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GEOLOGIC REPORT NO. 13

Geological and Geochemical Investigations Near Paxson, Northern Copper River Basin, Alaska

By

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INTRODUCTION

The area covered by this report is in southcentral Alaska along the Richardson and Denali Highways, which join at Paxson (figure 1). Interest in the area was generated by two copper showings near Paxson and others to the west in similar lithology, plus several granitic intrusives south and southwest of Paxson. The purpose of this project was to visit and describe the known copper showings, map the geology of the area surrounding the showings and the granitic intrusives, and collect stream sediment samples for geochemical analysis from as much of the region as possible.

The mapping and sampling were carried out mainly during June and July 1964 by the writers assisted by Walter Phillips. Mr. Saunders is responsible for stream sediment sampling in the Amphitheatre Mountains northwest of the Denali Highway, along the Richardson Highway, and in the western part of the Twelvemile Creek drainage. Most of the remaining stream sediment sampling was done by Phillips. Gordon Herreid, geologist, and assistant Michael Mitchell spent three days mapping and sampling in the Meier area along with Rose and Phillips.

Rock outcrops are very poor up to an elevation of about 3500 feet, the upper limit of thick brush cover. Above 3500 feet, outcrops, talus, and frost-riven blocks close to outcrop are relatively abundant, but an almost complete cover of lichens obscures the character of the rocks and structural relationships, so that very few determinations of contact relations, attitudes and other structures and textures have been made.

Previous geologic work in the area has been done by Moffit (1912, 1954). He recognized three geologic units in the area. A unit of greenston schist, and limestone, plus basic and dioritic intrusives, was mapped extending westward from the south end of Paxson Lake. An age of Carbonifero or older was assigned to these rocks. The second unit of "amygdaloidal lava flows, diabase, and basalt," also trending east-west, was shown passing through the north end of Paxson Lake and the south end of Summit Lake. Thes rocks were tentatively assigned to the Permian and Triassic. His third unit consisted of granitic intrusives of Mesozoic age, one in the Meier area and another on Flat Top Mountain.

Andreason and others (1964), in a report on an aeromagnetic and gravity survey of the Copper River Basin, recognize the same geologic units as Moffi and show a few additional outcrops. The magnetic map clearly shows the east west trend of the rocks west of the Richardson Highway and suggests that relatively nonmagnetic rocks (sediment?) are present between the bands of moderately to highly magnetic greenstone that are exposed in the Meier and Hogan Hill areas.

VOLCANIC AND SEDIMENTARY ROCKS

Pre-Triassic greenschist and amphibolite (ga)

This group includes much of the Carboniferous (?) greenstone, schist, and limestone unit of Moffit (1954). Exposures of this group were mapped in the Meier, Hogan Hill and Twelvemile Creek areas (figures 2, 3, and 4). The rock is typically medium to dark green or grayish green, and has fair to goo foliation. Most specimens are fine-grained, but a few are medium-grained. In the Meier area, most exposures consist of greenschists, composed mainly o albite, chlorite, epidote and calcite along with minor quartz and sphene. Amphibolites or epidote amphibolites are exposed in the Hogan Hill and Twelv mile Creek areas. These rocks contain sodic andesine and green hornblende along with minor amounts of epidote, carbonate, quartz, chlorite, magnetite, and sphene. In the Hogan Hill and Meier areas, a few vesicular zones are visible in the rocks, and in all three areas, the composition and massive nature of most exposures indicates that the parent rocks were mainly mafic volcanic flows, although some sills and dikes may be present. However, gray wacke is present in outcrops on the highway near Meier, and thin quartzite beds were seen near Meier and on Hogan Hill. Thinly interbanded light-color carbonate-rich rocks and dark-colored hornblende-rich rock were seen locally on Hogan Hill. These banded rocks, which may have originated as limy tuffs, contain abundant magnetite.

The greenschist and amphibolite are exposed mainly in areas of high magnetic intensity on the aeromagnetic map of Andreason et al (1964). Magnetite is present in all the greenschist and amphibolite specimens, makin these rocks a reasonable source for the beltlike positive magnetic anomalies The minor amounts of sediments found in this study are consistent with the suggestion of Andreason et al (1964) that nonmagnetic sediments are present in at least some of the intervening covered zones of low magnetic intensity. However, granitic to dioritic igneous rocks may also be responsible for some of the magnetic lows.

The age of the parent rocks of the greenschist and amphibolite remains uncertain. The lithology bears some similarity to andesitic volcanics, gray wackes, and impure limestones of Mississippian and Pennsylvanian age describ by Hanson (1963) in the Alaska Range, but this correlation must be considere speculative, as is the age of metamorphism.

Pre-Triassic(?) greenstone and andesite (g)

A variety of fine- to medium-grained mafic igneous rocks form the countr rock in the northern part of the Meier area, and possibly on the northern sid of Twelvemile Creek in the Flat Top Mountain area (figures 3, 4, and 5). These rocks differ from the greenschist and amphibolite mainly by a lack of foliation, or by weak foliation. They also tend to be coarser-grained than the greenschist and amphibolite, although exceptions are not uncommon. The most common variety is a dark green to gray-green rock that contains a few percent plagioclase phenocrysts as much as 2 mm in diameter in a matrix of fine-grained (less than 0.5 mm) plagioclase and mafic minerals. The proportion of mafic minerals is typically a third to a half. Some specimens are altered to chlorite, epidote, actinolite, albite, and carbonate, but others are apparently unaltered. The origin of these rocks is not clear. No vesicles, flow tops or other indications of an extrusive origin were seen, but the grain size is finer than normal plutonic rocks. Possibly both thick flows and hypabyssal intrusives are present. In several exposures, these rocks have been intruded by coarser, lighter-colored diorite (group A).

An exposure of dacite porphyry with an aphanitic green groundmass was found east of Meier. The dacite porphyry is included with this group because of its location with other rocks of the group, but may belong with the basalt, andesite, and dacite intrusives of Flat Top Mountain.

The age of the greenstone and andesite is not clear. They may be (1) part of the greenschist-amphibolite sequence that has undergone less intense metamorphism, (2) a post-metamorphic but pre-Triassic group of extrusives and shallow intrusives, or (3) a basal part of the Amphitheatre basalt described below.

Permian(?) slate, quartzite, rhyolite and andesite (Ps, Pv)

Weakly to moderately foliated slate, quartzite, rhyolite, andesite, and minor limestone are exposed on Fish Creek below Lower Fish Lake (figure 7). These rocks are intruded by a variety of andesite or basalt dikes, and are overlain with apparent conformity by Amphitheatre basalt flows of Triassic age.

The lowest rocks of this group are exposed in a small gully on the north side of Fish Creek. They consist of south-dipping quartzite, sandstone and minor limestone. The arenaceous rocks are considerably iron-stained and sericitized, and as a result the characteristics of the parent rock are not very clear. One limonite-stained shear zone about 10 feet wide was noted in this interval, and it seems likely that an intrusive body is present nearby. In the lower part of the gully and on the opposite slope of Fish Creek, a thick sequence of black slaty argillite and slate is exposed. Abundant fine pyrite is present in some of the slate, and several mafic dikes were seen. At least 2000 feet of slate is present.

About 1/3 mile south of Fish Creek, a unit of southerly-dipping weakly-foliated chloritized rhyolite and massive dark andesite are exposed in a small drainage and in the flat areas at the head of the drainage. Foliation and banding in these rocks are parallel to the attitude of the underlying slate. Near the top of the volcanics is a zone about 50 feet thick of thin-bedded limestone, separated from the volcanics by a diorite sill.

The rocks of this group are tentatively considered as Permian, based mainly on correlation of the black slate with similar black shales in the Permian Mankomen formation (Mendenhall, 1905, Rose, 1965), plus the stratigraphic relation to mafic flows tentatively considered as Triassic. However, the rocks in question could also be a basal part of the Triassic sequence, or an older part of the Paleozoic.

Triassic Amphitheatre basalt (TRa)

An east-west belt of weakly altered mafic volcanic rocks plus minor amounts of other rock types forms most of the Amphitheatre Mountains in the northwestern part of the Copper River Basin (Moffit, 1912, Chapin, 1918). This belt of volcanics is known to extend from the Gakona River westward to the Susitna River, a distance of nearly 100 miles, and the rocks may be present farther to the east. The name Amphitheatre basalt is here used for this group of rocks. They have previously been described as "undifferentiat amygdaloidal lava flows, diabase and basalt, with intercalated tuffaceous an shaly beds" (Moffit, 1954).

In the area mapped, the Amphitheatre basalt is exposed on Paxson Mounta and on hills to the east, northeast, and northwest (figures 6, 7, and 8). I was also examined in the southern part of the Rainy Creek area about 20 mile north of Paxson Mountain (Rose, 1965). The rock in the Paxson area is mostl a dark green massive fine-grained basalt containing a few plagioclase phenocrysts. Some of the basalt contains hornblende phenocrysts. Sparse vesicles and amygdules composed of epidote, chlorite, calcite, and other minerals are present in many localities. Vesicular zones, some of which are reddish-brown in color, are presumed to be flow tops and are most abundant on the north and northwestern sides of Paxson Mountain. Although individual units are rarely discernible, most of the basalt is believed to occur as flows. Some flow-breccias and agglomerates, as well as shallow intrusives, are also probably present but the complete coating of lichens on outcrops makes distinctions of this type very difficult. No sedimentary units were found.

In thin section, the least altered specimens consist of porphyritic basalt composed of sparse plagioclase phenocrysts in a matrix of plagioclase and augite with an intergranular texture. In all specimens examined microscopically, the plagioclase is albite, even when the augite is completely unaltered. Most samples contain moderate amounts of epidote and variable amounts of calcite which may have formed from calcium released by albitizatio. Chlorite is the most common mineral in the amygdules, but calcite, epidote, and quartz were also noted. In the more highly altered samples, the augite is altered to actinolite, chlorite, and/or epidote. A few patches of chlorit may have developed from olivine.

