GEOLOGICAL SURVEY OF WYOMING

REPORT ON INVESTIGATIONS RELATED TO PROSPECTING FOR DIAMOND-BEARING KIMBLERLITE AND RELATED PLACER DEPOSITS IN WYOMING.

by

W. Dan Hausel
Karl Albert
Carl Brink
Jay Roberts

The Geological Survey of Wyoming
Laramie, Wyoming

1982

OPEN FILE REPORT 82-1

This report has not been reviewed for conformity with the editorial standards of the Geological Survey of Wyoming.

CONTENTS

ILLUSTRATIONS

Figures | Page

TABLES

Table | Page

PLATES

ACKNOWLEDGEMENTS

Special thanks are given to P.R. Glahn and T.L. Woodzick for their efforts on the geophysical surveys, and to Kevin Blair, Lori Chamberlain, Pablo Duque, Gregg Holloman, Mary Moran and Connie Walker for their efforts with the stream sediment sampling surveys.

Additionally, the authors extend their appreciation to Rocky Mountain Energy Company and to Tom Sharps, Principal Geologist with Rocky Mountain Energy Company, for providing the Geological Survey with numerous stream sediment samples from the central Laramie Range. This project was also conducted in cooperation with M.E. McCallum of Colorado State University, to whom we are greatly indebted for his assistance.

This material is based upon work supported by the U.S. Office of Surface Mining, Department of the Interior under Grant No. G5195051. Any opinions, findings and conclusions or recommendations expressed in this publication are those of the authors and do not necessarily reflect the views of the Office of Surface Mining, Department of the Interior.

INTRODUCTION

Nearly 100 kimberlite dikes, pipes (diatremes), and blows have been identified in the Colorado Front Range and the Wyoming Laramie Range of northern Colorado and southeastern Wyoming (Hausel, 1979a, b). These occurrences are scattered from as far south as Boulder, Colorado to as far north as Sybille Canyon in the central Laramie Range (Figure 1). Twelve of these occurrences are presently classified as diamond-bearing (McCallum, et al., 1977; 1979).

In addition to the kimberlite occurrences, placer diamonds have been identified in the Snowy Range (Medicine Bow Mountains) near Mullison Park (Hausel, 1977). More recently, chrome-diopside and pyrope garnet (both possible indicators of kimberlite) were recognized in Tertiary sediments in the Green River Basin (Hausel, et al., 1979b) and in the Big Horn Basin (J.C. Antweiler, personal communication).

These discoveries have led to numerous investigations which are designed to examine regions of the Colorado-Wyoming kimberlite province for additional kimberlite and diamond occurrences (Hausel and McCallum, 1980). This investigation reports on the two-year accomplishments (Oct. 1, 1979 to Dec. 31, 1981) made by the Geological Survey of Wyoming under funding from Office of Surface Mining Grant G5195051.

Kimberlite defined

According to Dawson (1971), kimberlite is: "a very rare, potassic, ultra-basic, hybrid igneous rock that occurs in small diatremes, or dikes, or sills of limited extent. It has in inequigranular texture, the porphyritic aspect being due to megacrysts of olivine, enstatite, chrome-diopside, pyrope, picro-ilmenite and phlogopite, set in finer-grained matrix of which serpentine, carbonates, phlogopite, magnetite and perovskite form the major part. Many of the megacrysts are derived from fragmentation of mantle-derived garnet lherzolite (blocks of which are embedded in the kimberlite) and are in various stages of reaction with the kimberlite matrix. The matrix may or may not contain diamonds; even in the most diamondiferous kimberlites, diamond is a very rare and widely dispersed mineral."

Many kimberlites found in the Colorado-Wyoming region display these characteristics described by Dawson.

Historical background

The historical events which led up to the present investigation are worth reiterating and indicate the significance and potential importance of the Colorado-Wyoming province to the scientific and industrial community.

The first reference to ultrabasic rocks of unusual composition was made by Whitaker in 1898. Whitaker (1898) described a dike on Green Mountain west of Boulder, Colorado as olivinite with picrotitanite and pyrope garnet. Whitaker's description closely resembled that of a description of kimberlite; although it wasn't until the late 1960's that the Green Mountain occurrence was re-examined and classified as kimberlite (Kridelbaugh,

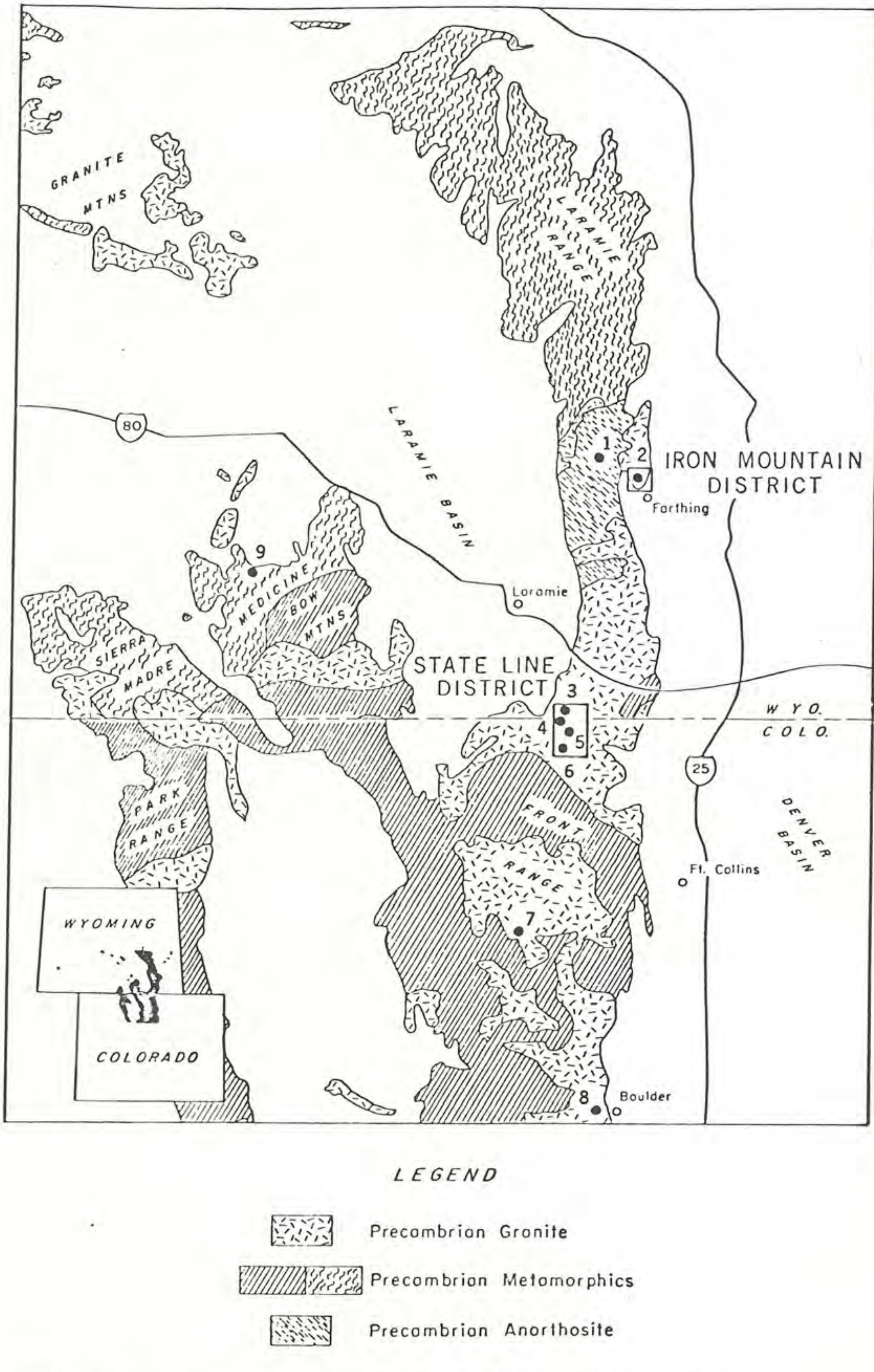


Figure 1. Generalized geologic map showing locations of (1) Radichal 1 pipe; (2) the Iron Mountain District; the State Line District showing locations of (3) the Ferris and Aultman pipes, (4) the Schaffer pipes, (5) the Nix-Moen pipes, (6) the Sloan pipes; (7) the Estes Park dike; (8) the Green Mountain pipe; and (9) the Medicine Bow placer diamond occurrence. (Kimberlite locations modified from McCallum and Smith, 1978; geology modified from maps of Colorado and Wyoming on the Southern Rocky Mountain Region and Northern Rocky Mountain Region Geological Highway Map published by AAPG).

et al., 1972).

The next report of an unusual ultrabasic rock was of some material found on the Sloan property in Colorado. During 1959, this rock was quarried by the Sterling Sand and Gravel Company and was used as a decorative building stone by the Wyoming Tile and Terrazzo Company located in Cheyenne, Wyoming. It is reported that the quarrying operations terminated (in 1960) after some of the rock purchased from the Sloan property scratched and damaged the carborundum wheel used in the grinding and polishing process (Hausel, et al., 1979b). Four years later, in 1964, this material was identified as diamond-bearing kimberlite.

The first authenticated discovery of diamonds in this region occurred in 1975. During that year, a serpentinized garnet peridotite nodule was collected from the Schaffer 3 kimberlite pipe in Wyoming. During thin-section preparation of the nodule, several deep scratches were carved in a carborundum grinding wheel at the U.S. Geological Survey rock preparation laboratory in Denver. Several small crystals responsible for the scratches were isolated and positively identified as diamond (McCallum and Eggler, 1976). Since this discovery, 11 additional kimberlites in the Colorado-Wyoming State Line District have been found to contain diamond (McCallum, et al., 1979).

Another diamond discovery was made in the Snowy Range in 1977. Two diamonds (1.5 mm and 3 mm in average diameter) were extracted from stream sediments by a local prospector, and positively identified as diamond by X-ray diffraction methods at the Geological Survey of Wyoming (Hausel, 1977). The source of these diamonds has not yet been identified.

The discovery of diamonds in Colorado and Wyoming kimberlites represents the second authenticated occurrence of diamonds found in place in North America. The Colorado-Wyoming region contains more individual kimberlite intrusions and more diamond-bearing kimberlites than the rest of North America. Industrial interest recently has been indicated by the many private mining companies which began exploration programs in this region, and elsewhere in the United States, for commercial diamond deposits. At present time, two mining firms are testing diamond pipes in both Colorado and Wyoming for commercial mineralization. Cominco American, Incorporated is testing several pipes in the Wyoming portion of the State Line district, and the Minerals Division of the Superior Oil Company, in joint venture with Falconbridge, is testing kimberlite in Colorado.

PROSPECTING FOR KIMBERLITE

Introduction

Various techniques are employed in the exploration of kimberlite intrusions throughout the world, and, depending upon the nature of the kimberlite and the type of host rock intruded by the kimberlite, the methods of exploration have had differing degrees of success. Several exploration methods have been examined in Colorado and Wyoming; the most efficient being that of reconnaissance stream sediment sampling. Geophysical and geochemical surveys have had limited success and both remote sensing and input surveys show potential promise (Hausel, et al., 1979a, b).

Stream Sediment Sampling

Methods

At the initial stage of reconnaissance stream sediment sampling surveys, preliminary sample sites are located on topographical maps. The sample sites are located on the maps to ensure that all significant drainages are sampled in sufficient detail to detect possible kimberlite intrusives. Sample site spacings generally are set 0.5 to 1.0 mile apart on all major drainages. This sample site spacing is based upon work by Leighton and McCallum (1979), where it was observed in the State Line district that the kimberlitic heavy mineral indicators chrome-diopside, pyrope garnet and picro-ilmenite, transported apparent maximum distances from their kimberlite host of 0.25 miles, 1.5 miles, and 2.5 miles, respectively.

Sample site locations designated on the preliminary reconnaissance maps can be, and often are, changed in the field during sampling. Changes in sample locations result in order to take advantage of the best possible heavy mineral traps observed in the field which cannot be observed on the topographical maps. Favorable heavy mineral traps commonly occur at distinctive stream meanders, at nearly any size of waterfall, and where obstructions (rocks, tree roots, etc.) tend to diminish water flow velocity. In dry drainages, large samples, (approximately 100 pounds) are carried to nearby wet drainages for field processing.

After the field sample site is selected, a few preliminary shovelfulls of material are panned and the concentrates are examined for heavy minerals, and in particular for garnet. If heavy minerals are lacking, a search is continued for a more favorable sample site. When the final sample site is selected, two-man field crews spend two to four hours panning with 14-inch gold pans, a piece of fly screen (with 1.2 mm square hole openings) and a grizzley pan (with ¼-inch diameter hole openings).

The sample is dug from a hole to depths of one to three feet. Prior to panning, the samples are screened to increase the efficiency of panning. The samples are shoveled onto the grizzley pan, which sandwiches the fly screen between the grizzley and the underlying gold pan. Material finer than ¼ inch in diameter is washed through the grizzley. The remaining coarse material is briefly examined for any possible indicator minerals and then tossed. The remaining sample is washed and the fine-grained material (less then 1.2 mm square) is worked through the fly-screen and into the gold pan. The coarser material trapped on the screen is set aside on the stream bank to await processing. The fine-grained material is panned until only black heavy minerals and garnets (if present) remain. These concentrates are dumped into a sample bag. The coarser sample on the fly screen (greater than 1.2 mm square and smaller than ¼ inch in diameter) is then dumped into the gold pan and processed until only heavy minerals remain. These concentrates are placed in a separate sample bag. This process is repeated over and over until approximately three to five pounds of concentrates are collected. The panned concentrates are transported to the Geological Survey of Wyoming heavy mineral processing laboratory for additional concentration.

At the lab, the samples are dried, run through a magnetic separator to remove all magnetic constituents (magnetite, ferro-ilmenite, etc.), and then further concentrated in a jig and on a Wilfley Table to remove any remaining low specific gravity (less than 3.2 specific gravity) material. The final concentrates are examined microscopically.

Heavy mineral identification

Examination of the heavy mineral concentrates is conducted to search for essentially one or more of three mafic minerals: chrome-diopside, pyrope garnet, and picro-ilmenite. Other potential indicator minerals have been suggested (e.g. Kresten, et al., 1975; Turskiy, 1967) although these lack demonstrated practical use. If a preliminary reconnaissance sample contains one of these mafic indicators, the general procedure is to retake a sample at the same site -- and if still positive, then to conduct close space (100 to 500 yards) sampling up the positive drainage until no indicator minerals are found. Theoretically, the host rock (or rocks) for the indicators should then lie between the positive samples and the first negative sample further up the drainage.

It should be noted that the presence of the indicator minerals does not imply that they were derived from a kimberlite host, for they could just as well have been eroded from some other volcanic source containing upper mantle material. Although such mantle material is not common at the earth's surface, mantle xenoliths and megacrysts have been found in some volcanic rocks in the western United States. One fairly well-known example is that of the Vulcan's Throne basalts along the north rim of the Grand Canyon. These contain abundant peridotite fragments. However, the presence of the indicator minerals in a known kimberlite area is likely to be derived from a kimberlite host. Kimberlite intrusives commonly occur in clusters and thus where one kimberlite is found, other related ultrabasic intrusives may also occur nearby.

Identification of the three indicator minerals can be accomplished by a couple of different methods. The most reliable technique is solid chemical analysis by electron microprobe. However, microprobe analysis requires easy access to the instrument. Additionally, electron microprobes are very expensive instruments, costly to operate and maintain, require a good set of standards for accurate information, the sample preparations are lengthy, and operation of such an instrument requires a well-trained technician. Electron microprobes are excellent instruments for large exploration firms or universities with large exploration and research budgets, but for small exploration groups it is not practical. More practical examination techniques are discussed below.

Picro-ilmenite

Three end-members occur in solid-solution in the ilmenite series: ilmenite (iron-end member), pyrophanite (manganese-end member) and geikielite (magnesium-end member). When magnesium replaces some iron in the ilmenite structure, a magnesium-rich ilmenite is produced. The mineral is termed picro-ilmenite, picrotitanite or magnesian ilmenite. Picro-ilmenites reported by Mitchell (1973) contain from about 6.5% to nearly 20% MgO. Additionaly Mitchell (1973) suggests that the magnesian ilmenites are uniquely confined to kimberlites. Thus, the presence of picro-ilmenite in stream sediment samples is a strong indicator of kimberlite.

Picro-ilmenite forms short tabular rhombohedral to rounded crystals with the rounded crystals being most common. They are opaque and generally iron-black to brownish-black metallic crystals often exhibiting leucoxene (dull white opaque substance) coating on some specimens.

Distinguishing physical properties of picro-ilmenite are its specific gravity (approx. 4.05; Sinkankas, 1964), hardness (5 to 6), black to brownish-black streak, and its lack of magnetism (the latter property appears to be very diagnostic of picro-ilmenite). According to Leighton and McCallum (1979), magnetic separation can be 100% effective in separating ferro-ilmenite from the magnesian ilmenite.

Optically, the reflectance of magnesian ilmenites is very characteristic. By measuring reflectance of the ilmenite grains at about 460 nm, the magnesium-rich members can be positively determined (Craig and Vaughn, 1981).

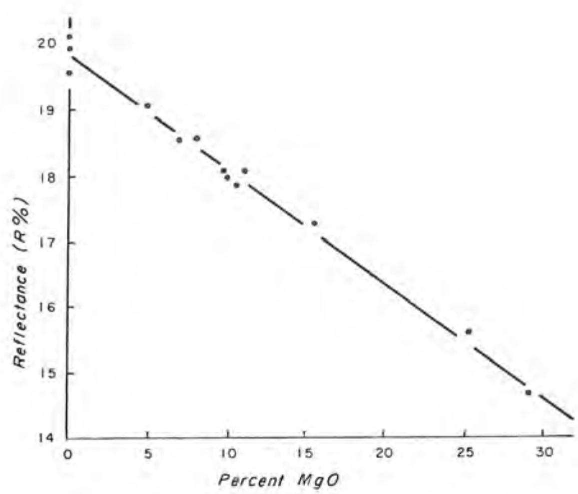


Figure 2. Plot of reflectance (R%), at about 460 nm against percent MgO content for ilmenites ($FeTiO_3$ - $MgTiO_3$ series). (After B. Cervelle, et al., 1979 and Craig and Vaughn, 1981).

Chrome-diopside

Chrome-diopside crystals have a very characteristic emerald-green color. Weathered specimens accent the excellent parting parallel to c(100). Good cleavage parallel to m(110) is sometimes also distinguishable in weathered specimens when magnified by microscope. The cleavage and parting produce rough rectangular cube-like crystals with distinctive flat-smooth surfaces with rounded edges.

Optically, the crystals are anisotropic, being in the monoclinic crystal system, with refractive indices of 1.670 to 1.740. Specific gravity ranges from 3.20 to 3.40, hardness = 6, and grains will give positive tests for chromium. The temperature of fusion is relatively high, requiring heating of the mineral powder in a borax bead by a Bunsen burner flame for one to two minutes. The bead and platinum wire will turn red hot for several seconds prior to coloring the bead green.

Pyrope garnet

The magnesian-rich garnets derived from kimberlite host rocks are often rounded and produce subangular fracture. Dodecahedral and octahedral crystal faces are rare. Color is often diagnostic. Pyrope garnets generally are light-purple to lavender, dark-red or orange, whereas almandine garnets generally are light-pink to reddish-brown.

Specific gravities of pyropes are lower than almandine garnets with specific gravities of the former being less than 3.80.

Optically, the garnets are isotropic with the pyopes having refractive indices of less than 1.760, whereas almandine is higher. Color, isotropcy, and index of refraction are used together for pyrope identification.

Geophysics

Geophysical surveys appear to have limited prospecting value in the Colorado-Wyoming province. Magnetics, electromagnetics, and resistivity have shown some exploration successes, but gravity and seismics appear to have little use (Hausel, et al., 1979a, b). Input surveys have not been tested, but these offer potential success because of the detailed information that is produced.

Magnetics

Magnetic surveys in the Colorado-Wyoming region have successfully detected kimberlite over known intrusives. Magnetic responses vary from weak anomalies (20 to 30 gammas) to a high of 1000 gammas above background (Hausel, et al., 1979b).

The weak localized anomalies suggest that airborne surveys will have poor chances of success, although ground magnetic surveys may be used successfully in isolating kimberlitic intrusive phases buried by alluvial debris.

Electromagnetics and resistivity

Weathered kimberlite produces eluvial clays composed principally of carbonate, serpentine and montmorillonite. These clays are susceptible to electrical currents and often produce electromagnetic and electrical resistivity anomalies. Apparent resistivities of weathered kimberlite lie between 80 and 250 ohm-feet, as compared to 500 to 7,400 ohm-feet in granitic grus and granite. Electromagnetic surveys also show pronounced conductivity anomalies over weathered kimberlite. For example, a weathered kimberlite dike buried under alluvial debris produced approximately a 36.0 mmhos/meter conductivity high compared to a 5.0 to 10.0 mmhos/meter background (Hausel, et al., 1981).

Geology

Kimberlites are found in clusters and in groups of clusters trending along fractures, and often along intersections of fractures or faults (Hausel, et al., 1979a, b). These trends are important in exploration in that once a kimberlite trend is established, additional kimberlites often can be found by following these trends (Hausel, et al., 1979c, 1981).

DIAMOND EXTRACTION AND IDENTIFICATION

Diamond extraction laboratory

A diamond extraction laboratory was constructed in the basement of the Geological Survey of Wyoming in order to test newly discovered kimberlites for their diamond occurrences. A flow chart of the pilot mill is shown in Figure 3.

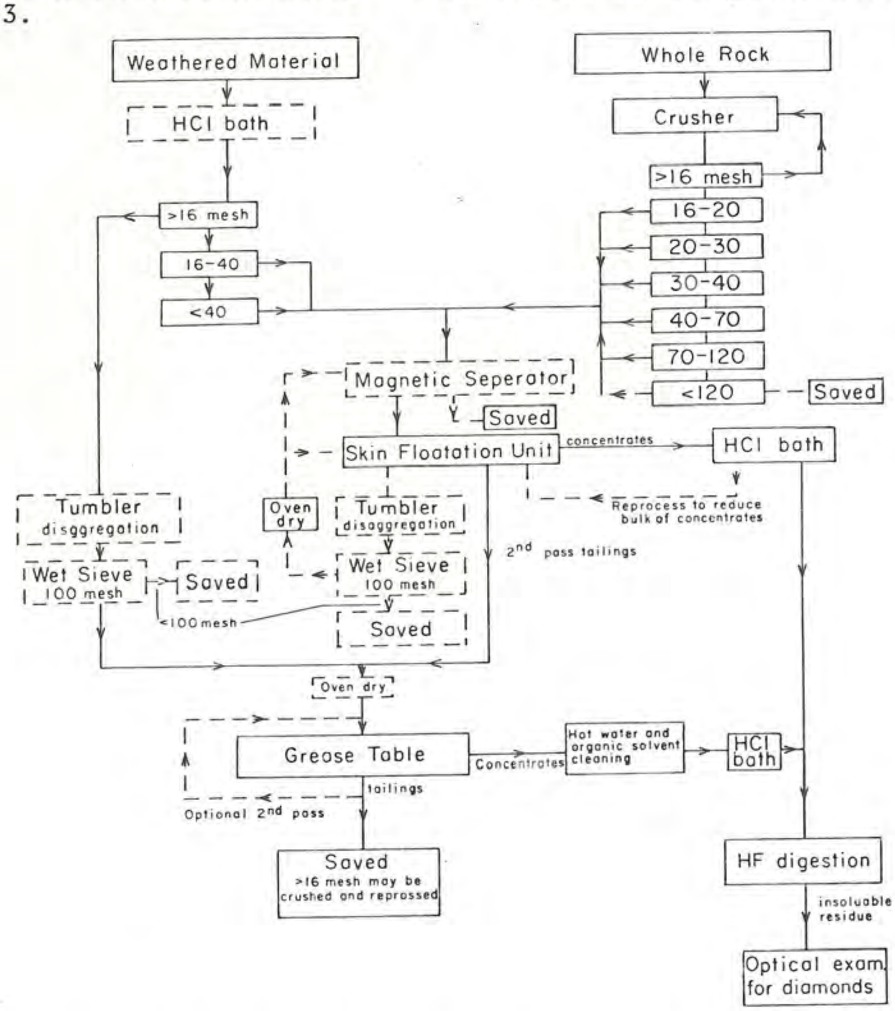


Figure 3. Flow chart diagram of diamond extraction laboratory designed and constructed by the Geological Survey of Wyoming. Dashed segments of chart represent optional procedures not always used or redundancies aimed at increasing diamond recovery.

