United States Department of the Interior
BUREAU OF MINES
RENO RESEARCH CENTER
1605 EVANS AVENUE
RENO, NEVADA 89512

February 25, 1985

Mr. Ray Harris
University of Wyoming
Box 3008, University Station
Laramie, WY 82071

Dear Mr. Harris:

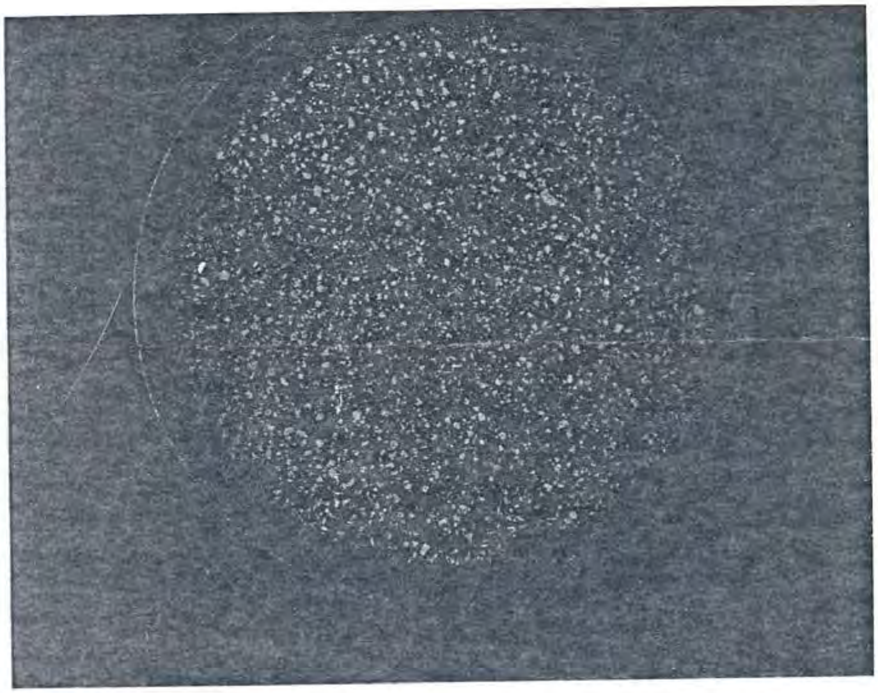
Enclosed are the whole-grain mounts of Mr. Cosgrove's sample. The mounts were not suitable to determine the identity of the silver-opaque mineral by electro microprobe analysis. Attached you will find a mineralogical report on a sample prepared by heavy liquid separation (3.3 s.p. diiodomethane) on the table concentrate you submitted to me. The sink fraction was treated by a low intensity magnetic separation to remove magnetite. The sample was mounted and polished for the electron microprobe analysis.