The stratigraphic relations and petrographic character of the Amphitheatre basalt suggest Triassic age. In the Valdez Creek area (Ross, 1933), the basalt is overlain by Triassic sediments and contains interbedded limestone with Triassic fossils. Near the mouth of Eureka Creek the basalt overlies Permian rocks (Rose, 1965), and as mentioned previously, it also overlies presumed Permian rocks on Fish Creek. The petrography is very simil to the Nikolai greenstone on the southern side of the Wrangell Mountains (Moffit, 1938, MacKevett, 1964a), where a Triassic age has been demonstrated. Assuming that the few attitudes obtained are representative, the basalt is at least 2000 feet thick on the northeast side of Paxson Mountain. Sections of 3500 feet and more have been reported in other areas (Chapin, 1918).

Pleistocene and Recent deposits

Several hundred feet of gravel and sand of presumed Pleistocene age are exposed along Paxson, Summit, and Fielding Lakes and on the Gulkana River above Paxson. Superficial examination suggests that this gravel originated as outwash from glaciers in the Alaska Range during the late Pleistocene. Glacial drift covers much of the lower parts of the area. In general, outcrops on the lower hills are restricted to the northern or northeastern sides of the hills, with drift cover elsewhere. A discussion of the Pleistocene history of the area is given by Péwé (1961).

INTRUSIVE ROCKS

Gabbro, diorite, and quartz diorite in the Meier and Twelvemile Creek Areas (A1, A2)

Medium-grained diorite and quartz diorite (A1) are present in the Meier area and on the north side of Twelvemile Creek (figures 3 and 4). Sample 4AR38 (Table 1) is typical of these rocks. Augite is the dominant mafic mineral in most samples, but hornblende appears to be common in some. In the Meier areas, the diorite is clearly intrusive into greenschist and greenstone North of Twelvemile Creek, the relations are less clear. Dikes of andesite (group F?) cut the diorite, but andesite (unit g?) also occurs as inclusions in the medium-grained diorite. The large exposure of andesite west of the diorite is tentatively considered to be older than the diorite, but the contacts between the two rocks could not be interpreted with certainty, and this andesite may be part of intrusive group F.

Coarse-grained to pegmatitic diorite or gabbro (A_2) is present in the Meier area, and some of the diorite north of Twelvemile Creek is locally coarse-grained or has diabasic texture similar to the coarse diorite. The most extensive outcrops of this rock type are on the ridge a mile or two north-west of Meier Lake. The coarse-grained diorite is composed of euhedral tablets of plagioclase separated by hornblende, or in some cases, coarse euhedral prisms of hornblende and subhedral plagioclase separated by coarse interstitial grains of hornblende and plagioclase. In the specimen examined in thin section (4H16), plagioclase is altered to albite and epidote, and the hornblende is partly altered to actinolite. The stumpy outline of the hornblende suggests that it may have developed from augite, but no trace of augite can be seen. The coarse-grained diorite intrudes both greenschist (ga and unfoliated andesite (g) near Meier. The coarse-grained diorite is not foliated, except in a few outcrops adjacent to the gneissic granodiorite at Meier. The foliation in this locality is believed to be the result of local deformation of the country rock by intrusion of the granodiorite.

The gabbro, diorite, and quartz diorite are similar to gabbro and diorite in the Amphitheatre Mountains (group C) and may have a Triassic or later age. If this tentative correlation is incorrect, group A may be Devonian to Triassic in age as suggested by Moffit (1954).

Hornblende andesite and coarse gabbro in the Paxson Mountain area (B_1, B_2)

Two small plugs of coarse-grained gabbro (B_1) were found on Paxson Mountain. A thin section shows coarse augite and albite, along with small amounts of various alteration products.

Numerous narrow (1-10 feet wide) dikes of light-colored andesite (B_2) containing long prismatic crystals of hornblende were mapped on Paxson Mounta (figure 7 and 8). A thin section of the andesite discloses about 10% hornblende in a matrix of fine lath-shaped plagioclase accompanied by 5% quartz.

The gabbro is considered as an intrusive phase of the Amphitheatre basal and the andesite may be a relatively leucocratic differentiate.

Gabbro and diorite of the Amphitheatre Mountains (C)

The upper part of the hill northwest of Mile 8 on the Denali Highway and south of Fielding Lake is composed of gabbro and diorite of variable texture and composition (figure 8). The typical rock is medium-grained and medium gray in color. Crystals of plagioclase and augite are visible, in some cases with a diabasic texture but usually with granitic texture. Sample 4AR174 in Table 1 gives the mineralogical composition of a relatively dark phase of this intrusive. The color index ranges from about 40 to 60. In addition, pieces of mafic-rich gabbro or pyroxenite containing small amounts of chalcopyrite were found as float on the southeast side of the hill, but could not be found in place and may have been carried in by glaciers from th north. However, Moffit (1912) reports peridotite "in the Tangle Lakes vicinity".

The gabbro and diorite are clearly Triassic or younger, and are tentatively considered as plutonic representatives of the same magmatic episode that formed the Triassic Amphitheatre basalt flows.

Gabbro, diorite and granodiorite of Flat Top Mountain (D_1, D_2, D_3, D_4)

A variety of basic and intermediate rocks is exposed on Flat Top Mounta (figure 5). Some of these rocks have similarities to rocks discussed in oth groups, but others do not; however, it seems simplest to discuss all as a geographic group.

The most mafic-rich members (D_1) were found along the west side of the southern part of Flat Top Mountain. These rocks are gabbros containing 50 to 70 percent mafic minerals, mostly hornblende, along with plagioclase. Grain size varies from fine to medium. In several cases, a poor foliation was observed.

The top of the southern part of Flat Top Mountain and part of the ridg extending southeast from it are composed of medium-grained quartz-bearing hornblende gabbro (D_2) typified by specimens 4AR223 and 4AR235. Plagioclase and hornblende are the major constituents, along with smaller amounts of quartz and biotite. Foliation and banding were observed locally on the ridg southeast of the peak, but have no consistent attitude. Igneous breccia composed of dark fragments in a light-colored dioritic matrix was found in several locations in the saddle between the two peaks of Flat Top Mountain.

The northern part of Flat Top Mountain is composed of biotite granodiorite (D_3, sample 4AR231 in Table 1). This rock is light-colored and medium-grained and is shown on maps by Moffit (1912, 1954). It is similar in composition to the intrusives at Meier and Hogan Hill, but differs in being finer-grained and in lacking the muscovite found in those two bodies. This body was visited only along its southern margin but appears quite homogeneous in this area. Slightly coarser-grained granodiorite was found southeast of the southern peak (section 19). The granodiorite locally contains orthoclase phenocrysts as much as a half inch in length.

Coarse-grained quartz-rich granodiorite (D_4) is present on the southern most ridge of Flat Top Mountain (section 25). No thin section was made of this rock, but an X-ray fluorescence analysis for K_2O indicates a potash feldspar content of about 10%. Numerous mafic dikes cut this body.

Leucocratic biotite granodiorite at Meier and Hogan Hill (E)

Light-colored biotite quartz diorite and granodiorite is exposed in the Hogan Hill and Meier areas (figures 2 and 3). Mineralogical compositions of these rocks are shown in Table 1 (samples 4AR19, 4AR44, and 4AR68). The margins of the biotite granodiorite at Meier are strongly foliated, but the central parts of the body are massive, and it is believed that the foliation is primary and developed by intrusion of the central part of the mass while the margins were largely consolidated. This conclusion is also supported by the fact that narrow aplite dikes cut the foliation but are not deflected by it. The rocks in both areas are medium to coarse-grained, and in addition to their similarity in general composition, both contain primary muscovite along with the biotite. The country rock adjacent to both intrusives has been noticeably metamorphosed, and at Meier considerable cataclastic deformation is evident near the contact.

These intrusives are tentatively considered as Jurassic by correlation with muscovite-biotite granodiorite in the eastern Talkeetna Mountains (Grantz, et al, 1963).

Intrusive basalt, andesite and dacite of Flat Top Mountain area (F)

Porphyritic basalt, andesite, and dacite as plugs and dikes intrude gabbro and granodiorite in the southern part of the Flat Top Mountain area (figure 5). Some bodies are unaltered and are completely aphanitic at contacts but other dikes are chloritized and sheared. The andesite (labeled g?) on the north side of Twelvemile Creek, and the dacite northeast of Meier Lake may be part of the same group of rocks, but are included in the older group of andesites on a geographic basis.

The age of these hypabyssal intrusives can be given only as later than the gabbro and coarse granodiorite of intrusive group D. If group D is older than Amphitheatre basalt, the hypabyssal intrusives may be co-magmatic with the Amphitheatre basalt magma.

STRUCTURE

West of the Gulkana River, the aeromagnetic data plus the few observatic of foliation made in this project suggest that litholigic units in the greenschist-amphibolite group strike approximately east-west. However, in both the Hogan Hill and Meier areas, the foliation trends southeast or south. The most obvious interpretation of this change in trend is that the foliation has been deflected around the biotite granodiorite plutons at Hogan Hill and Meier. No continuation of the beltlike aeromagnetic highs and lows east of the plutons is obvious, and it seems possible that the granitic rocks are intruded in a zone of more complex structure. Unfortunately, geologic data for a strip about 25 miles wide on the east side of the Richardson Highway are almost nonexistent.

In the Meier area, the plunge of minor fold axes is northwest to west at about 50 degrees. At Hogan Hill the axes plunge 50-75 degrees to the east and northeast. The significance of this difference is not known.