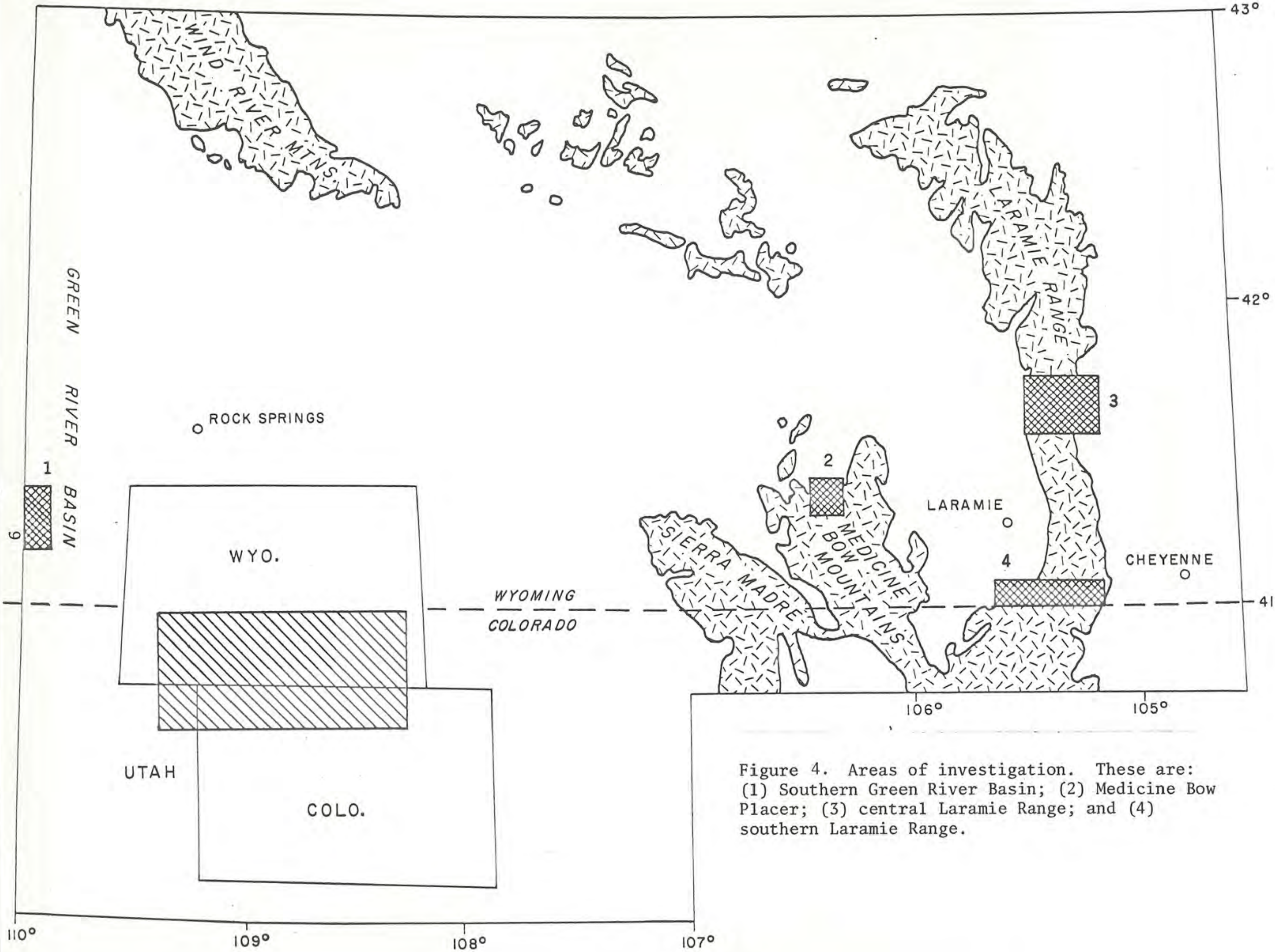


Figure 4. Areas of investigation. These are: (1) Southern Green River Basin; (2) Medicine Bow Placer; (3) central Laramie Range; and (4) southern Laramie Range.

The State Survey's laboratory is designed to benefit from a characteristic property of most diamonds. This characteristic is that most lode diamonds are non-wettable and grease attractive.

Sample preparation starts with crushing rock specimens to powder. The powdered and soil samples are sieved to separate into three or more sizes. The sieved material is run through a magnetic separator to remove any magnetic constitutents. Depending upon size, the remaining samples are either processed on a side-shaking grease table (+16; greater than 1.19 mm) or are processed in a skin-flotation unit (-16; less than 1.19 mm in average diameter).

The grease table is a modified Wilfley Table top with steps constructed from 2x4's covered with an aluminum sheet. The grease is a mixture, at a ratio of 10:1, of Vaseline to paraffin, and is coated on the table in layers 1/8 to ¼ inch thick. Water temperature is kept at a constant $20^{\circ}C$.

The skin flotation unit consists of a plastic pan with a water faucet built in the center of the base. This allows the water to rise and flow over the sides creating a smooth water tensional surface. The sample falls on this surface from a vibrating sample feeder. Small diamonds (less than 1.19 mm), being non-wettable, float on the surface and fall off of the pan's edge into a catchment pan where the water surface tension is broken by the falling water. The diamonds sink in this pan or are recovered in a 200 mesh sieve at the water outlet.

Both the grease table and skin flotation units were tested for diamond recovery efficiency. Salted samples were processed in both units. The grease table proved to be 100% recovery efficient for diamonds greater than or equal to 1 mm diameter, while the skin flotation unit was only about 80% efficient for diamonds less than 1 mm diameter.

Diamond Identification

Diamond is an isotropic mineral occurring within the cubic crystal system. Most diamonds form in octahedral habits or slight modifications of octahedral crystals. Some cubes and rounded diamonds occur, but are not common. Characteristically, diamond has a greasy to adamantine luster and commonly shows trigonal buildups, or steps on the octahedral (111) faces.

Specific gravity is approximately 3.5, and the hardness is diagnostic at 10 (Moh's hardness scale), it being the hardest naturally-occurring substance. The hardness of microdiamonds can be evaluated by a micro-indentor.

REGIONAL STUDIES

Introduction

Four general regions were examined for diamond-bearing kimberlite under this study using the prospecting and sampling techniques outlined in the foregoing text. These regions are: (1) southern Green River Basin, (2) Medicine Bow placer, (3) central Laramie Range, and (4) the southern Laramie Range (Figure 4). Each area is discussed separately:

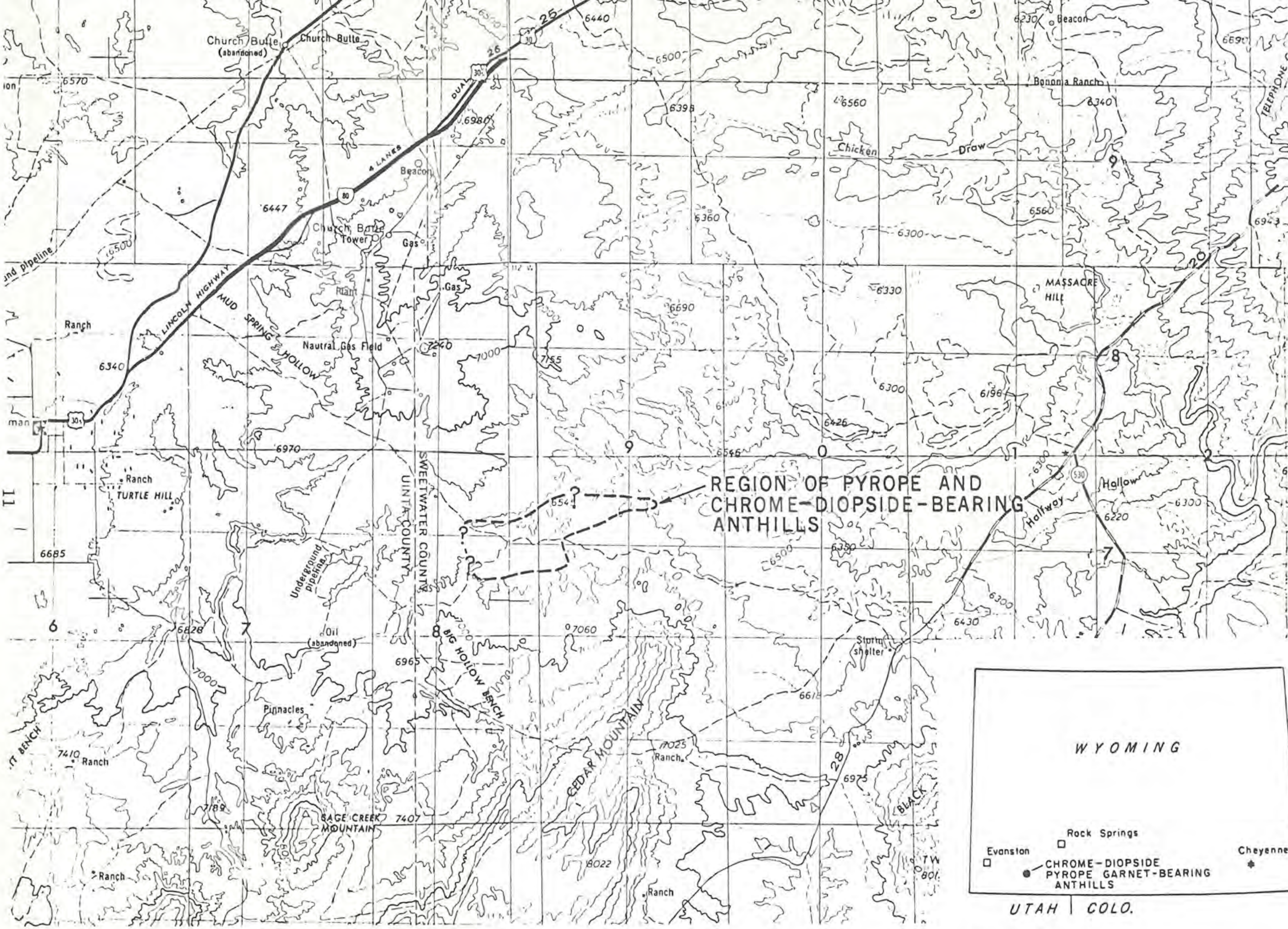

REGION OF PYROPE AND
CHROME-DIOPSIDE-BEARING
ANTHILLS
Church Butte
(abandoned)
Church Butte
Church Butte
Tower
Gas
Beacon
4 LANES
DUAL
LINCOLN HIGHWAY
MUD SPRING HOLLOW
Nautral Gas Field
Gas
Ranch
TURTLE HILL
Underground pipeline
Oil
(abandoned)
SWEETWATER COUNTY
UINTA COUNTY
BIG HOLLOW BENCH
CEDAR MOUNTAIN
SAGE CREEK MOUNTAIN
Pinnacles
Storm shelter
BLACK
Chicken
Draw
Bonana Ranch
Beacon
MASSACRE HILL
Hallway
Hollow
TELEPHONE
Ranch
WYOMING
Rock Springs
Evanston
Cheyenne
CHROME-DIOPSIDE
PYROPE GARNET-BEARING
ANTHILLS
UTAH
COLO.

Figure 5.

Southern Green River Basin

A cursory reconnaissance survey of ant hills containing pyrope garnet and chrome-diopside in the southern Green River Basin was undertaken to try to: (1) define the area of extent of the anomalous mineral occurrences; (2) attempt to find a source area for the anomalous minerals and (3) test material for diamonds.

The area underlain by the anomalous ant hills is bedded sedimentary rocks of the Bridger Formation of middle to late Eocene age. The Formation is composed principally of tuffaceous mudstone sandstone, siltstone, pumaceous crystal tuff, limestone and marl. The anomalous ant hills appeared to terminate to the north, south and east. However, the western extent of the anomalous minerals was not defined in that the ant hills terminated altogether to the west (Figure 5). The last ant hills observed in the west were pyrope- and chrome-diopside-bearing.

Because of the large area containing the anomalous ant hills, ground magnetic surveys could not efficiently be used. Two magnetic profiles were run on the eastern boundary of the anomalous mineral field, and no anomalous magnetic regions were detected.

Two pyrope-rich ant hills were sampled and processed for diamond. The grease table concentrates were composed principally of quartz, quartzite pebbles and chert with lesser pyrope, chrome-diopside, minor calcite, hornblende, and epidote. No diamonds were found in these samples.

A recent solid-geochemical study of pyropes collected from ant hills in the Green River Basin by T. McCandless at the University of Utah suggested that the pyrope garnet compositions are not chemically similar to those found as inclusions in diamond (Figure 6). The compositional differences suggest that the host rock of the Green River Basin garnets may not be diamond-bearing.

Medicine Bow placer

Two diamonds were found along Mullison Creek on the northern flank of the Medicine Bow Range by a local prospector in 1977 (Hausel, 1977). The placer mining operation is located on the Tertiary Hanna-Ferris formations which onlap Precambrian metamorphics. A small number of samples were collected and examined for indicator minerals including diamond. No indicators or diamond was found.

Central Laramie Range

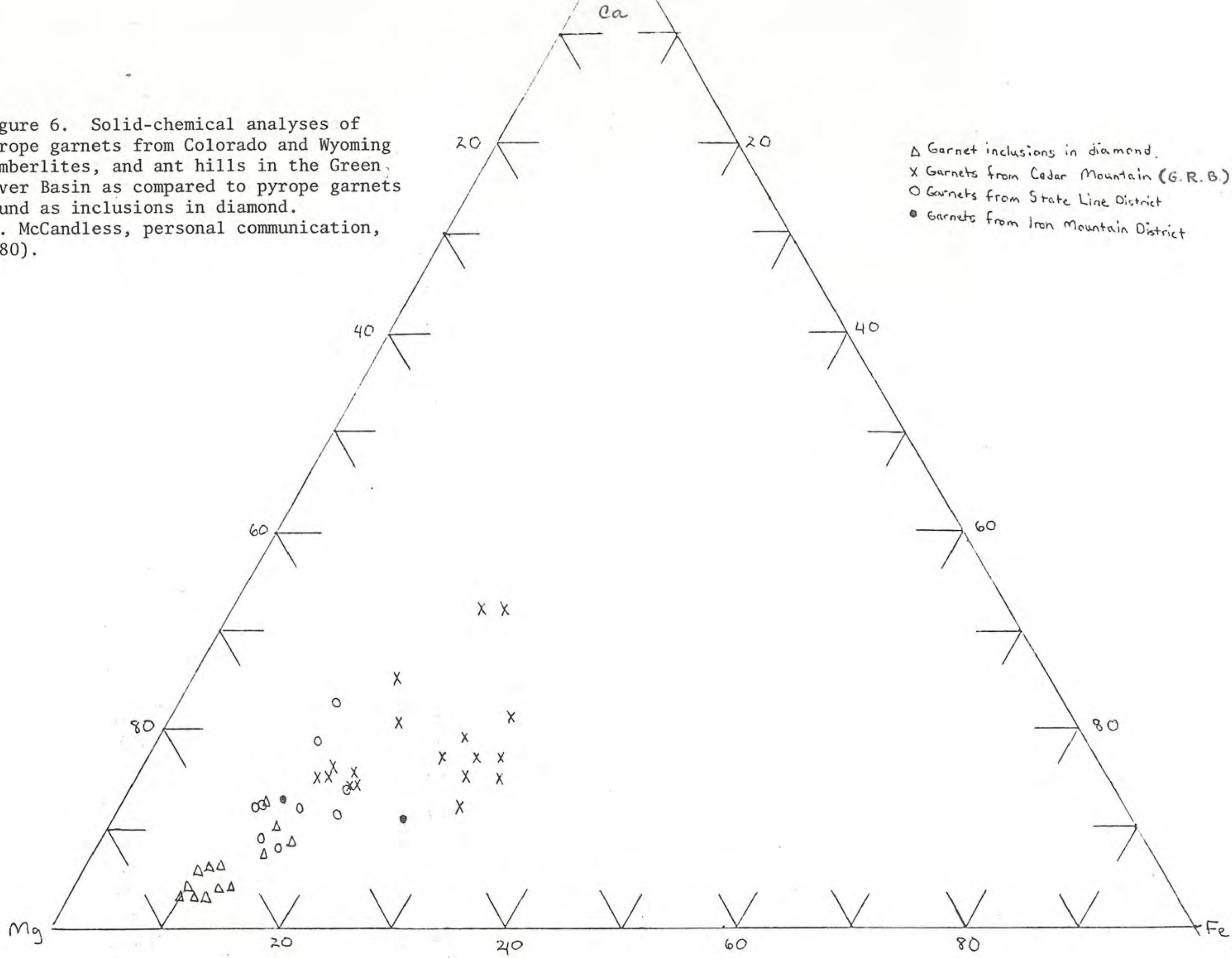
Introduction

Stream sediment sampling surveys in the central Laramie Range prospected six quadrangles for kimberlitic heavy minerals (Plate 1). These quadrangles are Sheep Rock (Plate 2), Sybille Springs (Plate 3), Baldy Mountain (Plate 4), Bosler SE (Plate 5), Indian Guide (Plate 6) and Goat Mountain (Plate 7). Samples collected in the Indian Guide, Goat Mountain and Bosler SE quadrangles have not yet been examined.

Geology

During stream sediment sampling surveys of the Sheep Rock quadrangle, a new kimberlite pipe was located and has been named the Radichal 1 pipe

Figure 6. Solid-chemical analyses of pyrope garnets from Colorado and Wyoming kimberlites, and ant hills in the Green River Basin as compared to pyrope garnets found as inclusions in diamond. (T. McCandless, personal communication, 1980).



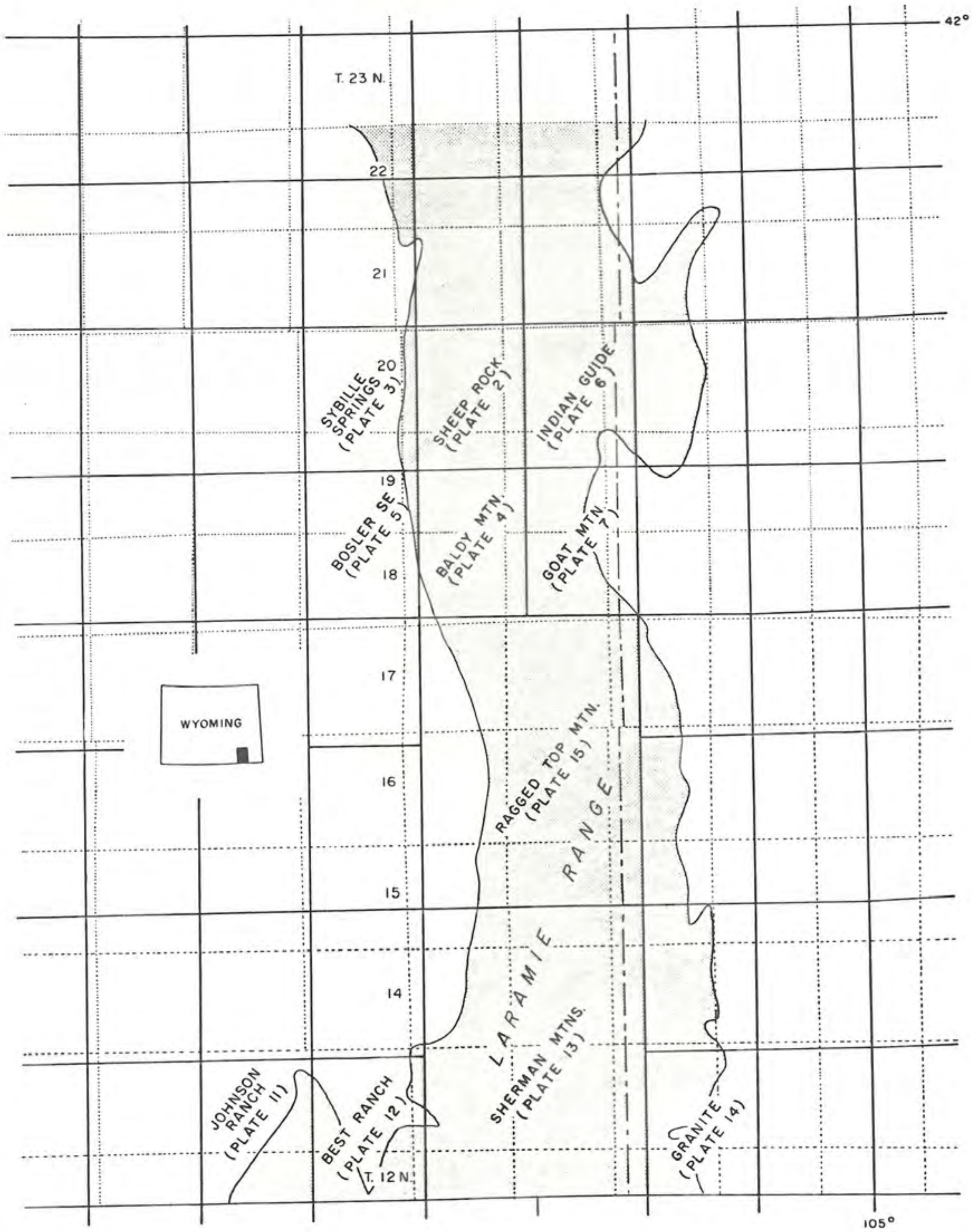


Plate 1. Index of topographical maps.

after the present ranch owners. The Sheep Rock district lies near the northern edge of the Laramie Anorthosite Complex (Figure 1). The anorthosite complex is the oldest batholith in the region, and is exposed over a region of nearly 350 square miles (1,000 square kilometers). The anorthosite is bounded on the north by Precambrian hornblende and hypersthene syenites, and by Precambrian gneisses and schists (Smithson and Hodge, 1972) which include the Elmers Rock greenstone belt (Graff, personal communication). The gneisses and schists are older than the anorthosite and are dated at approximately 2.5 b.y. (Smithson and Hodge, 1972).

The southern edge of the anorthosite is bounded by the Sherman Granite batholith. Rocks of the Sherman Granite are younger than the anorthosite and have been dated between 1.33 and 1.38 b.y. (Giletti and Gast, 1961; Hills, et al., 1968; Peterman, et al., 1968).

Biotite and hornblende within the anorthosite are dated between 1.4 and 1.53 b.y. (Smithson and Hodge, 1972). The east and west flanks of the complex are bounded by sedimentary rocks of the Laramie and Denver-Julesburg basins. A portion of the eastern flank complex is bounded by Sherman Granite. This portion of the Sherman Granite contains Devonian kimberlites of the Iron Mountain district (Figure 1).

In the immediate vicinity of the Radichal 1 blow, two general types of anorthosite are recognizable. On the east side of Middle Sybille Creek, the anorthosite is predominately gray, composed of plagioclase (An_{37} to An_{54}) with minor mafic minerals and magnetite-ilmenite (less than 10%). On the west side of the creek, the anorthosite is more mafic with plagioclase compositions as calcic as An_{64}. Mafic and opaque minerals are more predominate and constitute greater than 10% of the rock.

Granitic dikes are common in the anorthosite, and at some locations the dikes are pegmatitic. The dominant trend of these dikes is N20°W.

Some titaniferous masses and pods are scattered throughout the district and were formed as late magmatic injections. Within the Sheep Rock district, some of the titaniferous pods were found near the dolomitic marble in section 20, T. 20 N., R. 70 W. (Plate 3). These pods are small and occur in masses of less than 10 feet in length.

