sand and gravel are given in Tables 1, 2, 3, 4 and 5.

The distribution of the heavy mineral fraction in the gravel deposits of the flood plains and terraces along the Indus Valley between Thore in the west of Chilas and Sasi in the east of the confluence of Indus with Gilgit River is depicted in Figure 13. It appears from this figure that the gold content and the heavy mineral content of the alluvium deposits in this area are only very broadly related: the gold content increases with a relatively gradual increase in the heavy mineral content of the material. At the same time, in some cases the content of the heavy mineral fraction seems to increase with decrease in the gold content, particularly below a gold content of less than 0.0015 oz/l. ton. The case of the alluvium deposits of the Gilgit Valley is not very different from the one described above. Here also, the gold content shows a tendency to decrease with decrease in the heavy mineral content but other relationship is also present. The above discussions, however may be read with certain amount of caution because they are based on the results obtained through primitive 'Nava' (sluicing) operations.

A microscopic study of two samples of the heavy mineral fraction has confirmed presence of the minerals zircon, garnet, scheedlite, ilemnite and several other rock-forming silicate minerals of no economic significance. The present

quantitative results confirm the earlier findings of Dr. R. A. Khan Tahirkheli (1960) and Karl W. Stauffer (1968).

TABLE 1—*Details of gold contents and other relevant data for each sampling site in Upper Indus Valley in Gilgit Agency (for locations, see Figure 2&3) form downstream to upstream.*

Name of the area	Location Nos.	Bulk gravel in long tons	Heavy mineral fraction		Gold content and value	
			Wt. in lb.	Percent	Oz/L.T.	Value in Rs.
1						
Thore area ..	SA 32 & 33	29.4	93.2	0.14	0.0038	5.46
	SA 30 & 31	20.3	92.7	0.2	0.0037	5.22
	SA-36	1.78	1.1	1.03	1.0033	4.74
	SA-35	8.9	4.6	0.02	0.0045	5.47
	SA-13	1.78	—	..	0.0011	1.58
	SA-16, 19 & 20	6.2			0.0049	6.04
	SA-11	1.78			0.0034	4.88
	SA-3, 4 & 5	5.8			0.0045	5.47
	SA-7	1.78			0.0011	1.58
Chilas area ..	SA-28 & 29	21.4	61.5	0.12	0.0016	2.30
	SA-15	4.8			0.0004	0.57
	SA-8 & 9	6.16			0.0029	4.17
	SA-10,14,17,18 & 21	20.17			0.0041	4.89
	SA-2, 21,2C, 2D, & 2E	24.3			0.0027	3.88
	SA-22,23 & 24	31.69			0.0023	3.31
	SA-25,26 & 27	42.8			0.0018	2.59
	SA-1	2.68			0.0022	3.16
Gine area ..	SA-39	8.9	25.6	0.12	0.0059	8.48
	SA-38	8.0	22.7	0.12	0.0041	4.89
	SA-40 & 41	16.9	33.7	0.08	0.0059	8.48
	SA-42 & 43	18.7	39.2	0.09	0.0056	7.04
Bunar-Gunar Farm area	SA-44	8.0	7.3	0.04	0.0020	2.87
	SA-45	8.48	9	0.04	0.0036	5.17
	SA-46	6.69	12.7	0.08	0.0027	3.87
	SA-47	6.69	14	0.09	0.0066	9.48

(*Continued*)

1	2	3	4	5	6	7
Thelichi area ..	SA-48 T	2.68	7.6	0.12	0.011	15.80
	SA-48	2.68	7.7	0.12	0.0046	9.19
	SA-49	3.1	10.5	0.15	0.0059	8.47
	SA-51	1.33	1.1	0.03	0.0005	0.72
	SA-50	9.37	11.4	0.05	0.0017	2.44
	SA-53	1.33	3.1	0.1	0.011	15.80
	SA-52	11.6	10.8	0.04	0.0024	3.45
	SA-54	2.68	1.8	0.03	0.0016	2.34
	SA-55	5.8	6.9	0.05	0.0017	2.44
Bunji-Jaglot area ..	SA-56	2.2	1.3	0.02	0.0028	4.02
	SA-57,58, & 59	22.3	96.6	0.19	0.0092	13.22
	SA-60 & 61	10.7	34.1	0.14	0.0072	10.34
	SA-62	2.68	5.2	0.08	0.0063	9.05
	SA-63	1.78	5	0.12	0.0049	7.04
	SA-64	3.56	9.9	0.12	0.0017	2.44
	SA-65	1.78	6.2	0.16	0.0049	7.04
	SA-66	1.78	3.8	0.09	0.0072	10.34
	SA-67	2.68	11.1	0.18	0.0063	9.05
	SA-68	3.56	7.7	0.09	0.0058	8.33
	SA-70	2.68	5.0	0.08	0.0048	6.89
	SA-69	0.89	1.7	0.08	0.000	0.00
	SA-72 T	0.045	2.3	2.28	0.05	71.83
	SA-71	1.33	2.15	0.07	0.0002	2.87
	SA-72	1.33	4.7	0.15	0.0001	1.43
	RN-12	2.1	16	0.34	0.0039	5.60
	RN-11	2.1	16	0.34	0.220	2.87
	SA-73	3.56	8.7	0.10	0.0047	6.75
	RN-4	2.7	7	0.11	0.0026	3.73
Partab Pul-Sasi area	RN-10	2.9	8	0.12	0.0007	0.86
	RN-6	2.2	5	0.10	0.0023	3.30
	RN-7	1.8	7	0.17	0.0034	4.88
	RN-8	1.4	4	0.12	0.1114	2.01
	RN-9	1.6	8	0.22	0.0006	0.86

Distribution of gold

Perhaps the best way to describe and discuss the gold content of the alluvium deposits is to treat the deposits in the different major rivers or their portions separately. Therefore, the description that follows deals with : (1) the upper Indus Valley between Thore in the west of Chillas and Sasi in the east of Alam Pul (Figures 2 and 3); (2) the lower Indus Valley in the Darband-Tarbela-Attock area (Figures 4 and 5); (3) the valleys of the Gilgit and Hunza Rivers (Figures 6 and 7), north and east of Alam Pul and the Chitral River Valley (Figure 8). Figures 9 and 10 show the distribution of gold in the alluvium at different sampling sites along the above mentioned valleys. Figure 11 is a frequency distribution diagram of the gold contents of alluvium in different localities. In this diagram the gold contents in ounce per long ton have been divided into four categories. Figure 12 is a simple scatter diagram of the daily labour expenses on the local sand washers plotted against the total sand washed by them on their country made Nava (sluice).

Upper Indus Valley :

The flood plain and the terrace gravel deposits in this part of the valley are generally smaller and fewer in number than in the lower reaches. The deposit frequently contains pebbles and boulder, the latter often several feet in diameter. Such boulder-strewn deposits are more frequent than the boulder free mantle sand deposits. The material in these deposits are generally poorly sorted, but the individual pieces are rounded. Poor sorting and gravity separation is indicated by the absence of any positive relationship between the contents of the heavy mineral fraction and the gold in these deposits (Figure 13). In places, however relatively homogenous clays, sand and gravel layers are present in the terrace deposits. Also, several of the large terraces are covered with varying thicknesses of poorly sorted and subrounded debris which constitute fan deposits. This fact, plus the frequent presence of large to very large boulders, will have a direct bearing on any future mining activity for the heavy mineral fraction including gold.

1. *Thore area.*—The Thore area in this report includes the part of the valley between Thore and Hudar villages, west of Chilas town. It is the westernmost section of the Indus Valley investigated during the present survey (Figure 2). The deposits have been sampled as SA-32, 33; 30, 31: 35 ; 36; 13,16, 19, 20; 3, 4, 5; 7; and 11. The distribution of the gold content in these samples is given in figure 9a. In the Thore area as a whole, the gold content ranges from the lowest of 0.0011 to the highest of 0.0049 oz/l. ton, valued at Rs. 1.58 and Rs. 7.03, respectively. The richest part of the section lies in the middle. It is also interesting to note that the sharp meandering at the site of sample SA-7 has failed to produce enrichment of gold in the sand.

2. *Chilas area.*—The Chilas area in this report is taken to include the Indus Valley from a few miles west of the town of Chilas to about 2 miles east of this town (figure 2). The gold contents of the samples from this area (Table 1) are plotted on figure 9a.

It appears from figure 9a that the Chilas area is generally poor in gold content as compared to the Thore area. The lowest gold content of the gravel deposits, as recorded during the present investigations, is 0.0004 and the highest 0.0041 oz/l. ton, valued at Rs. 0.57 and Rs. 5.89, respectively.

3. *Gine area.*—In the Gine area, east of the town of Chilas, the Indus Valley deposits were sampled at four favourable sites (Figure 2) whose essential data are given in Table 1. The minimum and maximum gold contents in these deposits are 0.0041 and 0.0059 valued at Rs. 5.89 and Rs. 8.48, respectively.

The plot of the gold contents on figure 9 a, indicate a slight rise in the gold contents in general as compared to the deposits in the downstream sections of the valley described above.

4. *Bunar and Gunar Farm area.*—The Indus Valley alluvium in this area, which is east and west of Gunar Farm (Figure 2), was sampled at four widely spaced locations. Essential details of the samples are given in table 1 and the gold contents are plotted on figure 9a.

The slight rise in the gold contents towards the upstream of the Indus Valley continues through this area. The deposits in the area were found to contain a minimum of 0.002 and a maximum of 0.0066 oz/l. ton of gravel, valued at Rs. 2.87 and Rs. 9.48, respectively.

5. *Thelichi area.*—The Thelichi area in this report includes the Indus Valley between Thelichi Gah in the south and a point about three miles north of Thelichi Rest House (Figure 3). The gold content in the gravel deposits (Table 1 and Figure 9 a) shows a continuation of its general upward trend. Further, it is in this region that it reaches its peak of 0.011 oz/l. ton, before declining once again upstream of the Thelichi area. The minimum and maximum gold contents of this area are 0.0005 and 0.011 oz/l. ton valued at Rs. 0.72 and Rs. 15.80, respectively.

6. *Bunji-Jaglot area.*—The Bunji-Jaglot area in this report includes the Indus Valley section from upstream of the Thelichi area, through the villages of Bunji and Jaglot to Partab Pul (Figure 3 and 9 a : and Table 1). As depicted on figure 9 a, the gold contents of the gravel deposits in this area decrease slowly but erratically towards the upstream of the valley as compared to the Thelichi "high". Also, it is in a terrace gravel deposit of this area that the highest gold content of 0.05 oz/l. ton, valued at Rs. 71.85, has been recorded. Further, in the Bunji-Jaglot area, as at some other places mentioned above, a prominent meander in the Indus Valley sampled at SA-73 (Figure 3) was not found to contain more gold than those found in the deposits outside the meander.

The lowest and the highest gold content recorded from this area are zero and 0.0092 oz/l. ton, valued at Re. nil and Rs. 13.22, respectively.

7. *Partab Pul-Sasi area.*—This area includes the Indus Valley between Partab Pul in the south (about a mile downstream of the confluence of Indus and Gilgit Rivers) and Sasi in the northeast (Figure 3). The gold contents of the five samples, bearing the numbers RN-10, RN-6, RN-7, RN-8 and RN-9, collected from this area are plotted on figure 9a and their essential data recorded in table 1.

The general downward trend of the gold content with respect to the highest in the Thelichi area and a relative high in Bunji-Jaglot area, continues through this area. The minimum and maximum gold contents among the samples from this area are 0.0006 and 0.0034 oz./l. ton, valued at Rs. 0.86 and Rs. 4.88, respectively.