Sincerely,

George M. Martinez

George M. Martinez
Metallurgist

Enclosure



5M-13,14 -SINK

5M-13-14 SINK

Mineralogy Lab Report

Sample No. SM 13, 14 Date 12-24-84
Submitted by: Martinez

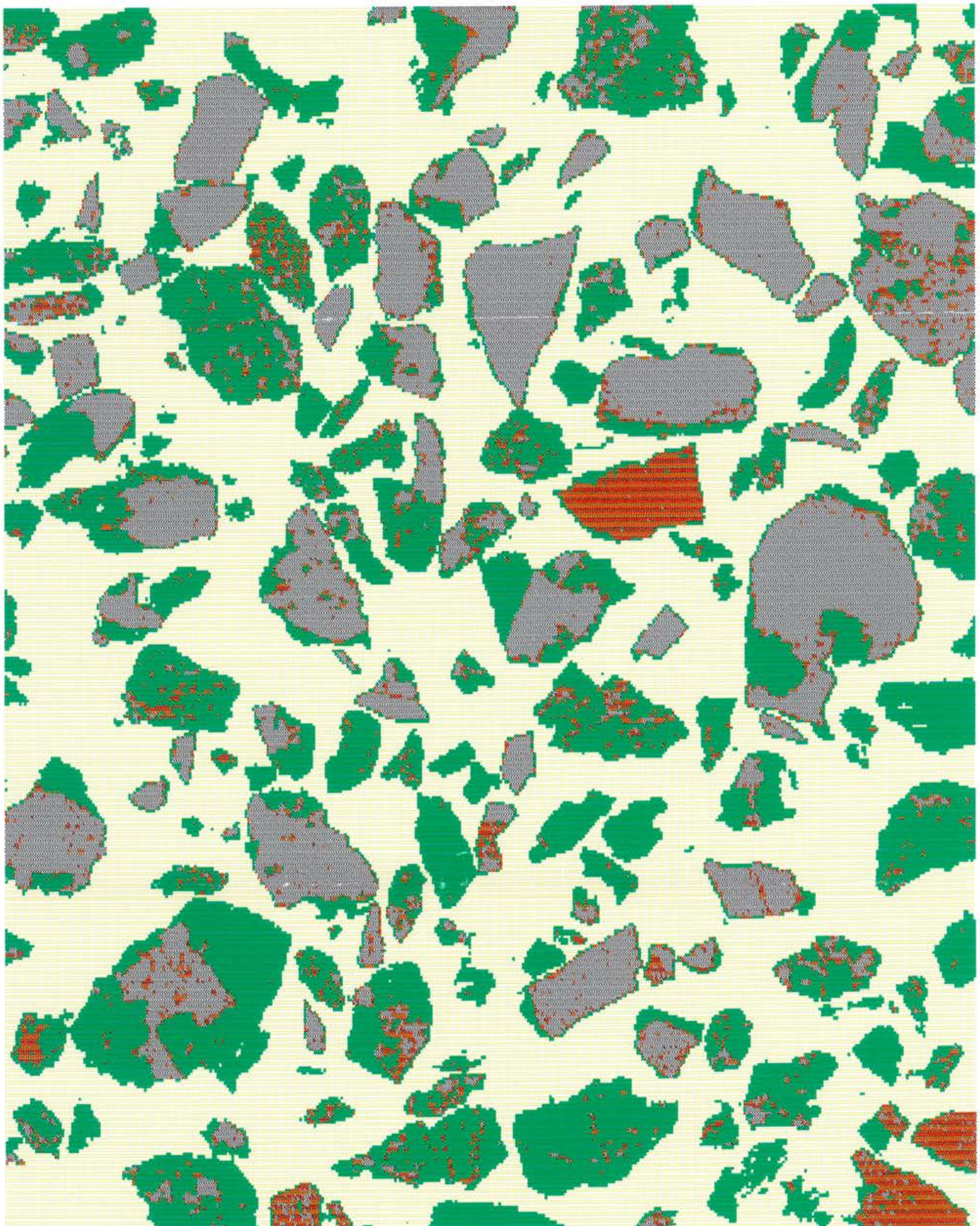
CONCENTRATE +3.3 s.g. sink of table conc with magnetite removed

SAMPLE CONTAINS ABOUT EQUAL AMOUNTS OF ILMENITE AND SILICATE GANGUE. THE LATTER CONSISTS OF A VARIETY OF Ca, Fe, Mg, Al SILICATES. MINOR IRON-OXIDE (HEMATITE?) IS PRESENT AND ONE OR TWO SMALL PIECES OF METALLIC IRON WERE NOTED.

Analyst: ________ Date ____________

3.3 S.G.

SAMPLE 5M-13 (SINK) of Table Conc with Magnetite Removed



100 X

		~ vol %
Green = Silicates	=	55
Gray = Ilmenite	=	30
Reddish Brown = Hematite	=	15

THE GEOLOGICAL SURVEY OF WYOMING
Gary B. Glass, State Geologist

MINERAL REPORT 87-3

TANTALUM-BEARING MAFIC DIKES IN THE NORTHERN BIGHORN MOUNTAINS SHERIDAN AND BIG HORN COUNTIES, WYOMING

by

Ray E. Harris

Laramie, Wyoming

1987

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

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Illustrations

Table

Introduction

Tantalum minerals (tantalite, stibiotantatlite and tapiolite) have been identified in two mafic to ultramafic dikes of Precambrian age that intrude Precambrian granitic and metamorphic rocks in the northern Bighorn Mountains. Anomalous tantalum is present in two other ultramafic dikes. The area in which the dikes are located is shown on the accompanying maps. Access to the dikes is from paved U.S. Highway 14A west of Burgess Junction and U.S. Highway 14 east of Burgess Junction. The dikes are short hikes from the highways. The area is usually accessible from July 1 through September, but may be under snow the remainder of the year since the altitude is over 8,000' above sea level.

No production of tantalum has been recorded from these dikes. They were intensely prospected, in the past, probably for gold, as shown by numerous small (less than 10 feet in length or depth) shafts, adits and pits developed on them. A mafic dike two miles north of Burgess Junction has been quarried for ornamental stone (known as Leopard Rock) and for highway construction aggregate and riprap (Haff, 1944).

Currently (1987) these dikes are claimed by Mr. Richard Cosgrove of Powell, Wyoming. Many of the samples analyzed for this report were sent to the author by Mr. Cosgrove. The names of the dikes given in this report are from Mr. Cosgrove's claim names. In addition to the dikes discussed in this report, other dikes in the area (Mr. Cosgrove's claims Lone Star and Lonesome Pine) are similar in mineralogy and trend to the Bald Mountain, Wolverine, Sundance, Sheltering Pines, and Brook Pines dikes studied by the author.