The Radichal 1 blow is less than 50 feet in diameter based on rock exposures in a small prospect pit on the west side of Middle Sybille Creek. This rock is hard, silicified, olive drab in color, and is porphyritic with numberous autocrysts (xenocrysts?) ranging in size from ½ inch or less (in average diameter) that have been completely replaced by serpentine and carbonates (Figure 7). Pyrope and chrome-diopside are rare, ilmenite is common and forms up to one percent by volume of hand specimens. The groundmass is highly serpentinized and carbonated. A whole rock chemical analysis of Radichal kimberlite is compared to similar Colorado-Wyoming kimberlites in Table 1. A grid was set up over the Radichal blow and both electromagnetic and magnetic surveys conducted over the blow (Figures 8 and 9).

The blow being exposed as hard massive kimberlite (hardebank), was expected to be electrically resistive (Figure 8). For example, Hausel et al., (1979b) reported that in the State Line district resistivity sounding surveys

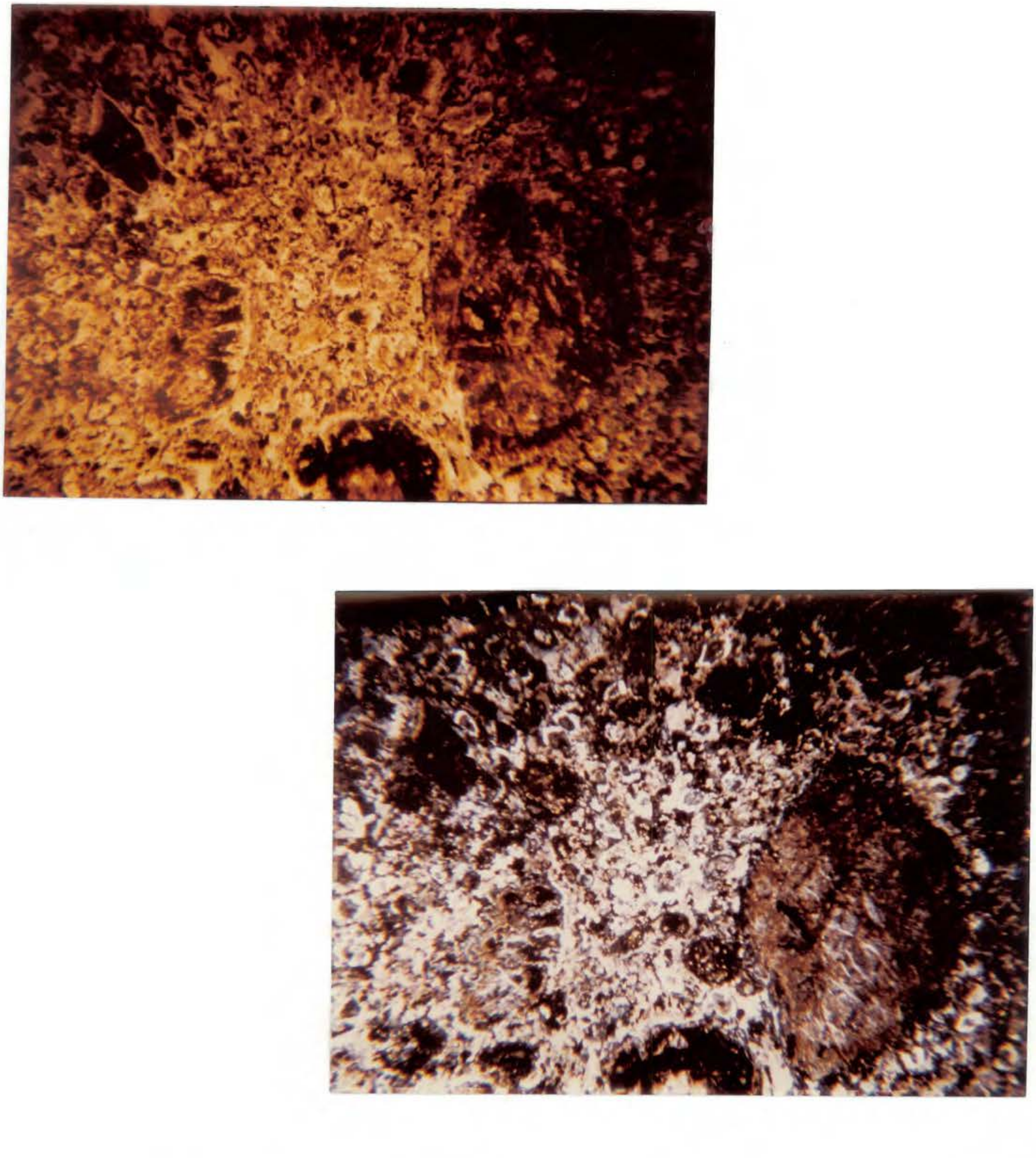


Figure 7. Photomicrographs of the Radichal kimberlite in transmitted light and with cross nichols. The original mineralogy has been nearly completely replaced by serpentine and carbonate.

CONDUCTIVITY CONTOURS OVER THE RADICHAL 1 PIPE (SHEEP ROCK DISTRICT)

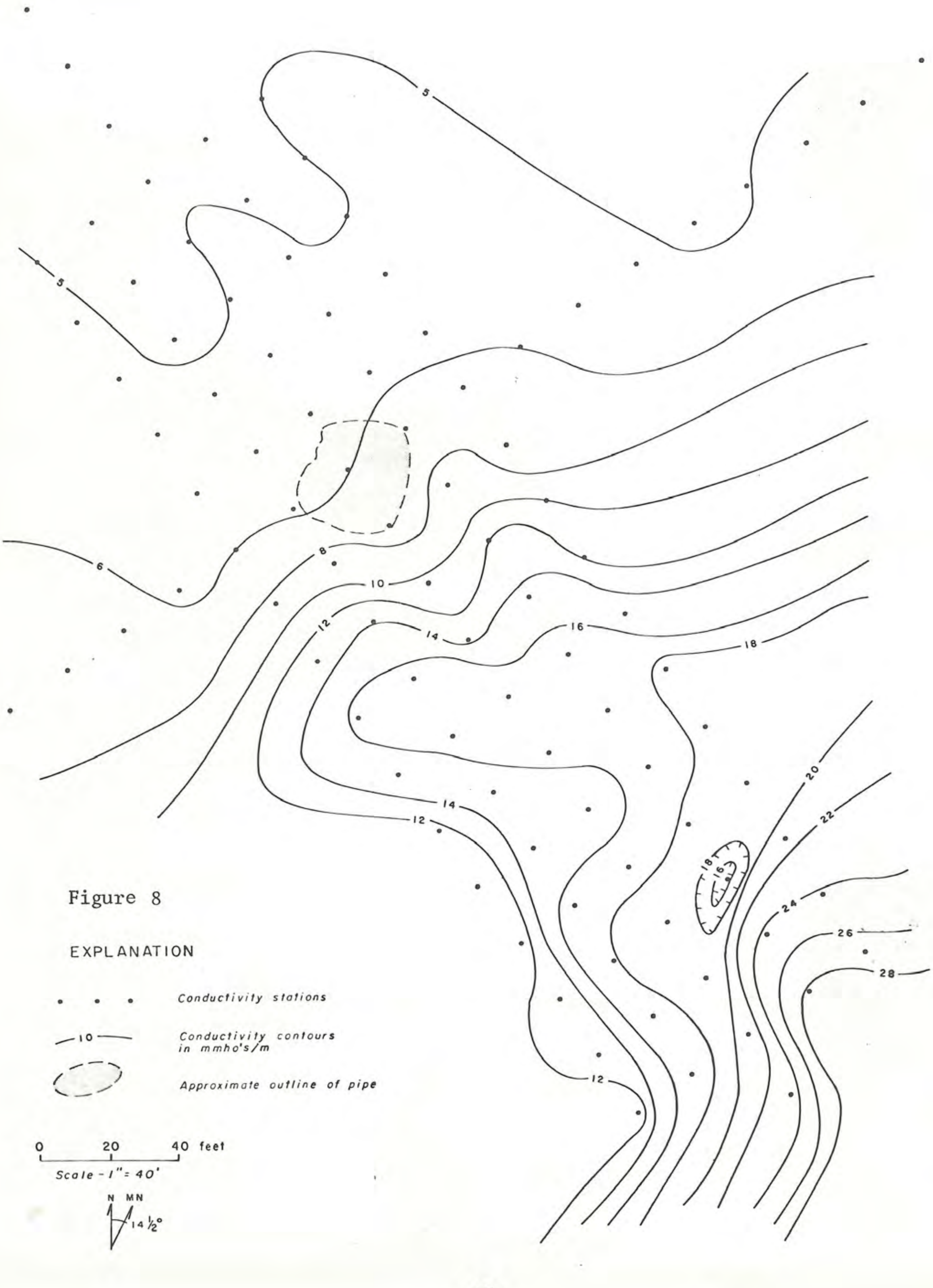


Figure 8

EXPLANATION

Conductivity stations

10 *Conductivity contours in mmho's/m*

Approximate outline of pipe

0 20 40 feet

Scale - 1" = 40'

N MN 14 ½°

showed weathered kimberlite to have low resistive electrical characteristics; whereas the hardebank kimberlite, at depth, was highly resistive (low conductivity). As expected, the Radichal 1 exposure produced low conductive signatures as measured by a Geonics EM-31 electromagnetic unit. No clear electrical anomaly was detected, and the blow gave electrical responses of about 6 mmhos/meter, or essentially the same as the noritic anorthosite outcrop. To the southeast of the blow the conductive properties increase. This increase is due to an increase in thickness of alluvial material associated with the Middle Sybille Creek.

Table 1. Chemical composition of Colorado-Wyoming kimberlites (weight percent).

	a	b	c	d	d	b	a	a	e
Oxide	NX3s-1	IM1-8	ED1-1	SD1-86	SD1-88	IM16-5	NX4-16	NX4-16	RAD1-1
SiO_2	24.8 %	25.7 %	29.6 %	30.4 %	32.5 %	33.6 %	34.2 %	34.2 %	30.94%
TiO_2	1.4	2.6	5.2	0.90	0.60	3.0	0.75	0.95	2.73
Al_2O_3	3.1	2.1	2.7	1.9	1.9	2.8	2.4	2.7	3.06
Cr_2O_3	0.10	0.10	0.19	0.14	0.10	0.14	0.13	0.16	NA
Fe_2O_3	7.0	8.7	5.6	4.0	3.5	7.7	3.7	6.4	10.80*
FeO	1.3	0.87	5.0	2.0	1.9	3.8	2.1	1.5	NA
MnO	0.15	0.16	0.25	0.13	0.09	0.18	0.13	0.14	0.16
NiO	0.07	0.07	0.08	0.11	0.10	0.10	0.14	0.12	NA
MgO	22.2	12.6	23.1	25.9	27.4	28.4	31.2	30.7	28.61
CaO	16.2	19.9	10.2	14.8	12.5	5.1	7.9	6.8	9.02
Na_2O	0.07	0.05	0.03	0.04	0.03	0.05	0.07	0.09	0.01
K_2O	0.16	1.0	0.94	0.29	0.20	1.4	1.1	0.42	1.04
P_2O_5	1.4	0.35	0.09	0.35	0.15	0.35	0.15	0.03	0.24
BaO	0.06	0.07	0.07	0.03	0.01	0.08	0.07	0.08	NA
CO_2	10.5	21.0	5.8	8.9	7.0	1.7	3.5	2.2	NA
L.O.I.	10.0	4.4	9.9	10.2	11.6	11.2	9.8	14.0	12.88
Total	98.5 %	99.7 %	98.8 %	100.0 %	99.6 %	99.6 %	98.3 %	100.7 %	99.5 %

(a) Nix pipes (Smith et al., 1979)
(b) Iron Mountain district (Smith et al., 1979)
(c) Estes Park dike (Smith et al., 1979)
(d) Sloan diatremes (Smith et al., 1979)
(e) Radichal kimberlite
* Total iron as Fe_2O_3

The Radichal 1 blow showed a clear localized magnetic high of nearly 57,400 gammas, or a net anomaly of 600 to 700 gammas (Figure 9). This is the second largest reported magnetic anomaly associated with a kimberlite pipe in the Colorado-Wyoming province. Only the Nix 1 pipe showed a more clear anomaly of approximately 1,000 gammas (Hausel, et al., 1979b). This anomaly should be detectable by low altitude airborne magnetic surveys; however, low altitude surveys in the vicinity of the anorthosite complex should have difficulty in distinguishing anomalies resulting from kimberlite pipes and those anomalies resulting from the scattered magnetite-ilmenite deposits.

About 500 pounds of rock was collected from the Radichal blow. This material is being processed for diamonds, although to date no diamonds have been identified in these concentrates.

Stream sediment samples collected in the vicinity of the Radichal kimberlite intrusive suggest that more than one ultrabasic or ultramafic intrusive lies within the Sheep Rock quadrangle.

Stream sediment sampling

The following tables discuss results of examined stream sediment samples and abstract those results. The samples are grouped by quadrangle, and only those quadrangles containing positive samples are discussed in the tables. It should be noted that picro-ilmenite was not used as a reliable

MAGNETIC CONTOURS OVER THE RADICHAL 1 PIPE (SHEEP ROCK DISTRICT)

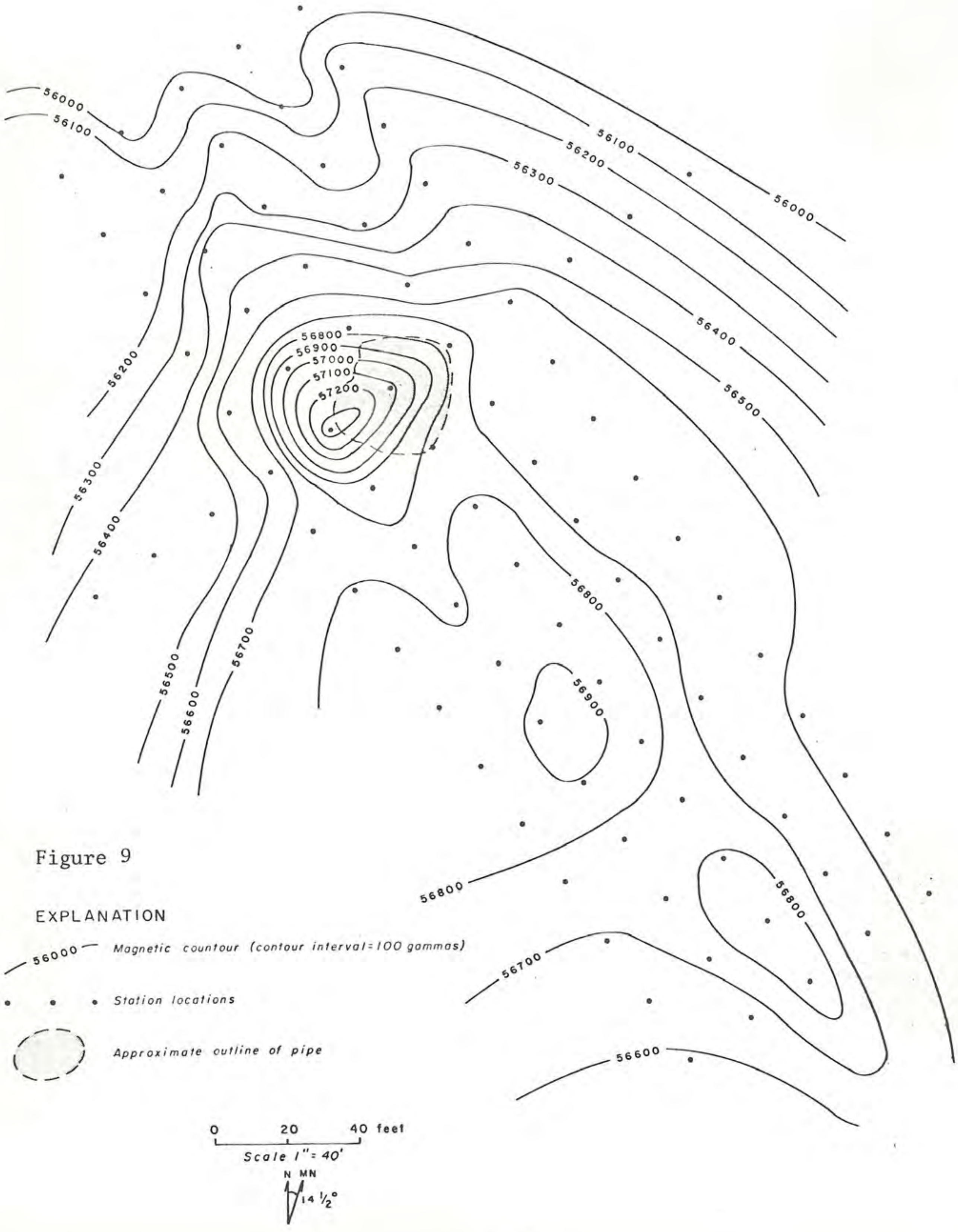


Figure 9

indicator in the central Laramie Range in that ilmenite (both magnetic and non-magnetic) was abundant (for example, all ilmenites examined in Radichal kimberlite samples were magnetic). We were unable to examine the reflectance of the ilmenites in that our laboratory is not equipped with a metallurgical microscope. Samples of the non-magnetic ilmenite were saved for later studies. Where picro-ilmenite is indicated, it is questionable and only listed because of the presence of other indicator minerals.

The abundance of the minerals inthe concentrates is listed as A = Abundant (greater than 15% volume of the sample; VC = 10-15%; C = 5-10%; UC = 1-5%; R = less than 1%. Garnet types are abbreviated (Alm = almandine; Pyr = pyrope).

SHEEP ROCK QUADRANGLE (See Plate 2)

Sample No.	Garnet Type	Garnet Abundance	Picro-Ilmenite Abundance	Chrome-Diopside Abundance	Comments
IM-1	Alm.	R	--	--	Sample contains several small carbonate (limestone) fragments.
IM-2	Alm.	R	--	--	Sample contains several small carbonate (limestone) fragments.
IM-3	Alm.	R	--	--	---
IM-4	Alm.	R	--	--	---
IM-8	Alm.	R	--	--	---
IM-9	Alm.	R	--	--	---
IM-10	Alm.	R	--	--	---
IM-11	Alm. Pyr.	R ?R?	--	--	only one red pyrope in sample
IM-11R	Alm.	C	--	--	---
IM-11A	Alm.	C	--	--	Several fragments of non-magnetic ilmenite?
IM-11B	Alm.	C	--	--	---
IM-12	Alm.	R	--	--	---
IM-13	Alm.	C	--	--	1 pyrite grain in sample

1M-14	Alm.	UC	--	--	Abundant non-magnetic ilmenite?
1M-15	Alm.	R	?R?	?R?	2 small grains of chrome-diopside several non-magnetic ilmenites?
1M-16	Alm. Pyr.	R ?R?	R	--	Pyrope grain - questionable? 2 hexagonal leucoxene coated non-mag. ilmenite grains.
1M-16R	Alm.	UC	--	--	---
1M-16A	Alm. Pyr.	UC R	--	--	one red pyrope grain
1M-16B	Alm.	UC	--	--	---
1M-16C	Alm. Pyr.	UC R	--	--	1 red pyrope grain. 1 small hexagonal (euhedral) red ruby.
1M-16D	Alm.	R	--	--	---
1M-17	Alm.	UC	--	--	---
1M-18	Alm.	UC	--	--	Several +16 size non-magnetic ilmenite grains.
1M-19	Alm.	UC	--	--	---
1M-20	Alm.	UC	--	--	---
1M-21	Alm.	UC	--	--	---
1M-22	Alm.	C	--	--	---
1M-22R	Alm.	UC	--	--	---
1M-22A	Alm. Pyr.	UC R	--	--	1 purple pyrope grain. 1 pyrite grain.
1M-23	Alm.	C	--	--	---
1M-24	---	--	--	--	---
1M-25	---	--	--	--	---
1M-26	---	--	--	--	---
1M-27	Alm. Pyr.	UC R	--	--	1 pink - orange pyrope

1M-27R	Alm. Pyr.	C R	--	--	8 purple pyropes.
1M-28	Alm. Pyr.	UC R	--	--	1 orange pyrope.
1M-28R	Alm. Pyr.	UC R	--	--	5 purple and 1 red pyrope.
1M-29	Alm.	UC	--	--	---
1M-30	Alm.	UC	--	R	2 grains of chrome-diopside.
1M-30R	Alm. Pyr.	C R	--	--	1 purple and 2 orange-yellow pyropes.
1M-31	Alm.	UC	--	--	---
1M-32	Alm. Pyr.	R R	--	--	1 pink pyrope.
1M-32R	Alm Pyr.	UC R	--	--	1 purple, 1 orange-yellow & two orange-red pyrope.
1M-33	Alm.	UC	--	--	---
1M-34	Alm. Pyr.	R R	--	--	1 purple, 1 orange-yellow & 1 orange-red pyrope.
1M-34R	Alm. Pyr.	R R	--	?R?	Several purple, red, and orange-yellow pyropes. Several sulfide grains, and 2 possible chrome-diopside (fuchsite colored) grains?
1M-35	Alm. Pyr.	R R	--	--	3 orange-yellow, 2 red, and 1 purple pyrope.
1M-35R	Alm. Pyr.	R R	--	--	5 purple to lavendar pyropes.
1M-35A	Alm. Pyr.	UC R	--	R	pyrite grains and 3 chrome-diopside, 1 lavendar pyrope.
1M-35B	Alm. Pyr.	R ?R?	--	R	1 deep-green emerald, 1 chrome-diopside, 1 yellow-orange pyrope?
1M-35C	Alm. Pyr.	R R	--	--	1 pyrite grain. 3 purple & 1 red pyrope.
1M-35D	Alm.	R	--	--	---

1M-35E	Alm. Pyr.	R R	--	R	1 chrome-diopside, 2 very tiny red pyropes.
1M-35F	Alm.	R	--	--	---
1M-35G	Alm.	R	--	--	---
1M-36	Alm. Pyr.	R R	--	R	3 chrome-diopside grains. 1 pink-red pyrope.
1M-36R	Alm.	R	--	--	---
1M-36A	Alm.	R	--	--	---
1M-37		N O S A M P L E			
1M-38	Alm.	R	--	--	---
1M-39	Alm.	R	--	--	---
1M-40	Alm.	R	--	--	---
1M-41	Alm.	R	--	--	---
1M-42	---	--	--	--	---
1M-43	---	--	--	--	---
1M-44	Alm.	R	--	--	---
1M-45	Alm.	R	--	--	---
1M-46	---	--	--	--	---
1M-47	Alm.	R	--	--	---
1M-48	Alm.	R	--	--	---
1M-49	Alm.	R	--	--	---
1M-50	Alm.	R	--	--	grains coated by $CaCO_3$.
1M-51	Alm. Pyr.	R R	--	--	1 yellow-orange, 1 purple-red, 1 red, 1 orange pyrope.
1M-51R	Alm.	R	--	--	---
1M-51 R#2	Alm.	R	--	--	---
1M-52	---	--	--	--	---

1M-53	Alm.	R	--	--	---
1M-54	Alm.	R	--	--	---
1M-55	---	--	--	--	Abundant heavy minerals, but no garnets.
1M-56	Alm.	R	--	--	---
1M-57	Alm. Pyr.	UC ?R?	--	--	1 pyrope grain.
1M-57R	Alm.	UC	--	--	---
1M-58	Alm.	UC	--	--	---
1M-59	Alm.	R	--	--	---
1M-60	Alm.	R	--	--	---
1M-61	Alm.	R	--	--	---
1M-62	Alm.	R	--	--	---
1M-63	---	--	--	--	---
1M-64	---	--	--	--	---
1M-65	Alm.	R	--	--	---
1M-66	---	--	--	--	---
1M-67	Alm.	UC	--	--	---
1M-68	Alm.	R	--	--	---
1M-69	Alm.	R	--	--	---
1M-70	Alm.	R	--	--	---
1M-71	---	--	--	--	---
1M-72	---	--	--	--	---
1M-73	Alm.	R	--	--	---
1M-74	Alm.	R	--	--	---
1M-75	Alm.	R	--	--	---
1M-76	Alm.	R	--	--	---
1M-77	Alm.	R	--	--	---

IM-78	Alm.	R	--	--	---
IM-79	Alm.	R	--	--	---
IM-80	Alm. Pyr.	R R	--	--	1 light-purple pyrope
IM-80R	Alm. Pyr.	UC R	--	--	11 very tiny purple pyrope grains
IM-81	Alm.	R	--	--	---
IM-82	Alm.	R	--	--	---
IM-83	Alm.	R	--	--	---
IM-84	Alm.	R	--	--	---
IM-85	Alm.	R	--	--	---
IM-86	Alm.	R	--	--	---
IM-87	Alm. Pyr.	R R	--	--	1 orange-red pyrope.