In gross form, the Amphitheatre basalt appears to occur in a broad syncline with older rocks exposed both north and south. West of the area shown on figure 1, the syncline trends approximately east-west with its axis near the Denali Highway. Near Paxson it curves southeastward. The synclinal nature of the north side is clearly indicated by southward dips of flows on Fish Creek (figure 7) and to the northwest near Eureka Creek (Rose, 1965). Flows on Paxson Mountain tend to strike northwest and dip gently both to the northeast and southwest. It is therefore concluded that the axis of the syncline is in this vicinity. The south limit of the basalt is presumed to be synclinal, but could equally well be faulted.

In the few exposures not covered by lichens, the Amphitheatre basalt was seen to be cut by numerous fractures, faults, and quartz-epidote veins. The attitudes of flows also appear to change abruptly in two localities, and vesicular zones could be followed only short distances. Based on this meager evidence, it is concluded that the basalt is broken into numerous small fault blocks, perhaps as a result of folding this brittle rock into a broad syncline.

Taken as a whole, joints in the Paxson Mountain area strike northwest and dip steeply southwest. The strike of the joints parallels the trend of the inferred syncline and may have developed during folding. East-west and north-south trends of joints are present on the lower slopes near Paxson and near the north end of the mountain. A series of light-colored hornblende andesite dikes (B_2) trends northeastward across the mountain near Paxson and are accompanied by several coarse gabbro or diorite bodies (B_1). Dikes are also common near the north end of the mountain. As discussed under economic geology, small copper prospects are concentrated in both areas of dikes and anomalous jointing.

From a regional view, the following tectonic and geologic units can be distinguished (from south to north):

1. Well-foliated greenschist and amphibolite.

2. Unfoliated greenstone, and andesite, intruded by gabbroic and dioritic rocks which may be plutonic equivalents of the Amphitheatre basalt.

3. Amphitheatre basalt, in the central part of a broad syncline, cut by gabbroic and dioritic intrusives.

4. Permian(?) sediments and volcanics dipping northward under the Amphitheatre basalt.

Units 1, 3, and 4 can be traced westward from the map area for many miles, based on the aeromagnetic data and reconnaissance mapping, but do not appear to continue to the east in such simple form (figure 1). This feature, plus the change in foliation and attitude of the rock units near the Richardson Highway suggests that an important north-south structural discontinuity may lie between the Richardson Highway and the Gakona River.

ECONOMIC GEOLOGY

Paxson Mountain Area

The occurrence of copper in the Paxson area was noted by Martin (1960, p. 20) as follows: "There is also a low-grade copper deposit in the gulch 1-1/2 or 2 miles west of Paxson's roadhouse". During construction of the Denali Highway, two claims were staked on other copper shows at Mile 7, and the prospect was visited and reported on by Saunders (1962) of the Division of Mines and Minerals. A dozen or more copper showings are known farther west in the Amphitheatre basalt (Kaufman, 1964, Saunders, 1961, MacKevett 1964b). Mineralized rock at these prospects typically consist of chalcopyrit bornite, and chalcocite accompanied by epidote and quartz in vesicular zones, volcanic breccias, and veins or pods. The Kathleen-Margaret prospect (Chapman and Saunders, 1954, MacKevett, 1964a) and locality 8 of Kaufman (196 which has since been trenched and drilled, are the largest known copper occurrences of this type. The K-M prospect is on a quartz vein in greenstone cut by diabase and light-colored porphyry. Locality 8 of Kaufman (1964) consists of copper sulfides and oxides in a volcanic(?) breccia zone. Limestone and argillite occur nearby, and a gabbro dike cuts the breccia.

About a dozen occurrences of copper were found on Paxson Mountain and are described below. Locality numbers refer to figure 7.

Locality 1

At this location, several narrow (less than 1 inch) bornite-chalcopyrite veins cut epidotized vesicular basalt. The veins strike N85W and dip 75°N. Asbestiform actinolite occurs in one vein. A few feet away from the copper-bearing veins, chrysocolla occurs in vesicles in epidotized basalt. A thin section shows that quartz accompanies the epidote, but that some pyroxene from the basalt remains unaltered.

Locality 2

A 1/4 inch vein of epidote and quartz striking N30W, vertical, contains bornite partly oxidized to chrysocolla. The vein occurs in altered and highly fractured rock that was probably basalt. A dark aphanitic dike cuts the outcrop. Alteration consists of epidote and chlorite, but does not appe any stronger near the mineralized vein.

Locality 3

This locality has been prospected by a pit, and may be the prospect referred to by Martin (1920). The exposure is on the steep east slope of an abandoned glacial stream channel cut in the basalt. Chrysocolla and chalcocite occur in a highly vesicular purplish-brown basalt flow. The relation are sketched in figure 10. The chrysocolla and chalcocite are most abundant near a fracture or fault at the north side of the exposure, and appear to die out near the south side of the vesicular zone. Faulting apparently offsets the mineralized unit at both the north and south sides of the exposure. The mineralized vesicular zone strikes N75E and dips about 35° NW. A chip sample across a thickness of 10 feet of the mineralized zone assayed 6.9% copper with no gold or silver. Although the grade is very encouraging, the mineralization appears to be limited in every direction except into the hill side. Additional geologic study combined with soil sampling may be effectiv in finding extensions of the mineralized zone that have been offset by faults.

Locality 4

Several pieces of copper-stained float containing minor chalcocite were noted in a frost boil at this location.

Locality 5

This copper show occurs in a zone of limonite-stained rock about 30 feet wide and extending along the wall of a gorge for 250 feet. The zone appears to dip north at about 20 degrees. The copper staining is at the southern end of the gorge. Pyrite, chalcopyrite, and bornite are associated with quartz-epidote veinlets and vuggy pods up to a foot long and 6 inches wide. The country rock is highly fractured and chloritized basalt.

Locality 6

Copper occurs as chrysocolla in a pod of highly altered vesicular basalt. The pod is about 3 X 2 feet in size. Vesicular basalt is common in this vicinity, but massive non-vesicular basalt or andesite with abundant hornblende prisms is exposed 3 feet above the copper-stained zone. Aleratio minerals are quartz, epidote and prehnite.

Locality 7

Several 1/2 inch veinlets of bornite cut vesicular purplish lava at thi location. The veinlets strike N3W and dip 80° W. Minor amounts of chalcoci accompany the bornite and both minerals are partly oxidized to malachite and chrysocolla. Amygdules in the lava are composed of opal. Float from the mineralized zone could be traced for about 100 feet along the strike of the zone.

Locality 8

An area about 20 feet long and 2-3 feet high on a cliff face in a gorge is coated with chrysocolla and malachite. The source of the copper appears to be a nearly flat zone of vesicular basalt containing minor amounts of bornite. Copper-bearing float was found in a gully a few tens of feet north, and an old claim post and several stakes were found at the top of the cliff. Traces of copper were also found on the opposite side of the gorge. A light-colored hornblende andesite dike cuts the flows a few hundred feet west. The dike and the mineralization at locality 8 are in line with the strike of the bornite veinlets at locality 7.

Locality 9

Bornite and quartz occur in a 1/2 inch vein trending N35E. Several pieces of float showing good copper stain were found downslope from the vein.

Locality 10

Mineralization at Mile 7 on the Denali Highway was staked in 1962 by Jack Tripp of Fairbanks. As can be seen on figure 11, copper minerals occur in the roadcut near the milepost, and also in pits and outcrops a few hundred feet southwest. The copper minerals are chalcopyrite, bornite and chalcocite or digenite, plus chrysocolla and possibly other oxidation products. Pyrite is present in a few places, especially in the road cut northwest of milepost 7 but is very sparse in the main part of the prospect and is not generally associated with the copper minerals. The copper minerals occur both in and adjacent to veins, pods and amygdules of quartz and epidote. Prehnite was identified in one well-mineralized sample. The host rock is vesicular basalt, mostly altered to chlorite and some epidote. The veins and pods are generally less than one inch wide, and can be traced only a few feet. A grab sample of quartz veins bearing chalcopyrite and bornite contained 1.38% copper, a trace of gold, and 0.30 ounces per ton of silver (Saunders, 1962). The exposed mineralized rock appears to be too spotty and low grade to mine, but there is extensive cover to the north and east of the claims and it is possible that better mineralization may exist in the vicinity.

Other copper occurrences in the Paxson Area

Traces of copper minerals were noted at several other locations on Paxson Mountain. These are similar to those discussed above, and generally amounted to only a few grains or amygdules filled with chalcopyrite. Small amounts were also found in basalt on the east side of Paxson Lake, north of the microwave relay tower.

Origin of copper in Paxson Mountain area

The geology, mineralogy, and host rock of the copper prospects on Paxson Mountain exhibit many similarities to the copper deposits of northern Michigan. In both areas, the host rock is amygdaloidal basalt in which plagioclase has been albitized. In northern Michigan, epidote, quartz, calcite, and prehnite are the main constituents of amygdules, and copper occu in amygdule zones at the top of flows; pumpellyite, microcline, and laumontit are also locally present. An obvious mineralogical difference is that the copper in northern Michigan occurs as native copper, while in the Paxson area it is in the form of chalcopyrite, bornite and chalcocite. This difference may not be important in considering the origin of the copper, because minor amounts of chalcocite are present in Michigan, and the formation of the sulfides at Paxson may result from a greater abundance of sulfur in the rocks of the area.

In a recent paper, Stoiber and Davidson (1959) demonstrate a mineralogical zoning in the amygdules and show that concentrations of copper occur most commonly near boundaries between alteration types, principally near the boundary between epidote and quartz. These writers find that the zoning is regional in extent, and attribute it to "hydrothermal" solutions generated by low grade matamorphism of more deeply-buried parts of the lavas. This theory seems reasonable for the Paxson area, in view of the lack of any obvious igneous source related to the mineralization, plus the presence of similar mineral occurrences throughout the Amphitheatre basalt.

