U.S. DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

SAUDI ARABIAN MISSION

MISCELLANEOUS DOCUMENT 37

(INTERAGENCY REPORT 379)

EVALUATION OF GEOCHEMICAL SAMPLING MEDIA IN GRANITOID TERRANE OF THE SOUTHERN ARABIAN SHIELD, KINGDOM OF SAUDI ARABIA

by

Edward A. du Bray

U.S. Geological Survey
Open-File Report 81-1293

The work on which this report was based was performed in accordance with a cooperative agreement between the U.S. Geological Survey and the Saudi Arabian Ministry of Petroleum and Mineral Resources.

U.S. Geological Survey
Jiddah, Saudi Arabia
1981

CONTENTS

ILLUSTRATION

TABLE

EVALUATION OF GEOCHEMICAL SAMPLING MEDIA IN GRANITOID TERRANE OF THE SOUTHERN ARABIAN SHIELD, KINGDOM OF SAUDI ARABIA

by

Edward A. du Bray

ABSTRACT

Seven different sample media were obtained in granitoid terrane of the southern Arabian Shield in order to identify the most effective geochemical prospecting medium for this type of region. Five of the media, including the ferromagnetic part of pan concentrates, the -10+30-mesh and -30+80-mesh size fractions of each pan concentrate's nonmagnetic fraction, and the -10+30-mesh and -30+80-mesh size fractions of wadi sediment, are splits produced from raw wadi sediment samples collected at 49 sample sites. A raw pan concentrate was created from a second sample of wadi sediment collected at each of the 49 sites. Granitoid rock samples representative of the sediment samples' source terrane were collected at 35 locations. A geometric mean of the sample population was computed for each of 30 elements in each of the seven sample media. The sample media were evaluated relative to enhancement achieved with respect to detection limit for each of the 30 elements. Among the media tested, the nonmagnetic -30+80-mesh fraction of a pan concentrate of wadi sediment appears to be the most effective geochemical

prospecting medium in the terrane tested. Similar studies should be conducted in other bedrock terranes.

INTRODUCTION

Mineral exploration geologists have discussed at length the most effective geochemical sampling medium for prospecting in the Precambrian shield of Saudi Arabia. Thus far, wadi-sediment sampling has been the basis for most sampling programs. Theobald and others (1975) chose the -10+30 mesh-fraction as the most informative fraction of bulk wadi-sediment samples. They also prepared pan concentrates from wadi-sediment samples, removing ferromagnetic minerals prior to analysis. However, Overstreet (1978) chose the -30+80-mesh fraction as the most informative fraction of bulk wadi-sediment samples and, in addition, analyzed a ferromagnetic fraction. Elliott (in press) considered the following sample media most effective: -30+80-mesh wadi sediment, pan concentrate, and representative rock, and he used this combination in his geochemical sampling program. However, El Shazly and others (1977) indicated that alluvial sampling in arid Egyptian environments has been fruitless. Cheeseman and Thekair (1979) discussed the relative merits of hot and cold nitric acid extractions of copper, lead, and zinc, with regard to prospecting in gossany environments. Allcott (1969, 1970) discussed the difficulties associated with geochemical prospecting in the Arabian Shield and placed particular emphasis on the possible success of biogeochemical prospecting. Clearly, a comparative test of the various sample media is necessary.

A primary problem in exploration geochemical sampling is that many elements of interest are so dispersed in geologic material that they are difficult to detect by a rapid analytical method, such as semiquantitative spectrographic analysis. Thus, criteria for an effective geochemical sample medium are that the medium enhance elemental concentrations relative to analytical detection limits and that the medium be easy to collect, be quick to process, and present no analytical problems.

Because of the extreme aridity and sparse vegetation, water and plant sampling are impractical in the Arabian Shield. Soil sampling is likewise unfeasible, because most Arabian Shield soils are either very poorly developed or non-existent. Wind-transport problems rule out collection of fine-grained (less than 100 mesh) material. Therefore, only wadi-sediment and rock sampling remain as viable alternatives, and samples must be processed in such a way that the maximum amount of information is derived from each. If geochemical data are to be obtained by semiquantitative spectrographic analysis, little in the way of sample preparation can be done to enhance the elemental concentrations in rock samples.