Some of the initial sample sites showed traces of indicator minerals such as IM-11, but retake samples did not pick up any indicators. Such samples are difficult to explain and are considered to be of very low priority in follow-up investigations.

Sample sites such as IM-34 and IM-35 are considered high priority for field investigations because both the initial and retake samples contain indicator minerals. During the late fall, 1981, regions around sample sites IM-35C and IM-35E were field examined. No source rock was found near either sample site. Both sample sites are in drainages that drain east facing alluvial covered slopes. The possibility that small ultrabasic or ultramafic veins or dikes could lie beneath the alluvium is plausible.

The abundance and average grain size of indicator minerals was noticeably small as compared to samples collected in the State Line district (Hausel, et al., 1979c). The lack of garnet and chrome-diopside may be due to the lack of these minerals in their host intrusives. For example, the Radichal kimberlite is both pyrope and chrome-diopside poor.

BALDY MOUNTAIN QUADRANGLE (See Plate 4)

Sample No.	Garnet Type	Garnet Abundance	Chrome-Diopside Abundance	Picro-Ilmenite Abundance	Comments
1M-88	Alm.	R	--	--	---
1M-89	Alm.	C	--	--	---
1M-90	Alm.	UC	--	--	---
1M-91	Alm.	R	--	--	---
1M-92	Alm.	R	--	--	---
1M-93	Alm.	R	--	--	---
1M-94	Alm.	R	--	--	---
1M-95	Alm.	R.	--	--	---
1M-96	Alm. Pyr?	R ?R?	--	--	one red pyrope?
1M-96R	Alm.	UC	--	--	---
1M-97	Alm.	R	--	--	1 grain of mallable whitish metallic material
1M-98	Alm.	UC	--	--	---
1M-99	Alm.	R	--	--	---
1M-100	Alm.	R	--	--	---
1M-101	SAMPLE MISSING				
1M-102	Pyr.? Alm.	?R? UC	--	--	1 orange-red pyrope?
1M-102R	Pyr. Alm.	R R	-- --	-- --	1 Reddish-brown garnet tested as pyrope. 1 light-purple (lavender) garnet tested as almandine.
1M-103	Alm.	R	R	--	1 chrome-diopside grain? (contaminated?)
1M-103R	Alm.	R	--	--	---
1M-103A	Alm.	UC	--	--	---
1M-103B	Alm.	R	--	--	---
1M-103C	Alm.	R	--	--	---

1M-103D	Alm.	R	--	--	Ten sulfide grains in sample.
1M-104	Alm	UC	--	--	---
1M-105	Alm.	R	--	--	---
1M-106	Alm.	UC	R	--	1 chrome diopside grain? (contaminated?)
1M-106R	Alm.	UC	--	--	---
1M-106A					
1M-106B					
1M-106C					
1M-107	Alm.	UC	--	--	---
1M-108	Alm.	C	--	--	---
1M-109	Alm.	UC	--	--	1 Fluorite grain found in sample
1M-110	Alm.	UC	R	--	4 chrome diopside grains? (contaminated?)
1M-110R	Alm.	UC	--	--	---
1M-110A					
1M-110B					
1M-110C					
1M-110D					
1M-111	Alm.	R	R	--	2 chrome-diopside grains? (contaminated?)
1M-111R					
1M-111A					
1M-111B	Alm.	R	--	--	---
1M-111C					
1M-112	Alm.	UC	--	--	---
1M-113	Alm.	UC	--	--	---
1M-114	Alm.	UC	--	--	---
1M-115	Alm.	R	--	--	---
1M-116	Alm.	UC	R	--	1 chrome-diopside grain? (contaminated)

1M-116R					
1M-116A					
1M-116B					
1M-117	Alm.	--	--	--	---
1M-117A					
1M-117B					
1M-118	Alm.	C	R	--	1 chrome-diopside grain? (contaminated)
1M-118R					
1M-119	Alm.	R	--	--	---
1M-120	Alm.	R	--	--	---
1M-121	Alm.	R	--	--	---
1M-122	Alm.	R	--	--	---
1M-123	Alm.	R	--	--	---
1M-124	Alm.	C	R	--	2 chrome-diopside grains? (contaminated)
1M-124R	Alm.	C	--	--	---
1M-125	Alm	UC	UC	--	Several chrome-diopside grains? 1 fluorite. (contaminated?)
1M-125R	Alm.	UC	--	--	---
1M-125A	Alm.	R	--	--	---
1M-125B	Alm.	R	--	--	---
1M-125C					
1M-125D					
1M-125E	Alm.	UC	--	--	---
1M-125G	Alm.	UC	--	--	---
1M-125X					
1M-125Y					
1M-126	Alm.	UC	--	--	---
1M-126R	Alm.	C	--	--	---

1M-127	Alm	UC	--	--	1 beryl crystal in sample
1M-128	Alm.	R	--	--	---
1M-129	Alm.	UC	--	--	---
1M-130	Alm.	R	--	--	---
1M-131	Alm.	R	--	--	---
1M-132	Alm.	R	--	--	---
1M-132R	Alm.	R	--	--	---
			SYBILLE SPRINGS (Plate 3)		
1M-4	Alm.	R	--	--	---
1M-5	---	--	--	--	---
1M-6	Pyr. Alm.	R R	--	--	3 pyrope grains
1M-6R	Alm.	UC	--	--	---
1M-7	Pyr. Alm.	R R	--	--	2 dark red pyropes
1M-7R	Pyr. Alm.	R UC	--	--	1 dark-red pyrope grain
IM-10?	Alm.	R	--	--	---
IM-39	Alm.	R	--	--	---

A group of samples collected in the Baldy Mountain quadrangle contained one or more grains of chrome-diopside but no pyrope or picro-ilmenite. All of these samples were recollected during the 1981 field season, and at some localities very close-spaced sampling was initiated to verify the samples. None of the follow-up samples were positive.

We assume that the initial samples were contaminated. Only one follow-up sample on the Baldy Mountain quadrangle was positive (IM-102R)and contained one small grain of pyrope. The initial samples showing contamination are indicated by a question mark on Plate 4.

Sample sites IM-6 and IM-7 on the Sybille Springs quadrangle (Plate 3) contained pyrope grains.

Southern Laramie Range

Introduction

The Southern Laramie Range of southeastern Wyoming (Figure 4) includes a block of five quadrangles that were sampled for indicator minerals, and one of these quadrangles (Sherman Mountains) was examined in greater detail by geophysical surveys, since a portion of the State Line district lies in that quadrangle (Figure 1).

State Line District

The Wyoming portion of the Colorado-Wyoming State Line district is situated 20 miles south of Laramie, and immediately south of Tie Siding. This district was named by McCallum et al. (1975) for its location straddling the Colorado-Wyoming state line. The Wyoming part of the district extends 2.5 miles north, and the Colorado portion extends 12 miles south, of the border (Figure 1). Approximately 35 kimberlites have been located within this district (McCallum, et al., 1977, 1979) (Figure 1). Most of the occurrences are within two miles of U.S. Highway 287 between Tie Siding and the state line. All access roads are controlled by local landowners. The surface and mineral estates of the Wyoming portion of the State Line district are subdiviced into a rough checkerboard pattern of State and private land. The major private mineral estate owner is the Union Pacific Corporation. State sections include sec. 32, T.13N., R.72W.; and secs. 4, 6, 8, W½ and NE¼ sec. 10, W½, NE¼ and SE¼SE¼ sec. 14, sec. 16, W½ sec. 18, and N½ N½ sec. 20, T.12N., R.72W.

The geology of the State Line district is dominated by the nearly nine-mile diameter Virginia Dale ring-dike complex which is readily observable on high altitude aerial photographs. The complex is part of the Sherman Granite batholith that discordantly intrudes a sequence of folded metamorphic rocks. Eggler (1967) subdivided the complex into four zones: an outer granite ring-dike, a composite zone of metamorphic and basic igneous rocks, and two inner core zones of quartz monzonite. To the south of the ring-dike complex the Log Cabin Granite batholith locally intrudes the Sherman Granite.

Diabasic (andesite) dikes crosscut metamorphic rocks and granites of the Sherman and Log Cabin batholiths. These dikes occur from at least as far south as Golden, Colorado to as far north as the Iron Mountain district, Wyoming. In many places, single dikes can be traced for more than one mile.

These dikes are strikingly linear, reflecting joint control (Eggler, 1967; Hausel, et al., 1979a, b; McCallum and Mabarak, 1976). For example, 744 joint measurements in the State Line district show a maximum equivalent to the Precambrian disbasic dike trends of N10^{o}W to N20^{o}W (Hausel, et al., 1979a, b). Both the diabasic dikes and the granitic dikes were apparently emplaced during igneous activity associated with, and following, intrusion of the Log Cabin and Sherman Granites, and have roughly similar radiometric ages (1.42 b.y.) (Ferris and Krueger, 1964).

The sedimentary rocks nearest to the State Line district are Pennsylvanian sediments of the Fountain Formation which unconformably overlie Precambrian rocks to the north and west of the district.

Kimberlites in the district occur in a narrow north-south band about two miles wide and 15 miles long. Nearly 35 kimberlite dikes and pipes occur in the district (McCallum, et al., 1977, 1979). These vary in surface extent from a few feet wide for some of the smaller dikes to nearly 1,800 feet for the two largest diatremes in their maximum dimension (McCallum, et al, 1977).

A few pipes in the Colorado portion of the district are fault controlled (McCallum, et al., 1975). Many of the Wyoming kimberlites are aligned along northwest trends -- about N20°W to N45°W -- with a maximum between N30°W and N40°W (Hausel, et al., 1979a, b, b). That these linear trends vary several degrees from trends of pervasive joints suggests that reactivation of predominant Precambrian joint systems was probably not important in the emplacement of most of the kimberlites. However, the Ferris 1 and the Schaffer 15 pipes do straddle Precambrian diabasic dikes, so reactivation of an older Precambrian structure may have played an important role in the emplacement of these pipes and possibly others.

In general, outcrops of kimberlite are rare. Mapping is commonly based on the characteristics of eluvium covering kimberlite, such as presence of blue ground, mantle and crustal nodules, vegetative differences (McCallum and Mabarak, 1976; Hausel, et al., 1979b; Smith, 1977), or conductivity differences as measured by electrical resistivity surveys (Hausel, et al., 1979a, b; Puckett, et al., 1972). Alteration of the host granites by kimberlite magma is minor to absent (McCallum and Mabarak, 1976; Smith, 1977).

Surface exposures of the State Line kimberlites are commonly elongate to ellipsoidal. Some, which contain abundant Paleozoic xenoliths, are probably not as deeply eroded as those in the Iron Mountain district (McCallum and Mabarak, 1976). However, a few thousand feet of vertical pipe column were undoubtedly removed by erosion during the Ancestral Rocky Mountain and Rocky Mountain orogenies.

Within the Wyoming portion of the State Line district, two major types of Precambrian rocks crop out (Plate 9). In the southern half of the area the dominant rock is the Inner Cap Rock Quartz Monzonite, which is characteristically porphyritic. The dominant phenocryst is tabular euhedral microcline which averages about one inch in length. Plagioclase phenocrysts are commonly ½ inch in length. Most samples contain about 25 percent quartz and 5 to 10 percent dark minerals. The main ferromagnesian mineral is partially chloritized biotite. Magnetite is partially replaced by hematite. Some secondary sericite and epidote replace plagioclase (Eggler, 1967).

The Trail Creek Granite and the Inner Cap Rock Quartz Monzonite are facies of Sherman Granite. The Trail Creek Granite exhibits coarse-grained hypidiomorphic granular texture. Primary minerals are subhedral microcline and plagioclase, anhedral quartz, subhedral hornblende, and minor biotite. Ferromagnesian minerals are extensively replaced by epidote, chlorite, biotite, and silica, and oxide minerals by hematite and meta-ilmenite (ilmenite and rutile) (Eggler, 1967).

Granitic dikes intrude all facies of the Sherman Granite and compositionally are hornblende, quartz monzonites, biotite quartz monzonites,

MAGNETIC AND CONDUCTIVITY PROFILES
IN THE SLSS DRAINAGE (STATE LINE DISTRICT)

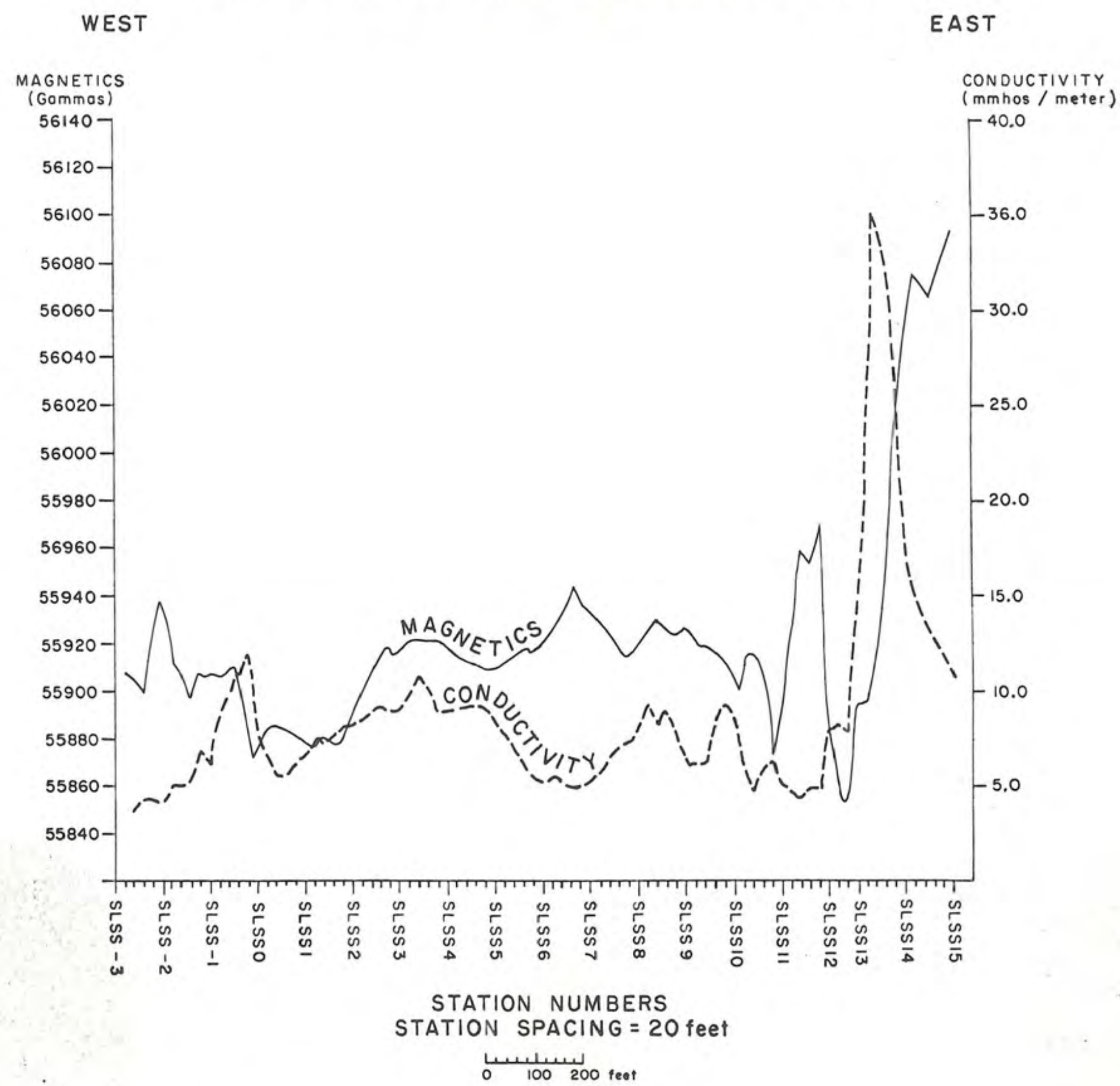


Figure 10

porphyritic alaskites, and equigranular fine- to medium-grained alaskites. Commonly, the granitic dikes are more resistant to weathering than the host rocks, and stand out as low-lying, linear ridges.

The diabasic dikes crosscut diorites, pegmatites, and granitic dikes. These diabases are predominately dark brown to black with diabasic, porphyritic, and aphanitic textures. Plagioclase phenocrysts or biotite clots (or both) in an aphanitic groundmass give some dikes a porphyritic or diabasic appearance. Compositionally, the rocks are andesitic (Eggler, 1967).

The older dioritic rocks are extensively feldspathized as a result of metasomatic reaction with the granitic magma (Eggler, 1967).

Much of the State Line area is covered by a thin blanket of grus developed on the Sherman erosional surface.

Previous geophysical investigations concerning kimberlite exploration and detection in the Laramie-Front ranges were reported by Hausel et al. (1979a, b), and by Puckett et al. (1972). The reader is referred to these papers for discussions on the geophysical differences between the Colorado-Wyoming kimberlites and the country rock.

During stream sediment sampling of drainages in the Wyoming State Line district in the 1978 field season, anomalous quantities of ultramafic material were recognized in a drainage, designated SLSS, that crosscuts the Schaffer kimberlite trend between the Schaffer 16 and 18 pipes (Hausel et al., 1979c). Although the large amount of ultramafic material may have been derived from the erosion of nearby pipes (Schaffer 3, 16, 17, and 18), it could also reflect a kimberlite dike or blow under the alluvial material between the Schaffer 16 and 18 diatremes.

To check this latter possibility, magnetic and electromagnetic profiles (Figure 10) were measured in an easterly direction in the SLSS drainage starting at the boundary between sections 16 and 21 (Plate 10). A Geonics EM-31 electromagnetic unit and Geometrics proton precession magnetometer were used in the survey. The eastern edge of the survey coincides with the projected kimberlite trend, and electromagnetic and magnetic highs of 36 mmhos/meter and 56,100 gammas, respectively, were recorded between stations SLSS 13 and SLSS 15. The electromagnetic high is compared to an average background of about 7 mmhos/meter, and the magnetic high to a magnetic background of approximately 55,900 gammas.

A grid (Figure 11) was set up over the region where magnetic and electromagnetic highs were recorded. Results of the magnetic survey show a strong N20^{o}W linear anomaly east of the projected trend between the Schaffer diatremes (Figure 12). This magnetic high appears to coincide with a diabasic dike that has a N20^{o}W trend and crosscuts the Schaffer trend between the Schaffer 16 and 18 pipes. Additional magnetic studies of the diabasic dikes indicated that these dikes were commonly more magnetic than the surrounding granitic rocks.

Electromagnetic measurements gave a clear conductive anomaly along the Schaffer trend at about N35^{o}W to N40^{o}W (Figure 13). The high conductivity suggests the presence of a weathered kimberlite dike or blow enlargement which apparently connects the Schaffer 16 and the Schaffer 18. Where kimberlite is deeply weathered, the EM-31 electromagnetic unit is apparently

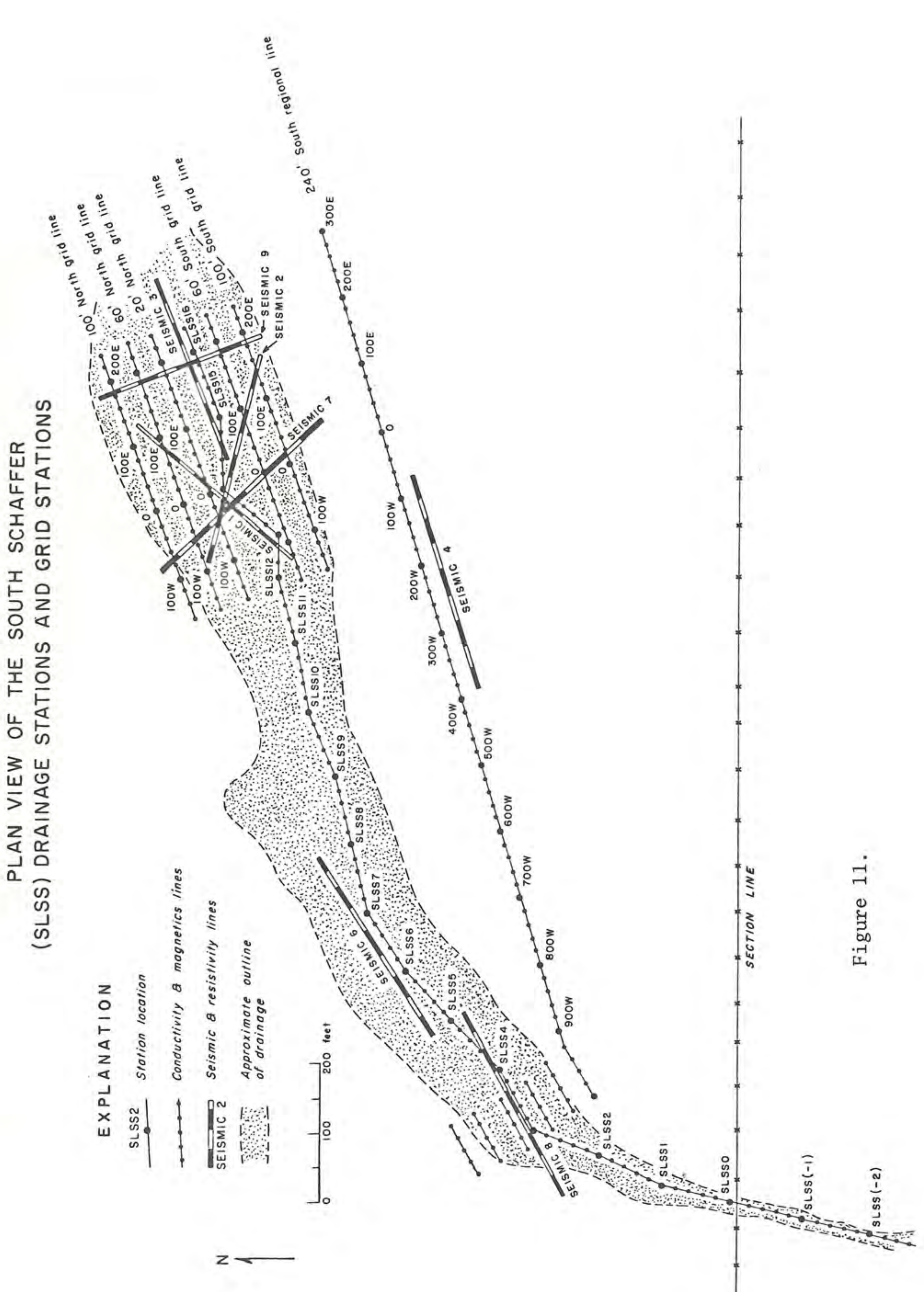

PLAN VIEW OF THE SOUTH SCHAFFER
(SLSS) DRAINAGE STATIONS AND GRID STATIONS
EXPLANATION
SLSS2
Station location
Conductivity & magnetics lines
SEISMIC 2
Seismic & resistivity lines
Approximate outline of drainage
0
100
200 feet
N
100' North grid line
60' North grid line
20' North grid line
20' South grid line
60' South grid line
100' South grid line
240' South regional line
SEISMIC 1
SEISMIC 2
SEISMIC 3
SEISMIC 4
SEISMIC 6
SEISMIC 7
SEISMIC 8
SEISMIC 9
SLSS(-2)
SLSS(-1)
SLSS0
SLSS1
SLSS2
SLSS4
SLSS5
SLSS6
SLSS7
SLSS8
SLSS9
SLSS10
SLSS11
SLSS12
SLSS15
SLSS16
300E
200E
100E
0
100W
200W
300W
400W
500W
600W
700W
800W
900W
SECTION LINE

Figure 11.