As discussed under structure, the copper prospects are concentrated in areas of anomalous jointing and dike intrusion. The presence of structures cutting through the flows, plus a higher-than-average abundance of vesicular zones along the northeast side of Paxson Mountain may have allowed relative free circulation of copper-bearing solutions.

Areas south of Paxson Lake

Minor to trace amounts of copper were found in the following locations:

1. Traces of chalcopyrite occur with magnetite in greenschist and sheared diorite about 1/4 mile northwest of Meier Lake. The magnetite occurs in irregular pods up to an inch wide and a few inches long.

2. Pyrite and traces of chalcopyrite occur on fractures in biotite granodiorite in a quarry near the north end of the Hogan Hill outcrop area. Rock adjacent to the fractures is partly altered to orthoclase and chlorite.

3. In a quarry near the north end of the amphibolite exposures on Hogan Hill, small chalcopyrite-quartz veins are locally present along foliation. Minor copper stain was also noted near the southern end of Hogan Hill.

Several magnetic anomalies of 1500-2500 gammas are shown on the map of Andreason and others (1964). These anomalies probably result from magnetite in the greenschist. However, some mobilization of magnetite may have taken place to cause the strongest parts of the anomalies. If so, base metals might also be concentrated in these areas.

GEOCHEMICAL DATA

Locations of stream sediment samples are shown on figures 2 to 9 and data are in Table 2. The field results represent readily extractable copper, lead, and zinc by the University of Alaska cold extraction field procedure (Mukherjee and Mark Anthony, 1957). The analyses for copper, lead, zinc, molybdenum, and nickel were done by the Division of Mines and Minerals laboratories and Rocky Mountain Geochemical Laboratories using colorimetric methods designed to measure total metal content. These methods have been more completely discussed elsewhere (Rose, 1965).

For copper, the background averages about 50 parts per million (ppm) in stream sediments from the area, and a value of 100 ppm is taken as the lower limit or threshold of anomalous values. For zinc, background is mostly in the range 40-100 ppm, and 125 ppm is taken as threshold. For lead, most values are 5-15 ppm and 30 ppm is taken as threshold. For molybdenum, a value of 5 ppm is taken as threshold. For nickel, it is likely that background differs appreciably for different rock types, but too few samples were analyzed for nickel to determine probable threshold values. Samples 530 and 532 may be anomalous.

Of the known copper occurrences on Paxson Mountain, anomalous results were obtained only below locality 1 (sample R116). Sample 4WP41, just below locality 10, is not anomalous despite the presence of sparse pieces of copper-bearing float in the stream. It thus appears that weakly anomalous copper values in samples 4WP68, 4WP110, and 4AR196 may be derived from larger or more strongly mineralized areas than locality 10. However, these anomalies are still quite weak to be caused by an ore deposit.

The anomalies shown by samples 576, 79, 80, 81, 82, 83, 84, 85, 86, 87 and 88 deserve more follow-up work. The lithology in this area is apparent mainly basalt or other mafic rocks, based on observations while collecting stream sediments. Contamination during processing is another alternative, but other than the fact that every sample in this sequence is anomalous, there is nothing to suggest this.

The anomalies in total metal in the southern part of the area are relatively weak, with the lead content of sample W239 in the Twelvemile Creek area being the only strong anomaly. In addition to the total metal anomalies in samples H2, S69, W9, and W239, anomalies in readily-extractable metal were found in samples S62, S64, W250, and W251. These could result from an oxidizing sulfide body not exposed to physical erosion.

The following minerals were identified by Donald Stein, Assayer, Division of Mines and Minerals, in a panned concentrate from location S56: magnetite, chromite, ilmentite, olivine, zircon, scheelite, gold and sphalerite, plus a number of silicates. A trace of lithium was detected in spectroscopic examination. Glacial till may be the source of some of these minerals, but granite has been reported in this vicinity.

SUMMARY

The oldest rocks mapped in this project are pre-Triassic greenschists and amphibolites in the Meier and Hogan Hill areas. The greenschist and amphibolite underwent regional metamorphism accompanied by folding along east-west to southeast axes, probably in late Paleozoic time, before eruption or intrusion of greenstone and andesite in the Meier and Twelvemile Creek areas. Permian shale, limestone, and volcanic rocks were deposited on the north side of the area, but are not recognized in the southern part. Eruption of a thick sequence of mafic volcanics in Triassic time produced the Amphitheatre basalt. Gabbro and diorite intrude the Amphitheatre basalt and may have formed as part of the same magmatic epoch. Two leucocratic biotite granodiorite plutons of Jurassic(?) age intrude the pre-Triassic rocks in the southern part of the area, and gabbro, diorite and granodiorite of uncertain age are present in the Flat Top Mountain, Meier and Twelvemile Creek areas. The location of the granodiorite intrusives, combined with apparent deflection and termination of well-defined tectonic trends suggests that a major change in structural pattern occurs approximately along the Richardson Highway. A broad syncline with its axis along the belt of Amphitheatre basalt may have developed sometime between Jurassic and Middle Tertiary.

Small copper deposits on Paxson Mountain occur mainly in vesicular zones in Amphitheatre basalt. The copper occurrences are clustered in areas of dikes and anomalous joint trends. Chalcopyrite, bornite, and chalcocite in the deposits are associated with epidote, quartz, calcite, chlorite, and prehnite as veins, pods, amygdules, and replacements of rock minerals. The deposits are similar in geologic setting, gangue minerals, and local structural control to the copper deposits of northern Michigan, but differ in containing copper sulfides rather than dominantly native copper.

Numerous stream sediment samples from an area in the Amphitheatre Mountains are weakly to moderately anomalous in copper, zinc, and lead. Scattered samples elsewhere are weakly anomalous in one of these metals.

SUGGESTIONS FOR PROSPECTING

The geochemical anomalies in the Amphitheatre Mountains north of the Denali Highway deserve follow-up by additional sampling and prospecting. Because of the variety of metals present, the source does not appear to be a copper deposit of the type found on Paxson Mountain. The lead and zinc anomalies in the Twelvemile Creek area (W239, S69) and Meier area (H2) merit resampling and further work.

Assuming that the analogy with the copper deposits of northern Michigan is correct, a more thorough structural and mineralogical study of the entire belt of Amphitheatre basalt, using the criteria described by Stoiber and Davidson (1959), might allow selection of preferred parts of the belt for mineral deposits. However, in view of the relatively small amount of prospecting done to date in the area, it is probable that stream sediment sampling and ordinary prospecting are a cheaper and faster method of finding the more obvious deposits in the belt.

A rapid examination of the stronger magnetic anomalies in the southern part of the area seems justified to evaluate them for iron and other metals.

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Table 1 - Mineralogical Composition of Intrusive Rocks

	4H16	4AR19	4AR38	4AR44	4AR68	4AR174	4AR223	4AR231	4AR235
Quartz		27	10	21	30		7	29	7
K-feldspar		13		6	7		5	13	
Plagioclase	44(An_0)	53(An_{25-30})	30(An_{0-10})	64(An_{30})	59(An_{15})	28(An_{55})	4(An_{35})	41(An_{30})	50(An_{55})
Augite			tr			55			
Hornblende	35						10		25
Actinolite	5		29			5			
Biotite		4		5	3		15	10	5
Chlorite			5		1	2	tr		
Epidote	15		12	2		10	5	5	10
Muscovite-sericite		3	5	2	1		1		2
Carbonate	tr		8						
Opaque oxides	1		1	tr			1	tr	1
Pyrite			tr						
Apatite		tr	tr		tr		tr		
Sphene				tr			2	tr	
Name	Diorite or Gabbro	Grano-diorite	Quartz Diorite	Grano-diorite	Grano-diorite	Gabbro	Quartz Diorite	Grano-diorite	Quartz Gabbro
Intrusive Group	A_2	E	A_1	E	E	C	D_2	D_3	D_2

4H16 Coarse diorite or gabbro from ridge northwest of Meier.
4AR19 Gneissic biotite granodiorite from road cut at Meier Lake.
4AR38 Quartz diorite intruding greenstone in NW corner, Section 9, T12N-R1W. (Meier area)
4AR44 Biotite quartz diorite or granodiorite, SW Section 24, T12N-R2W (Meier area)
4AR65 Biotite quartz diorite or granodiorite, quarry at north end of Hogan Hill outcrop.
4AR174 Gabbro, Amphitheatre Mountain about 1½ miles NW of Mile 8, Denali Highway.
4AR223 Moderately foliated quartz diorite or granodiorite, SW Section 18, T13N-R2W (Flat Top Area)
4AR231 Biotite granodiorite, west side Section 1, T13N-R3W, (Flat Top area).
4AR235 Quartz-bearing gabbro, center Section 13, T13N-R3W (Flat Top area).