Geology and Mineralogy

Country rocks in the area of the tantalum bearing mafic and ultramafic dikes include metasomatic quartz monzonitic and quartz dioritic rocks (Manzer and Heimlich, 1974 and Ross and Heimlich, 1972). These rocks were involved in a regional metamorphic episode dated at about 2.75 b.y. (Heimlich and Armstrong, 1972). There are two groups of mafic and ultramafic dikes in the area. Metadolerite and metapyroxenite dikes were emplaced prior to the 2.75 b.y. metamorphic episode. Dolerite and dolerite porphyry dikes unaffected by the metamorphic event (Manzer and Heimlich, 1974) were emplaced following the event (Heimlich and Armstrong, 1972). Table 1 shows the mineralogy of selected dolerite, metadolerite, and metapyroxenite dikes from the Burgess Junction area.

Table 1. Mineralogical analysis of dolerite, metadolerite, and metapyroxenite dikes from the Burgess Junction area (after Manzer and Heimlich, 1974) (data in percent).

Rock Type	Dolerite		Metadolerite		Metapyroxenite/metaamphibolite	
Plagioclase	56.2	52.3	53.9	42.8	-0-	14.9
Pyroxene-amphibole	39.0	41.6	32.3	50.0	78.0	61.2
Biotite	-0-	1.0	3.9	0.4	-0-	-0-
Granophyre	0.9	0.6	-0-	-0-	-0-	-0-
Microcline	-0-	-0-	-0-	0.2	-0-	-0-
Epidote	-0-	-0-	1.7	1.7	-0-	2.4
Nonopaque accessories	0.6	0.9	4.5	3.8	2.0	3.8
Opaque accessories	3.3	3.6	3.7	1.1	20.0	17.7
	100.0	100.0	100.0	100.0	100.0	100.0

The dikes in the Bald Mountain area (Bald Mountain and Wolverine dikes) are of a different composition than the dikes in the Burgess Junction area (Sundance dike; Table 2). A thin-section of a sample of the Wolverine dike confirms it as being an unmetamorphosed dolerite of the later series. The Sundance dike exhibits strong foliation parallel to its margins and the mineralogy indicates that it is a metapyroxenite-metaamphibolite dike of the older series. The Sundance dike has been divided into zones of banding (foliation) parallel to the trend of the dike. These have been given letter designations. Concentrates of heavy minerals were made from the E and I zones. The Brook Pines dike is very poorly exposed. However, it is similar in composition to the Sundance dike, and is the dike U-2 of Manzer and Heimlich (1974), an older series metapyroxenite. The Sheltering Pines dike is also similar in trend and composition to the Sundance dike.

Table 2. Whole-grain mineralogical analysis of heavy mineral separations of mafic and ultramafic dikes, northern Bighorn Mountains, Wyoming.

	Bald Mountain	Wolverine 6	Wolverine 2	Wolverine 5	Sundance E1 black	Sundance E1 red	Sundance I1	Sundance I2
Light minerals	82.5	78.5	59.2	49.6	37.5	37.1	37.1	40.1
Amphibole - pyroxene	14.7	20.6	39.5	46.9	27.2	22.0	53.3	43.6
Magnetite - ilmenite	2.1	0.1	0.5	0.9	34.3	40.6	7.7	14.8
Olivine	--	--	--	0.4	--	--	--	--
Apatite	--	--	--	--	tr	tr	0.2	0.2
Zircon	--	--	0.1	0.8	--	--	--	--
Sphene	--	0.4	0.2	--	--	--	0.2	0.1
Monazite	tr	tr	tr	--	--	--	--	--
Brown spinel	tr	0.2	--	--	--	--	--	--
Rutile	--	--	--	0.4	--	--	0.2	0.1
Opaque	0.6	0.1	0.6	1.0	0.6	0.1	0.7	0.1
Columbite - tantalite	--	--	--	--	--	0.1	0.2	0.1
Total	99.9	99.9	100.1	100.0	99.6	99.9	99.6	99.1

Tantalum minerals

The Wolverine, Sundance, Sheltering Pines, and Brook Pines dikes are enriched in tantalum. No tantalum minerals have been found in the Bald Mountain dike. Tapiolite, identified in thin section, was found in the Wolverine dike. This identification was later confirmed by X-ray studies (John Sans, Ball State University, personal communication 1983). Dr. Sans (personal communication 1983) also reports of 6 "peanut" sized grains of tantalite taken from the Sundance dike. John Sans also picked several grains of a suspected tantalum mineral from a sample from the Sundance dike. These grains assayed 23.7 percent Ta, indicative of columbite-tantalite. Tentative optical identifications of columbite-tantalite were made by the author from the Sundance dike (El red, and I Table 2). X-ray diffraction analyses of heavy mineral concentrates from the Sundance dike (E and I zones) at the Geological Survey of Wyoming also indicate columbite-tantalite. Samples of the Sundance I zone concentrate were sent to the U.S. Bureau of Mines in Reno, Nevada for electron microprobe analysis. No tantalum minerals were noted in the section examined. The primary phases present are pyroxenes and amphiboles (silicates) and magnetite-ilmenite with hematite alteration (see attachment).