MAGNETIC CONTOURS IN THE SLSS DRAINAGE (STATE LINE DISTRICT)

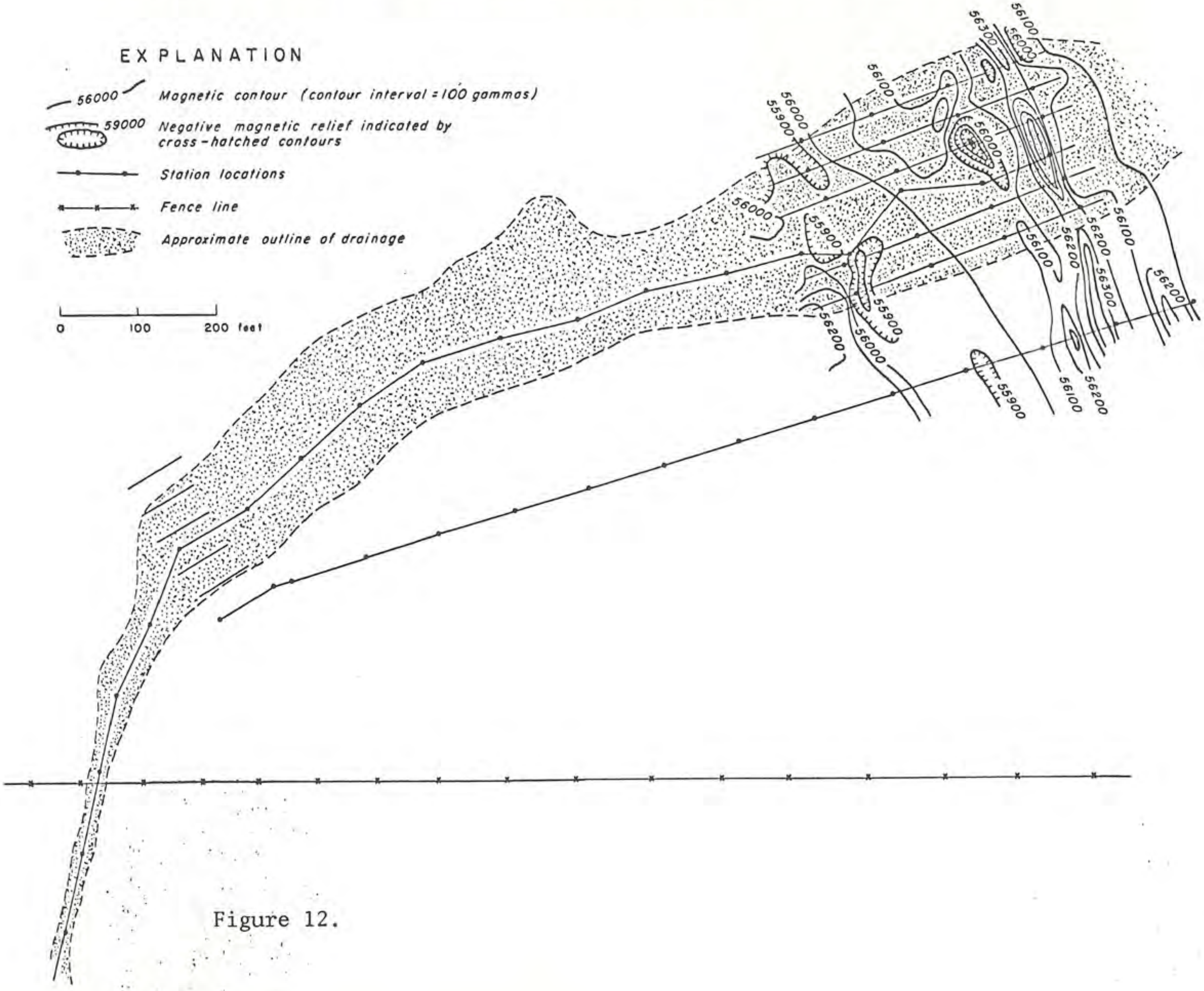


Figure 12.

an excellent prospecting tool for rapid delineation of kimberlite-granite contacts, or for prospecting for alluvium-covered weathered kimberlite along structures containing exposed kimberlite. The electromagnetic survey gave results similar to those expected from electrical resistivity surveys. However, there is a major drawback in prospecting for alluvium-covered kimberlites by the use of electromagnetic and resistivity surveys. The electrical responses produced by buried, weathered kimberlites undoubtedly can be duplicated by buried clay zones, and possibly by water-saturated, alluvium-covered scour features or potholes. Furthermore, massive un-weathered hardebank kimberlite under alluvial cover apparently will not produce an electrical anomaly within the enclosing granitic host rocks.

The possibility of detecting placer traps which could contain diamond was tested. Three shallow drainages below diamondiferous kimberlite were examined by electromagnetic, magnetic and seismic surveys. The initial examination of the drainages was done by running electromagnetic and magnetic profiles along the strike of the drainage. Anomalous areas were examined by electromagnetic and magnetic grids and by seismic profiles. Presuably, the placer traps would show magnetic and conductivity highs in that such traps should contain higher concentrations of heavy minerals (magnetite, etc.) and, potentially, greater volumes of water.

It should be noted from Figure 12 that the diabasic dikes are detectable by magnetics. These dikes, as well as the granitic dikes which cross-cut drainages can act as riffles and provide excellent placer traps.

A small conductive high lying between stations SLSS 2 and 4 was examined on a grid survey (Figure 14): this conductive high is suggestive of a scour feature in the drainage. The increase in conductivity at this station may result from an increase in the amount of water held in the alluvium at this point. Such a feature could potentially trap diamonds and other heavy minerals.

Seismic lines were run across some anomalous areas in the drainage, in an attempt to verify some potential traps (Figure 15). Seismic line #5 was run within the Schaffer 15 pipe as a comparison of data expected to be received from the conductive high on the eastern edge of the SLSS drainage. Unfortunately, the seismic velocities received from the seismic line #1 survey were not indicative of kimberlite. This result is probably due to the small size of the dike and the similar velocity characteristics of kimberlite and granite. Seismic line #3 (Figure 15) verified the presence of the mafic dike.

Conductivity and magnetic profile surveys revealed some isolated anomalies in the North Schaffer (NSSS) drainage (Figure 16a, b).

The conductivity (Figure 17) and magnetic (Figure 18) anomalies near station NSSS 4 probably result from a mafic dike. The mafic dikes in the State Line district produce good linear magnetic anomalies. The trend of such a dike can be projected through the drainage near station NSSS 4 (Plate 9). The conductivity high (Figure 17) is undoubtedly the result of water entrapment in alluvial material behind the dike. Many of the mafic dikes in the State Line district act as riffles in a sluice box trapping heavy minerals. These dikes may act as placer traps providing a target for placer diamond exploration.

During the course of this study, two types of potential traps were detected by geophysics, dikes crossing drainages, and scour features. It is doubtful, however, that any of the structures examined could hold or

CONDUCTIVITY CONTOURS
IN THE SLSS DRAINAGE (STATE LINE DISTRICT)

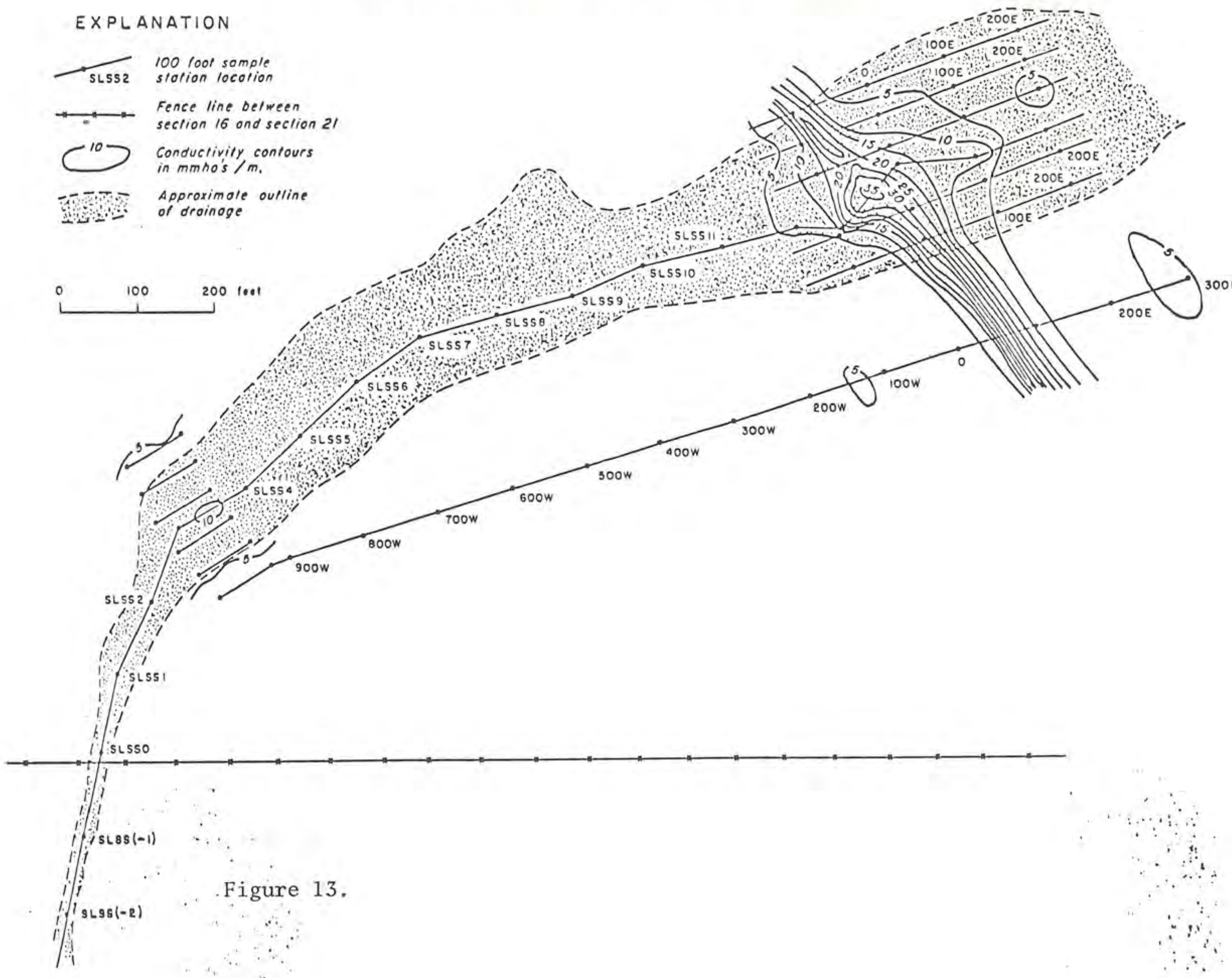


Figure 13.

CONDUCTIVITY CONTOURS OVER A PORTION OF THE SLSS (SLSS 2 to SLSS4) DRAINAGE (STATE LINE DISTRICT)

Figure 14.

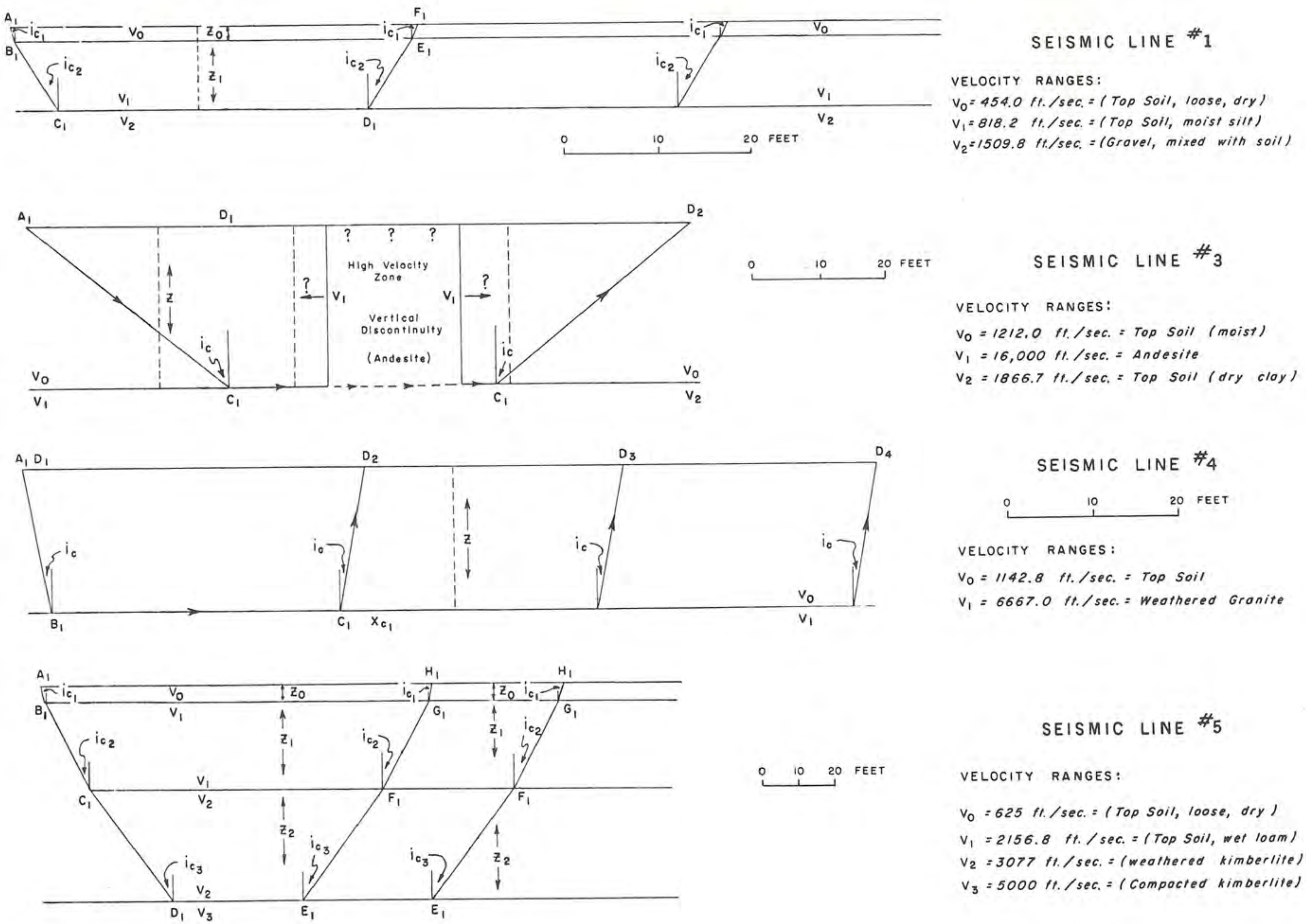

SEISMIC LINE #1
VELOCITY RANGES:
V0= 454.0 ft./sec. = (Top Soil, loose, dry)
V1= 818.2 ft./sec. = (Top Soil, moist silt)
V2= 1509.8 ft./sec. = (Gravel, mixed with soil)
SEISMIC LINE #3
High Velocity Zone
Vertical Discontinuity
(Andesite)
VELOCITY RANGES:
V0 = 1212.0 ft./sec. = Top Soil (moist)
V1 = 16,000 ft./sec. = Andesite
V2 = 1866.7 ft./sec. = Top Soil (dry clay)
SEISMIC LINE #4
VELOCITY RANGES:
V0 = 1142.8 ft./sec. = Top Soil
V1 = 6667.0 ft./sec. = Weathered Granite
SEISMIC LINE #5
VELOCITY RANGES:
V0 = 625 ft./sec. = (Top Soil, loose, dry)
V1 = 2156.8 ft./sec. = (Top Soil, wet loam)
V2 = 3077 ft./sec. = (weathered kimberlite)
V3 = 5000 ft./sec. = (Compacted kimberlite)
0 10 20 FEET

Figure 15.

PLAN VIEW OF THE NORTH SCHAFFER (NSSS) DRAINAGE STATIONS

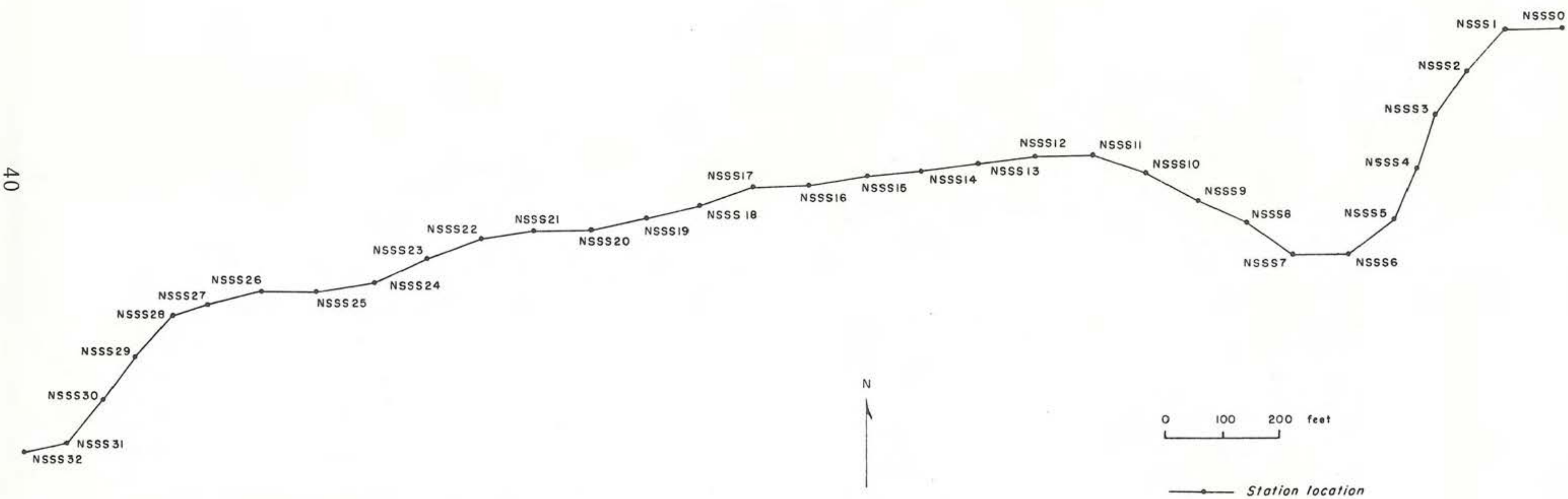


Figure 16a.

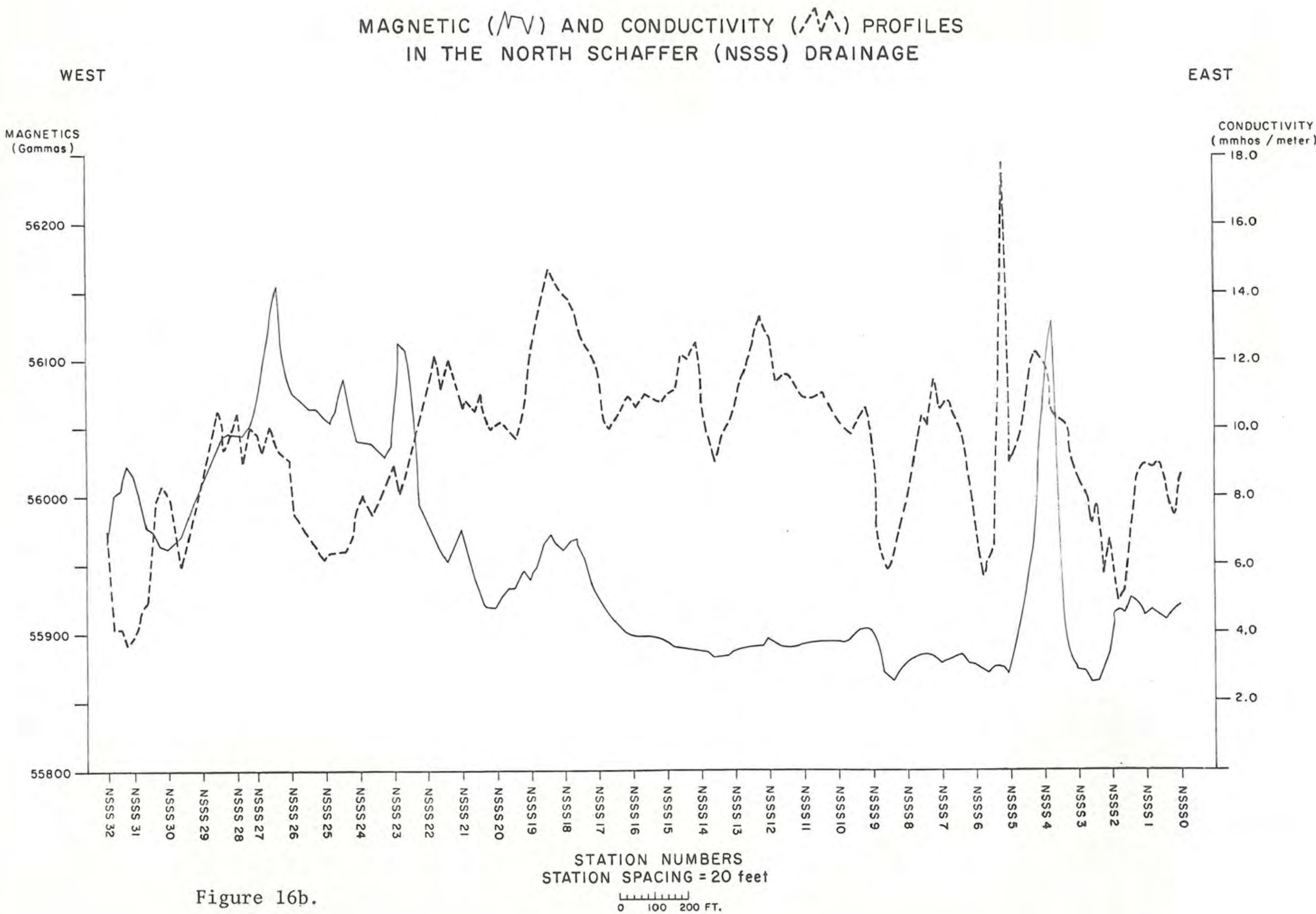

MAGNETIC AND CONDUCTIVITY PROFILES
IN THE NORTH SCHAFFER (NSSS) DRAINAGE
WEST
EAST
MAGNETICS (Gammas)
56200
56100
56000
55900
55800
CONDUCTIVITY (mmhos / meter)
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
NSSS 32
NSSS 31
NSSS 30
NSSS 29
NSSS 28
NSSS 27
NSSS 26
NSSS 25
NSSS 24
NSSS 23
NSSS 22
NSSS 21
NSSS 20
NSSS 19
NSSS 18
NSSS 17
NSSS 16
NSSS 15
NSSS 14
NSSS 13
NSSS 12
NSSS 11
NSSS 10
NSSS 9
NSSS 8
NSSS 7
NSSS 6
NSSS 5
NSSS 4
NSSS 3
NSSS 2
NSSS 1
NSSS 0
STATION NUMBERS
STATION SPACING = 20 feet
0 100 200 FT.

Figure 16b.