Summary of results

The results of the present study of the alluvium deposits of the upper Indus Valley, described in the preceding chapter, are summarised below for minimum

and maximum gold contents in different sections of the valley :

TABLE 2—*Minimum and maximum gold contents and values in different areas of upper Indus Valley.*

Area	Minimum gold contents		Maximum gold contents	
	oz/L. ton	value in Rs.	oz/L. ton	value in Rs.
1. Thore area	0.0011	1.58	0.0049	7.03
2. Chilas area	0.0004	0.57	0.0041	5.89
3. Gine area	0.0041	5.89	0.0059	8.48
4. Bunar and Gunar Farm area ..	0.002	2.87	0.0066	9.48
5. Thelichi area	0.0005	0.72	0.011	15.80
6. Bunji-Jaglot area	0.00	0.0	0.0092	13.22
7. Bunji-Jaglot area, terrace deposit ..			0.05	71.85
8. Partab Pul-Sasi area	0.0006	0.86	0.0034	4.88

Lower Indus Valley :

1. *Darband area.*—The Indus Valley deposit in the Darband area was examined between Tirbat village in the north and Kirpalian in the south (downstream) with the town of Darband in the middle of this total length of approximately 6 miles (Figure 4). A total of 15 samples were collected from the alluvium deposits at both the banks of Indus. There essential data are given in table 3 and their gold contents are plotted on figure 9(d). Figure 11 gives the frequency distributions.

Figure 9 (d) indicates a very prominent peak of gold content where it is between 0.011 and 0.014 oz/l. ton against very low values on both sides. When figure 9 (a) is read in conjunction with figure 4, it shows that this maximum concentration is where it is expected to occur, that is on the inside bank of a wide meander. The other sites in the Darband area outside the above mentioned meander are relatively very poor.

In the Darband area, the minimum and maximum gold contents are 0.002 and 0.014, valued at Rs. 2.87 and Rs. 19.12, respectively.

2. *Tarbela-Attock area.*—In the Tarbela-Attock area, two stretches of the Indus Valley have been examined during the present survey ; the first is from a mile south (downstream) of Attock Fort to Mansar camp (approximately 5-mile length) in the west, and the second is between Sheikh Chur to about 2 miles upstream of Sobrah in the northeast, a length of about 11 miles. The two sections of the valley are separated by several miles (Figure 5).

This part of the Indus River is characterized by a wide channel, in places several miles across, and by extensive deposit of sand which contain relatively lesser amounts of boulders and large pebbles than those present in the alluvium of the upper Indus Valley.

During the present brief survey, the sampling was largely confined along the southern bank of the river, with only three samples from the other bank from place near Attock Fort. Out of the 39 samples collected from this area

(Table 3), five have been collected from downstream of Attock Fort (two from the right bank and three from the left), 10 from the stretch between Attock Fort and Manser Camp and the rest from the stretch between Sheikh Chur and Sobrah.

The gold contents of the above samples are plotted on figure 10 and their frequency distribution in various categories on figure 11. In the vicinity of Attock Fort, the minimum and maximum gold contents are 0.0038 and 0.0086, valued at Rs. 5.46 and Rs. 12.36, respectively ; in the vicinity of Mansar Camp, they are 0.0032 and 0.010, valued at Rs. 4.60 and Rs. 14.37, respectively ; between Sheikh Chur and Ghazipur, they are 0.0048 and 0.0081, valued at Rs. 7.04 and Rs. 11.64, respectively ; and in the easternmost area between Ghazipur and Sobrah, they are 0.0055 and 0.130, valued at Rs. 7.90 and Rs. 18.68, respectively. In the whole of this area, the minimum and maximum gold contents, as recorded during the present investigations, are 0.0032 (Mansar Camp) and 0.013 (Sobrah), respectively.

TABLE 3—*Details of gold contents and other relevant data for each sampling site along the lower Indus Valley in Darband-Tarbela-Attock area (for locations, see figures 4 and 5) from downstream to upstream.*

Name of the area	Location Nos.	Bulk gravel in long tons	Heavy mineral fraction		Gold content and value	
			Wt. in Lb.	Percent	Oz/L.T. of Bulk	Value in Rs.
Darband area ..	AH-53	11.1	4	0.016	0.0029	4.17
	AH-52	11.1	4	0.016	0.0047	6.75
	AH-51	11.1	4	0.016	0.0029	4.17
	AH-54	11.1	4	0.016	0.0029	4.17
	AH-45	4.4	3	0.026	0.014	19.12
	AH-46	6.7	5	0.03	0.012	17.24
	AH-47	6.7	4	0.02	0.012	17.24
	AH-48	6.7	4	0.02	0.012	17.24
	AH-49	9	4	0.019	0.011	15.80
	AH-50	22.3	9	0.018	0.004	5.75
	AH-55	13.4	6	0.02	0.0036	5.17
	AH-56	13.4	6	0.02	0.0036	5.17
	AH-57	13.4	6	0.02	0.007	10.06
	AH-58	13.4	6	0.02	0.002	2.87
	AH-59	13.4	6	0.02	0.002	2.87
Tarbela-Attock area ..	AH-37	10	7	0.03	0.0086	12.36
	AH-36	10	7	0.03	0.0057	8.19
	AH-35	10	7	0.03	0.0057	8.19
	AH-39	30	21	0.03	0.0038	5.46
	AH-38	20	14	0.03	0.0057	8.19

(*Continued*)

Name of the area	Location Nos.	Bulk gravel in long tons	Heavy mineral fraction		Gold content and value	
			Wt. in Lb.	Percent	Oz/L.T. of Bulk	Value in Rs.
	AH-33	11.6	7	0.027	0.007	10.06
	AH-32	9.3	10	0.047	0.0052	7.47
	AH-25	14.1	7	0.022	0.0046	6.61
	AH-26	15	8	0.023	0.0032	4.60
	AH-27	10	7	0.03	0.0065	9.34
	AH-34	9.3	8	0.038	0.007	10.06
	AH-28	10	7	0.03	0.0065	9.34
	AH-29	10.2	8	0.034	0.0047	6.57
	AH-30	10.7	9	0.037	0.0061	8.76
	AH-31	11	8	0.032	0.010	14.37
	AH-10	19.3	12	0.027	0.0051	7.33
	AH-9	18.7	11	0.026	0.0081	11.64
	AH-11	16.7	10	0.027	0.0059	8.48
	AH-8	18	10	0.024	0.0054	7.76
	AH-7	41.2	25	0.027	0.006	8.62
	AH-6	43	23	0.023	0.005	7.18
	AH-12	13.4	7	0.023	0.0049	7.04
	AH-3	16	12	0.033	0.0067	9.63
	AH-2	20	11	0.024	0.0051	7.32
	AH-4	17.8	10	0.025	0.0057	8.19
	AH-5	20.3	12	0.026	0.0048	6.89
	AH-1	14.7	11	0.038	0.0066	9.48
	AH-17	14.7	8	0.024	0.0057	8.19
	AH-16	13.4	8	0.026	0.0081	11.64
	AH-15	12.2	9	0.032	0.0083	11.92
	AH-24	17.6	6	0.015	0.0057	8.48
	AH-23	15.4	8	0.023	0.0085	12.21
	AH-14	15.6	7	0.020	0.0063	9.05
	AH-13	14.5	8	0.024	0.0067	9.63
	AH-22	13	8	0.027	0.013	18.68
	AH-21	13.4	9	0.029	0.0078	11.21
	AH-20	12	7	0.026	0.0122	17.53
	AH-19	16	10	0.027	0.0055	7.90
	AH-18	13.8	8	0.025	0.0061	8.76

Gilgit and Hunza Valleys :

The Gilgit and Hunza Valleys alluvium deposits were sampled from the confluence of Indus and Gilgit Rivers in the downstream, about 23 miles south of Gilgit town, to a place about 4 miles west of Sikandarabad in Hunza (Figures 6 & 7). The Gilgit Valley upstream of the confluence of Gilgit and Hunza River was not examined during the present survey.

This part of the Gilgit and Hunza Valleys has several large and thick alluvial terrace deposits but many of them are covered with alluvial fan material. The alluvium deposits in the flood plains are generally small in extent and only a few feet above the water level. The deposits in both high terraces and flood plains are quite frequently strewn with large and small boulders, often measuring several feet across.

The sampling sites are plotted on figures 6 and 7 and the gold contents on figure 9 (b). The essential data regarding the samples are given in table 4. Frequency distribution are plotted on figure 12.

For the purpose of this report, the Gilgit-Hunza Valleys has been divided into the following segments for ease of description (from downstream to upstream) :

1. Alam Pul area
2. Parri area
3. Aushkhan Das area
4. Dainyor area
5. Jutal area
6. Matum Das area
7. Chalt area

TABLE 4. *Datails of gold contents and other relevant data for the sampling sites along the Gilgit and Hunza River Valleys, Gilgit Agency (for locations, see figures 6 and 7) from downstream to upstream.*

Name of the area	Location Nos.	Bulk gravel in long tons	Heavy mineral fraction		Gold content and value	
			Wt. in Lb.	Percent	Oz/L. T. of Bulk	Value in Rs.
Alam Pul area ..	BS—3	15.7	62	0.17	0.01	14.37
	RN—14	1.8	8	0.19	0.0051	7.33
	RN—1	1.5	6	0.18	0.0103	14.80
	RN—2	1.5	7	0.21	0.0083	11.92
	BS—5	41.9	115	0.12	0.0039	5.60
	BS—4	16.9	61	0.16	0.0082	11.78
	BS—6	40.8	87	0.09	0.0039	5.60

(*Continued*)

Name of the area	Location Nos.	Bulk gravel in long tons	Heavy mineral fraction		Gold content and value	
			Wt. in Lb.	Percent	Oz/L.T. of Bulk	Value in Rs.
	BS—1	9.4	89.5	0.42	0.013	18.68
	BS—2	23.7	108	0.2	0.0115	16.52
	RN—3	1.3	3	0.1	0.0094	13.51
	BS—9	35.7	73	0.09	0.0041	5.89
	RN—5	2.5	9	0.12	0.0057	8.19
	BS—10	37.4	113	0.13	0.0061	8.76
Parri area ..	BS—12	37.5	131	0.15	0.0065	9.34
	BS—7	37.7	78	0.09	0.0065	9.34
	BS—8	37.9	79	0.09	0.0035	5.03
	BS—13	34.8	118	0.15	0.0040	5.75
	BS—14	35.7	138.5	1.73	0.0036	5.17
	BS—11	35.8	78	0.10	0.0059	9.48
	BS—15	34.3	75.5	0.95	0.0056	8.05
	BS—16	33.5	49	0.06	0.0055	7.90
	BS—19	35.9	28.5	0.03	0.0109	15.66
	BS—18	33.5	44.5	0.06	0.003	4.31
	BS—17	36.4	55	0.06	0.0054	7.06
	BS—20	37.5	4.55	0.05	0.0026	3.73
Aushkhan Das area	BS—21	36.6	101.5	0.12	0.0045	6.46
	BS—22	33	54.5	0.07	0.0027	3.88
	BS—23	35.7	55	0.06	0.0028	4.02
	BS—24	37.3	52.5	0.06	0.0028	4.02
	BS—25	35.7	92	0.11	0.0025	3.59
	BS—26	36	61	0.07	0.0040	5.75
	BS—27	17.9	42	0.1	0.0041	5.89
	BS—28	10	69	0.09	0.0068	9.77
	BS—29	7.2	41.5	0.25	0.0062	8.76
	BS—30	6.2	43	0.3	0.0105	15.09
Dainyor area ..	BS—31	5.9	41	0.03	0.00118	16.95
	BS—32	5.9	33.5	0.25	0.0131	18.82
	BS—33	7.5	41	0.24	0.0062	8.91
	BS—34	8	50.5	0.28	0.0102	14.65
	BS—35	4.9	17.5	0.15	0.0067	9.63

(*Continued*)

Name of the area	Location Nos.	Bulk gravel in long tons	Heavy mineral fraction		Gold content and value	
			Wt. in Lb.	Percent	Oz/L.T. of Bulk	Value in Rs.
	BS—36	4.9	17.5	0.15	0.0067	9.63
	BS—37, BS—38	Results awaited from Lahore labs.				
	BS—39, BS—40	Results awaited from Lahore Labs.				
	RK—41	11.3	—	—	0.009	12.93
	RK—42	9.7	—	—	0.0045	6.46
	BS—43	Results awaited from Lahore Labs.				
	RK—44	20.3	50	0.11	0.0038	5.46
Jutal area ..	BS—45	Results awaited from Lahore Labs.				
	RK—46					
	RK—47					
	RK—48					
	RK—49	10	33	0.14	0.0041	5.89
	RK—50	15	28	0.08	0.0052	7.47
	RK—51	15	53	0.15	0.0041	5.89
	RK—52	15	23	0.06	0.0061	8.76
	RK—53	15	30	0.08	0.0043	6.18
	RK—54	6.4	9.25	0.6	0.0051	7.33
Chalt area ..	RK—64	9.8	25	0.11	0.0087	12.50
	RK—65	8	23.5	0.13	0.0081	11.64
	RK—66	9.8	24.5	0.11	0.010	14.37

1. *Alam Pur area.*—This area constitutes a stretch of about four miles of the Gilgit River immediately upstream of its confluence with the Indus River.