A split of the Sundance I zone concentrate was sent to Bondar-Clegg, Inc. for an x-ray fluorescence analysis of the magnetic versus nonmagnetic fraction to determine the tantalum minerals. Although little tantalum was detected, the weakly or semi-magnetic fraction contained four to five ppm tantalum, (and 28 to 31 ppm niobium), which would be expected if the phase is columbite-tantalite.

A sample of the Wolverine dike and the Sundance I zone concentrate was submitted to the laboratory at Sul Ross State University in Alpine, Texas for x-ray diffraction and x-ray fluorescence analysis. The tantalum phase identified for the Wolverine dike was stibiotantalite $(SbO)_2(Ta, Nb)_2O_6$. Phases identified from the Sundance I zone concentrate were tapiolite and stibiotantalite. These samples were also analyzed by electron probe methods. Stibiotantilite and niobian rutile were found (Nelson, 1987).

Amount of tantalum and other elements in the dikes

An x-ray fluorescence analyses of heavy mineral concentrates from the Sheltering Pines and Sundance E zone dikes performed by Ball State University shows Ta_2O values up to .70 percent (7,000 ppm) in concentrates (Table 3). The percent of this concentrate of the whole rock is not known. Another analysis performed on another concentrate from the I zone give values from 0.01 percent (100 ppm) to .59 percent (5,900 ppm) Ta_2O in the concentrates which here make up about 40 percent of the whole rock (Table 4). Whole-rock analyses have shown amounts of tantalum from less than .002 percent (20 ppm) to .245 percent (2,450 ppm). The amounts of columbium have been reported from less than .003 percent (300 ppm) to .074 percent (740 ppm) in whole rock samples. The tantalum content of the Sundance I zone concentrate averaged 0.2 percent by x-ray fluorescence.

Table 3. Tantalum analyses of concentrates from the Sheltering Pines and Sundance Dikes. Data from Sans (1983), using x-ray fluorescence.

Sample Number	Ta_2O (percent)
Sheltering Pines 2	.7
Sundance E3	.5
Sundance E2	.55
Sundance E1	.55

Table 4. Tantalum analyses, Sundance dike, I zone.

Sample Number	ICP[1] Ta_2O (percent)	Fusion[2] Ta_2O (percent)
Sundance I	.38	.02
Sundance I	.59	.01
Sundance I	.12	

[1] Hydrofluoric acid digestion, induction - coupled plasma analysis.
[2] Whole rock analysis by sample fusion.

The presence of tantalum has been confirmed by analyses using several different methods including x-ray fluorescence, induction coupled plasma (ICP and others. However, no cold acid extraction method detected any tantalum in the rocks. Total digestion methods appear to be necessary to assure that the tantalum is present in the solutions used in the final analysis. Unfortunately, all industry evaluations of this property to date have used cold acid extraction in their analytical procedure.

Tantalum, probably found as columbite-tantalite, is distributed erractically in the dikes. It is associated in a mafic zone with an oxidized fracture in the Sundance dike, and with the more mafic areas where found in the dikes. Tantalum found in tapiolite is of minor importance. It is probably an accessory phase found in the dikes in the less mafic areas.

Economic considerations

The tantalum content of heavy mineral concentrates of samples collected to date from the dikes seems to average around 220 ppm (0.02 percent) with higher zones. There are zones within the dikes containing no detectable tantalum. Extrapolating the percent tantalum in concentrates composing 20 to 35 percent of the total sample gives whole rock Ta_2O values in the range of less than .002 percent (20 ppm) to .24 percent (2,400 ppm). The higher values represent selected samples taken by visually selecting darker zones in the dikes.

Other elements in the dikes may be of interest. The content of niobium is relatively low. The presence of monazite as an accessory indicates possible rare earth element values. A semiquantative spectrochemical analysis of the Wolverine dike compared with the Brook Pines dike is shown in Table 5. Other elements of interest in the ultramafic Book Pines and Sundance dikes include nickel and chromium. Iron and tatanium were identified as occurring in magnetite-ilmentite in the Sundance dike (Table 2).

Table 5. Semiquantitative spectrochemical analyses of trace elements in the Wolverine Sundance and Brooks Pines Dikes.