Table 2

Geochemical Data on Stream Sediments

Sample No.	Field Test (ml)	Copper (ppm)	Zinc (ppm)	Lead (ppm)	Moly. (ppm)	Nickel (ppm)	Fig. No.
R 29	1	20	50	5			3
30	2	25	50	10			3
32	2	60	55	0			3
35	2	65	55	15			3
36	1	40	65	10			3
36b	1	40	80	5			3
37	2?	65	70	10			3
46	7	50	90	10			3
47	1	45	55	5			3
65	2	45	50	15			3
69	2						2
105	1	45	110	15			6
107	2	50	60	10			6
116	2	135	105	15	3		7
118	1	25	50	5			7
122	1	40	45	10			7
196	2	130	95	10	3	45	7
244	2	45	65	5	2	45	7
245	2	50	110	15	2	35	7
432	1	25	50	5	1	25	4
W 1	2	25	90	15	0		2
2	2	45	80	10	0		2
3	1	50	85	5	0		2
4	1	45	75	10	3		2
5	1	40	60	10	0		6
6	1	45	110	5	0		6
9	1	75	140	15	0		6
10	4	40	100	15	0		7
11	2	50	100	5	0		7
12	1	65	40	0	0		7
13	1	40	50	10	0		7
14	2	60	50	15	0		7
15	2	50	55	5	0		7
16	5	50	40	5	0		7
17	1	35	45	10	0		7
18	1	45	85	15	0		7
19	10	50	65	5	4		7
21	1	55	55	10	0		7
22	2	55	70	5	0		7
23	1	70	100	10	0		7
24	?	50	60	5	0		7

Sample No.	Field Test (ml)	Copper (ppm)	Zinc (ppm)	Lead (ppm)	Moly. (ppm)	Nickel (ppm)	Fig. No.
W 25	1	45	55	15	0		7
26	1	50	90	10	0		7
27	1	40	70	5	0		7
28	2	45	65	0	0		7
29	10?	85	70	5	0		7
30	1	75	90	10	0		7
31	1	50	80	15	3		7
32		35	65	5	0		7
33	1	50	65	10	0		7
34	4	50	70	0	0		7
35	1	65	85	15	0		7
36	1	55	70	10	0		7
37	1	70	90	10	0		7
38	1	50	80	15	0		7
39	1	45	60	5	0		7, 8
40	1	75	90	15	0		7, 8
41	1	65	80	10	0		7, 8
42	1	45	80	5	0		7, 8
43	1	65	65	5	0		7
44	1	60	70	5	0		7
45	3	40	30	5	0		7
52	1	50	80	5	0		7
53	1	50	90	10	0		7
54	1	45	60	5	0		7
55	2	35	55	0	0		7
56	6?	40	55	5	0		7
57	1	40	55	5	0		7
58	2	45	60	0	0		7
59	2	40	100	10	0		7
60	2?	35	45	5	0		7
68	3	110	110	5	1		7, 8
92	1	85	40	5	0		7
103	1	50	40	5	1		7
104	2	35	50	25	1		7
105	2'	50	70	<25	1		7
107	1	50	45	5	1		7
108	1	45	45	5	2		7
110	1	130	55	0	1		7
112	1	55	50	5	1		7
113	3	85	50	20	1		7
114	2	90	50	5	1		7
121	1	85	55	0	0		8
132	2	20	35	5	0		5
133	11?	35	80	5	1	50	5
237	1	25	50	5	3		4
238	5	20	45	5	3		4

Sample No.	Field Test (ml)	Copper (ppm)	Zinc (ppm)	Lead (ppm)	Moly. (ppm)	Nickel (ppm)	Fig. No.
W239	1	40	145	100	3		4
240	1	20	65	5	3		4
241	1	35	40	5	3		4
242	1	30	55	10	3		4
243	1	20	40	5	3		4
244	2?	20	35	5	3		4
245	1?	15	35	5	3		4
246	2?						4
247	1	20	40	5	3		4
248	2?	35	65	5	3		4
249	1	35	50	5	3		4
250	10?	20	45	5	2	15	4
251	25?	30	50	5	2	35	4
252	1	20	40	10	3		4
H 2	1	50	55	35			3
3	1	75	75	20	4		3
6	2	25	50	0			3
M 1	1	40	65	5			3
2	2	50	50	5			3
S 16	2	45	40	5	3	40	9
17	5	45	40	5	3	190	9
18	2						9
19	2						9
20	2						9
21	2						9
22	2						9
23	1						9
24	2						9
25	2						7
26	2						7
27	2						8
28	2						9
29	2						9
30	8	125	100	0	3	350	9
31	2						8
32	1	70	70	20	3	225	8
33	1						8
34	1						8
35	1						8
36	1						8,
37	1						7, 8
38	1						9
39	2						9
40	2						8
41	2						8

Sample No.	Field Test (ml)	Copper (ppm)	Zinc (ppm)	Lead (ppm)	Moly. (ppm)	Nickel (ppm)	Fig. No.
S 42	2						8
43	1						8
44	11	45	65	0	2		8
45	1						8
46	1						8
48	15	35	70	10	2		8
49	1						8
50	2						3
51	3	20	85	10	2		6
52	6	30	80	10	2		6
53	1	35	60	5	2	30	6
54	1						7
55	2						8
56	2						8
61	1	55	35	20	3		4
62	20	55	95	10	3		4
63	2	20	50	10	3		4
64	20	45	110	5	3		4
65	3	20	35	10	3		4
66	1	40	80	5	4		4
67	2	20	35	5	3		4
68	1	10	35	10	3		4
69	1	10	25	35	3		4
71	1	15	25	0	2	55	9
72	1	45	50	15	3	50	9
73	1	60	65	5	4	170	9
74	1	40	35	10	3	80	9
75	1	75	80	0	4	50	9
76	1	110	50	10	5	85	9
77	2	75	80	5	3	55	9
79	3	70	130	10	3	90	9
80	1	200	400	20	10	120	9
81	4	130	400	30	5		9
82	2	130	80	15	4	60	9
83	1	85	170	5	3	50	9
84	1	80	125	15	4	80	9
85	1	120	80	10	3	85	9
86	1	140	80	10	3	115	9
87	20	190	480	35	8		9
88	2	75	300	10	7	80	9

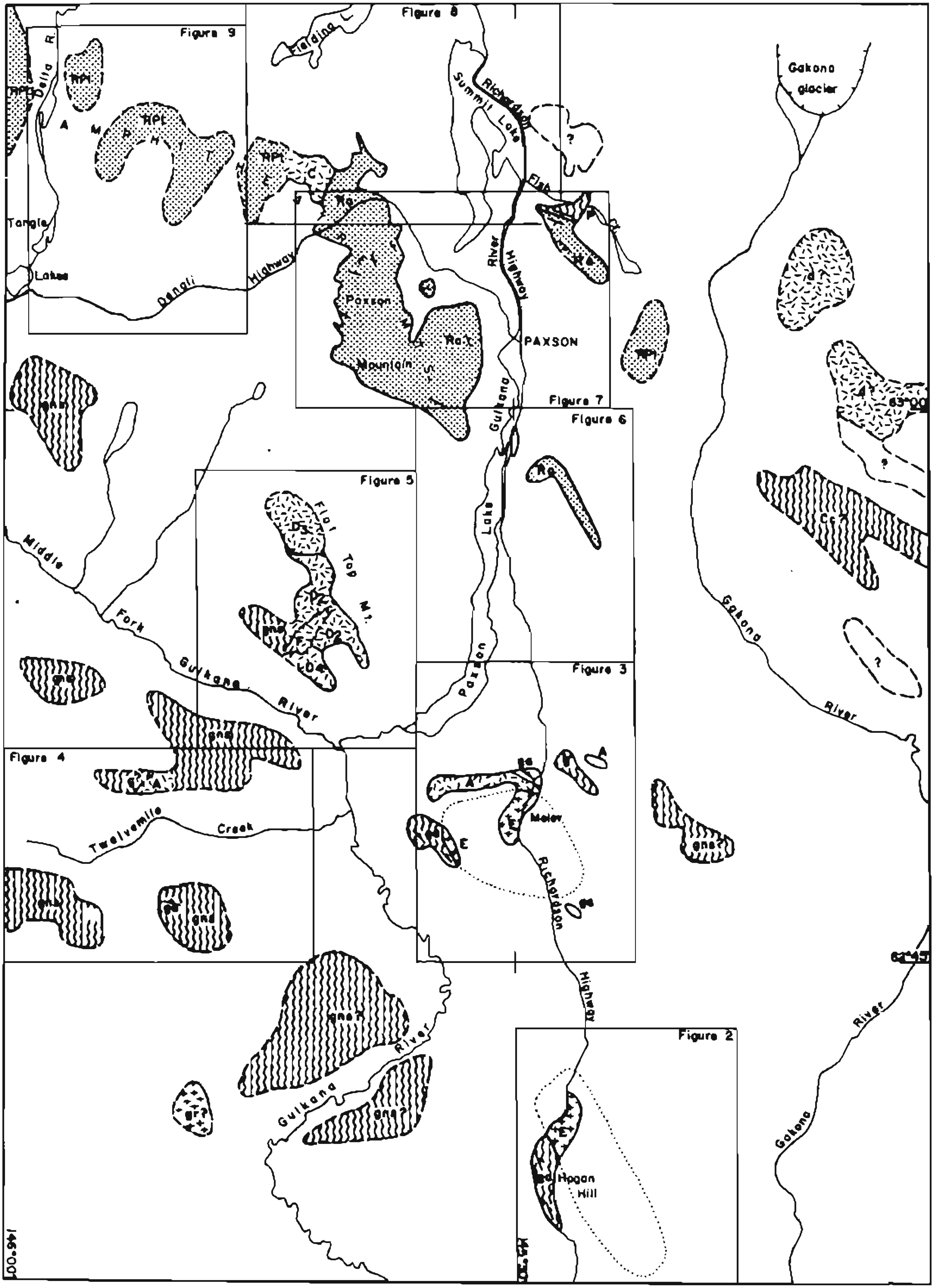


Figure 9
Figure 8
Figure 7
Figure 6
Figure 5
Figure 4
Figure 3
Figure 2
Delta R.
Tangle
Lakes
Denali Highway
Fielding
Summit Lake
Richardson
Flat
Gakona
glacier
Paxson
Mountain
PAXSON
River
Highway
Gulkana
Lake
Paxson
Flat Top Mt.
Middle Fork Gulkana River
Twelvemile Creek
Meier
Richardson
Highway
Gulkana River
Gakona River
Gakona River
Hogan
Hill
63°00'
62°45'
146°00'
145°30'

