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AL KUSHAYMIYAH AS A TARGET FOR A COLORADO-TYPE MOLYBDENITE DEPOSIT

by

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PREFACE

In 1963, in response to a request from the Ministry of Petroleum and Mineral Resources, the Saudi Arabian Government and the U. S. Geological Survey, U. S. Department of the Interior, with the approval of the U. S. Department of State, undertook a joint and cooperative effort to map and evaluate the mineral potential of central and western Saudi Arabia. The results of this program are being released in USGS open files in the United States and are also available in the Library of the Ministry of Petroleum and Mineral Resources. Also on open file in that office is a large amount of material, in the form of unpublished manuscripts, maps, field notes, drill logs, annotated aerial photographs, etc., that has resulted from other previous geologic work by Saudi Arabian government agencies. The Government of Saudi Arabia makes this information available to interested persons, and has set up a liberal mining code which is included in "Mineral Resources of Saudi Arabia, a Guide for Investment and Development," published in 1965 as Bulletin 1 of the Ministry of Petroleum and Mineral Resources, Directorate General of Mineral Resources, Jiddah, Saudi Arabia.

CONTENTS

ILLUSTRATIONS

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ABSTRACT

The granitic complex in the vicinity of Al Kushaymiyah was singled out by Whitlow (1969, 1969a, 1971) as one of the most promising areas for exploration in the Southern Najd quadrangle (Jackson and others, 1962). He noted in particular the intensity of shattering and silicification of these potassium-rich granites, and the presence of unusual concentrations of tungsten, molybdenum, and tin in samples from the area. In the light of shield-wide compilations, this area again stands out as the principal geochemical anomaly for the three metals. The similarity of these unusual geologic and geochemical features to those of Colorado-type molybdenite deposits is striking and suggests that the Al Kushaymiyah area provides a favorable environment to explore for a stockwork molybdenum deposit.

GEOLOGY

The alkalic granite mass at Al Kushaymiyah (fig. 1) has been described in reconnaissance fashion by J. W. Whitlow (1969, 1969a) and was singled out by him on an area for mineral exploration (1971). The 1000 square kilometer area bounded by 22°43' and 22°57' north latitude and by 44°7' and 44°43' east longitude attracted his attention because of intense shattering, pervasive silicification, anomalous