There are three peaks in this area but only one of them barely crosses the 0·125 oz/l. ton line. The minimum and maximum gold contents among the 13 samples collected from this area are 0·0039 and 0·013, valued at Rs. 5·60 and Rs. 18·68 respectively.

2. *Parri area.*—The Parri area, upstream of Alam Pul, is about eight miles long stretch of the Gilgit Valley. The villages of Parri and Chhamongarh are included in this area.

Twelve samples were collected from the flood plain alluvium deposits along both the banks. Their essential data are given in table 4 and the gold contents in oz/l. ton are plotted on figure 9(b).

In the Parri area there is only one peak of 0·0109 oz/l. ton. The minimum and maximum gold contents recorded during the present study are 0·0026 and 0·0109 oz/l. ton, valued at Rs. 4·31 and Rs. 15·66, respectively.

3. *Aushkhan Das area.*—The Parri area is followed upstream by the Aushkhan Das area. The flood plain and terrace gravel deposits in this seven miles stretch of the valley are not very extensive and mostly confined to very narrow patches along the river. Ten samples have been collected from this area whose essential data are given in table 4. Their gold contents are plotted on figure 9(b).

In the Aushkhan Das area the gold contents in the gravel deposits are generally lower than in the Parri and Alam Pul areas, and there are no peaks. The minimum and maximum gold contents are 0·0025 and 0·0105 oz/l. ton, valued at Rs. 3·59 and Rs. 15·09, respectively.

4. *Dainyor area.*—The Aushkhan Das area is followed upstream (westward) by the Dainyor area, northeast of the town of Gilgit (Figure 6). A total of 14 samples from both banks of the Gilgit and Hunza rivers have been collected (Table 4).

Most of comparatively richer gold concentrations occur on the southern bank of the river, a mile or so downstream of the confluence of Gilgit and Hunza Rivers. Further downstream, concentration of the metal drops off. There is only one prominent peak with a value of 0·0131 oz/l. ton (Figure 9b). The minimum and maximum gold contents in the Dainyor area are 0·0038 and 0·0131 oz/l. ton, valued at Rs. 5·46 and Rs. 18·82, respectively.

5. *Jutal area.*—The area designated in this report after the Jutal village is an eight mile long stretch of the Hunza Valley upstream of Dainyor.

The gold contents in the 10 samples collected from this area are relatively less than those in the samples from the Dainyor area further downstream. The minimum and maximum gold contents in this area are 0·0041 and 0·0061 oz/l. ton, valued at Rs. 5·89 and Rs. 8·76, respectively.

6. *Matum Das area.*—The area designated after the village of Matum Das includes a stretch of the Hunza valley between Nomal in the south and a point about 4 miles west and downstream of Chalt village. In this area there is again a general rise in the gold contents of the samples with respect to the Jutal area toward the downstream of the valley.

In the 9 samples collected from this area, the minimum and maximum gold contents are 0·0021 and 0·0131 oz/l. ton, valued at Rs. 3·01 and Rs. 18·82.

7. *Chalt area.*—The area designated in this report after the village of Chalt is located west of Sikandarabad on a prominent meander of the Hunza River. Among the three samples collected from this area, one of the two collected from the inside bank of the meander contains the highest amount of gold, 0·010 oz/l. ton, valued at Rs. 14·37. The other samples contain 0·0087 and 0·0081 oz/l. ton, valued at Rs. 12·50 and Rs. 11·64, respectively.

Chitral and Mastuj Valleys :

In the Chitral and Mastuj Valleys, seven widely spaced sites were examined. The northernmost site is located in the Mastuj Valley near Ishtan Lasht, about

20 miles northeast of Chitral town, and the southern-most is in the Chitral Valley near Khairabad (Figure 8). Each of these sites were subject to close sampling as follows : Site No. AK-1, four samples; Site No. AK-2, nine samples ; Site No. AK-3, 3 samples ; Site No. 4, three samples ; Site No. 5, fourteen samples ; Site No. 6, four samples ; and Site No. 7, thirteen samples. The sampling at any given site could not be legibly plotted on the available map and therefore have been shown by a single point. Their results have been added up and averaged (Table 5). The sampling was confined to the western banks of the valleys.

The Mastuj and Chitral valleys are characterized by general lack of extensive flood plain and terrace alluvium deposits except at a few places. Further, the alluvium generally contains pebbles and large boulders. The stream is fast flowing and meandering is restricted in occurrence and in size. The cold season, especially in the northern parts will restrict any manual sand-washing operations to summer months only.

The minimum and maximum gold contents, as recorded during the present investigations, are 0·003 (just north of Chitral town and 0·0108 (near Khairabad), valued at Rs. 4·31 and Rs. 15·52, respectively.

TABLE 5.—*Details of gold contents and other relevant data for each sampling site along Chitral and Mastuj Valleys in Chitral District (for locations, see figure 8) from downstream to upstream.*

Name of the area	Location Nos.	Bulk gravel in long tons	Heavy mineral fraction		Gold content and value	
			Wt. in Lb.	Percent	Oz L.T. of Bulk	Value in Rs.
Chitral Valley	AK-7	182.2	35	0.011	0.0108	15.52
	AK-6	39.3	5.4	0.006	0.0043	6.18
	AK-4	59.5	10.7	0.004	0.005	7.18
	AK-3	36.2	4.7	0.005	0.003	4.31
	AK-2	104.3	21.1	0.007	0.0052	7.47
	AK-5	211.6	63.4	0.013	0.0064	9.09
	AK-1	16.8	3.15	0.008	0.0049	7.04

Total contents of gold

Eight samples, prepared by combining a portion from several field samples were analysed by Mr. Mushtaq Ahmad, Senior Chemist, Geological Survey of Pakistan on the atomic absorption at PINSTECH, Nelore. The results, reported in parts per million (PPM) of the heavy mineral fraction and computed in ounce per long ton of the bulk gravel, are given in table 6.

TABLE 6.—*Atomic absorption determination of gold in heavy mineral fraction after separation of gold by mercury amalgamation and percent recovery by amalgamation.*

Lab. Nos.	Field Nos.	Total wt. of H.M.F. in approx. lbs.	Total wt. of bulk gravel in L. Tons	Gold in H.M.F. in ppm.	Ppm converted into oz/L.T. of bulk gravel	Mercury separated gold in. oz/L.T of bulk gravel, and % recovery in( )
A	BS-1 to BS-10 Gilgit ..	865	297	18	0.00084	0.0087
B	BS-11 to BS-20 Gilgit ..	769	359	46	0.00158	0.0049
C	BS-21 to BS-30 Gilgit ..	612	254	64	0.00246	0.0043
D	BS-31 to BS-44 Gilgit ..	401	126	24	0.00122	0.0098
E	RK-45 to RK-50 Hunza ..	110	70	37.5	0.00094	0.0057
F	RK-51 to RK-58 Hunza ..	231	93	63	0.00251	0.005
G	SA-46, 47, 48 T, 58, 60, 64, 65 66 & 73 Chilas.	50	43	13	0.00024	0.0060
H	RN-2 to RN-5, RN-9 to RN-14 Indus Valley, upstream of Alam pul.	90	20	20	0.00144	0.0063

(After Mushtaq Ahmad, Sr. Chemist, GSP)

CONCLUSION

A final assessment of the value of the gravel deposits that were examined during the present survey cannot be made at this stage in the absence of mineralogical and other data. The heavy fractions, including the gold tailings are under examination in the Engineering University and the Chemical Institute of the Punjab University. However, the data of gold washing, as practised locally and the content of gold in various flood plain deposits lead to some simple conclusions. Firstly, for any large or medium-scale mining activity the gold washing techniques involving a large labour force, similar to the one employed during the present survey is considered uneconomic. This is testified by the following statement which gives the values of gold produced for every Rs. 10·00 spent on labour alone in different parts of the area surveyed. The areas have been selected randomly from the daily reports of the field parties :

	Rs.
1. Chilas area	2·82
2. Bunji and Jaglot area	5·03
3. Thelichi area	3·06
4. Alam Pul area	5·26
5. Jutal area	3·35

In this regard, there may be only one exception. The gold washing by a large labour force may prove economic only in cases of exceptionally rich placer deposits. Such a deposit is not presently known in the areas investigated, except perhaps No. A-6 (ii).

This aspect can be looked into from yet another angle. The cost of labour per ton of gravel washed as incurred on the local sand washers during the present survey has been highly variable. This fact is amply testified by the scatter diagram (Figure 12) of cost plotted against the material washed. This again has been taken from the daily reports of the field parties. The following calculations have been made with the help of figure 12, taking 22·4 cubic feet in one long ton. The letters (a), (b), etc. are the same as they appear on the figure cited above :

(*a*) 0·7 tons bulk, washed at a cost of Rs. 60·00

(*b*) 6·2 tons bulk, washed at a cost of Rs. 220·00

(*c*) 8·2 tons bulk, washed at a cost of Rs. 340·00

(*d*) 8·7 tons bulk, washed at a cost of Rs. 130·00

(*e*) 42·0 tons bulk, washed at a cost of Rs. 550·00

Such high and variable expense can hardly be tolerated in a regular mining venture. The figures for other areas are equally discouraging. It is needless to emphasise that the above figures are against the labour expenditure alone. There have been several overhead expenses and would again be so in case of proper mining.

Turning to the question of economics of gravel deposits, any conclusion or judgement at this stage can be made with reference to gold alone and therefore, must be read with some reservations. Allowing for the reconnaissance nature of the survey, the quantitative estimates of gold and its monetary values given in the preceding chapters clearly point out that a large number of gravel deposits cannot be termed as ore even if they are found to contain some more values in the form of other metals and minerals. It may be pointed out that most of all precious metals and rare earths, in fact everything that a placer may contain, require for their separation complicated processes involving considerable capital and running expenditure. Necessarily, therefore, the important thing is to see whether the total value of gold and other recoverable metals and minerals justifies the cost of mining placers and of separating their useful constituents. In support of the above contention, some basic data are briefly given in table 7 which contains the minimum and maximum contents and values of gold found in different areas.

In table 7, certainly almost all of those deposits listed under the column "leanest ore" and similar ones that appear in different tables are too lean to be of more than academic interest. However, a few deposits from the right hand column of table 7 deserve a second colser examination. As stated earlier, a final opinion based on the total value, economics of mining and metallurgy, *etc.*, will necessarily have to wait until grades and reserves of individual deposits have been established. Nearly all these aspects, except the first, are beyond the scope of the present report, but nevertheless important.