SAMPLE MEDIA

In order to identify the most effective sample medium, a set of 49 sample sites in the granitoid terrane of the southern Arabian Shield was used for this study (fig. 1). These sites were originally occupied by J. E. Elliott and subsequently by the author. Each wadi-sediment sample collected by Elliott was split into the following five media:

1) -10+80-mesh, magnetic pan concentrate: sample sieved and panned in the field, magnetic medium then removed from the pan concentrate by using a hand magnet
2) -10+30-mesh, nonmagnetic pan concentrate: both this medium and medium 3 (below) were produced by sieving the nonmagnetic residue left after medium 1 (above) was removed from the pan concentrate
3) -30+80-mesh, nonmagnetic pan concentrate
4) -10+30-mesh, bulk wadi sediment
5) -30+80-mesh, bulk wadi sediment

In addition, Elliott collected 35 granitoid rock samples representative of the source regions for the sediment samples. The original 49 sites were then reoccupied by du Bray, and bulk pan concentrates were collected. These samples were neither sieved nor magnetically separated. These seven sample media were submitted to the DGMR-USGS (Saudi Arabian Directorate General of Mineral Resources-U.S. Geological Survey) chemical laboratory in Jiddah for a six-step semi-quantitative spectrographic analysis.

As only granitic terrane was sampled, the sample popu-

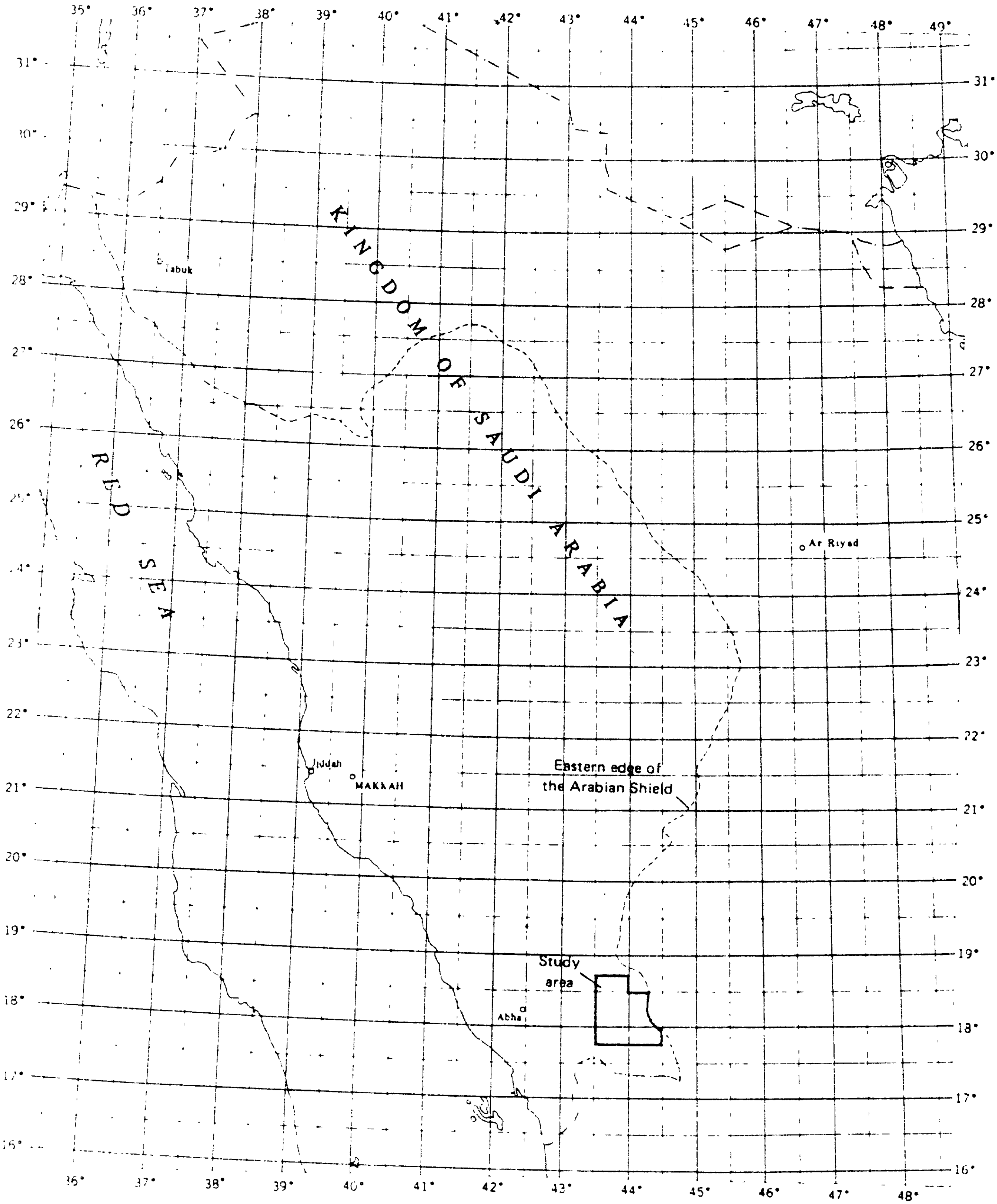

Figure 1.–Index map of western Saudi Arabia, showing the Arabian Shield and the location of the study area.