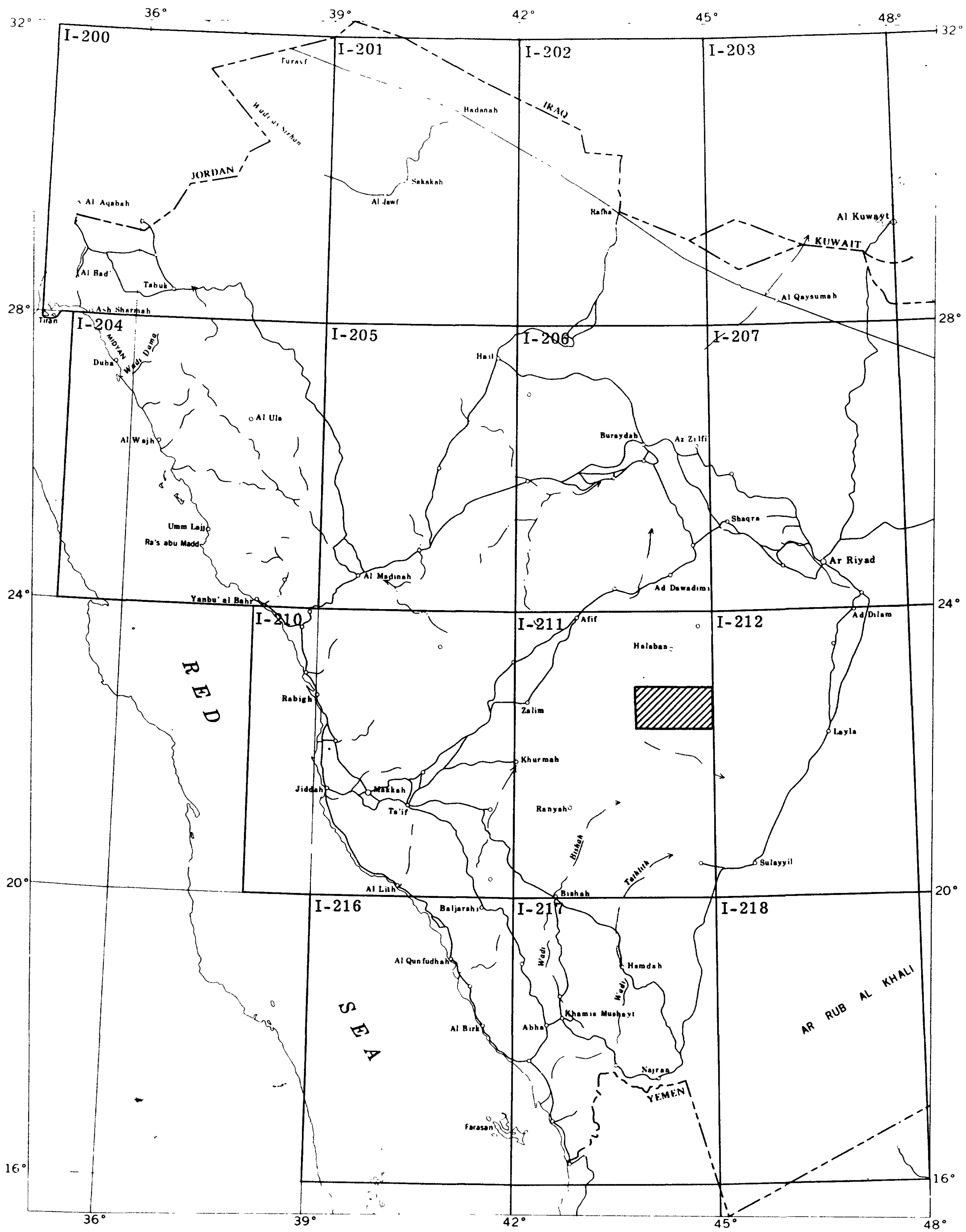


Figure 1. Index map of the Arabian peninsula showing the location of the Al Kushaymiyah area.

tungsten content of heavy-mineral concentrates, and anomalous molybdenum content of wadi sediments. The objective of this report is to reemphasize the area in the light of shield-wide geochemical comparisons and to point out the marked similarity of this assemblage of characteristics to those found in and around the large molybdenite deposits of Colorado U.S.A.

The intrusive suite described by Whitlow is dominated by an alkalic granite that serves as host to rhyolite and granite dikes, along with andesite, breccia, and lamprophyre dikes. High silica content is inferred from the petrographic character of the rock, which apparently grades only locally toward a granodioritic assemblage. Potassium enrichment is implied by the modifier "alkalic". The abundance of granite, rhyolite, and breccia dikes suggests a complex and somewhat shallow, or at least brittle, igneous history.

The major structure is controlled by the Najd fault and its subsidiary fractures, which are part of a regional system of faults. In this area, however, the fault pattern is augmented by the shattering accompanying the breccia dikes as well as a pervasive shattering that reduces local areas to the state where "unfractured rock greater than 7 cm across is difficult to find" (Whitlow, 1969a).

Alteration is intense. Silicified zones border rhyolite and breccia dikes, and pervasive silicification affects the more intensely sheared area along the central fault zone. The main pervasively silicified area is large, approaching 10 kilometers on a side.