North Schaffer (NSSS) 3.80 Grid Conductivity (1"= 100')

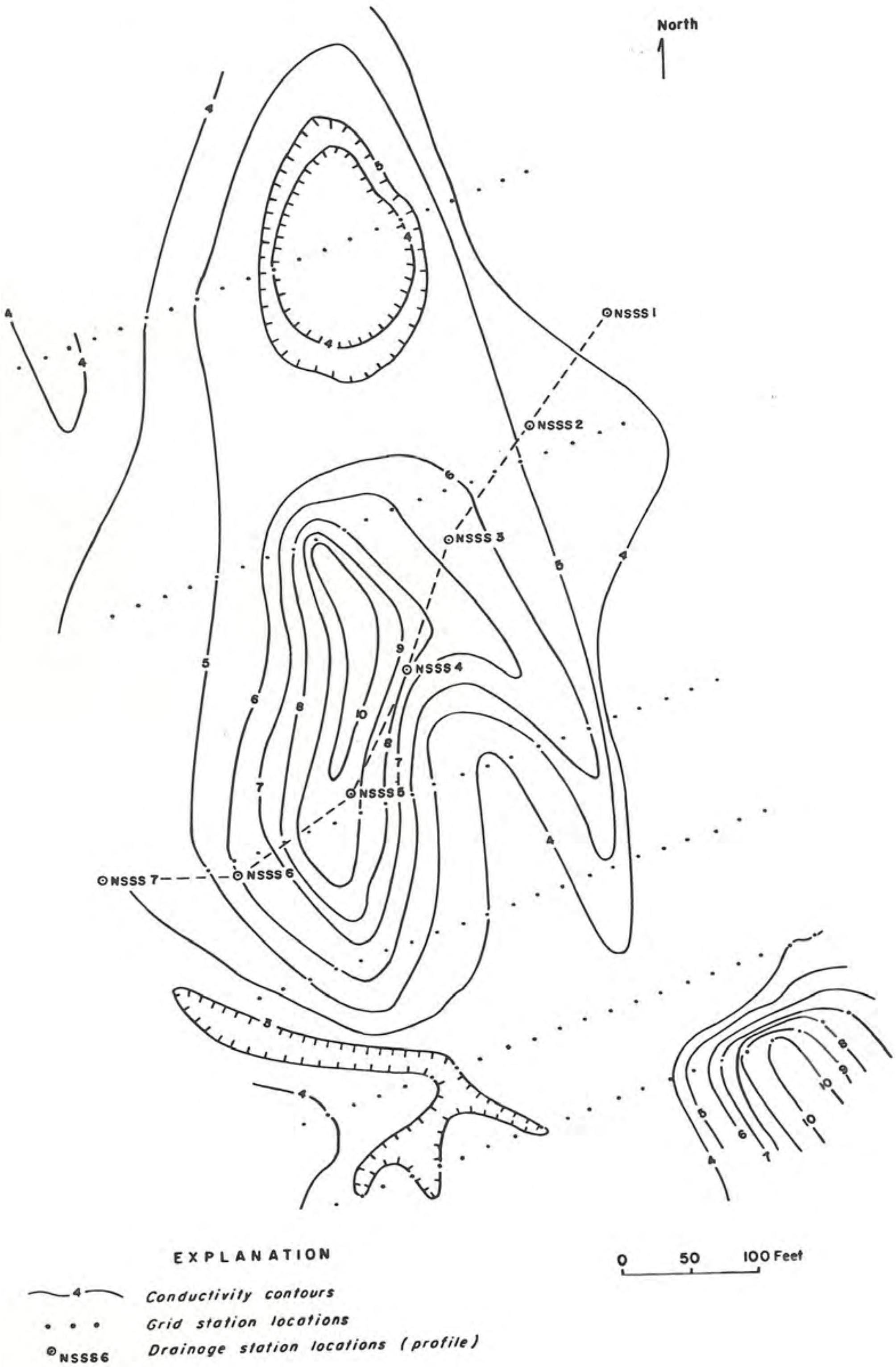


Figure 17.

North Schaffer (NSSS) 3.80 Grid Magnetics (1"=100')

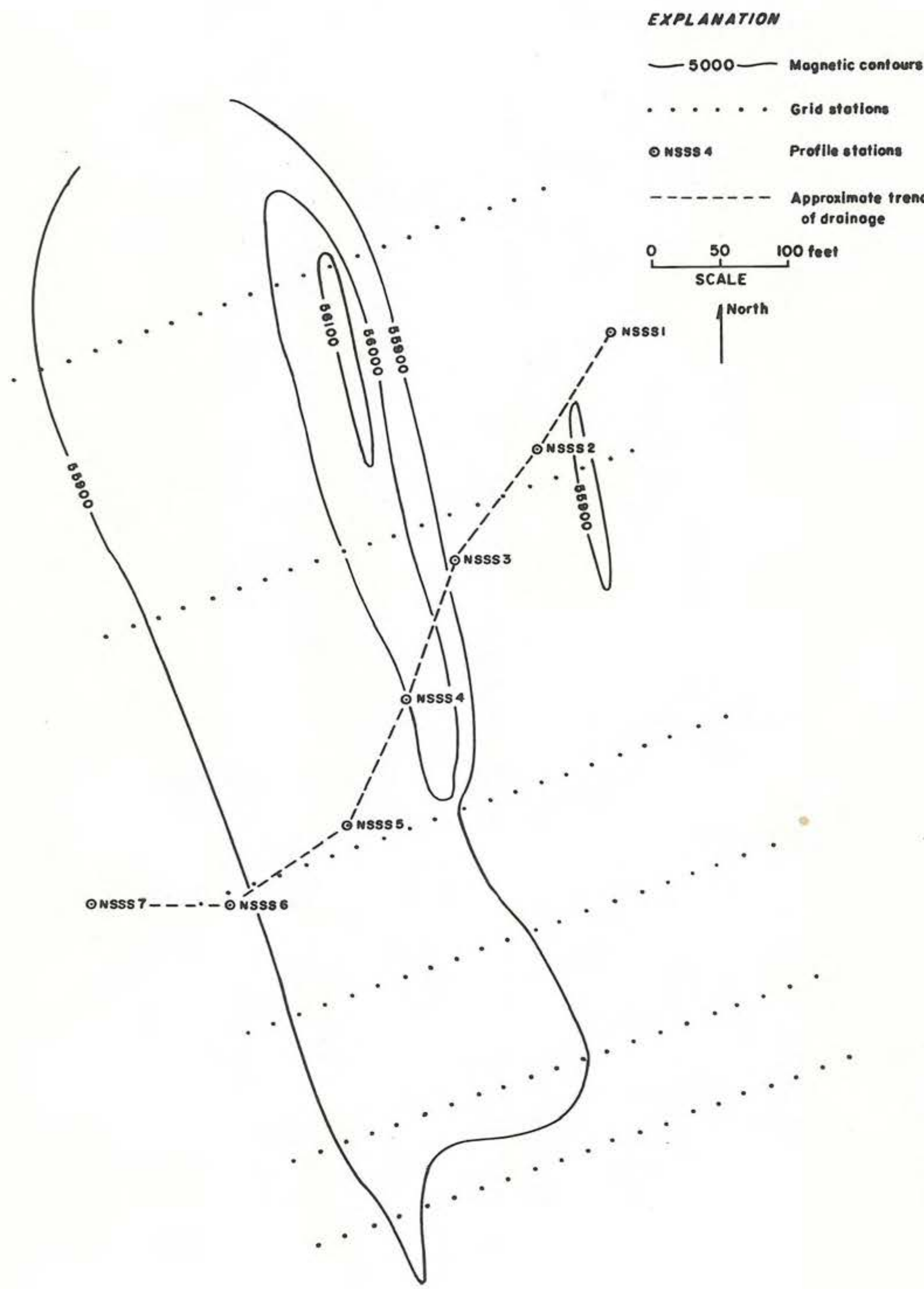


Figure 18.

contain significant diamond concentrations. Basically, these surveys were used to identify potential traps, rather than to locate actual diamond traps. The drainages (SLSS and NSSS) are in all probability too narrow and shallow to contain significant diamond concentrations. Better drainages lie south of these drainages, but access is not available at the present time.

Stream sediment sampling

Stream sediment samples were collected on five quadrangles in the southern Laramie Range (Plate 1). These quadrangles are the Johnson Ranch (Plate 11), Best Ranch (Plate 12), Sherman Mountains (Plate 13), Granite (Plate 14), and Ragged Top Mountain (Plate 15). Samples collected on the Granite and Ragged Top Mountain quadrangles have yet to be examined. Two samples on the Best Ranch quadrangle (nos. 67 and 71)(Plate 12) were positive. Sample BR-67 contained one pyrope grain and sample BR-71 contained several non-magnetic ilmenites.

Sample SH-32 on the Sherman Mountains quadrangle (Plate 13) contained one pyrope. Samples SH-35, 36, 37, 48, and 53 contained some non-magnetic ilmenite. We hope to reexamine these samples in 1982.

SUMMARY OF ACCOMPLISHMENTS

During the two-year period (Oct. 1, 1979 to Dec. 31, 1981) exploration for new kimberlites, partially financed by OSM, resulted in several accomplishments.

1. Four regions were sampled for kimberlite indicator minerals (Figure 1).
2. The Geological Survey of Wyoming's diamond extraction laboratory was tested and proven efficient for diamond recovery.
3. At least two small microdiamonds were recovered from kimberlite concentrates collected from the Slaon 2 kimberlite pipe located in the Colorado-Wyoming State Line district.
4. Two new previously unreported kimberlite occurrences were discovered.
5. Several positive stream sediment samples strongly suggest that additional kimberlite intrusions may be discovered in the near future.
6. Two professional papers were published on research partially financed by OSM.
7. Finally, it was shown that ground geophysical surveys can be used effectively to locate potential placer diamond traps.

RECOMMENDATIONS

From this two-year study, several recommendations can be made for future prospecting of kimberlite intrusives and related placers in the Colorado-Wyoming region.

1. Although no source of chrome-diopside and pyrope garnets contained in ant hills was found, future exploration in this region of the Green River Basin should probably be confined to airborne magnetic and input geophysical surveys. The anomalous region covers up to 8

square miles and could more efficiently be prospected by air.

2. More detailed stream sediment sampling and geophysical surveys are needed in the Sheep Rock area of the central Laramie Range in order to locate the source of indicator minerals sampled in that region.

3. Detailed studies on ilmenite reflectance could prove to be a valuable tool in prospecting and should aid in differentiating magnesian-ilmenite from ferro-ilmenite.

4. Potential placer diamond traps should be given much greater consideration.

5. The major portion of stream sediment samples collected during this two-year study have been analyzed. The remaining samples will be examined in the near future. The final results on all of the stream sediments will be published at a later date, copies of which will be forwarded to OSM.

REFERENCES

Cervelle, B., Levy, C., and Caye, R., 1971, Dosage rapide du magnesium dans les ilmenites: Mineral Deposita, v. 6, p. 34-40.

Chronic, J., McCallum, M.E., and Ferris, C.S., Jr., 1965, Lower Paleozoic rocks in diatremes in southern Wyoming and northern Colorado (abs.): Geol. Soc. America Spec. Paper 87, p. 280-281.

Craig, J.R., and Vaughan, D.J., 1981, Ore Microscopy and Ore Petrography: John Wiley and Sons, p. 86.

Dawson, J.B., 1971, Advances in Kimberlite geology: Earth Sci. Rev., v. 7, p. 187-214.

Eggler, D.H., 1967, Structure and petrology in the Virginia Dale ring dike complex, Colorado-Wyoming: Ph.D. thesis, Univ. of Colorado, 53 p.

Ferris, C.S., Jr., and Krueger, H.W., 1964, New radiogenic dates on igneous rocks from the southern Laramie Range, Wyoming: Geol. Soc. Amer. Bull., v. 75, p. 1051-1054.

Gilletti, B.J., and Gast, P.W., 1961, Absolute age of Precambrian rocks in Wyoming and Montana: in Geochronology of rock systems: New York Acad. Sci. Annals, v. 91, part 2 p. 454-458.

Hausel, W.D., 1977, Report on the Boden placer diamonds from the Medicine Bow Mountains, Carbon County, Wyoming: unpub. report for the Wyoming Geological Survey, 9 p.

Hausel, W.D., Glahn, P.R., and Woodzick, R.L., 1980, Exploration for diamond-bearing kimberlite in Colorado and Wyoming - an undate: A.I.M.E. Reprint no. 80-310, 4 p.

Hausel, W.D., Glahn, P.R., and Woodzick, T.L., 1981, Geological and geophysical investigations of kimberlite in the Laramie Range of southeastern Wyoming: Geol. Survey of Wyoming, Prel. Rept. no. 18, 13 p.

Hausel, W.D., and McCallum, M.E., 1980, General review of northern Colorado and southeastern Wyoming kimberlites, diamonds, and related research activity: Proceedings of the 15th Forum on Geology of Industrial Minerals: Colorado Geological Survey, Resource Series 8, p. 106-115.

Hausel, W.D., McCallum M.E., and Woodzick, T.L., 1979a, Preliminary report on exploration for diamondiferous kimberlites, Colorado-Wyoming: Colorado Mining Association, Mining Yearbook, p. 109-122.

Hausel, W.D., McCallum M.E., and Woodzick, T.L., 1979b, Exploration for diamond-bearing kimberlite in Colorado and Wyoming: An evaluation of exploration techniques: Geological Survey of Wyoming, Report of Investigations #19, 29 p.

Hausel, W.D., Reavis, G.L., and Stephenson, T.L., 1979c, Prospecting for kimberlites in Wyoming using heavy mineral alluvial sampling methods: Geological Survey of Wyoming, Open-File Report, W.G.S. 79-6, 14 p.

Hills, F.A., Gast, P.W., Houston, R.S., and Swainbank, I.G., 1968, Precambrian geochronology of the Medicine Bow Mountains, Southeastern Wyoming: Geol. Soc. Amer. Bull., v. 69, p. 1757-1784.

Kresten, P., Fels, P., and Berggren, G., 1975, Kimberlitic zircons - a possible aid in prospecting for kimberlites: Mineral Deposita (Berl.) 10 p. 47-56.

Kridelbaugh, S.J., Hobbitt, R., Kellogg, K., and Larson, E., 1972, Petrologic and paleomagnetic implications of the Green Mountain diatreme (abs.): Geol. Soc. Amer., Prog. w/Abstracts, v. 4, p. 386.

Leighton, V.L., and McCallum, M.E., 1979, Rapid evaluation of heavy minerals in stream sediments of the Prairie Divide area of northern Colorado - A tool for kimberlite exploration: U.S. Geological Survey, Open-File Report, 79-761.

McCallum M.E., and Eggler, D.H., 1976, Diamonds in an upper mantle peridotite nodule from kimberlite in southern Wyoming: Science, v. 192, no, 4236, p. 253-256.

McCallum, M.E., Eggler, D.H., and Burns, L.K., 1975, Kimberlite diatremes in northern Colorado and southern Wyoming: Physics and Chemistry of the Earth, v. 9, p. 149-161.

McCallum, M.E., Eggler, D.H., Coppersmith, H.G., Smith, C.B., and Mabarak, C.D., 1977, Field guide to the Colorado-Wyoming State Line District: 2nd International Kimberlite Conf., Santa Fe, New Mexico, 23 p.

McCallum, M.E., and Mabarak, C.D., 1976, Diamond in State-Line kimberlite diatremes, Albany County, Wyoming - Larimer County, Colorado: Geol. Surv. of Wyoming, Rept. of Inv. 12, 36 p.

McCallum, M.E., and Mabarak, C.D., and Coppersmith, H.G., 1979, Diamonds from kimberlites in the Colorado-Wyoming State Line District: Proc. 2nd International Kimberlite Conf., Am. Geophys. Union, v. 1, p. 42-53.

McCallum, M.E., and Smith, C.B., 1978, Minor and trace element contents of kimberlites of the Front Range, Colorado and Wyoming: U.S. Geological Survey Open File Report 78-1011, 20 p.

Mitchell, R.G., 1973, Magnesian ilmenite and its role in kimberlite petrogenesis: Jour of Geol., v. 81, p. 301-311.

Peterman, Z.E., Hedge, C.E., Braddock, W.A., 1968, Age of Precambrian events in the northeastern Front Range, Colorado: J. Geophy, Res., v. 73, p. 2277-2296.

Sinkankas, J., 1964, Mineralogy for Amateurs: Van Nostrand Reinhold Company, 585 p.

Smith, C.B., 1977, Kimberlite and mantle derived xenoliths at Iron Mountain, Wyoming: M.S. thesis, Colorado State Univ., 218 p.

Smithson, S.B., and Hodge, D.S., 1972, Field realtions and gravity interpretation in the Laramie Anorthosite complex: University of Wyoming, Contributions to Geology, v. 11, no. 2, p. 43-59.

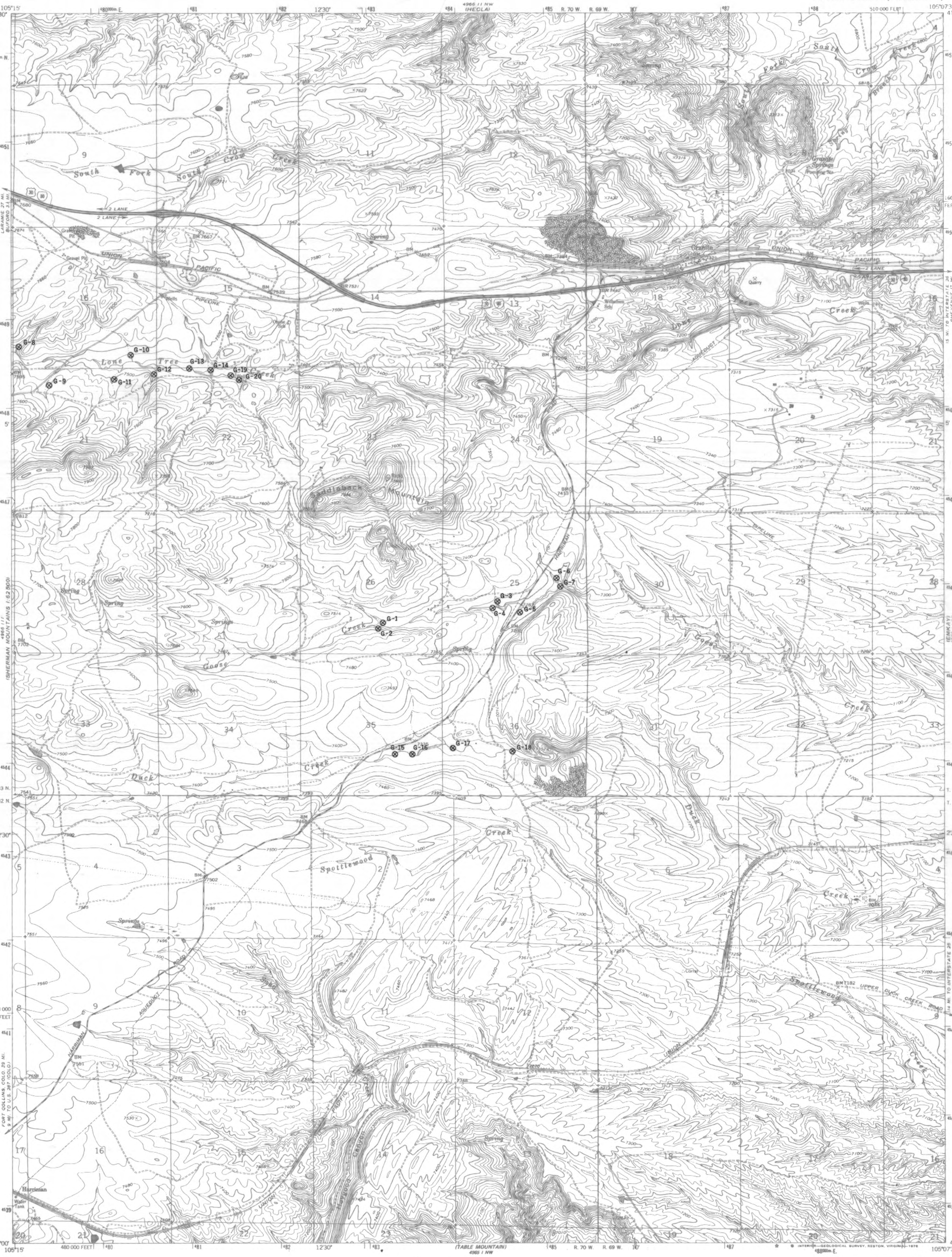
Puckett, J.L., McCallum, M.E., Johnson, R.E., and Filson, R.H., 1972, Preliminary evaluation of kimberlitic diatremes in northern Colorado and southern Wyoming (abs.): Geol. Soc. Americ. Abstracts, v. 3, no. 6, p. 403.

Turskiy, A.A., 1967, Determination of presence of pyrope and magnesian olivine in diamond prospecting: Internation Geol. Rec., v. 9, no. 3, p. 275-277.

Whitaker, M.C., 1898, An olivinite dike at the Magolia District and the associated picrotitanite: Colorado Sci. Proc., v. 6, p. 104-118.