Element	Wolverine[1]	Brook Pines[2]	Wolverine 5 and 6[3]	Wolverine 2	Wolverine 5	Brook Pines	Sundance I zone
Boron	T	W					
Barium	ND	M	260	260	150	300	160
Cobalt	ND	W					
Chromium	W	S	400	400	45	740	510
Copper	T	M	220	140	150	390	420
Gallium	ND	W					
Indium	T	ND					
Iron	M	S	78,000	96,000	88,000	95,000	120,000
Lead	T	T					160
Lithium	T	ND					
Lanthanum	ND	S					
Lutetium	T	ND					
Manganese	W	ND	750	940	730	2,700	1,500
Molybdenum	W	W					
Nickel	W	S	270	95	190	1,400	2,000
Niobium	T	ND	48	24		54	
Scandium	ND	T					
Silver	T	ND					
Strontium			260	510	160	320	290
Tantalum	T	ND					
Titanium	T	S	530	890	730	2,200	1,500
Tin	T	ND					
Thorium	T	ND					
Vanadium	T	M	85	260			
Yttrium	ND	T	110	110		84	
Zirconium	ND	W	210	270	90	200	
Zinc			190	130	180	370	240

S = Strong (1-10 percent) (100,000-10,000 ppm)

M = Moderate (.1-1 percent) (10,000-1,000 ppm)

W = Weak (.01-.1 percent) (1,000-100 ppm)

T = Trace (.001-.01 percent (100-10 ppm)

ND = Not detected.

[1] American Testing Institute, September 23, 1908; [2] Skyline Labs, Inc., updated report #MUY029; [3] Sherer, 1986 (data in ppm).

Conclusions

Low to moderate concentrations of tantalum and possibly rare earth elements are present in mafic and ultramafic dikes in the northern Bighorn Mountains, particularly in the older metamorphosed series. If the dikes are consistently enriched, the reserves could be very large. A detailed study of the occurrences of these elements is needed, including a study of the origin of the elements (syngenetic, metamorphic or hydrothermal) and a determination of their distribution within the dikes. A method of economically extracting tantalum from the dikes needs to be developed. Also, a surface mapping, sampling and drilling program to outline reserves is needed.

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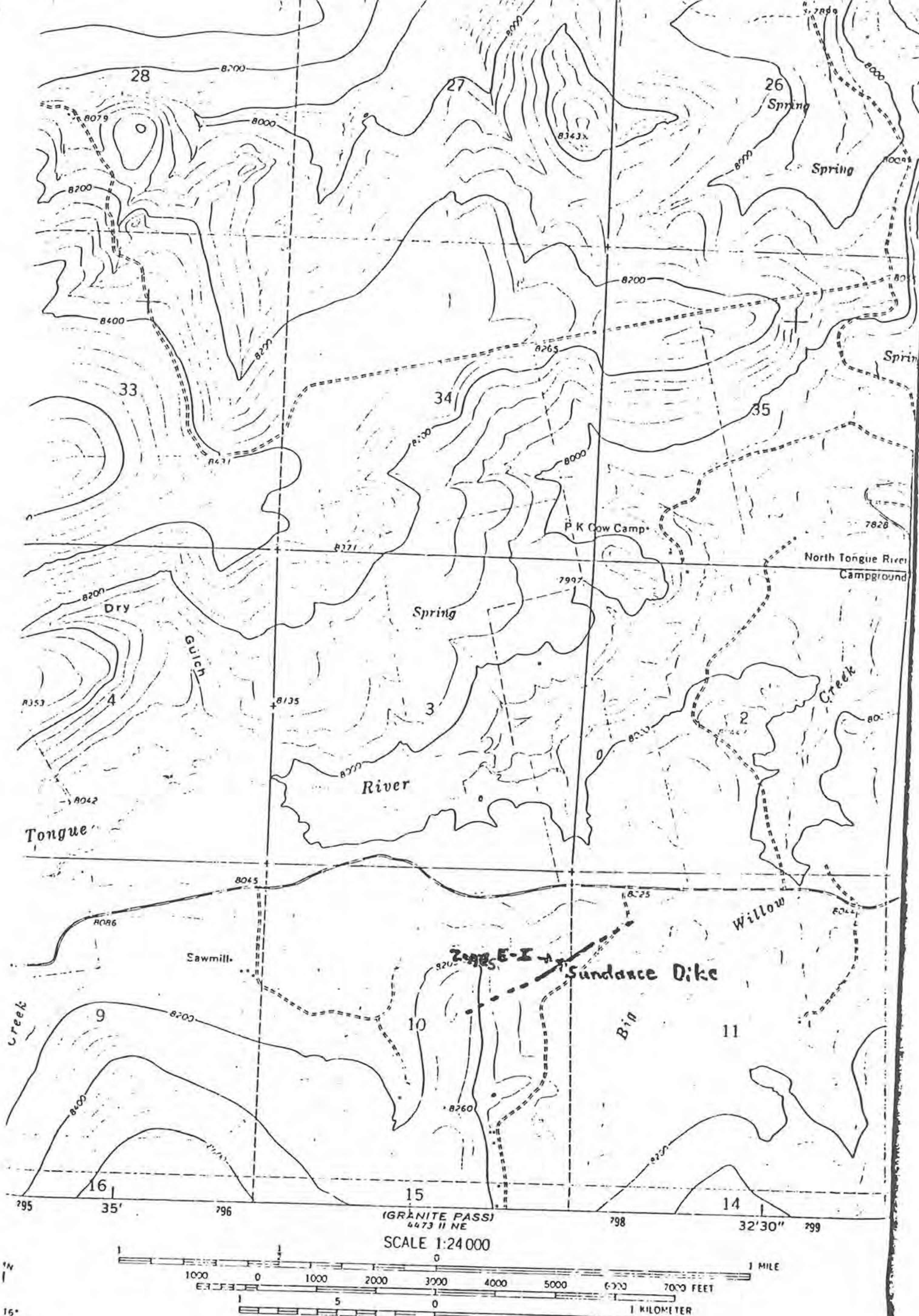