GEOCHEMICAL ANOMALIES

The metal suite enriched in this environment is tungsten, molybdenum, and tin. Unfortunately tin analyses are available only for wadi sediment, where levels are generally low and near the limit of analytical sensitivity. Tin does appear fairly consistently, however, in what seems to be an outer zone around the principal area of silicification. Tungsten, determined in heavy-mineral concentrates, provides the major anomaly, which is centrally located relative to the silicification. Molybdenum, as presented by Whitlow, was determined in the wadi sediments where the generally low level of concentration relative to the analytical sensitivity again hinders definition of a pattern; however, the presence of molybdenum is generally coincident with the tungsten distribution, and supports that anomaly. Whitlow noted a small amount of powellite or scheelite in the concentrates, but the amounts of these minerals seen were inadequate to explain the high concentrations of tungsten found chemically. He concluded that most of the tungsten is present in some other mineral, most likely a mineral of the wolframite series.

Plates 1 and 2 show the distribution of tungsten and molybdenum in heavy-mineral concentrates from much of the shield. For presentation at a scale of 1:2,000,000, the original sample matrix of 2571 samples has been averaged to a single point per 5 minutes of longitude and latitude, yielding an averaged matrix of 1179 points. Scattered tungsten highs occur throughout the southeastern part of the shield area, but at Al Kushaymiyah seven of 55 points in the highest class are at continguous 5-minute grid points. The only similar cluster is a group of four continguous points at the south end of the data. The molybdenum distribution (pl.2) does not show a high to match this second cluster of tungsten-rich samples. Instead, the area of maximum enrichment, 17 of 45 points in the highest class, is along the Red Sea escarpment north of Jiddah, where little tungsten was found. A group of six contiguous points in the highest class for molybdenum coincides with the tungsten high at Al Kushaymiyah, providing the only large area of overlap for highs in both metals in the area of data for the shield.

The distribution of tin in 30 to 80 mesh wadi sediment is shown on plate 3. The original sample matrix for this medium contained 5260 samples and these have been averaged to 1762 grid points for presentation. As has been noted above the limit of analytical sensitivity is well above the general level of tin concentration for this sample medium; only 15 of the 1762 points have average tin contents above the analytical limit. Five of these are adjacent to the tungsten-molybdenum anomaly at Al Kushaymiyah, four to the east and one to the west of the major anomaly. From Whitlow's description of the area, it appears that these tin-rich samples could be derived from a peralkalic granite rather than from the alkalic granite of Al Kushaymiyah proper. However, it seems more than fortuitous that one-third of the tin-rich samples should come from these particular peralkalic masses rather than the numerous other examples that dot the shield.

Taking the three elements together, it is clear that the Al Kushaymiyah area is the outstandingly anomalous segment of the shield represented by this sample matrix.

COLORADO MOLYBDENITE DEPOSITS

The "type" Colorado molybdenite deposit is at Climax, which was described most recently and completely by Wallace, et al., in 1968. The Climax deposit is the most extensively developed and most intensely studied of the deposits and provides the basis for classification of characteristics of this type of deposit. Other commercial deposits of the type are at Questa, New Mexico (Carpenter, 1968) and at Red Mountain, Clear Creek County, Colorado. The extent of the molybdenum mineralization at this last locality has only recently become known through mining of the Urad orebody and exploration and development of the Henderson orebody; hence, comprehensive geologic reports based on adequate mine development are only now being prepared. Two preliminary reports on the surface expression of the molybdenum at Red Mountain are provided by Theobald and Thompson (1959, 1961). Several additional examples of the "type" are being explored in the Rocky Mountains of Colorado as well as in other parts of the world.