LEGEND FOR FIGURES 2 THROUGH 9

INTRUSIVE ROCKS

Mesozoic(?)	F	Basalt, andesite and dacite (Flat Top Mountain area)
Jurassic(?)	E	Leucocratic biotite granodiorite (Meier and Hogan Hill areas)
Mesozoic(?)	D_4	Coarse granodiorite (Flat Top Mountain area)
	D_3	Biotite granodiorite (Flat Top Mountain area)
	D_2	Quartz gabbro (Flat Top Mountain area)
	D_1	Gabbro (Flat Top Mountain area)
	C	Gabbro and diorite (Amphitheatre Mountains)
Triassic(?)	B_2	Hornblende andesite (Paxson Mountain)
	B_1	Gabbro (Paxson Mountain)
	A_2	Coarse diorite or gabbro (Meier area)
	A_1	Diorite and quartz diorite (Meier and Twelvemile Creek areas)

VOLCANIC, SEDIMENTARY AND METAMORPHIC ROCKS

Triassic	TRa	Amphitheatre basalt
Permian(?)	Pv	Rhyolite, andesite and limestone
	Ps	Slate and quartzite
Pre-Triassic(?)	g	Greenstone and andesite
Pre-Triassic	ga	Greenschist and amphibolite

32	Strike and dip of flows or bedding
25 50	Strike and dip of foliation, and plunge of minor folds and other lineations
80	Strike and dip of joints
	Geologic contact (dashed where inferred)
O W8	Stream sediment sample and number
Cu	Anomalous stream sediment sample, and anomalous metal
X 3	Mineralized locality and number
	Geologic traverse (figures 2-5 only)

Figure 2

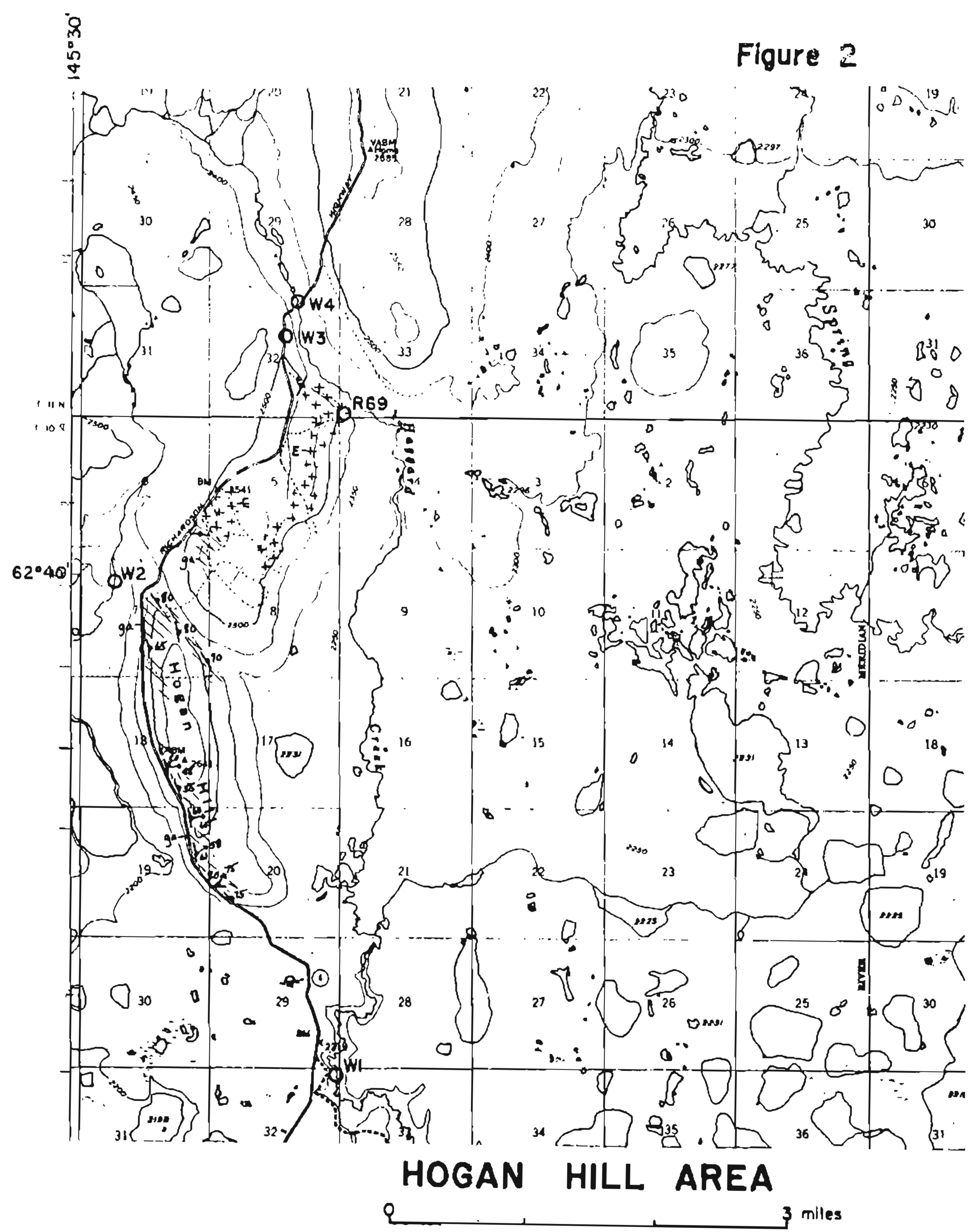
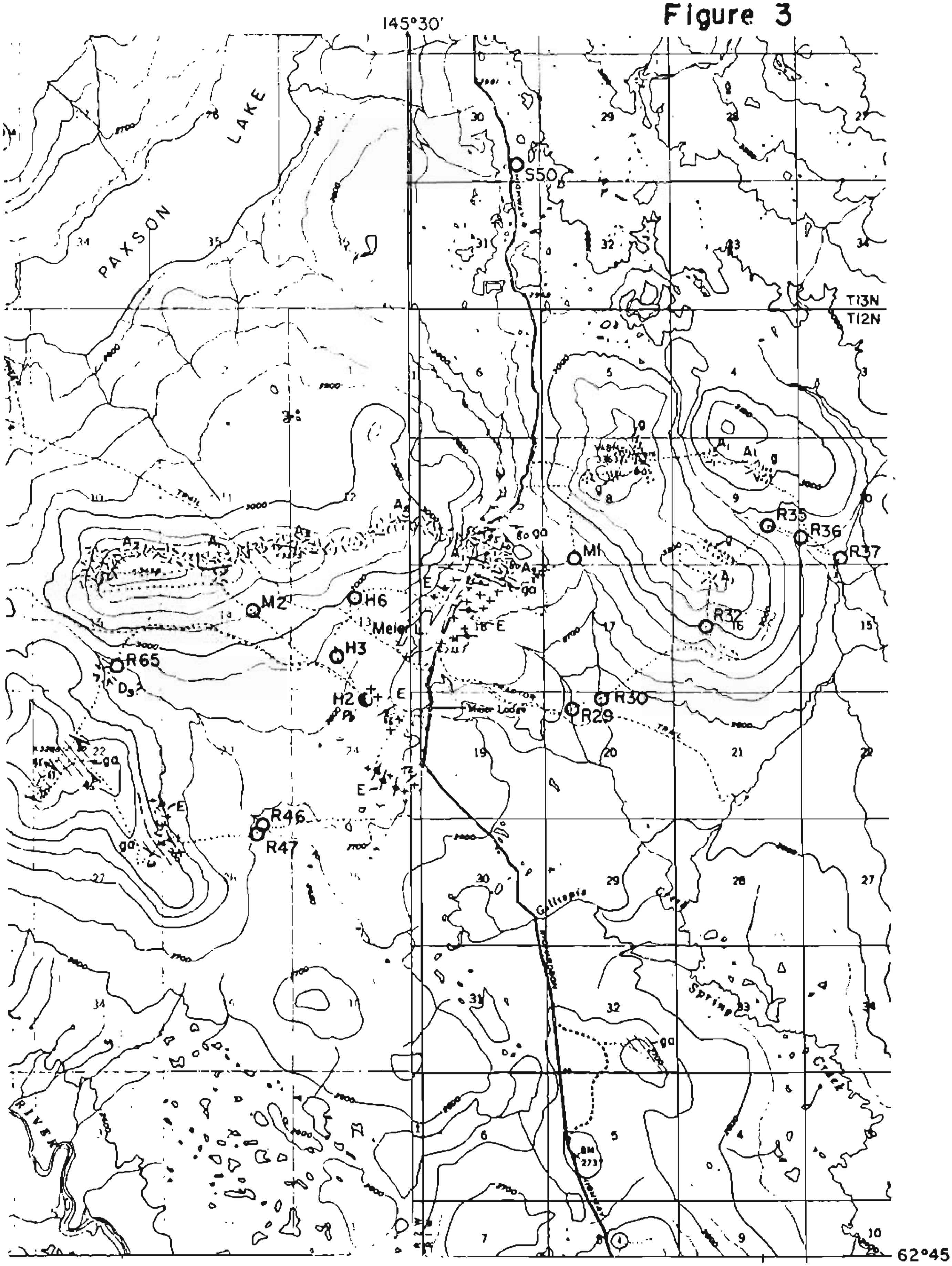
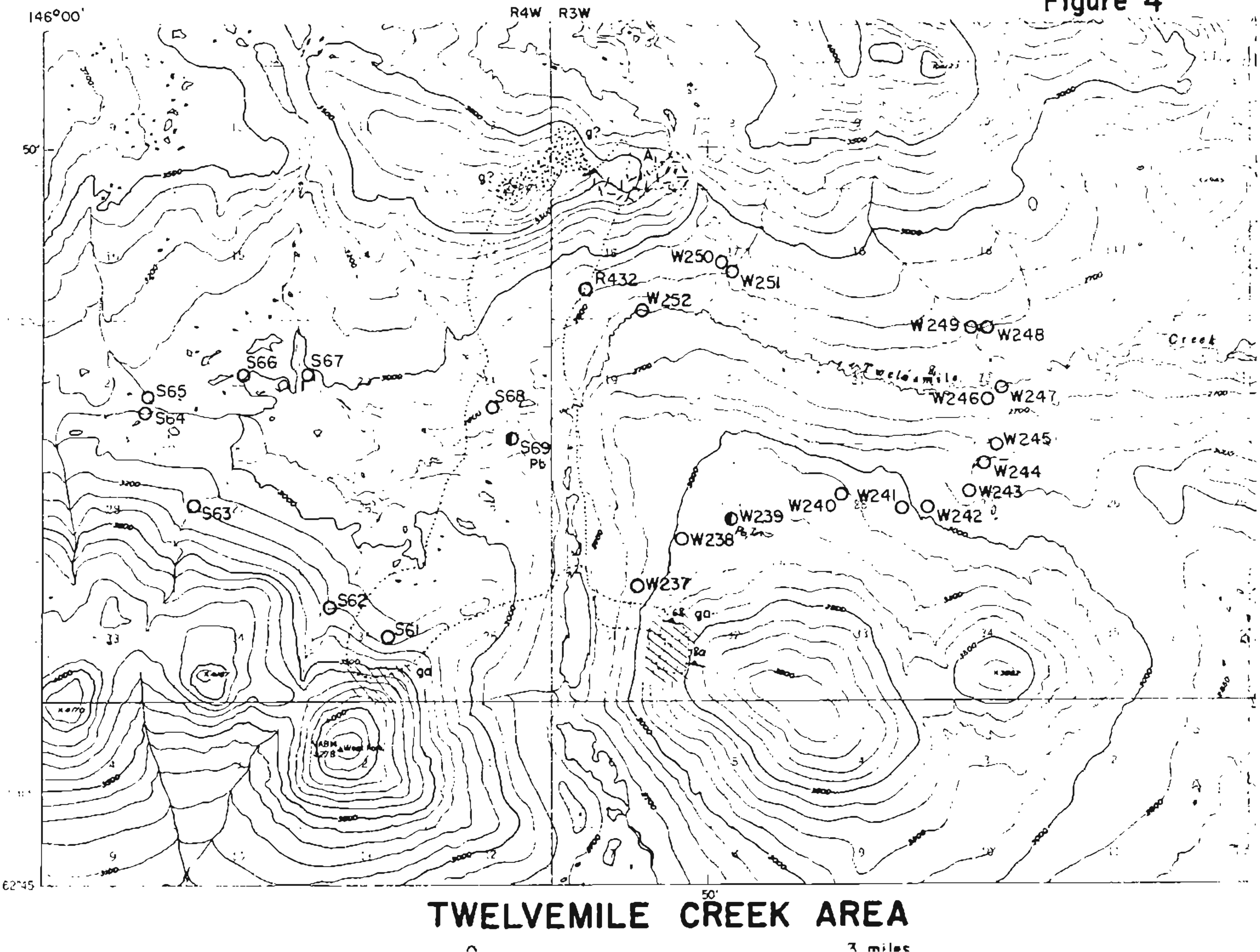