CONTOUR INTERVAL 40 FEET
DATUM IS MEAN SEA LEVEL

ETIC NORTH
OF SHEET

QUAD

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
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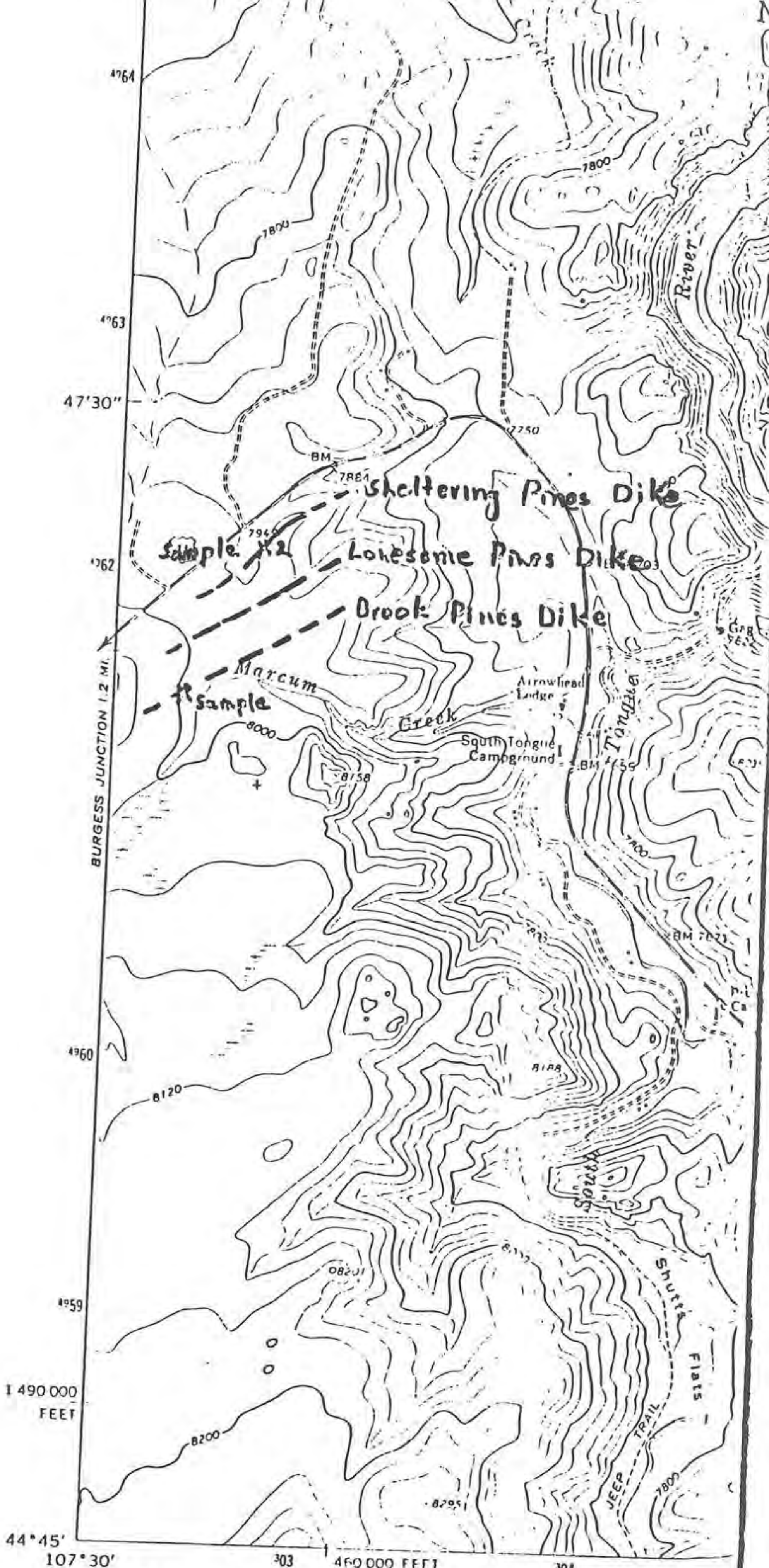
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