TABLE 7.—*Maximum and minimum contents of gold in oz/l. ton and values in Pak rupees; price calculated on the basis of Rs. 575 per tola (as of Karachi, 10-2-74) or Rs. 1.437 per ounce.*

AREAS	"Leanest ore"		"Richest ore"	
	oz/L. ton	Value	oz/L. ton	Value
A. UPPER INDUS VALLEY				
1. Tore area	0.0011	1.58	0.0049	7.03
2. Chilas area	0.0004	0.57	0.0041	5.89
3. Gine area	0.0041	5.89	0.0059	8.48
4. Bunar and Gunar Farm area ..	0.002	2.87	0.0066	9.48
5. Thelichi area	0.0005	0.72	0.011	15.80
6. Bunji-Jaglot area	0.00	0.02	0.0092	13.22
same terrace deposit	one sample only		0.05	71.85
7. Partab Pul-Sasi area	0.0006	0.86	0.0034	4.88
B. LOWER INDUS VALLEY				
8. Darband area	0.002	2.87	0.014	19.12
9. Tarbela-Attock area	0.0032	4.60	0.013	18.68
C. GILGIT AND HUNZA VALLEYS				
10. Alam Pul area	0.0039	5.60	0.013	18.68
11. Parri area	0.0026	4.31	0.0109	15.66
12. Aushkhan Das area	0.0025	3.59	0.0105	15.09
13. Dainyor area	0.0038	5.46	0.0131	18.82
14. Jutal area	0.0041	5.89	0.0061	8.78
15. Matum Das area	0.0021	3.01	0.0131	18.82
16. Chalt area	0.0081	11.64	0.010	14.37
D. CHITRAL AND MASTUJ VALLEYS	0.003	4.31	0.0108	15.52

RECOMMENDATION

It is recommended to determine grades in more detail and establish reserves, if necessary, on the basis of grade determinations, by the usual sampling methods at the following sites in order of preference (for explanation of numbers, see table 7: (1) No. A-6 (ii); (2) No. B-8 & 9; and (3) No. C-9 & 12. They all belong to the category of "richest ore" in table 7. If preliminary widely spaced sampling of each deposit does not show marked improvement over the presently known grades, the study may be discontinued. By that time their general potential will become known to the Geological Survey of Pakistan and they would be re-examined when

called for by the rise in gold price. Currently, since the initiation of this report in February, 1974, the price of gold has recorded a decline after a rise during the end of February and early parts of March, 1974. Further, some of the high terraces that have not been looked into may be subjected to spot sampling by panning and instrumental (both microscopic and chemical) determination of gold and other metals among the heavy minerals. If necessary, this should be followed by bulk testing, in the laboratory, milling, sizing, heavy mineral separation and separation of metals, and determination of possible economics of these processes. Economics need no overemphasis; aluminium is present even in common dirt but can not be won profitably.

REFERENCES

Bakr, M. A., 1965, Geology of parts of Trans-Himalayan region in Gilgit and Baltistan, West Pakistan, Recs., Geol. Surv. Pak., vol. 11, Pt. 3, 17 pp.

Danilchik, W., 1959, An investigation of alluvial sands for uranium and minerals of economic importance: The Indus, Gilgit, Nagar and Hunza Rivers, Gilgit Agency, West Pakistan, Info. Rel., Geol. Surv. Pak., No. 11, 7 pp.

Heron, A. M., 1954, Directory of economic minerals of Pakistan, Recs., Geol. Surv. Pak., Vol. 7, Pt. 2, pp. 75—79.

Ivanac, J. F., Traves, D. M. and King, D., 1956, The geology of northwest portion of the Gilgit Agency, Recs., Geol. Surv. Pak, vol. 8, Pt. 2, pp. 3—27.

Mc Kinstry, H.E., 1968, Mining Geology, Charles E. Tuttle Company, Tokyo, 680 pp.

Popov, G., 1971, The working of Mineral Deposits, Mir Publishers, Moscow, 616 pp.

Tahirkheli, R.A.K., 1960, Investigation of gold and other placer minerals in the Indus alluvium, Infor. Rel., Geol. Surv., Pak., No 14, 9 pp.

PCPPK—S/164/76/GSP—18-6-77—1,500.

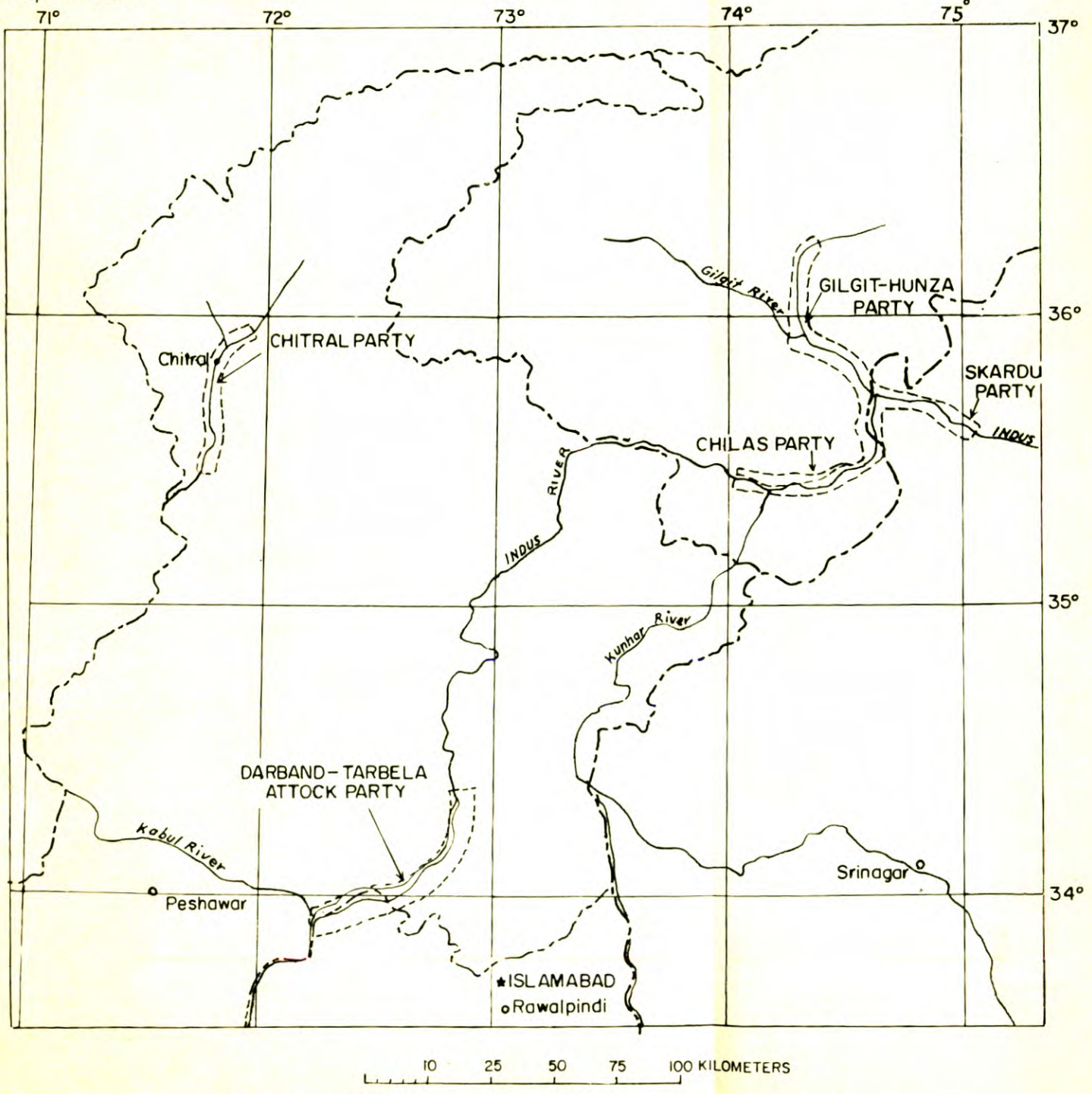


FIG I. INDEX MAP OF THE NORTHERN PART OF PAKISTAN SHOWING THE VALLEYS SURVEYED

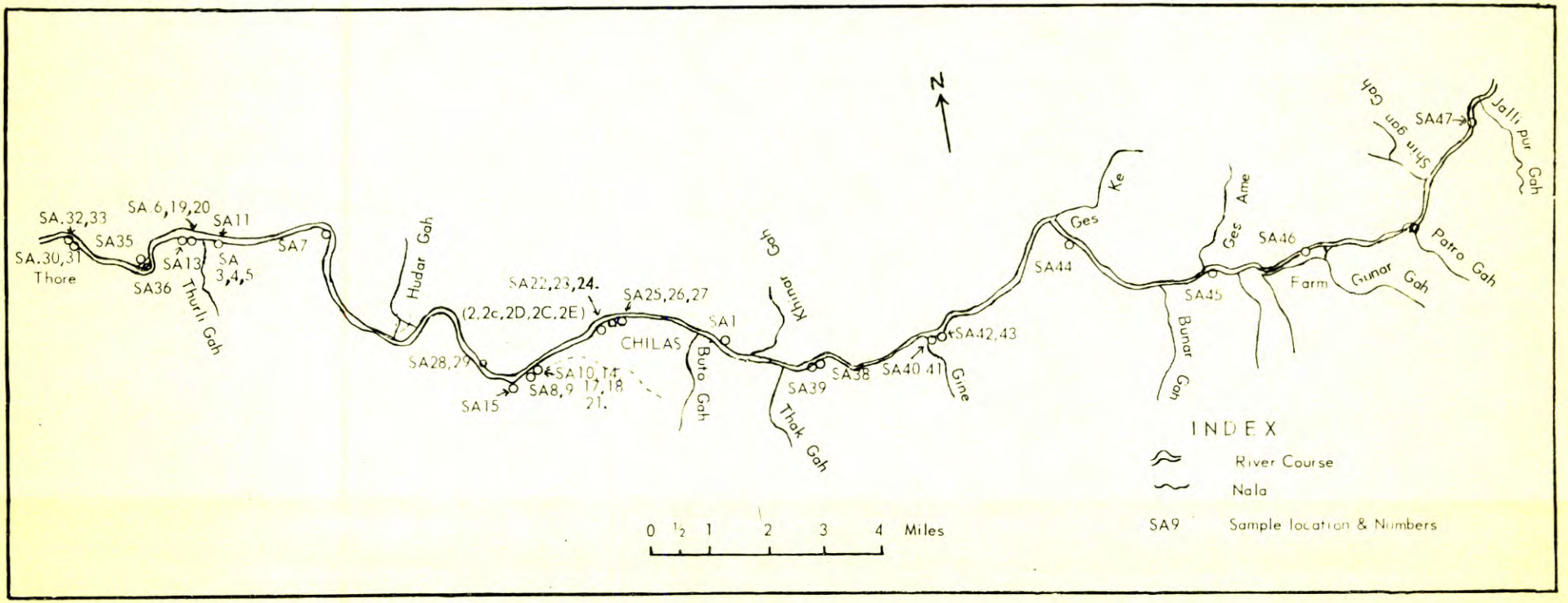


Figure 2 Sample location map of the Upper Indus Valley between Thore and Bunar Farm