GEOLOGICAL SURVEY OF WYOMING

OPEN FILE REPORT 82-1



EXPLANATION

- SAMPLE LOCATIONS
- PYROPE GARNET
- CHROME DIOPSIDE
- MAGNESIAN ILMENITE
- + NO INDICATORS
- X PROPOSED SAMPLE SITES

GRANITE QUADRANGLE SAMPLE SITE LOCATION MAP
1982

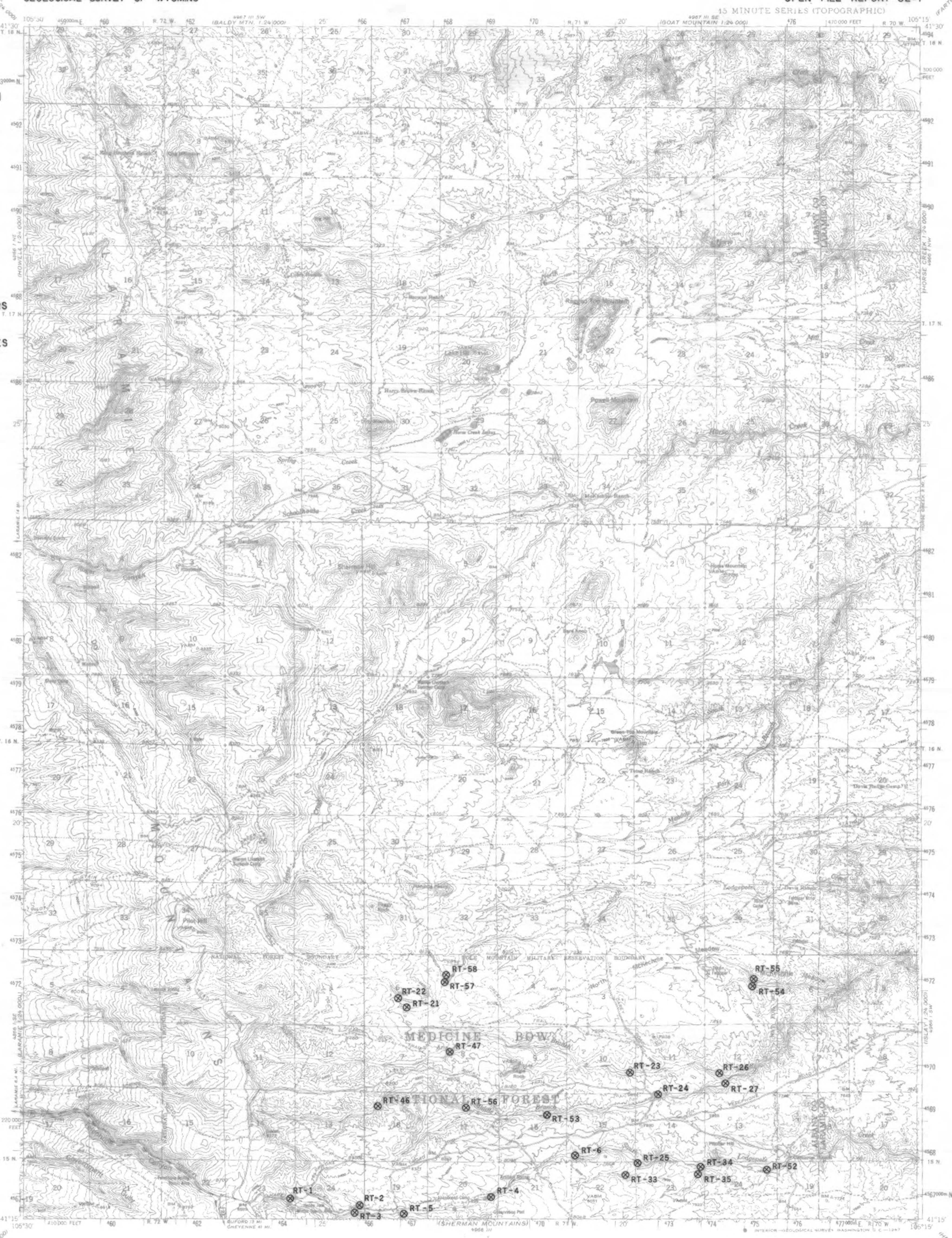
PLATE 14 OF 15

GEOLOGICAL SURVEY OF WYOMING

OPEN FILE REPORT 82-1

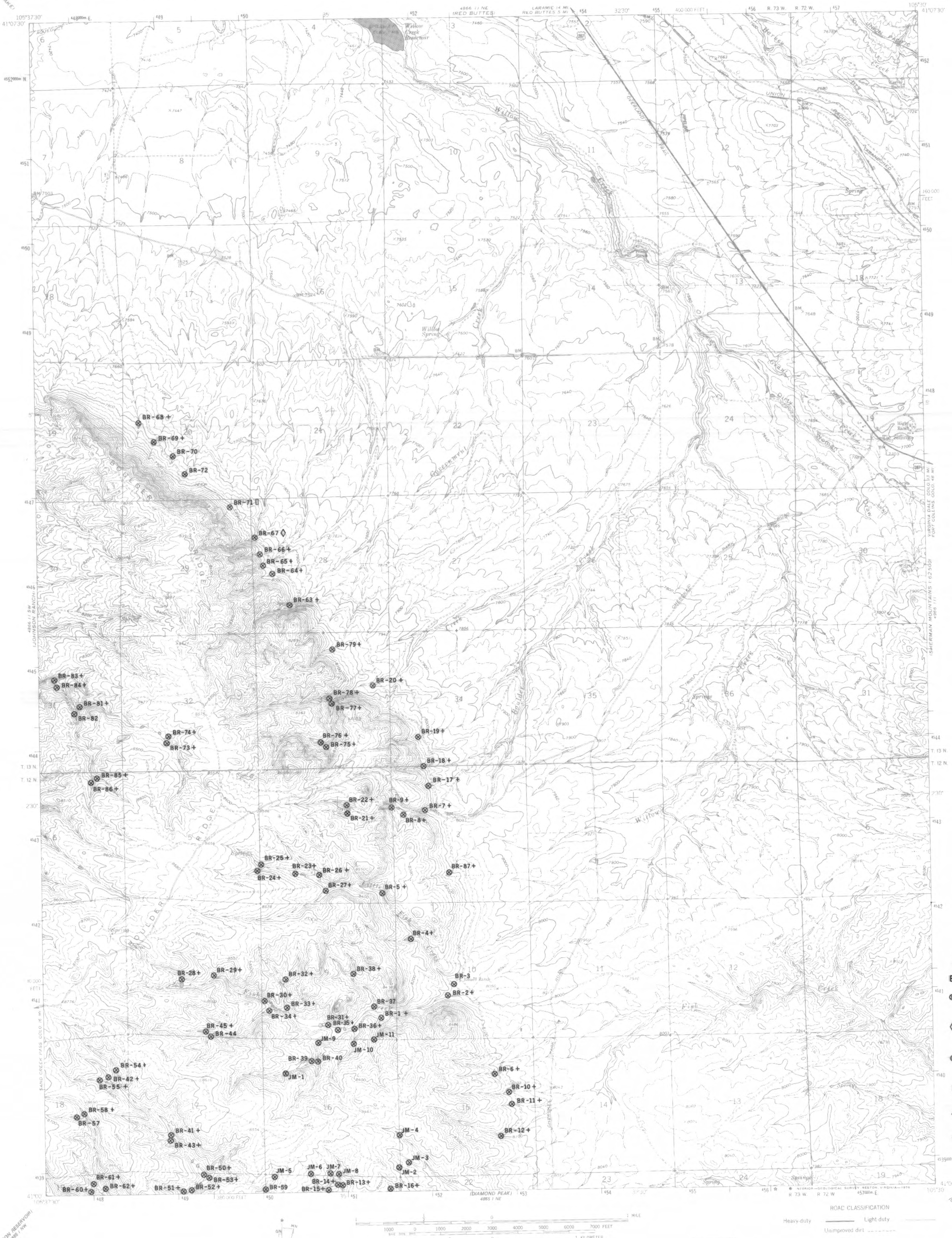
EXPLANATION

- SAMPLE LOCATIONS
- PYROPE GARNET
- CHROME DIOPSIDE
- MAGNESIAN ILMENITE
- + NO INDICATORS
- X PROPOSED SAMPLE SITES



RAGGED TOP QUADRANGLE SAMPLE SITE LOCATION MAP

PLATE 15 OF 15



EXPLANATION

- ⊗ SAMPLE LOCATIONS
- ◊ PYROPE GARNET
- ◎ CHROME DIOPSIDE
- ▯ MAGNESIAN ILMENITE
- \+ NO INDICATORS
- x PROPOSED SAMPLE SITES

BEST RANCH QUADRANGLE SAMPLE SITE LOCATION MAP
1982

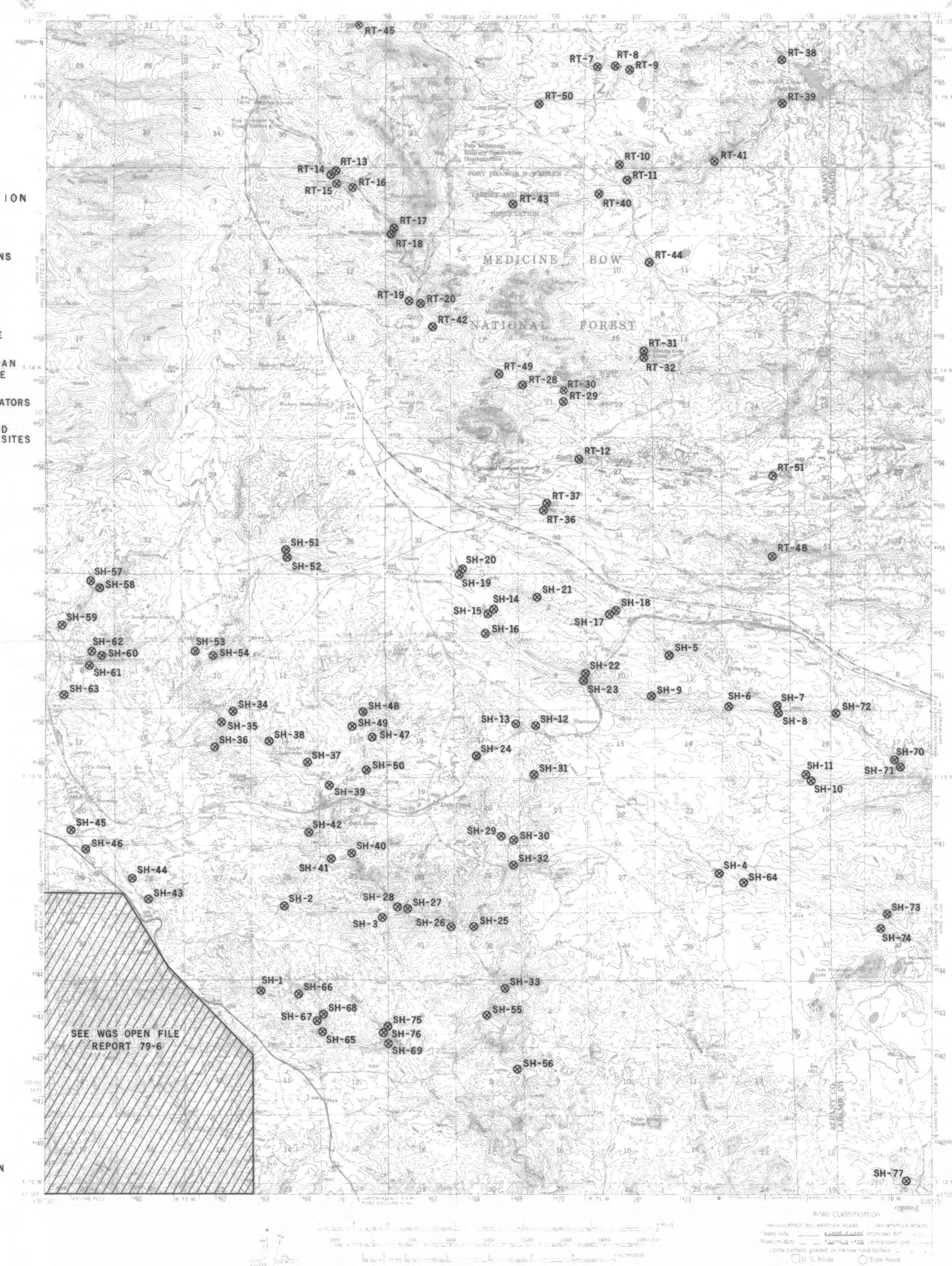
PLATE 12 OF 15

GEOLOGICAL SURVEY OF WYOMING

OPEN FILE REPORT 82-1

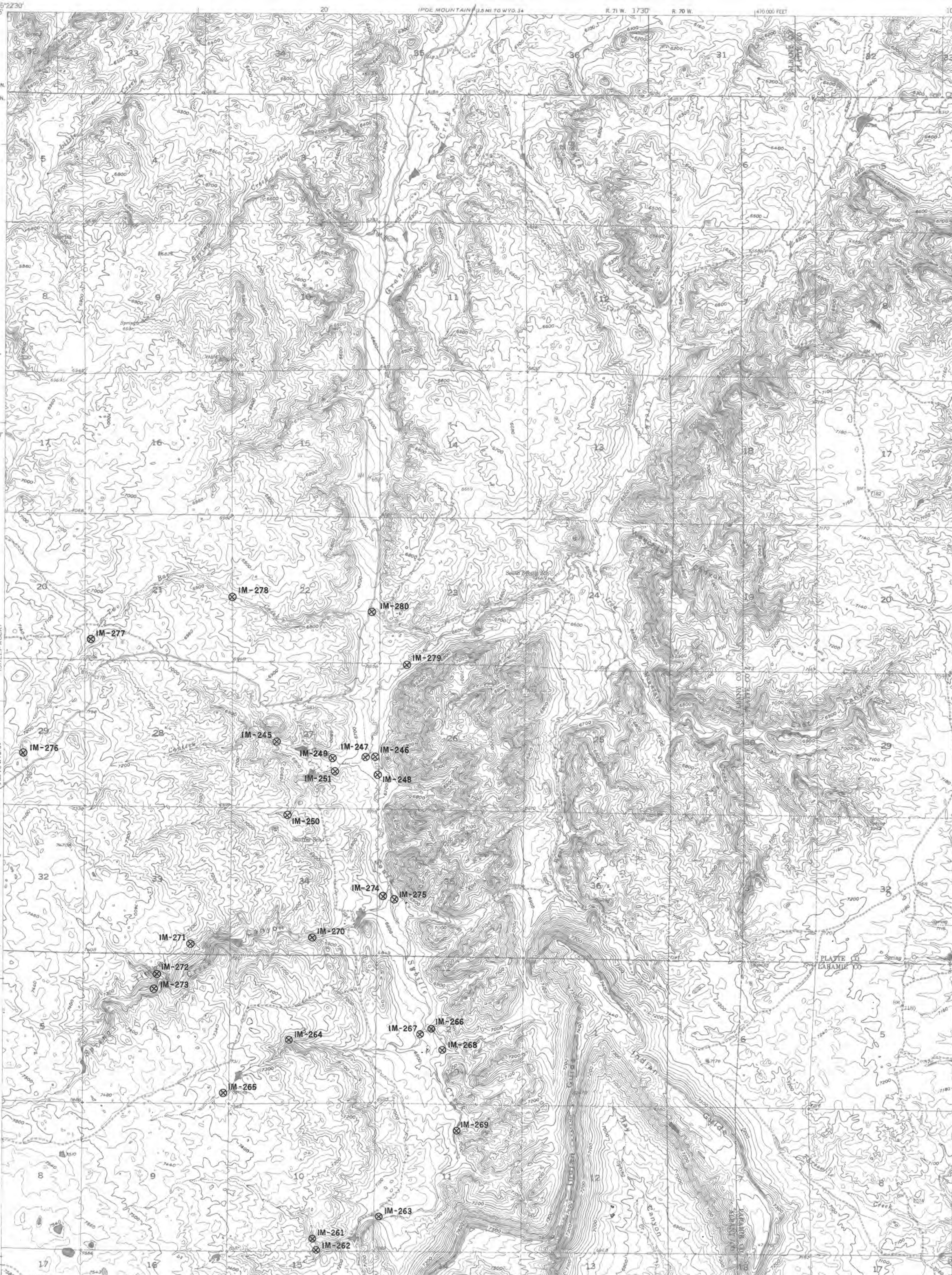
EXPLANATION

- ⊗ SAMPLE LOCATIONS
- ◊ PYROPE GARNET
- ◎ CHROME DIOPSIDE
- ▯ MAGNESIAN ILMENITE
- \+ NO INDICATORS
- x PROPOSED SAMPLE SITES



SHERMAN MOUNTAIN QUADRANGLE SAMPLE SITE LOCATION MAP
1982

PLATE 13 OF 15



EXPLANATION

⊗ SAMPLE LOCATIONS

◊ PYROPE GARNET

⊚ CHROME DIOPSIDE

▯ MAGNESIAN ILMENITE

\+ NO INDICATORS

x PROPOSED SAMPLE SITES

SCALE 1:24 000

CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL

APPROXIMATE MEAN DECLINATION, 1955

QUADRANGLE LOCATION

INDIAN GUIDE QUADRANGLE SAMPLE SITE LOCATION MAP
1982

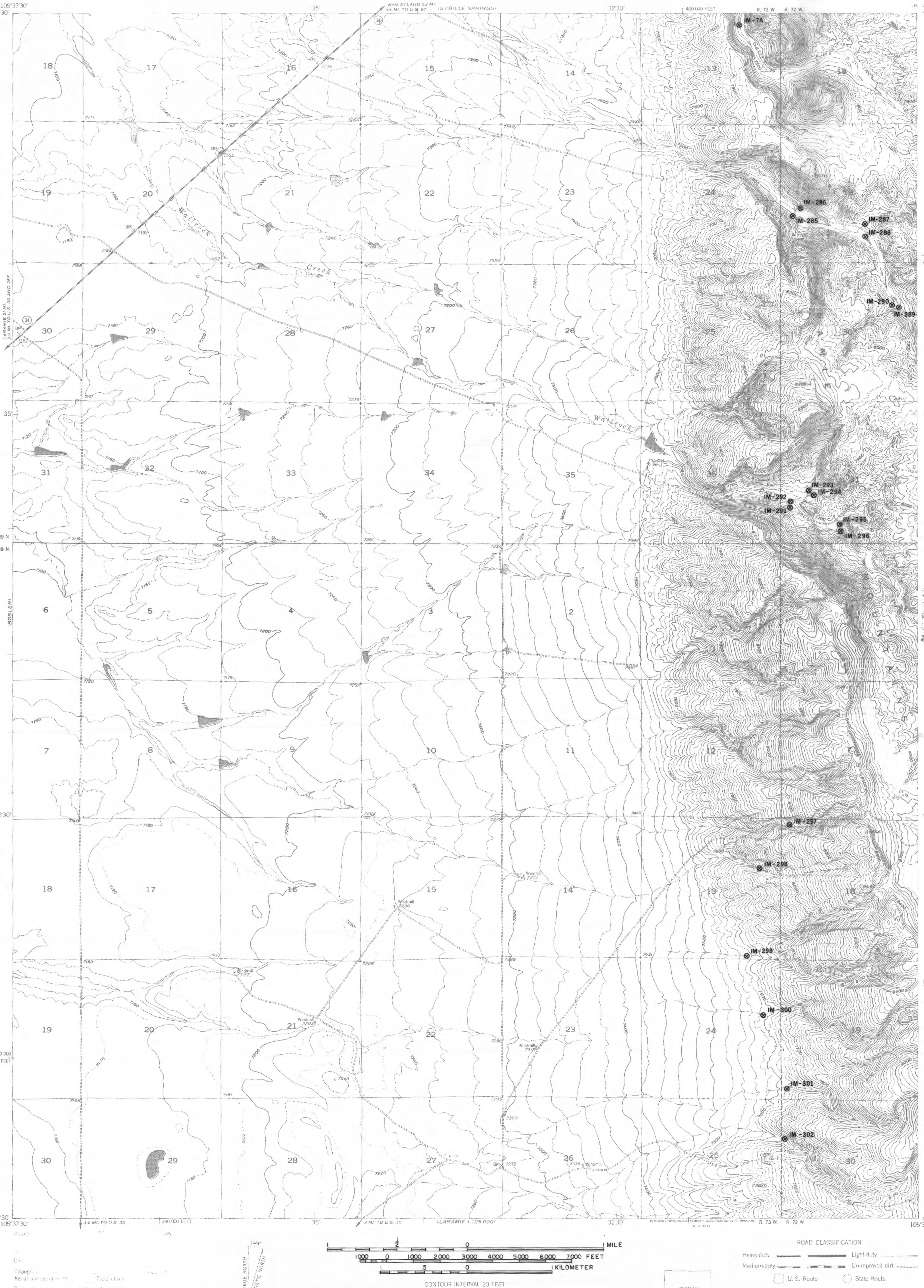
SCALE 1:24 000

CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL

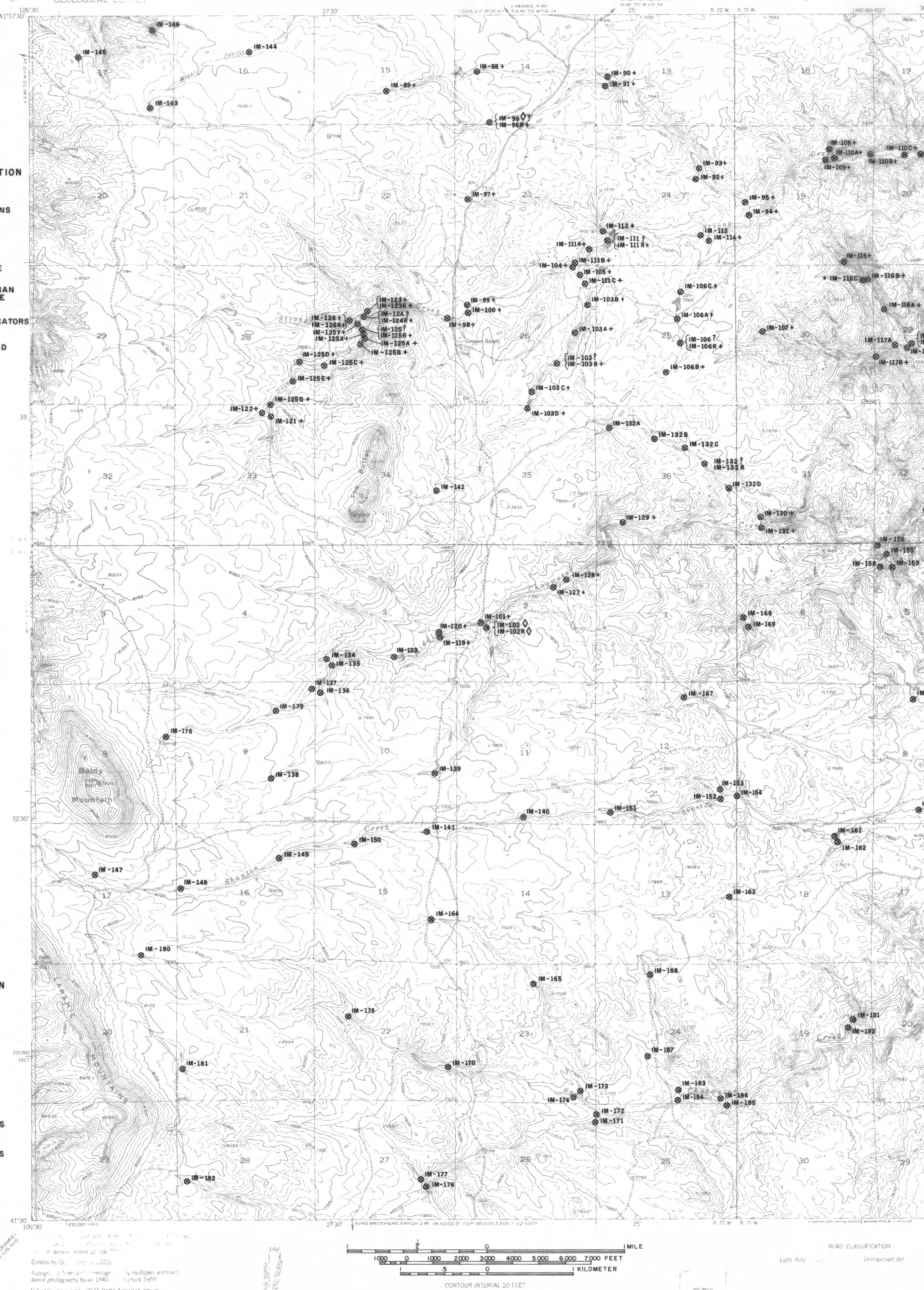
APPROXIMATE MEAN DECLINATION, 1955

QUADRANGLE LOCATION

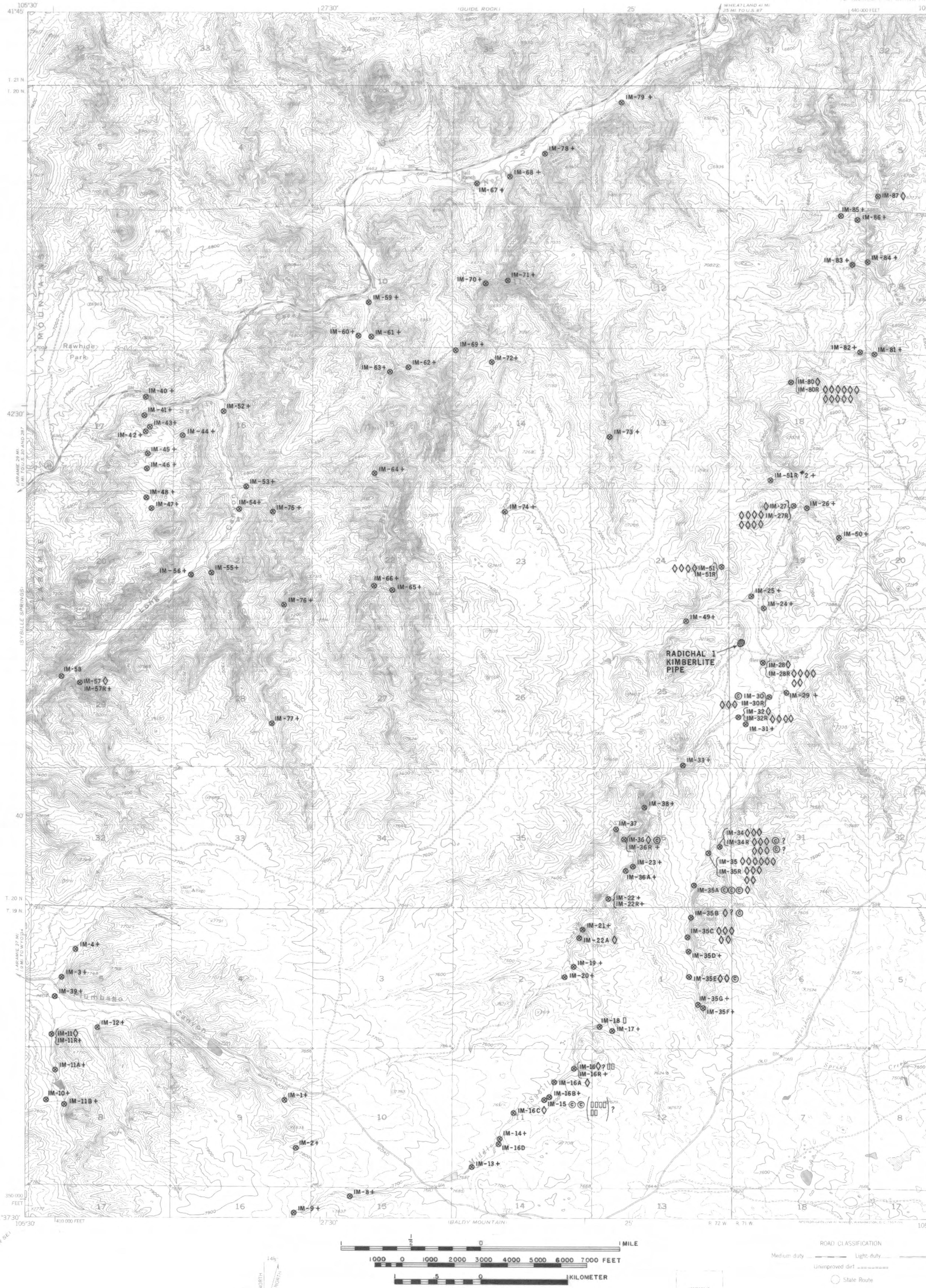
GOAT MOUNTAIN QUADRANGLE SAMPLE SITE LOCATION MAP
1982



BOSLER SE QUADRANGLE SAMPLE SITE LOCATION MAP



BALDY MOUNTAIN QUADRANGLE SAMPLE SITE LOCATION MAP



EXPLANATION

- ⊗ SAMPLE LOCATIONS
- ◊ PYROPE GARNET
- ◎ CHROME DIOPSIDE
- ▯ MAGNESIAN ILMENITE
- \+ NO INDICATORS
- x PROPOSED SAMPLE SITES