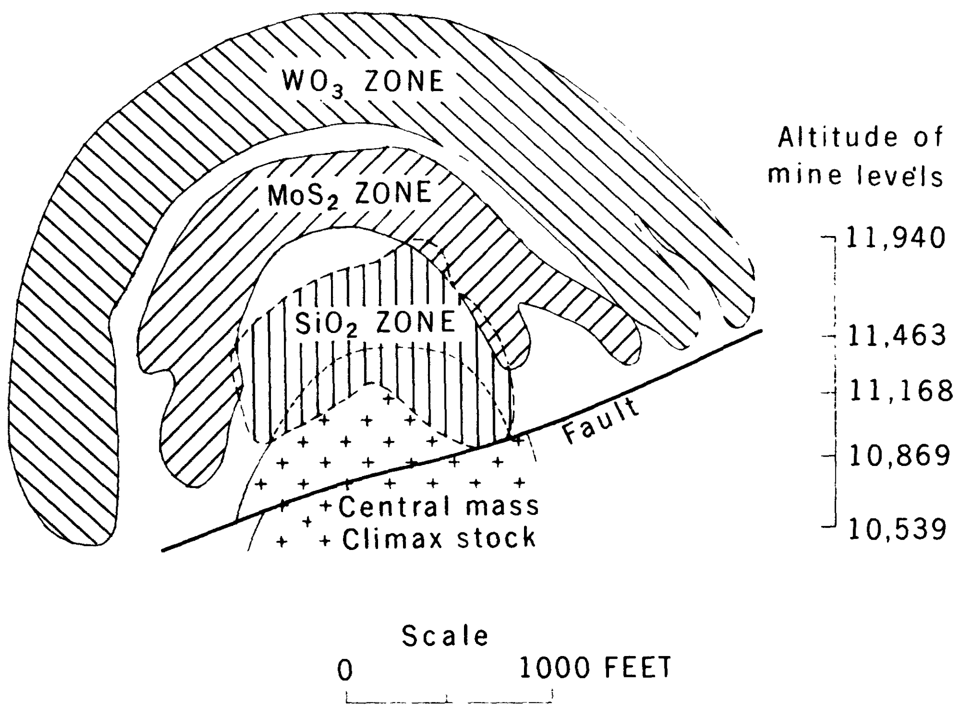
The Colorado deposits are associated with alkalic granite intrusives that range in texture from aplitic to porphyritic to hypidiomorphic granular. The intrusives are extreme differentiates in terms of silica and potash enrichment and were intruded to relatively shallow levels in the crust; the deepest, and apparently an exception, is the Climax stock, which may have had as much as 10,000 feet of cover. In Colorado the intrusives associated with the ore all appear to be middle to late Tertiary in age.

Intense shattering of host rocks is always evident. In most places regional faults of long active histories predate intrusion and mineralization, and most of these have continued active during and following the metallogenesis. The intrusives themselves aggravate the tectonic pattern and appear responsible for the tight mesh of fractures that eventually provided access to altering and mineralizing fluids. The habit of the deposits is best described as a stockwork, though more continuous veins also occur.

The dominant alteration product and gangue mineral is quartz, In the immediate vicinity of the ore, silicification is the rule to the extent that molybdenite veinlets are often saturated and completely enclosed in silica. Gangue and wall-rock quartz often merge. At Climax the silicification reaches an extreme wherein parental rock types cannot be recognized and a large body of rock beneath each of the ore bodies must be mapped simply as "high-silica rock". Peripheral to the silicification is a zone enriched in potassium. Both potassium feldspar and micas are abundant alteration products in this zone. Fluorine and the metals, iron, molybdenum, tungsten, and tin are enriched in the immediate vicinity of the ore. Pyrite, fluorite, molybdenite, manganese-rich wolframite (huebnerite), and cassiterite are the host minerals usually present. Questa may be an exception in that wolframite and cassiterite have not been identified at this locality. Late-stage galena, sphalerite, and rhodochrosite are common to most deposits in cross-cutting or peripheral veins.

The metals of the ore are usually zoned in a simple pattern that may be complicated by overlapping of several metallogenic events. The sequence is repeated four times at Climax (the fourth repetition is largely lost in what is called the "late barren stage") and twice at Red Mountain. The pattern is very well illustrated in the diagram of the "upper ore body" at Climax by Wallace, et al., (1968, p.628) reproduced in part as figure 2. Tin enrichment in places accompanies the tungsten.