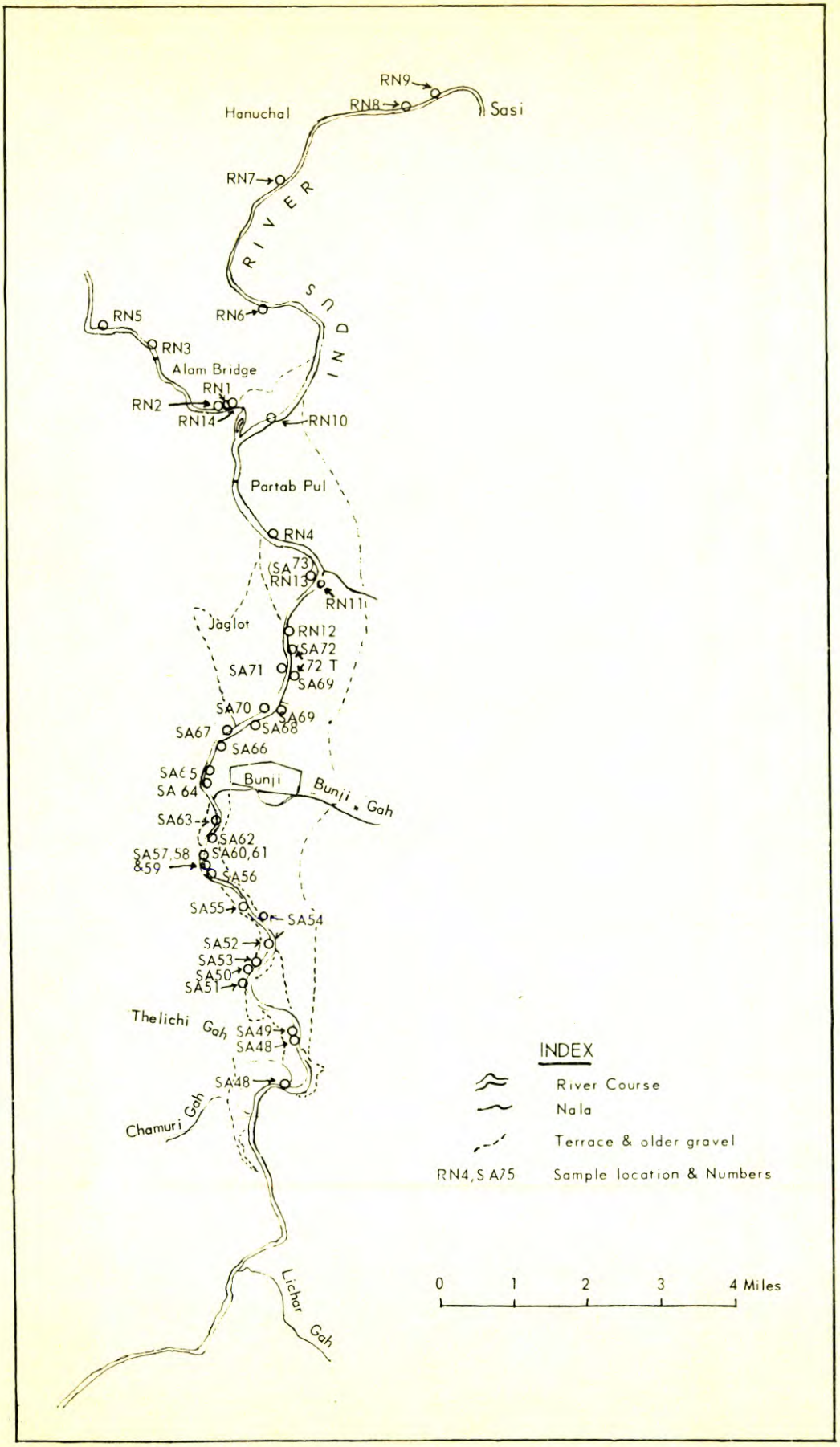


Figure 3. Sample location map of the Upper Indus Valley between Thelichi and Sasi

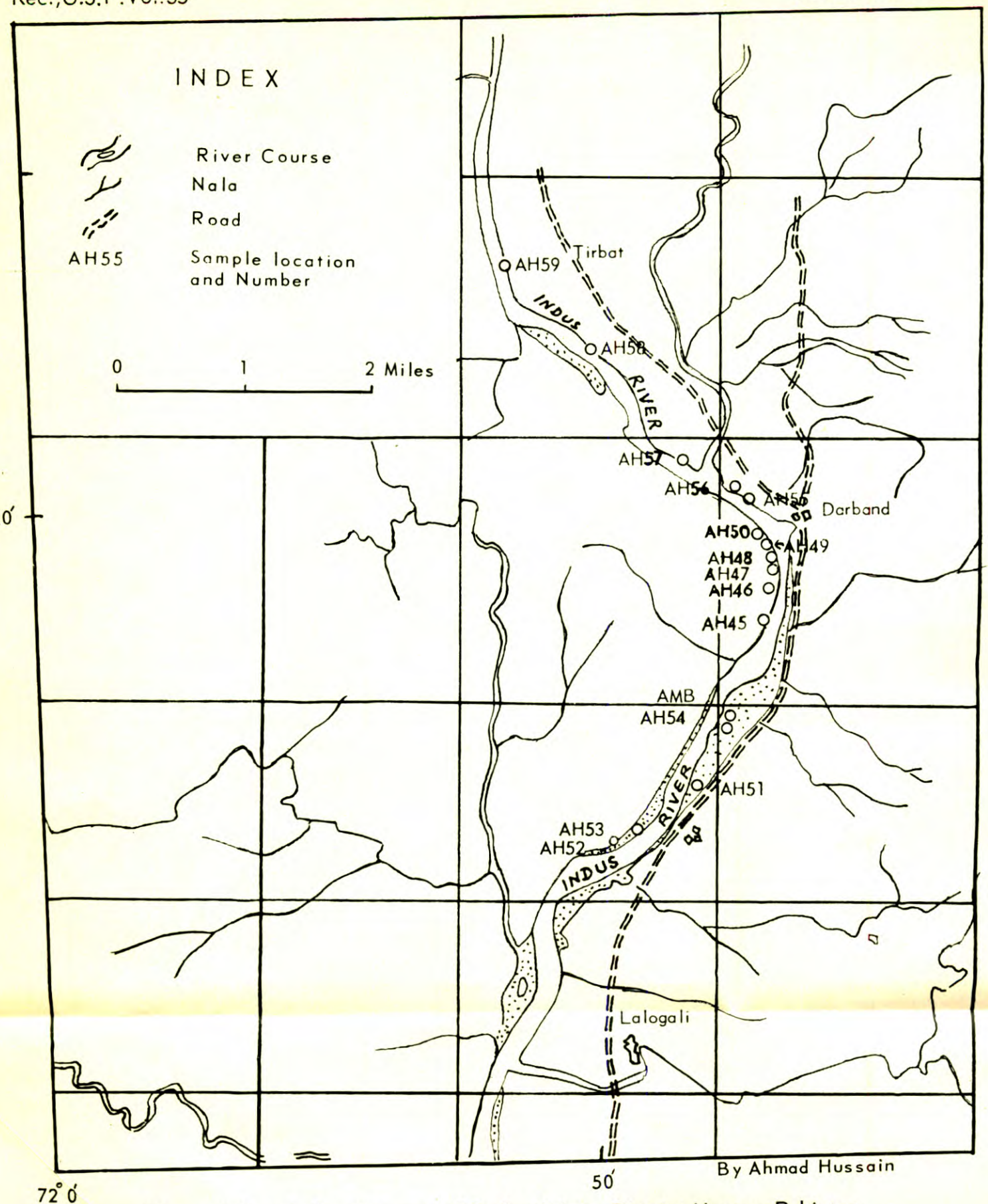
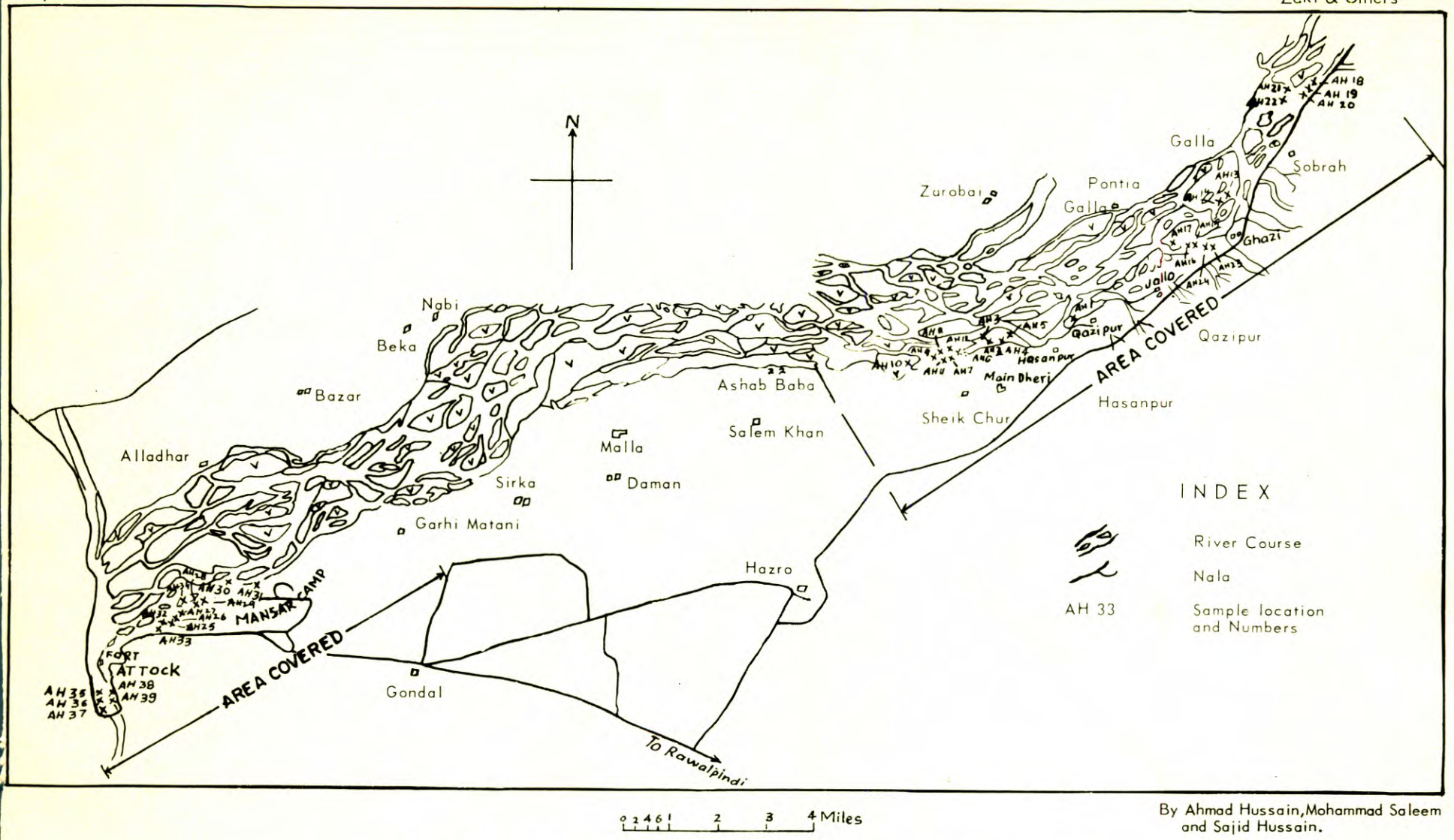
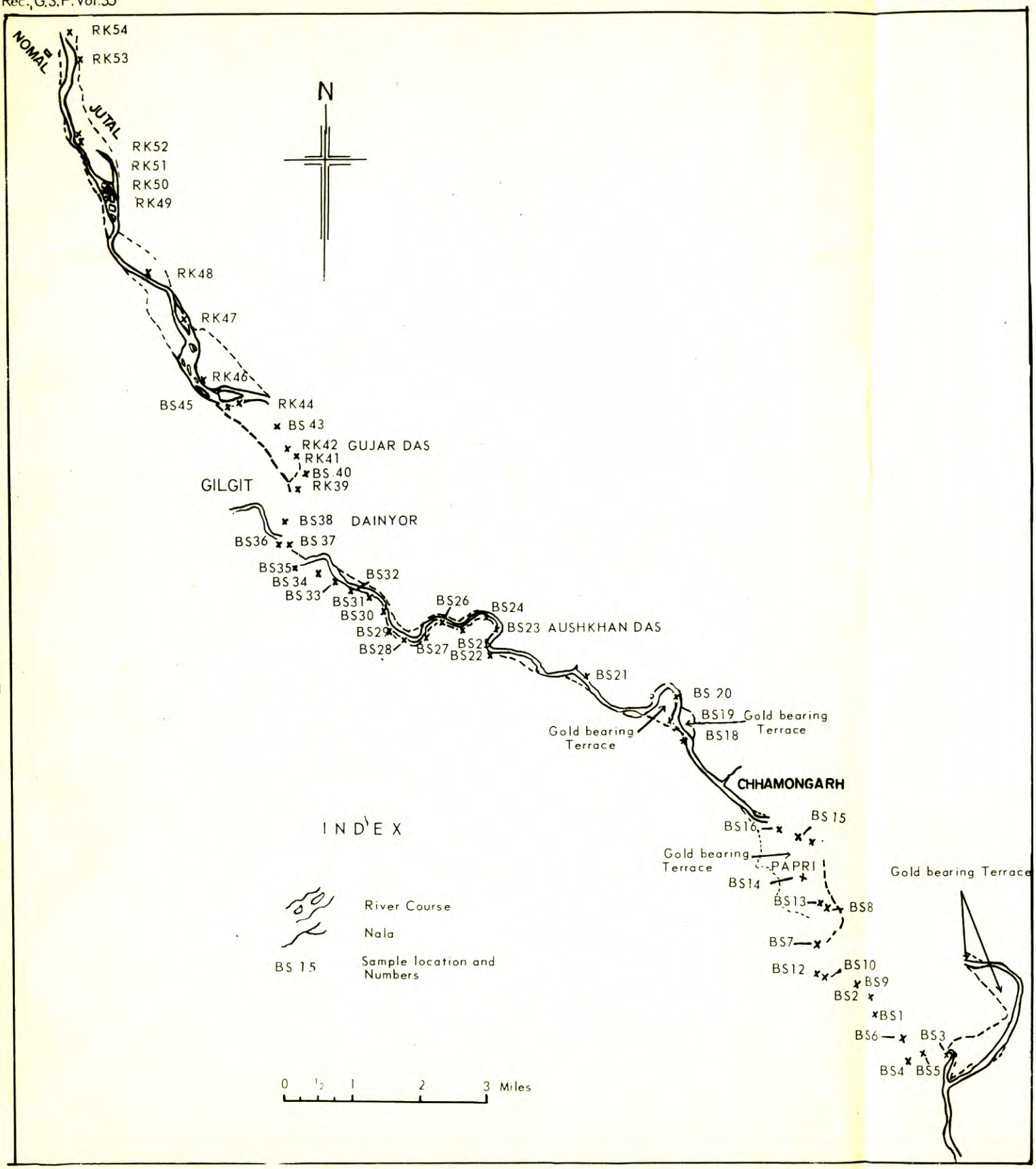