lation is biased. Besides one major and several minor tin anomalies, no known mineralized areas are present in the study area, so the partitioning of elements such as silver, arsenic, gold, cadmium, antimony, or tungsten among the various sample media is unknown. A similar sampling program in areas known to contain these elements and in areas in which other rock types are present would complete a study of sample media effectiveness.

RESULTS

Complete analytical data for each sample site, including latitude and longitude, are archived in the USGS-DGMR computerized Rock Analysis Storage System (RASS), Jiddah, Saudi Arabia. Rock data may be found in jobs numbered HM488 to 492 and 01062. Pan-concentrate data may be found in jobs 01052 and HM520 to 529. Wadi-sediment data may be found in jobs HM500 to 505.

In order to compare the different sample media, a population geometric mean was calculated by the method of A. J. Cohen (Miesch, 1967) for each element in each sample media. This calculation attempts to evaluate the distribution of a population containing data qualified by the prefix "less than." The geometric mean so calculated is a better measure of the statistical tendencies of the population than one calculated on the basis of unqualified data only. Table 1 summarizes the results of these calculations and gives the limit of determination for each element. The highest value

Table 1. *Geometric means by sample medium for each of 30 elements*

[Parts per million except for Fe, Mg, Ca, Ti, which are in percent. Means based on 49 samples (35 rock samples) collected in granitoid terrane (fig. 1). Double and single asterisks indicate highest and second highest values for each element, respectively. Single bar indicates all values less than detection limit. Double bar indicates calculation by Cohen's method not possible. Raw geochemical data on which the table is based are archived in the USGS base-data file, Jiddah, Saudi Arabia]

		Pan concentrate				Wadi sediment		Rock
		Magnetic	Nonmagnetic					
Element	Detection limit	-10+80 mesh	-10+30 mesh	-30+80 mesh	Bulk	-10+30 mesh	-30+80 mesh	
Fe	0.05	17.27**	10.27*	10.04	6.59	1.77	2.24	0.91
Mg	.02	1.23**	1.14	1.21*	0.92	0.28	0.38	.06
Ca	.05	1.86	2.35*	2.85**	1.77	.82	1.07	.32
Ti	.002	0.90**	0.53	0.69	.80*	.13	.25	.03
Mn	10	2448	3249**	2845*	1063	436	590	236
Ag	.5	-	-	-	-	-	-	=
As	200	-	-	-	-	-	-	-
Au	10	-	-	-	-	-	-	-
B	10	7	=	14**	12*	10	10	=
Ba	20	290	507**	407*	178	363	296	65
Be	1	.8	3*	2	2	2	2	4**
Bi	10	-	1**	=	=	-	-	1**
Cd	20	-	-	-	-	-	-	-
Co	5	47**	30	34*	13	5	6	2
Cr	10	314*	258	295	390**	228	659	194
Cu	5	80**	74	77*	43	15	16	14
La	20	63*	49	84**	62	=	22	20
Mo	5	1.5	2	2	3*	4**	4**	4**
Nb	20	21*	13	34**	3	10	=	21*
Ni	5	47*	42	48**	34	13	16	5
Pb	10	12	25	36**	13	14	13	30*
Sb	100	-	-	-	-	-	-	-
Sc	5	22	26*	30**	13	4	5	1
Sn	10	6	20*	40**	15	2	.7	4
Sr	100	97	184*	196**	111	118	123	23
V	10	269**	129	133*	131	53	62	16
W	50	-	-	-	-	-	-	-
Y	10	74	76*	109**	46	18	23	32
Zn	200	199	259**	228*	-	-	-	67
Zr	10	129	141	217*	740**	80	94	83
Enhancement coefficient		22	19	38	9	3	3	11

for each given element relative to the seven sample media is designated by a double asterisk, and the second highest is designated by a single asterisk. The highest value of geometric mean represents the sample media that achieved the greatest enhancement of that particular element relative to the limit of determination. In order to grade the effectiveness of each medium objectively, double asterisks are assigned a value of 3 and single asterisks a value of 1. A total enhancement coefficient is computed for each sample medium by summing these values (table 1).