The supergene zone is marked by the abundance of silica and is stained from the abundance of oxidized pyrite. Molybdenum-rich lepidocrosite, a characteristically bright-red iron oxide, is often conspicuous and may be accompanied by molybdenum-rich akaganeite in the somewhat more arid environment of Questa. The red hue of these iron oxides contrasts with the somber colors of the more common minerals of the limonite group found in supergene alteration halos from deposits of other metals. Ferrimolybdite is abundant as the first-formed alteration product of molybdenite. Powellite has been reported in the supergene zone at Questa (Carpenter, 1968, p. 1346),



(simplified from Wallace and others, 1968, p.628, showing zoning of tungsten, molybdenum, and silica relative to the genetically associated phase of the Climax stock)

Figure 2. Generalized cross section of the upper ore body at the Climax molybdenum mine

which implies that the supposed absence of tungsten in the primary zone noted above is only apparent. Wolframite and cassiterite survive supergene alteration and form prominent detrital trains, extending at least as much as 65 kilometers downstream from the source areas (Theobald and Thompson, 1959).

RECOMMENDATIONS

The remarkable similarity between the characteristics of the Al Kushaymiyah area and the characteristics of the Colorado-type molybdenite deposits suggests that a closer study of the Al Kushaymiyah area should be undertaken in search of a stockwork molybdenite deposit. Major characteristics in common are the silicic and alkalic igneous rocks, intensely shattered and silicified, with anomalous tungsten, molybdenum, and tin. The reconnaissance information on Al Kushaymiyah outlines a relatively large area favorable for exploration but does not define specific targets. Several Colorado-type deposits could be lost in an area of this size even during more closely controlled exploration. A systematic exploration of the area oriented toward the expectable features of the Colorado-type deposit would have the greatest likelihood of leading to the discovery of such a deposit if one exists at Al Kushaymiyah.

Much more detailed geologic mapping is requisite to any such search. Investigation of the details of the igenous sequence is needed to identify centers of magmatic resurgence, especially those centers where extremes in alkalic and silicic differentiates appear.

The distribution of alteration effects relative to these centers should be worked out, with particular attention to potash and silica redistribution. Difference in potash content can be most readily determined by gamma-ray spectrometry. Knowledge of the structure, especially of through-going faults and zones of shattering, will provide a basis for predicting the sites of buried intrusives or channels for hydrothermal solutions.

The mineralogy of critical metals in this area is not adequately known. One hopes that tungsten will be found in a manganese-rich member of the wolframite series as well as in the powellite and scheelite already reported. Tin should be present in cassiterite rather than dispersed in the micas or other rock-forming minerals. Molybdenum should be sought not only in molybdenite but also in the several iron-rich supergene compounds, ferrimolybdite, lepidocrosite, or akaganeite. Fluorite has not yet been identified in the Al Kushaymiyah area but is abundant in the "type" deposits.

Considerably more detailed geochemical data are needed to define the anomaly more closely and to determine zoning of metals within the anomaly. Evidence for zoning of metals already exists on a regional scale. This may be repeated on a local scale, with tin and tungsten peripheral to a molybdenum high.

Several geophysical techniques would provide valuable supporting evidence. The silicic and alkalic igneous rocks generally produce a gravity low intensified in zones of alteration. The low magnetite content of these igneous rocks generally yields a magnetic low, again intensified by alteration. Induced Potential methods often define the broad zone of disseminated pyrite even though insulation of the molybdenite by silica hinders its direct detection.