Figure 4. Sample location map of Darband Area, District Hazara, Pakistan



By Ahmad Hussain, Mohammad Saleem and Sajid Hussain.

Figure 5. Sample location map of the lower Indus Valley (Sobrah-Attock area)



Surveyed by Bashir Ahmad Saleemi

Figure 6. Sample location map of the Gilgit and Hunza Valleys, Gilgit Agency

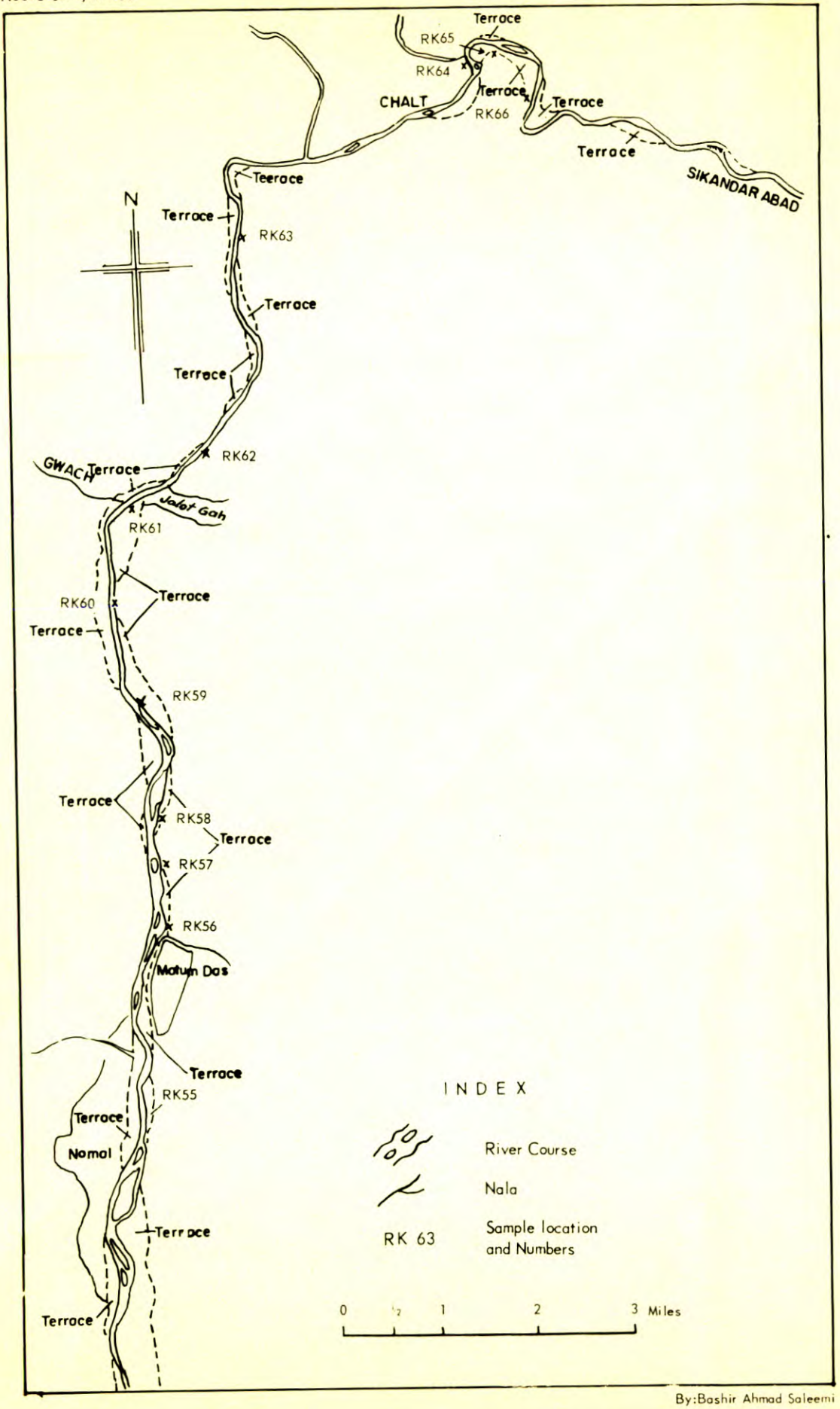


Figure 7. Sample location map of the Hunza Valley, Gilgit Agency

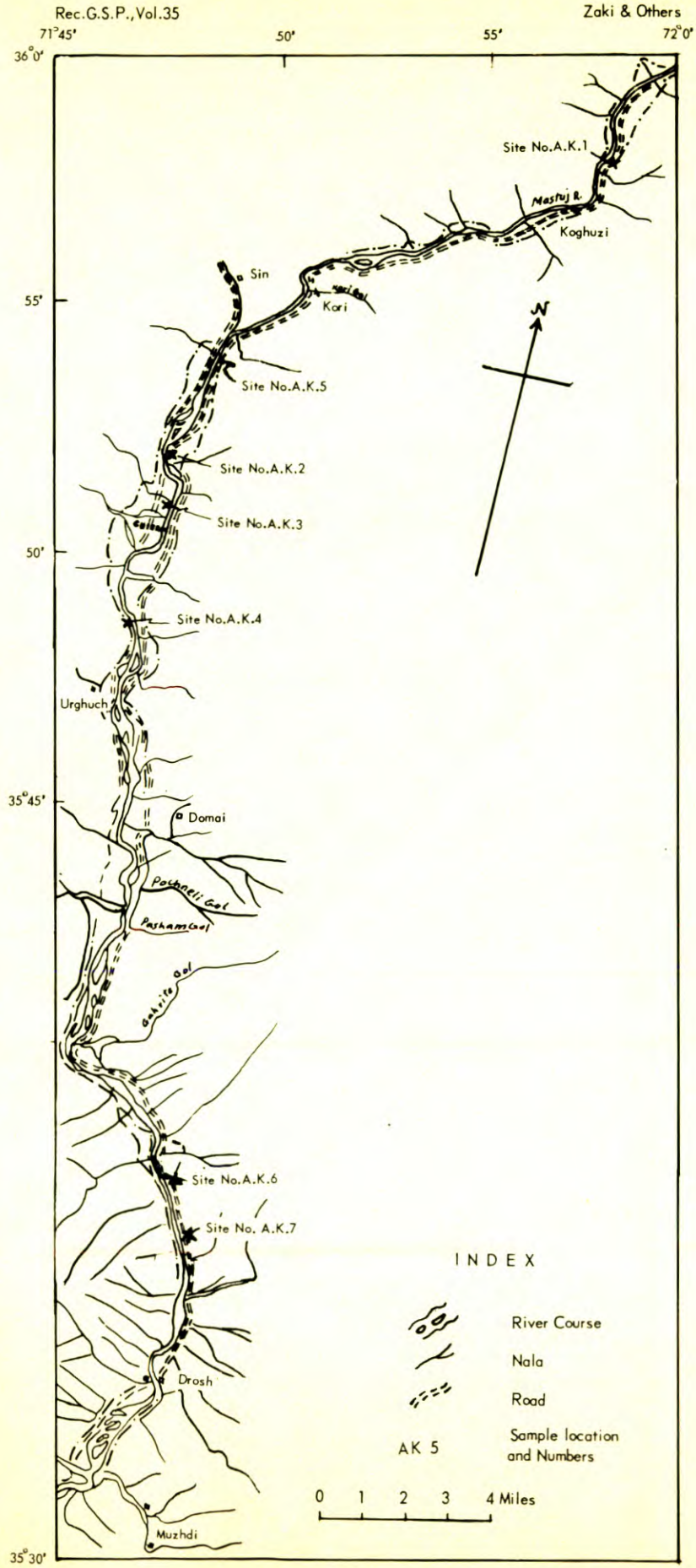


Figure 8. Sample location map of the Chitral Valley, Chitral District