145°30'
62°40'
W4
W3
R69
W2
W1
HOGAN HILL AREA
0
3 miles
See separate legend

Figure 3



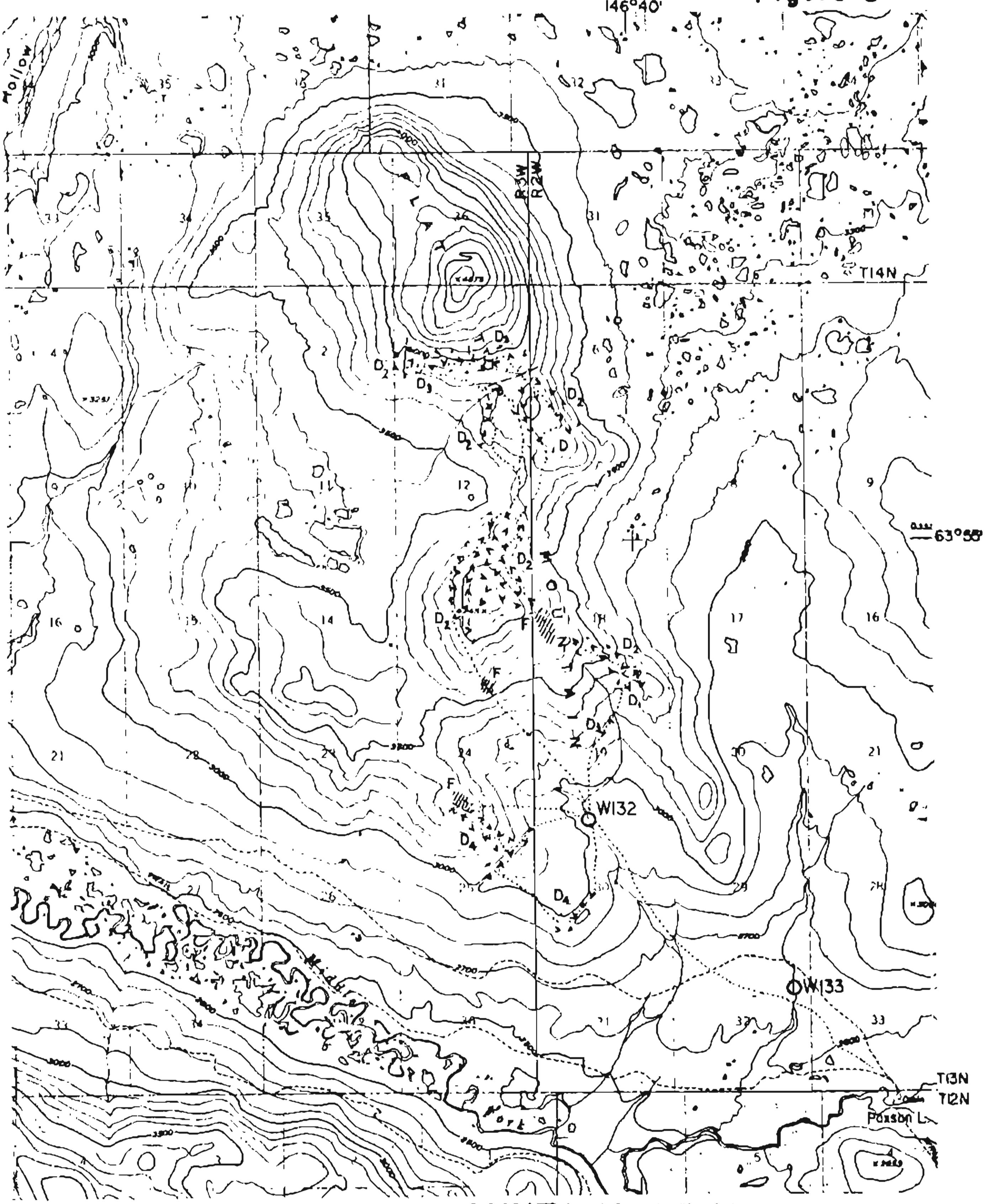
MEIER AREA

Figure 4



TWELVEMILE CREEK AREA

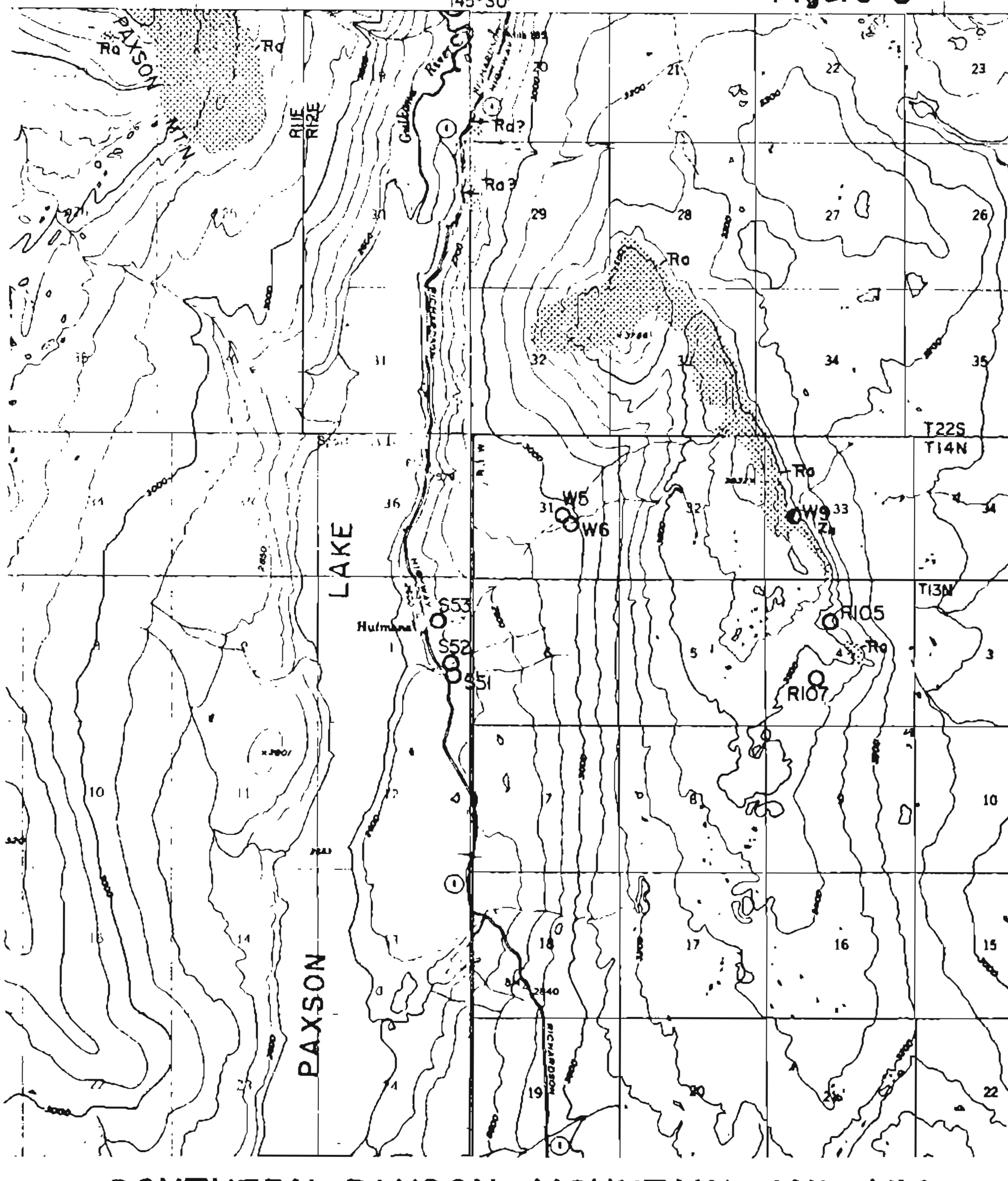