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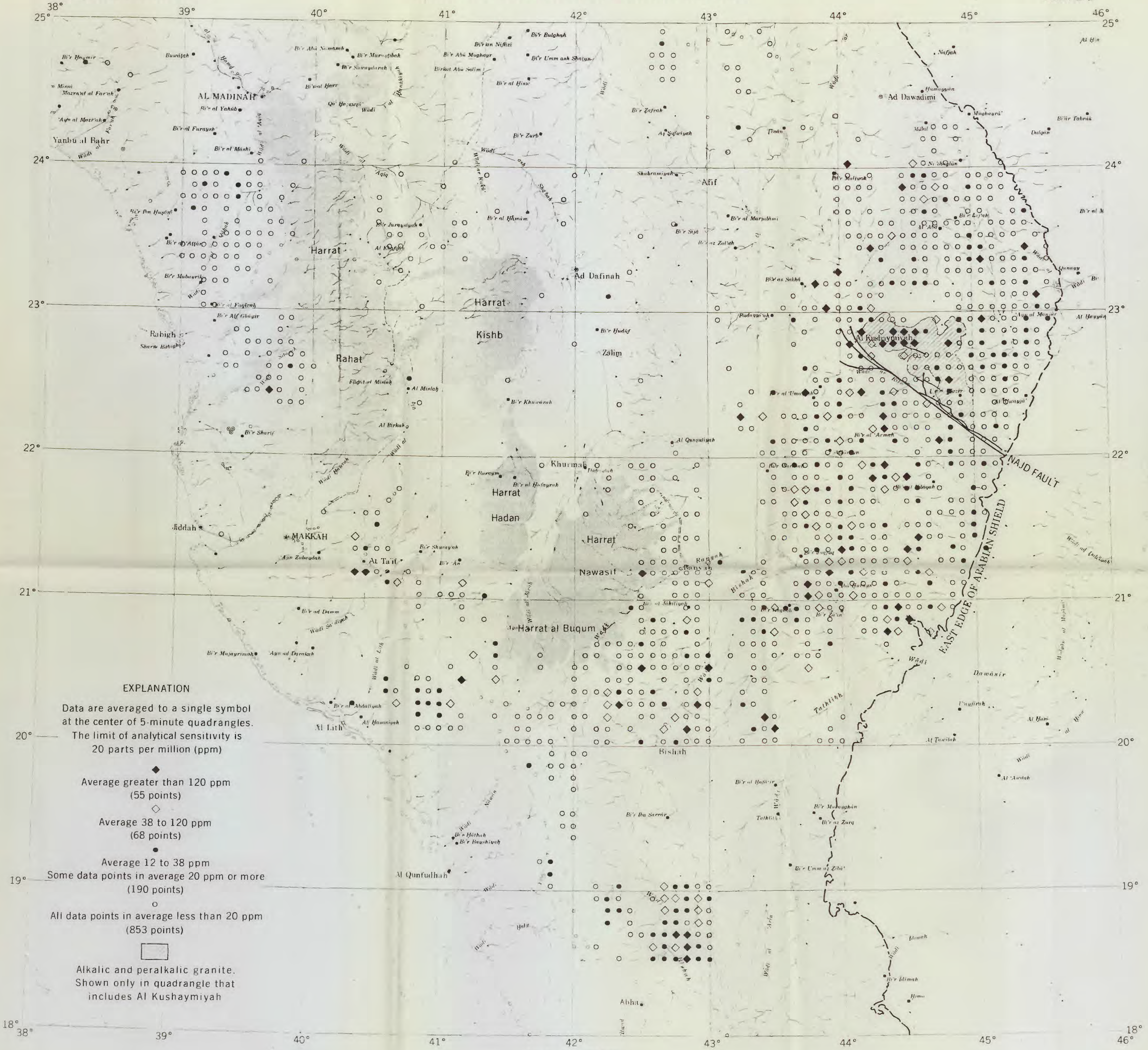