As shown in table 1, the -30+80 mesh, nonmagnetic fraction of pan concentrates has the highest total enhancement coefficient and would thereby appear to be the best sample medium for prospecting in felsic plutonic rocks of the Arabian Shield. Bulk wadi-sediment sampling is of virtually no value, an outcome not surprising considering the great dilution of ore minerals by quartz and feldspar. The magnetic fraction of pan concentrates provides the second greatest total elemental enhancement, but this is achieved solely on the basis of those elements known to occupy lattice sites within magnetite. Creation of a nonmagnetic pan concentrate by the removal of magnetite effectively enhances the concentration of ore minerals in the sample. In addition, pan concentrates containing magnetite are difficult to analyze spectrographically because of iron fluorescence (J. Curry, oral commun., 1981). Iron, titanium, chromium, and manganese signals are of such intensity that first-order peaks of the other elements are obliterated. Second- and third-order peaks are then evaluated, with a consequent loss of accuracy and greater consumption of the analysts' time. Analysis of bulk rock samples is surprisingly informative, especially with respect to elements most likely to be concentrated in deposits associated with felsic magmatism (beryllium, bismuth, molybdenum, niobium, and lead).

In order to reduce the processing procedure by one step, the nonmagnetic fraction of the pan concentrate, once separated from the magnetic fraction, need not be sieved to two size fractions. The two nonmagnetic pan-concentrate size fractions yield highly similar results. Thus, I conclude that geochemical sampling within the Arabian Shield may proceed most effectively by collection and analysis of a nonmagnetic pan concentrate and a representative rock sample from the nearest location.

RECOMMENDATIONS FOR GEOCHEMICAL SAMPLING PROCEDURE

1) At the sample site, enough wadi sediment is collected and passed through a 10-mesh screen, removing all gravel and rock, to fill a cloth sack with 10 kg of material. One to two kilograms of fresh rock may also be colledted for analysis.

2) In camp, the sample is split, yielding a sample weighing approximately 7.5 kg and a sample weighing approximately 2.5 kg. The latter is returned to the

original sample bag and is archived for potential additional work. The former is panned, placed in an envelope, and allowed to dry.

3) Prior to analysis, the bulk pan concentrate is spread in a thin layer; a magnet suspended from a string and shielded by glassine paper is passed over the layer, removing the magnetite. The magnetite is collected and archived, and the resulting nonmagnetic -10-mesh pan concentrate is submitted for semiquantitative spectrographic analysis.

REFERENCES CITED

Allcott, G. H., 1969, Geochemical prospecting in Saudi Arabia, in Mineral resources research, 1967-68: Saudi Arabian Directorate General of Mineral Resources, p. 87-88.

Allcott, G. H., 1970, Preliminary results from geochemical prospecting in Saudi Arabia, in Mineral resources research, 1968-69: Saudi Arabian Directorate General of Mineral Resources, p. 122-124.

Cheeseman, D. R., and Thekair, M. E., 1979, Pilot studies in drainage geochemistry: Saudi Arabian Directorate General of Mineral Resources Technical Record TR-1979-7, 60 p.

Elliott, J. E., in press, Tin-bearing granite of Jabal al Gaharra in the southern Arabian Shield, Kingdom of Saudi Arabia: Saudi Arabian Directorate General of Mineral Resources Bulletin.

El Shazly, E. M., Barakat, N., Eissa, E. A., Emara, H. H., Ali, I. S., Shaltout, S., and Sharaf, F. S., 1977, Geochemical exploration under extremely arid conditions: Journal of Geochemical Exploration, v. 8, p. 305-323.

Miesch, A. T., 1967, Methods of computation for estimating geochemical abundance: U.S. Geological Survey Professional Paper 574-B, p. B1-B15.

Overstreet, W. C., 1978, A geological and geochemical reconnaissance of the Tathlith one-degree quadrangle, sheet 19/43, Kingdom of Saudi Arabia: U.S. Geological Survey

Open-File Report 78-1072, 139 p., 4 pls.

Theobald, P. K., Allcott, G. H., Flanigan, V.J., and Andreasen, G.E., 1975, Tungsten anomalies in the Uyaijah ring structure, Kushaymiyah igneous complex, Kingdom of Saudi Arabia. Section A--Geology and geochemistry of the Uyaijah ring structure, by P. K. Theobald and G. H. Allcott; Section B--Regional geophysics, by V. J. Flanigan and G. E. Andreasen: U.S. Geological Survey Open-File Report 75-657 ((IR)SA-160), 86 p.