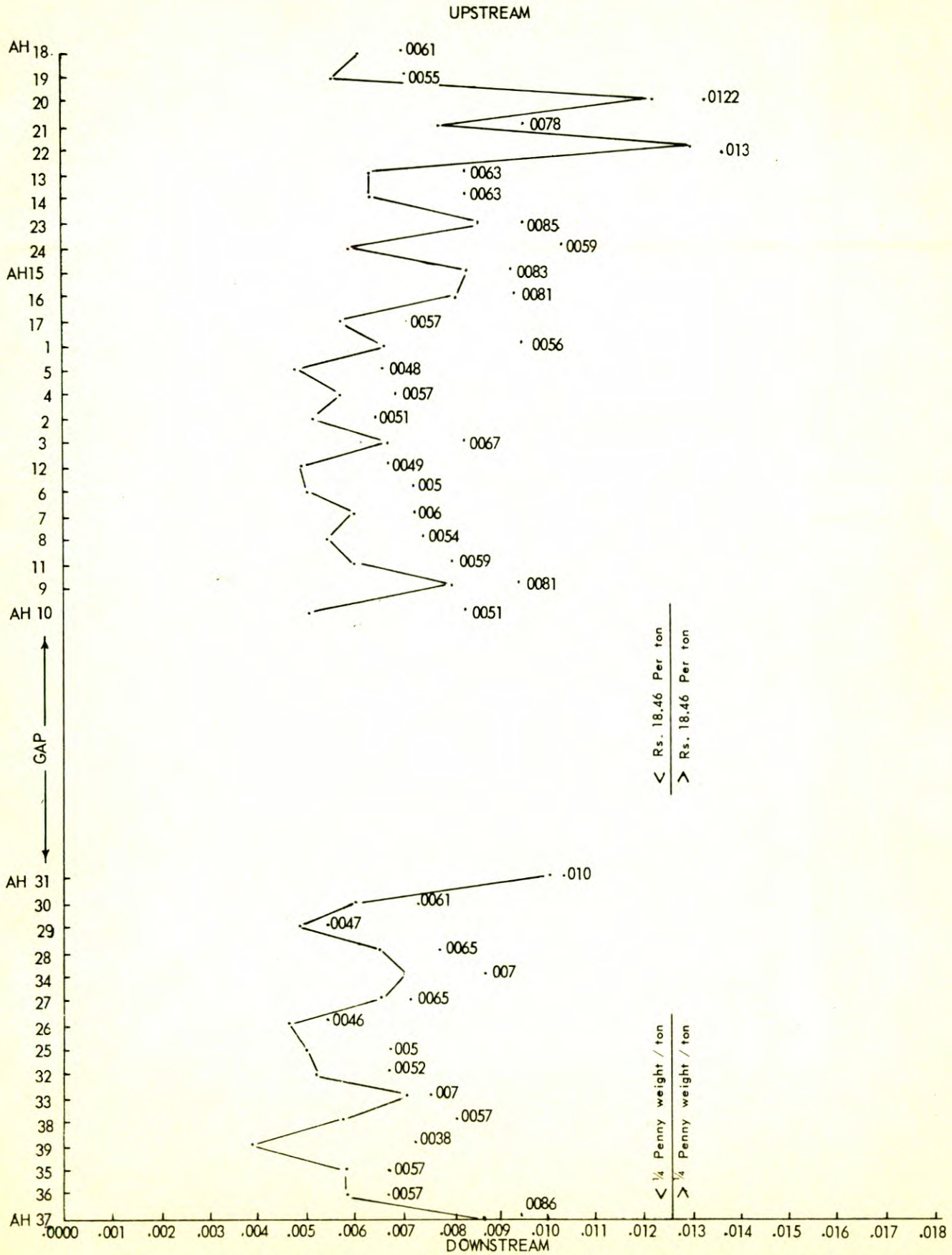


FIGURE -10. GRAPH SHOWING GOLD CONTENT IN OUNCE PER LONG TON OF GRAVEL IN THE ¼ PENNY WEIGHT (0125 OZ) PLOTTED FOR CONVENIENT REFERENCE.

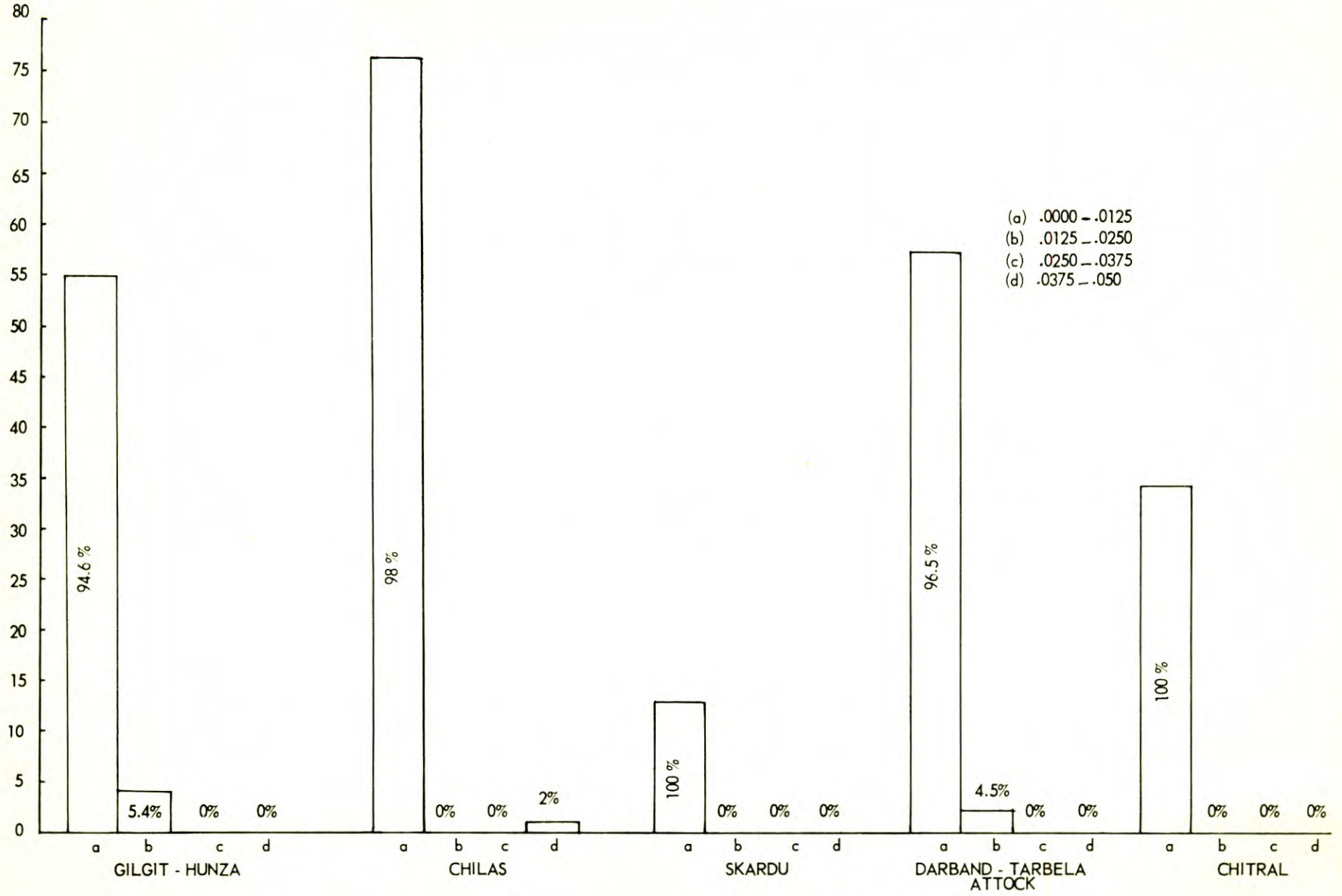


Figure 11. Frequency Distribution of Values of Gold in Terms of Ounce Per Ton in a Four - Fold Grouping of Values.

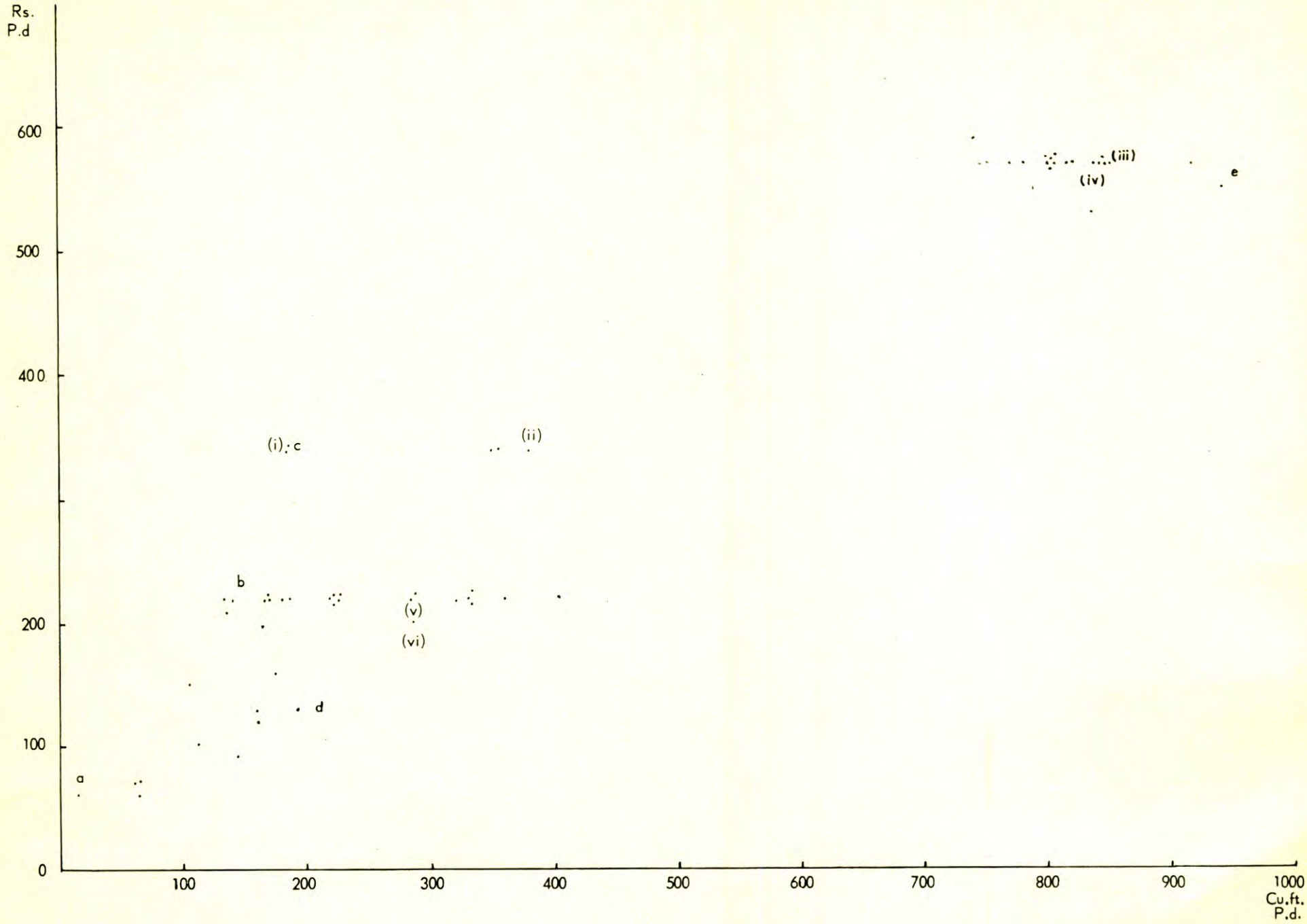


Figure 12. Graph showing daily labour expences in rupees per day against gravel in Cu. ft. washed per day for Gilgit-Hunza area.