CONTOUR INTERVAL 20 FEET

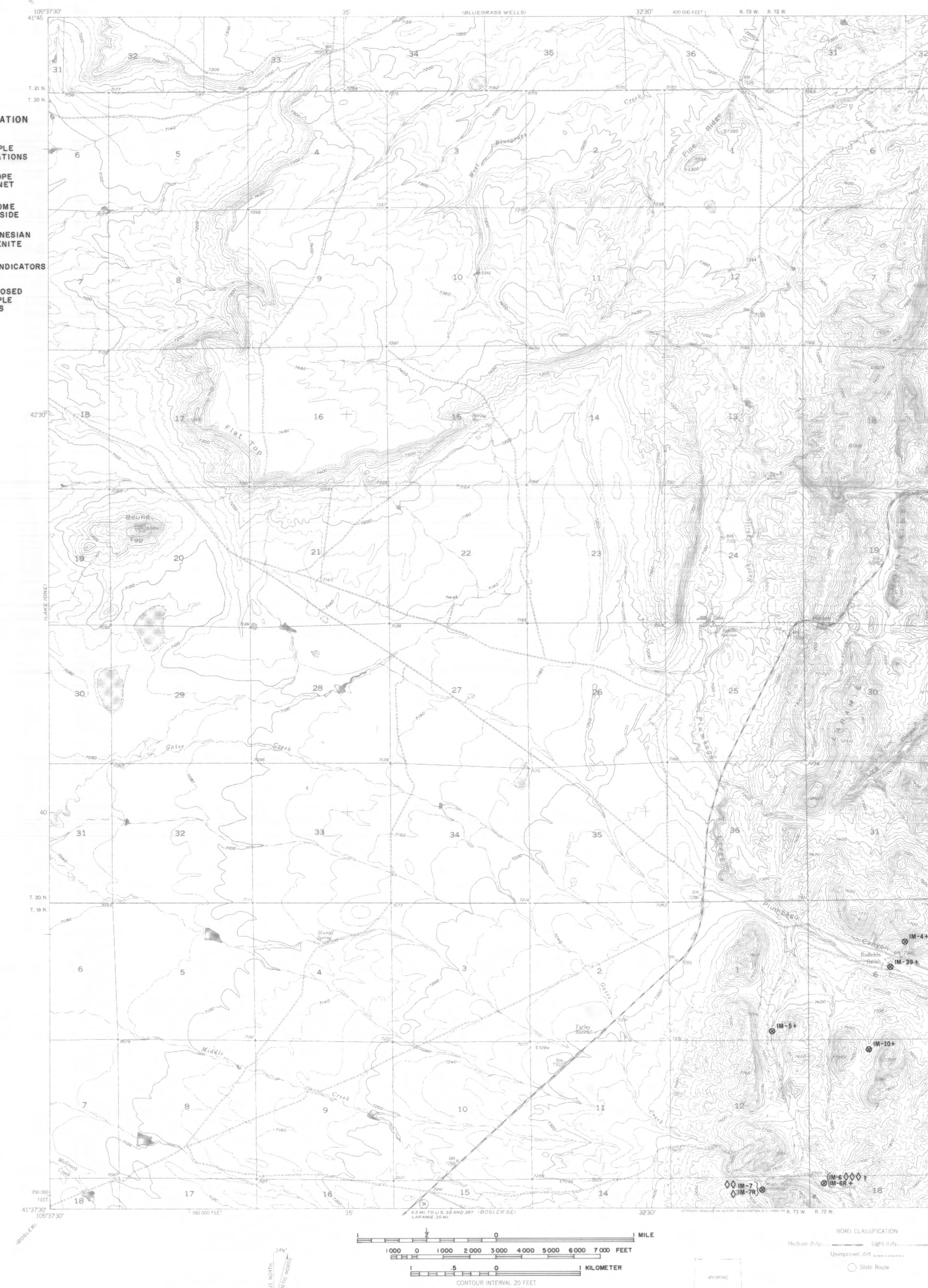
SHEEP ROCK QUADRANGLE SAMPLE SITE LOCATION MAP

1982

PLATE 2 OF 15

EXPLANATION

- ⊗ SAMPLE LOCATIONS
- ◊ PYROPE GARNET
- ◎ CHROME DIOPSIDE
- ▯ MAGNESIAN ILMENITE
- \+ NO INDICATORS
- x PROPOSED SAMPLE SITES



CONTOUR INTERVAL 20 FEET

SYBILLE SPRINGS QUADRANGLE SAMPLE SITE LOCATION MAP

1982

PLATE 3 OF 15

MAP OF KIMBERLITES IN SECTION 16, T.12 N., R.72 W.

By
W. DAN HAUSEL
1982

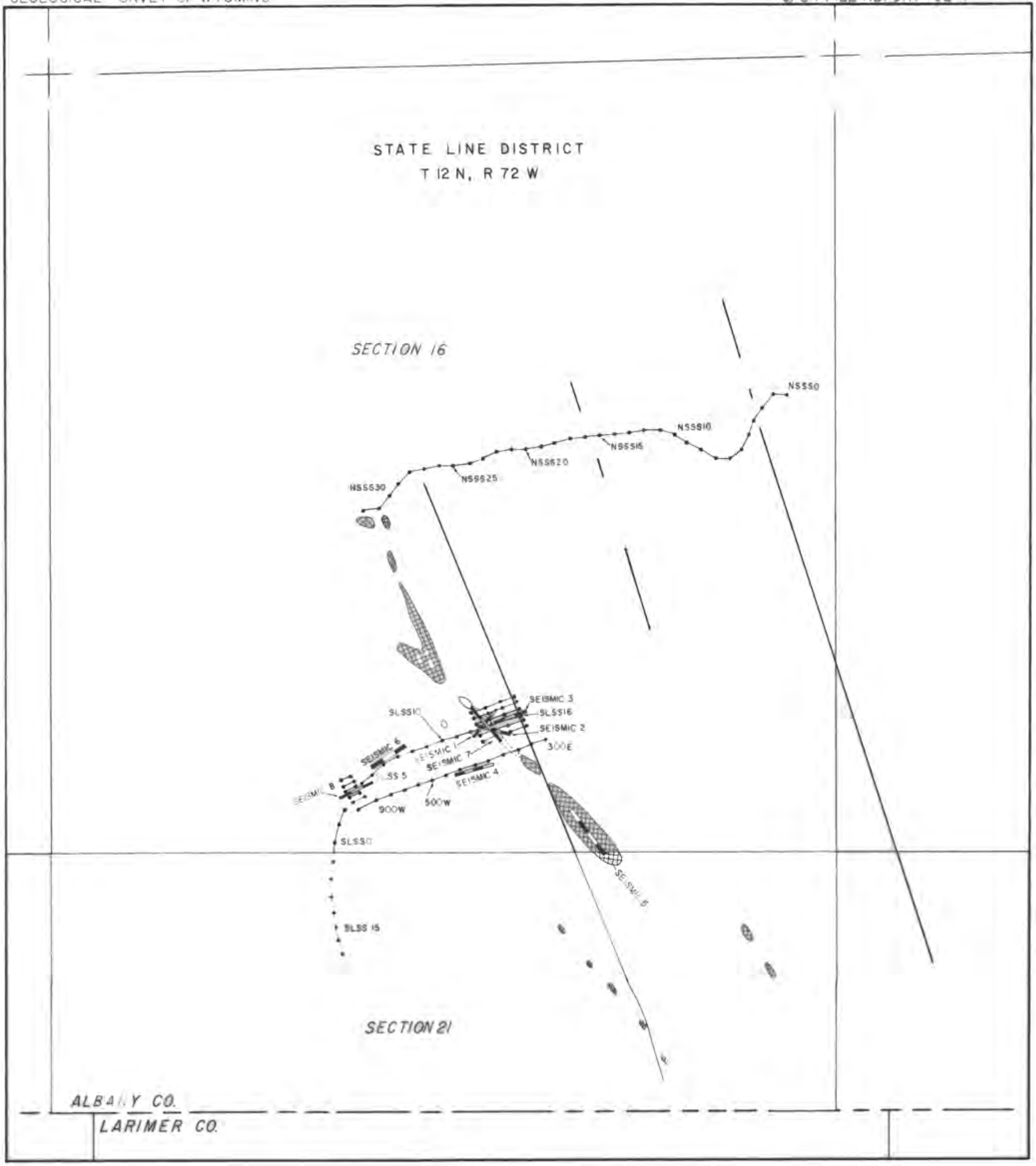
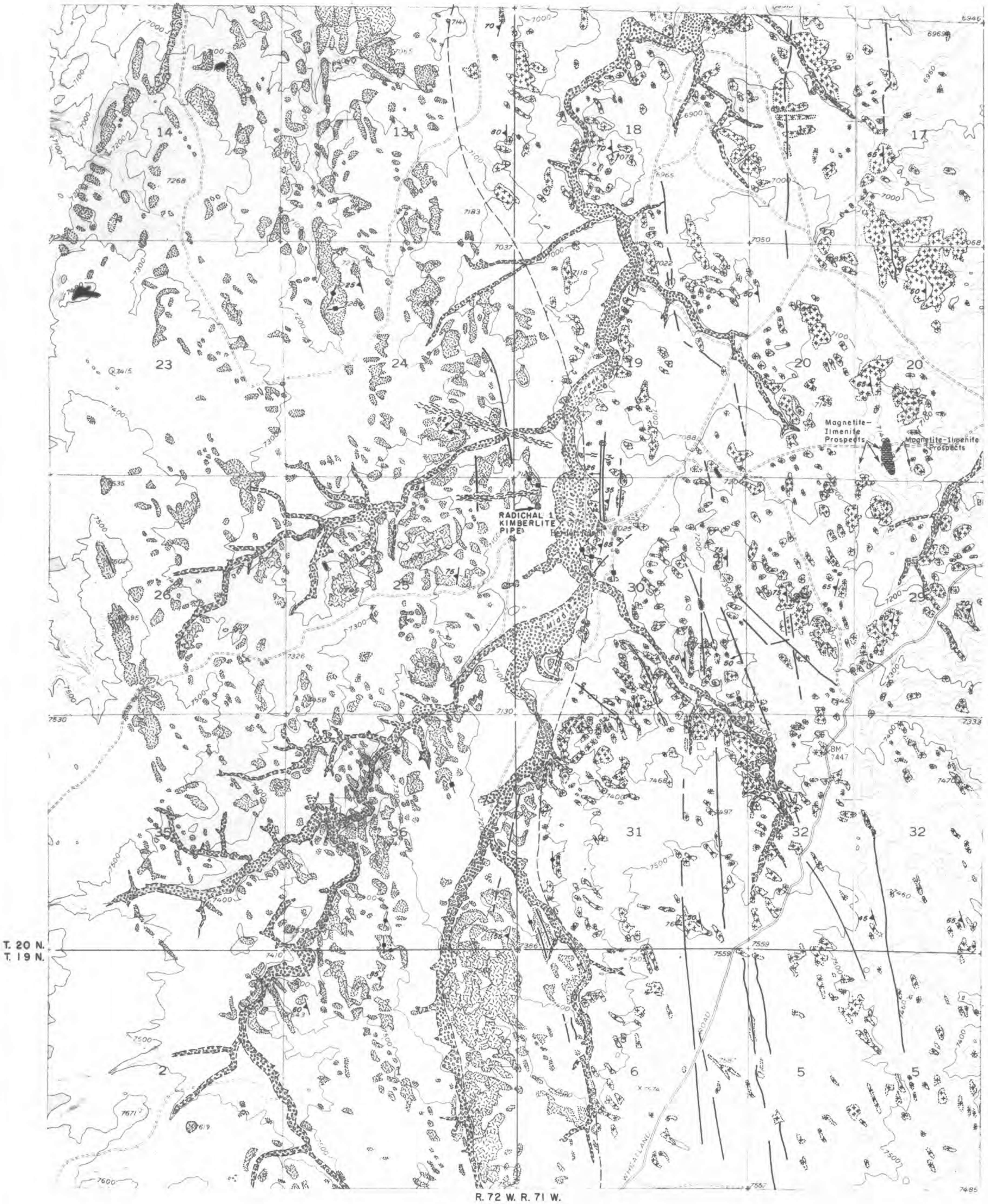


PLATE 10 OF 15

This map has not been reviewed for conformity with the editorial standards of the Geological Survey of Wyoming.



PRELIMINARY GEOLOGICAL MAP OF THE SHEEP ROCK KIMBERLITE DISTRICT ALBANY COUNTY, WYOMING

Geology by W. Dan Hausel, 1980

EXPLANATION

Quaternary and Recent alluvium and stream sediments.

DEVONIAN (?)

Kimberlite

Dark-green serpentinized porphyritic kimberlite

PRECAMBRIAN

Pegmatites

Coarse-grained simple granitic pegmatites commonly outlined by bull quartz and pink orthoclase.

Granitic Dikes

Fine-grained to porphyritic pink granitic dikes of similar composition to the Sherman Granite (Where measured, dip is noted.)

Noritic Anorthosite

Gray coarse-grained to porphyritic, massive to foliated, anorthosite containing plagioclase and 10 to 20 percent orthopyroxene and magnetite-ilmenite.

Anorthosite

Gray medium- to coarse-grained, massive to foliated, anorthosite with less than 10 percent orthopyroxene and magnetite-ilmenite.

Marble

White, fine- to medium-grained massive marble.

Island of predominate rock outcrop surrounded by anorthositic grus.

Contact

20 *Strike and dip of joint*

Strike of vertical joint

20 *Strike and dip of foliation*

Strike of vertical foliation

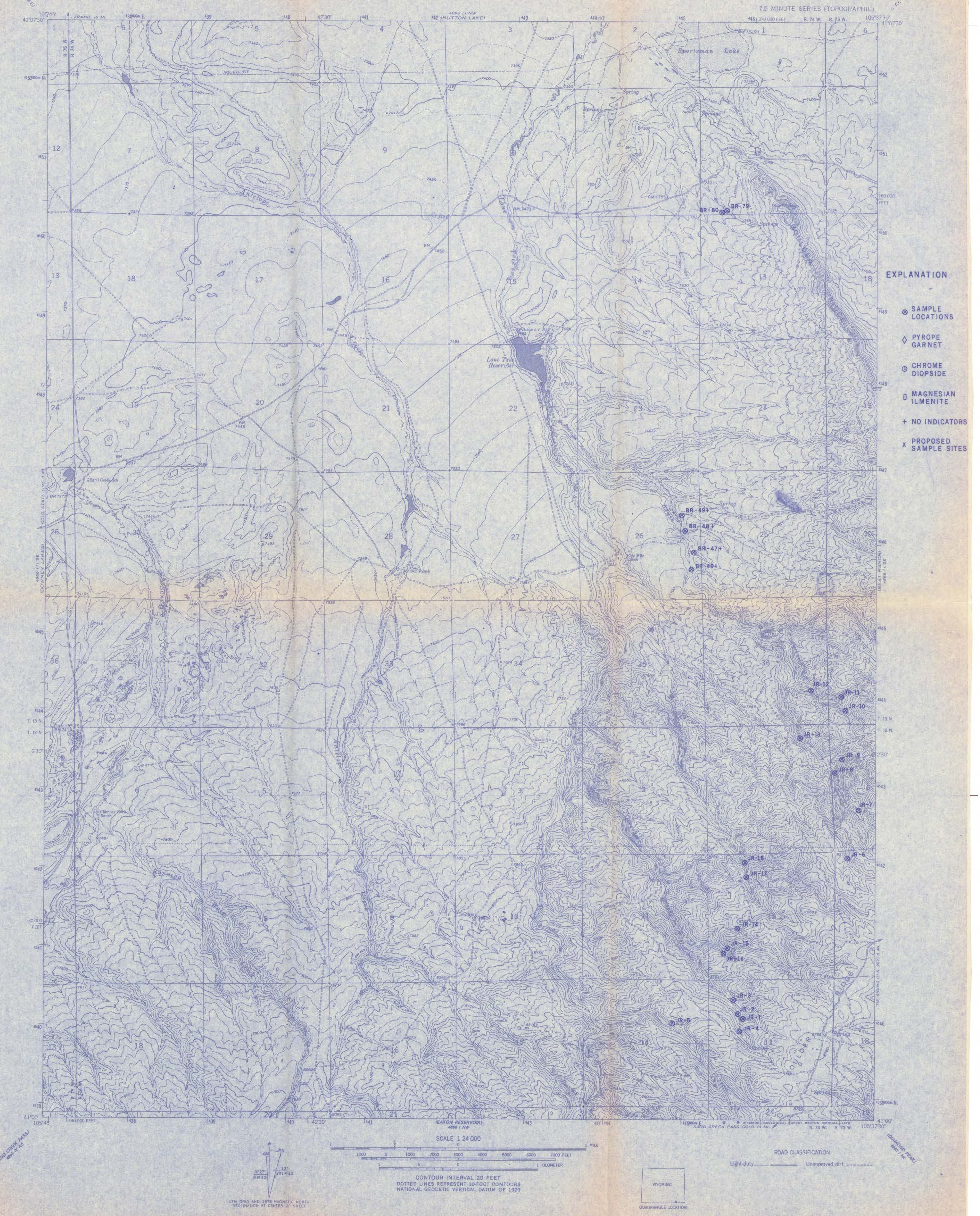
Shear zone

TN MN 14½°

0 ½ 1 MILE

SCALE 1:24,000

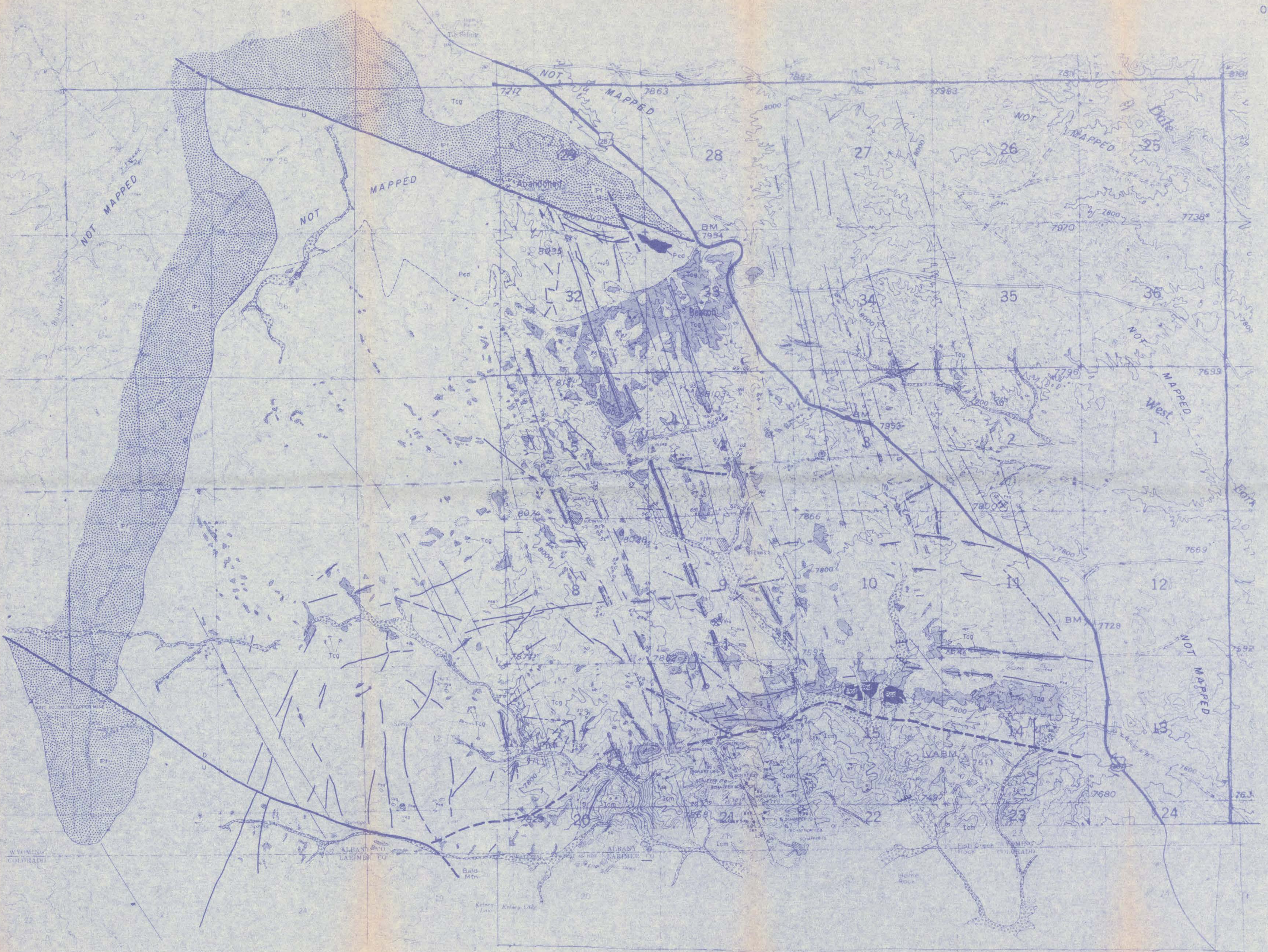
The Wyoming Geological Survey, 1981



JOHNSON RANCH QUADRANGLE SAMPLE SITE LOCATION MAP

PLATE 11 OF 15

OFR-82-1



PRELIMINARY GEOLOGICAL MAP OF THE WYOMING PORTION OF THE COLORADO-WYOMING STATE LINE DISTRICT

geology by W. Dan Hausel, 1979

(See Geological Survey of Wyoming Preliminary Report No. 18, Plate 1, 1981)

RECENT
- Stream Sediments & Alluvium
- Grus (alluvial-colluvial-eluvial grus derived from weathering of granitic rocks)

PENN.
- IPf — Fountain Formation

DEVONIAN
- FERRIS 1 — Kimberlite Pipes (age based on determination made by Naeser and McCallum, 1977)

PRECAMBRIAN
- peg — Pegmatites
- Diabasic Dikes
- Granitic Dikes (biotite quartz monzonite, hornblende quartz monzonite & alaskite dikes)
- Icm — Cap Rock Quartz Monzonite[1]
- Tcg — Trail Creek Granite[1]
- Ped — Older Dioritic Intrusives[1]

Fault or alteration zone

D / U — Fault with upthrown and downthrown side indicated

Island of predominate rock outcrop surrounded by grus.

Geologic contact—dashed where approximated and dotted where projected

77 Strike and dip of joint

Joint with vertical dip

Shear zone

82 Strike and dip of foliation

Prospect pit

Abandoned mines

Earthen dam

Alluvial sample collection site.

230 kv transmission line

TN MN 14½°

[1] See Eggler, 1967

0 — 1/2 — 1 Miles

SCALE 1:24,000

This map has not been reviewed for conformity with the editorial standards of the Geological Survey of Wyoming

The Wyoming Geological Survey, 1981

PLATE 9 OF 15

OFR-82-1