Burgess Junction Wyoming
7½ minute Quad 1964



Skull Ridge, Wyoming
7½ minute Quad
1964

Mapped, edited, and published by the Geological Survey

Control by USGS and USC&GS

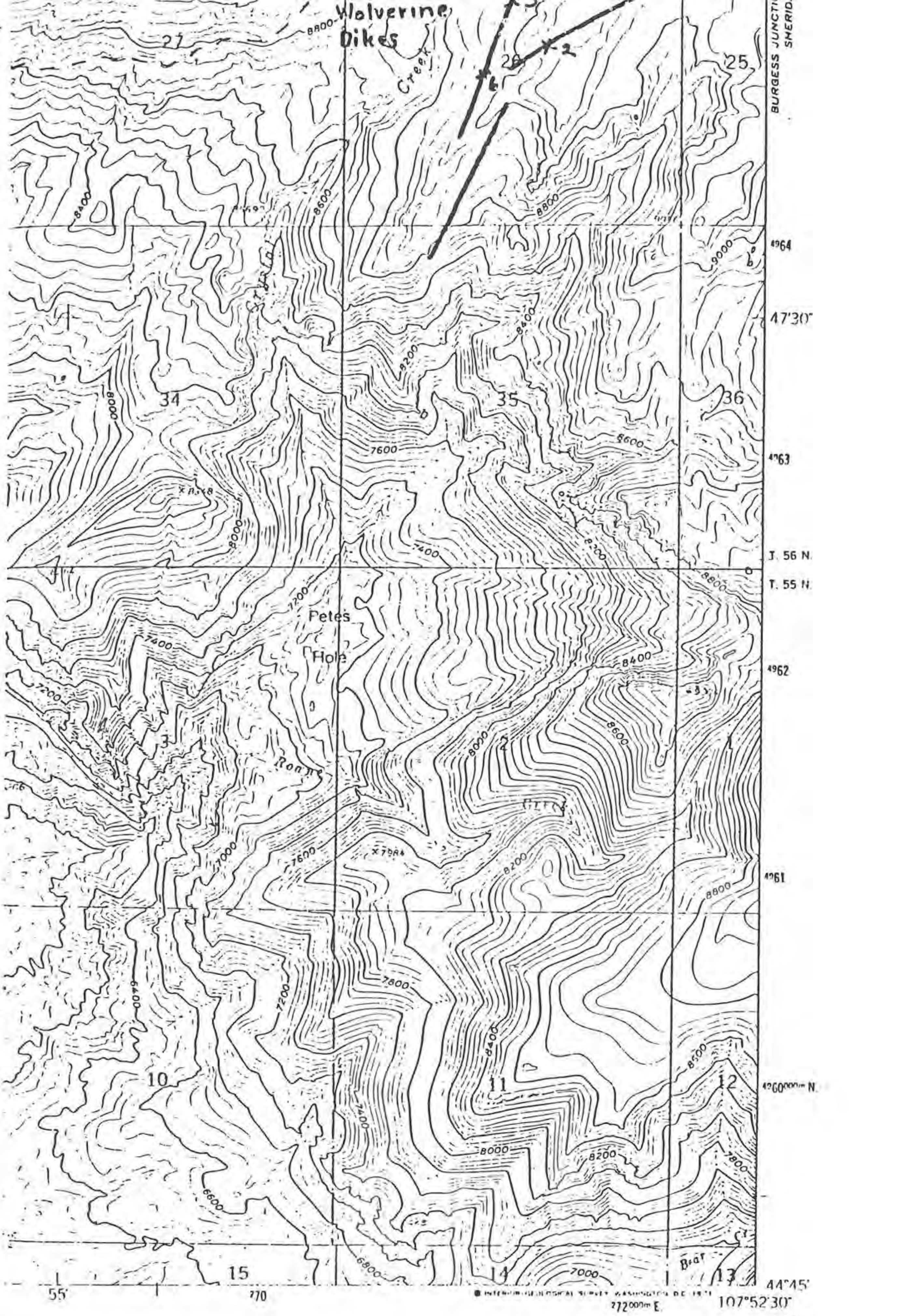
Topography by photogrammetric methods from aerial photographs taken 1963. Field checked 1964