Scale 1:2,000,000

25 0 25 50 75 100 125 150 175 200 Kilometers

25 0 25 50 75 100 125 150 175 200 Miles

PLATE 1.- TUNGSTEN CONTENT OF HEAVY-MINERAL CONCENTRATES FROM WADI SEDIMENT

By
Paul K. Theobald
1970

U.S. Geological Survey
OPEN FILE MAP
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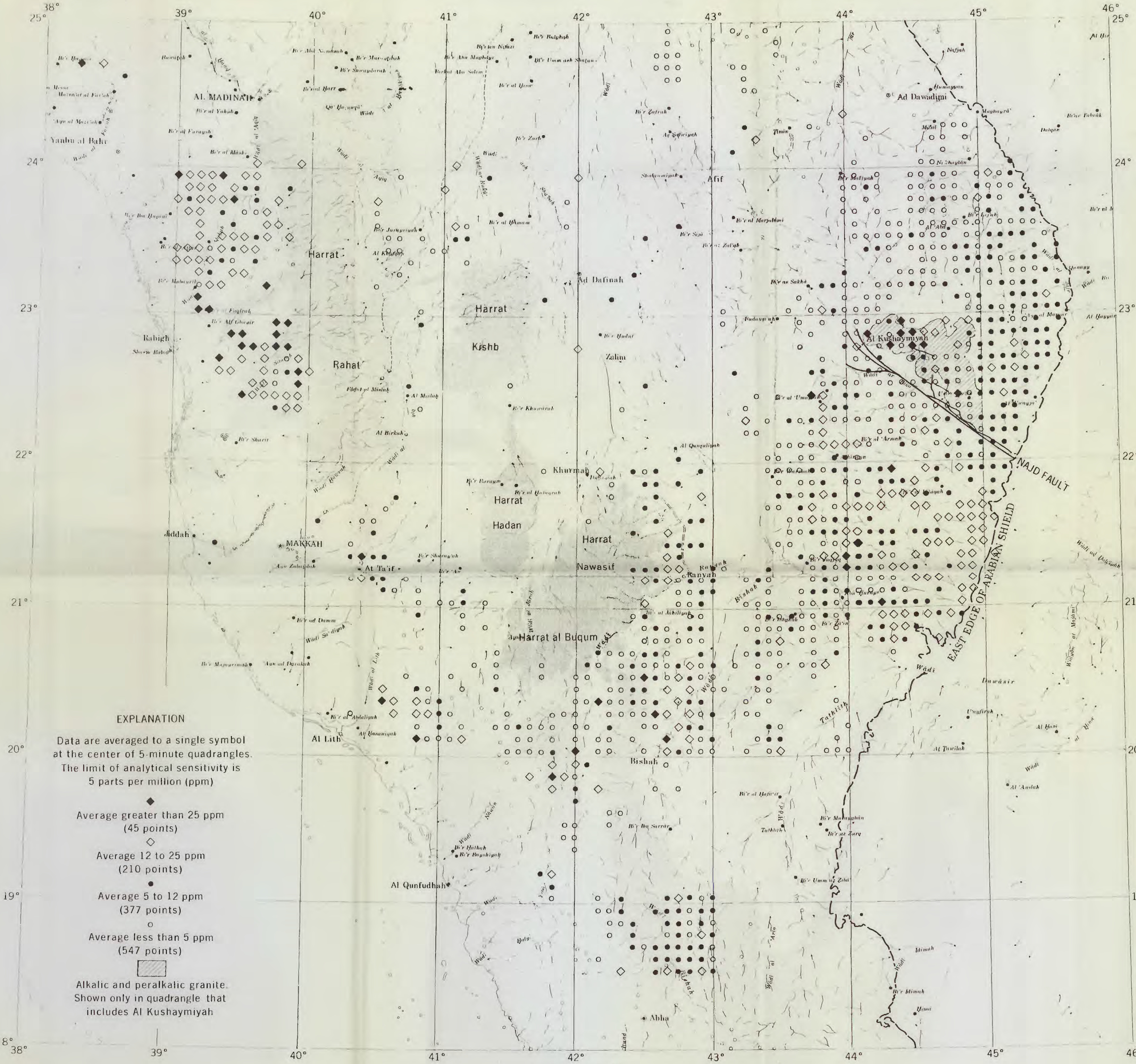
PLATE 2