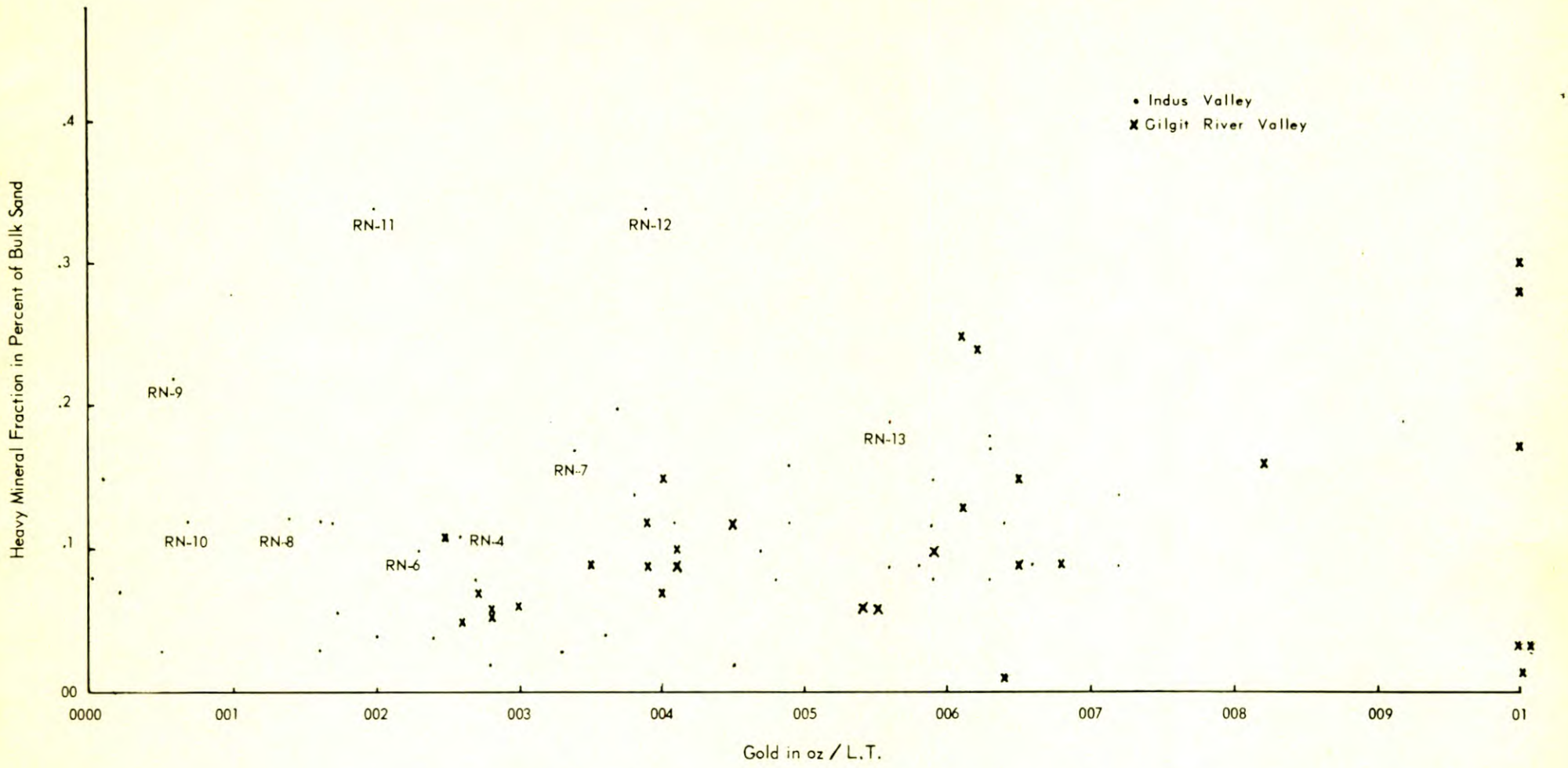


Figure 13. Plot of Gold content in oz/L.T. against heavy mineral content in percent of bulk gravel.

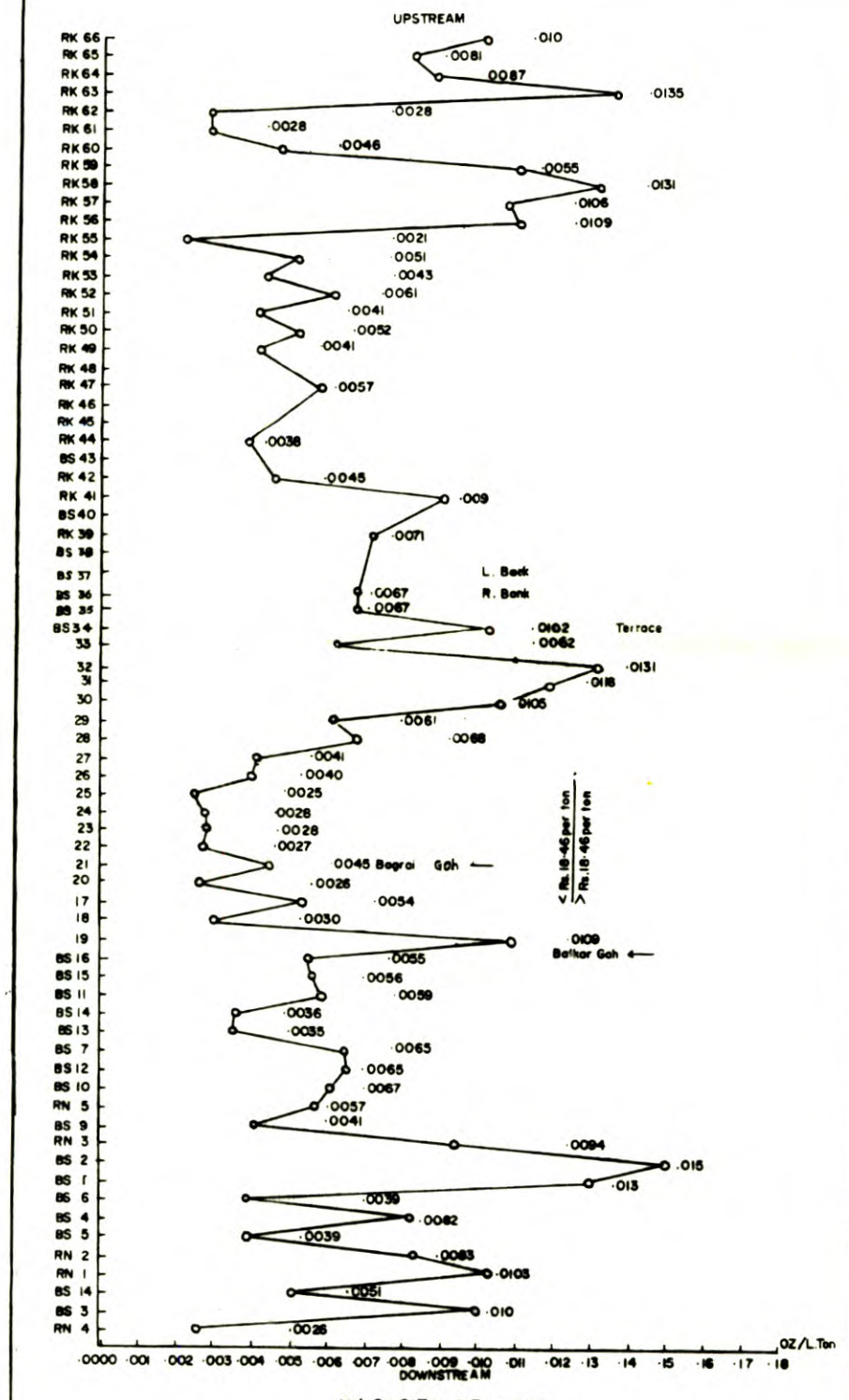
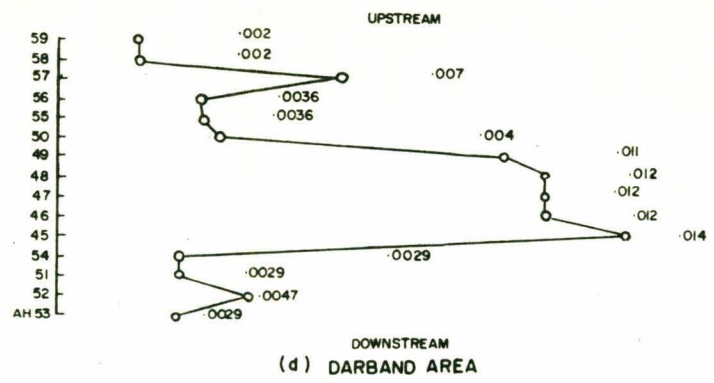
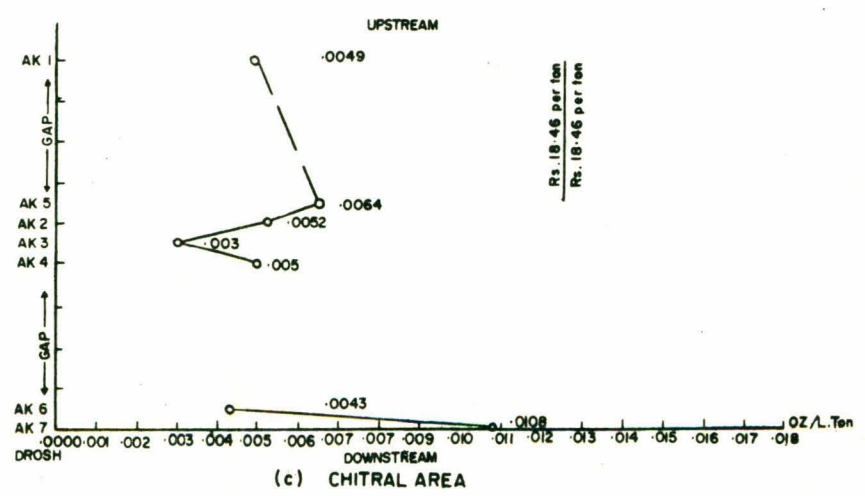


Fig. 9 Graph showing gold content in ounce per ton of gravel in various (a). indus Valley, Chilas area, (b) Gilgit-Hunza, (c) Chitral area, (d) Darband area. Horizontal line indicates gold content in ounce, vertical line indicates sample numbers downstream to upstream of valleys. 1/4 Penny weight line plotted for easy reference. Important tributories and direction of their flow are also plotted.



(d) DARBAND AREA

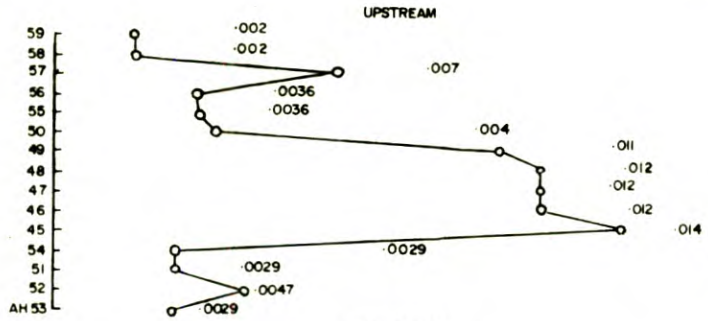


(c) CHITRAL AREA

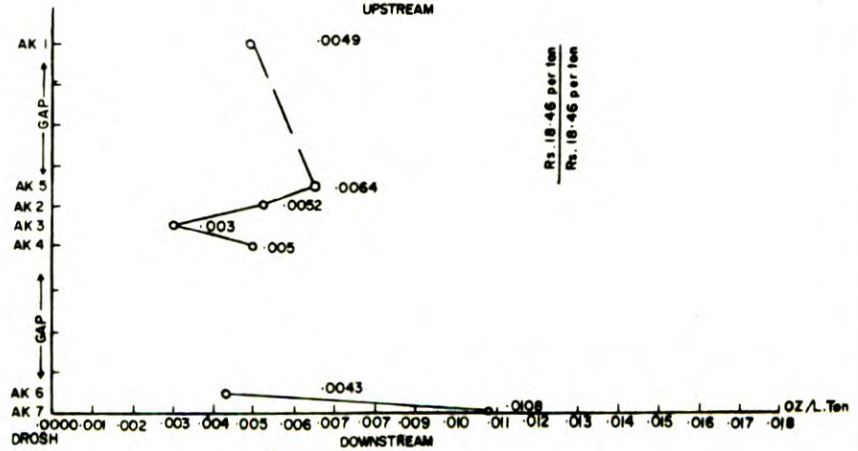
(b) GILGIT HUNZA AREA

(a) INDUS VALLEY, CHILAS AREA

Fig. 9 Graph showing gold content in ounce per ton of gravel in various (a). indus Valley, Chilas area, (b) Gilgit–Hunza, (c) Chitral area, (d) Darband area. Horizontal line indicates gold content in ounce, vertical line indicates sample numbers downstream to upstream of valleys. 1/4 Penny weight line plotted for easy reference. Important tributories and direction of their flow are also plotted.



(d) DARBAND AREA



(c) CHITRAL AREA