Polyconic projection. 1927 North American datum
10,000-foot grid based on Wyoming coordinate system, east central zone
1000-meter Universal Transverse Mercator grid ticks, zone 13, shown in blue

Fine red dashed lines indicate selected fence lines

Where omitted, land lines have not been established or are not shown because of insufficient data

UTM GRID AND 1964
DECLINATION AT



1 MILE

ROAD CLASSIFICATION

Medium-duty — — — Light-duty

Unimproved dirt

State Route

WYOMING

QUADRANGLE LOCATION

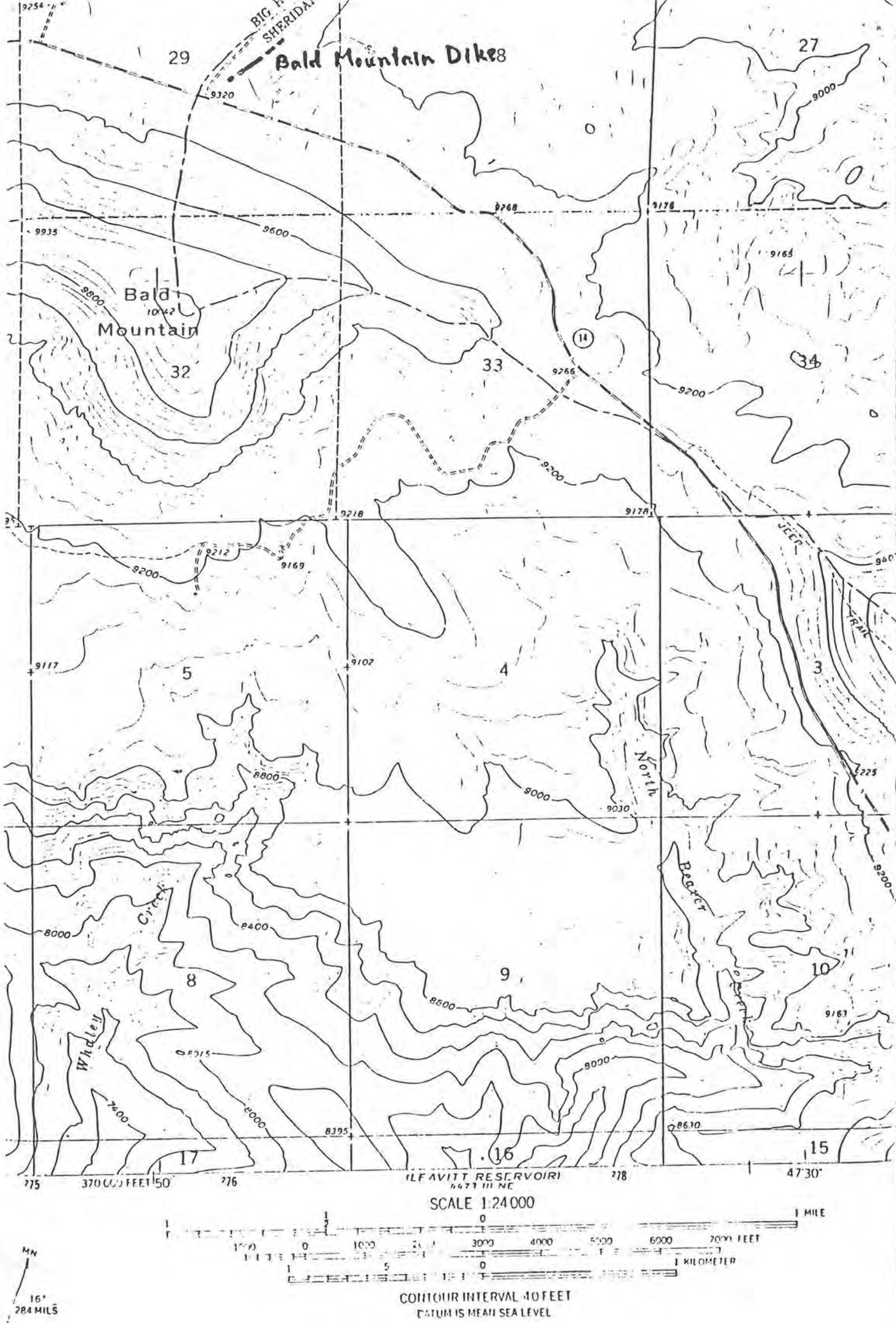
D. C. 20242

MEDICINE WHEEL, WYO.

N4445—W10752.5/7.5

1960

AMS 4473 IV SW—SERIES V874



MAGNETIC NORTH
CENTER OF SHEET

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BALD Mountain 7½-minute Quad
1960