Scale 1:2,000,000

25 0 25 50 75 100 125 150 175 200 Kilometers

25 0 25 50 75 100 125 150 175 200 Miles

PLATE 2.- MOLYBDENUM CONTENT OF HEAVY-MINERAL CONCENTRATES FROM WADI SEDIMENT

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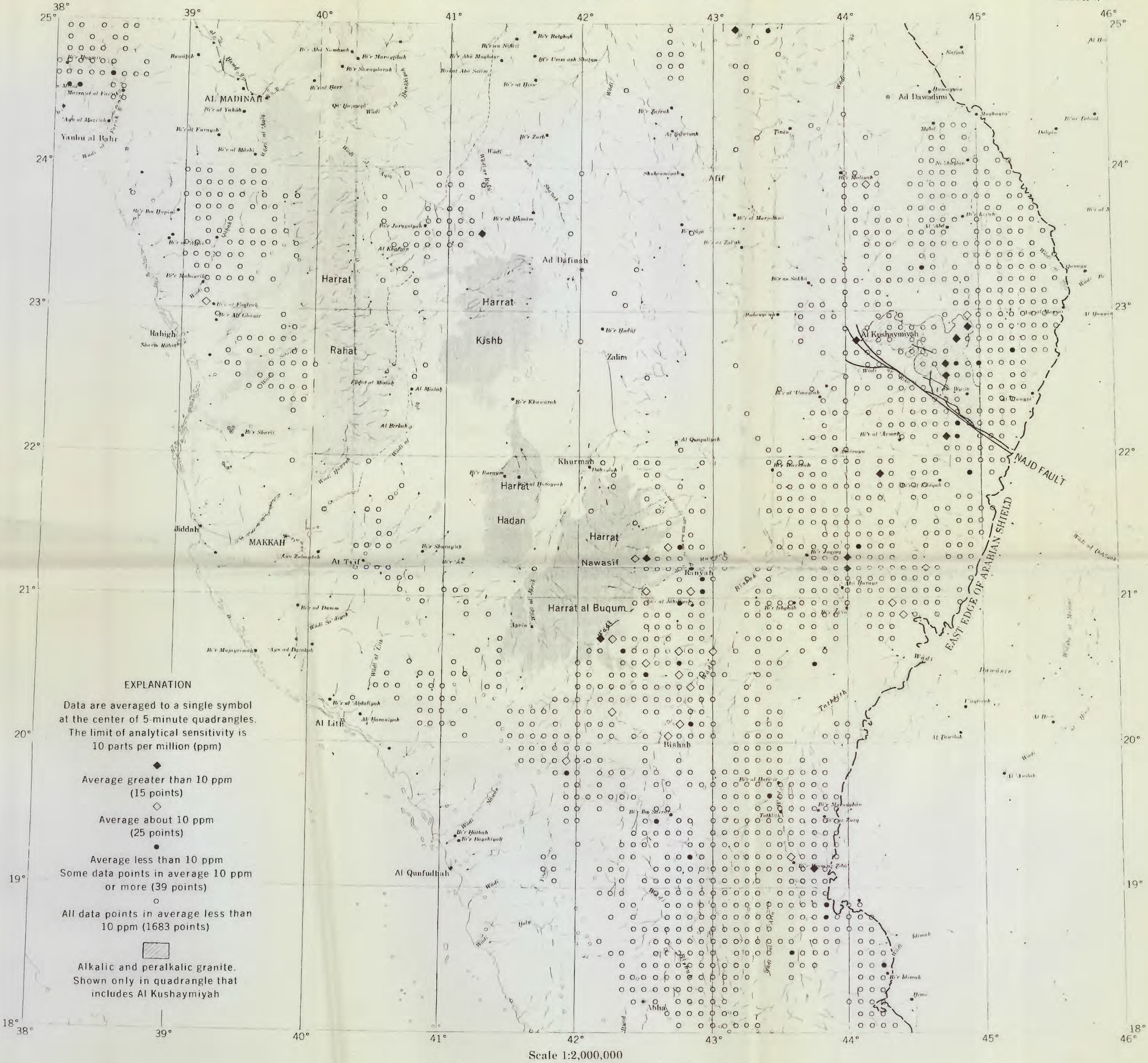
PLATE 3



Scale 1:2,000,000

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25 0 25 50 75 100 125 150 175 200 Miles

PLATE 3.- TIN CONTENT OF 30- TO 80-MESH WADI SEDIMENT

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