Figure 5



FLAT TOP MOUNTAIN AREA

0 3 miles

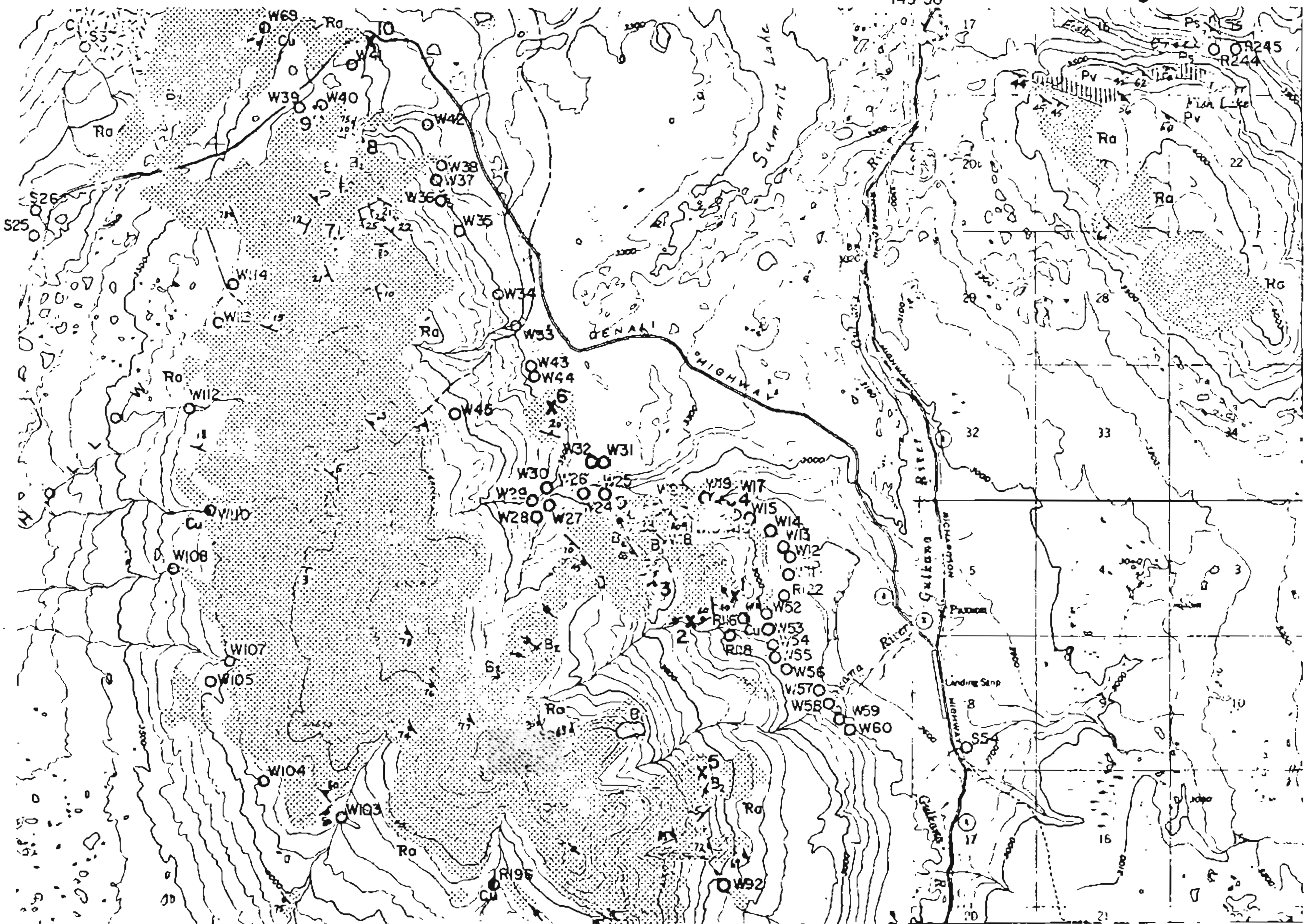
Figure 6



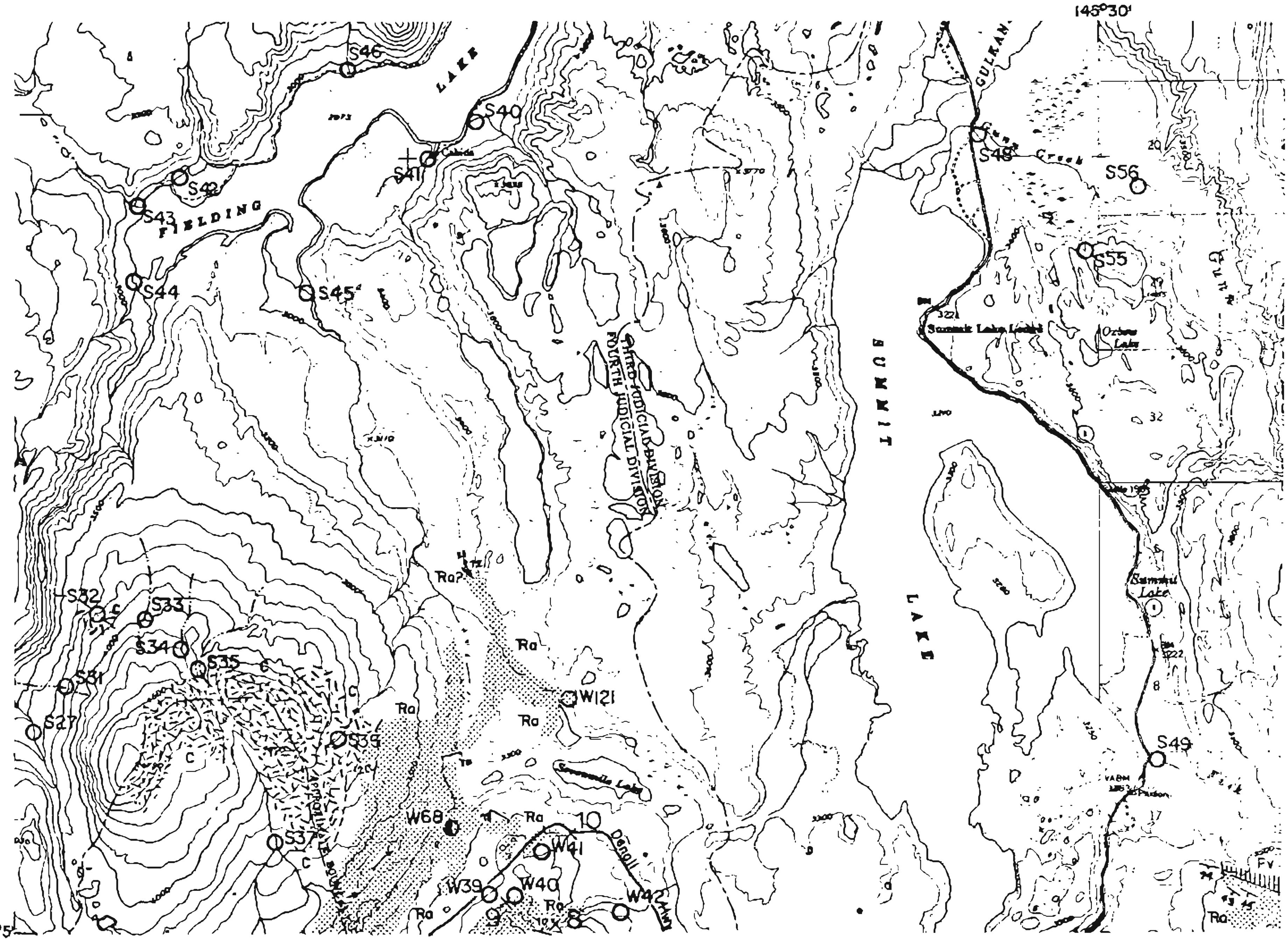
SOUTHERN PAXSON MOUNTAIN AND VIC.

0 3 miles

Figure 7



PAXSON MOUNTAIN AND FISH CREEK

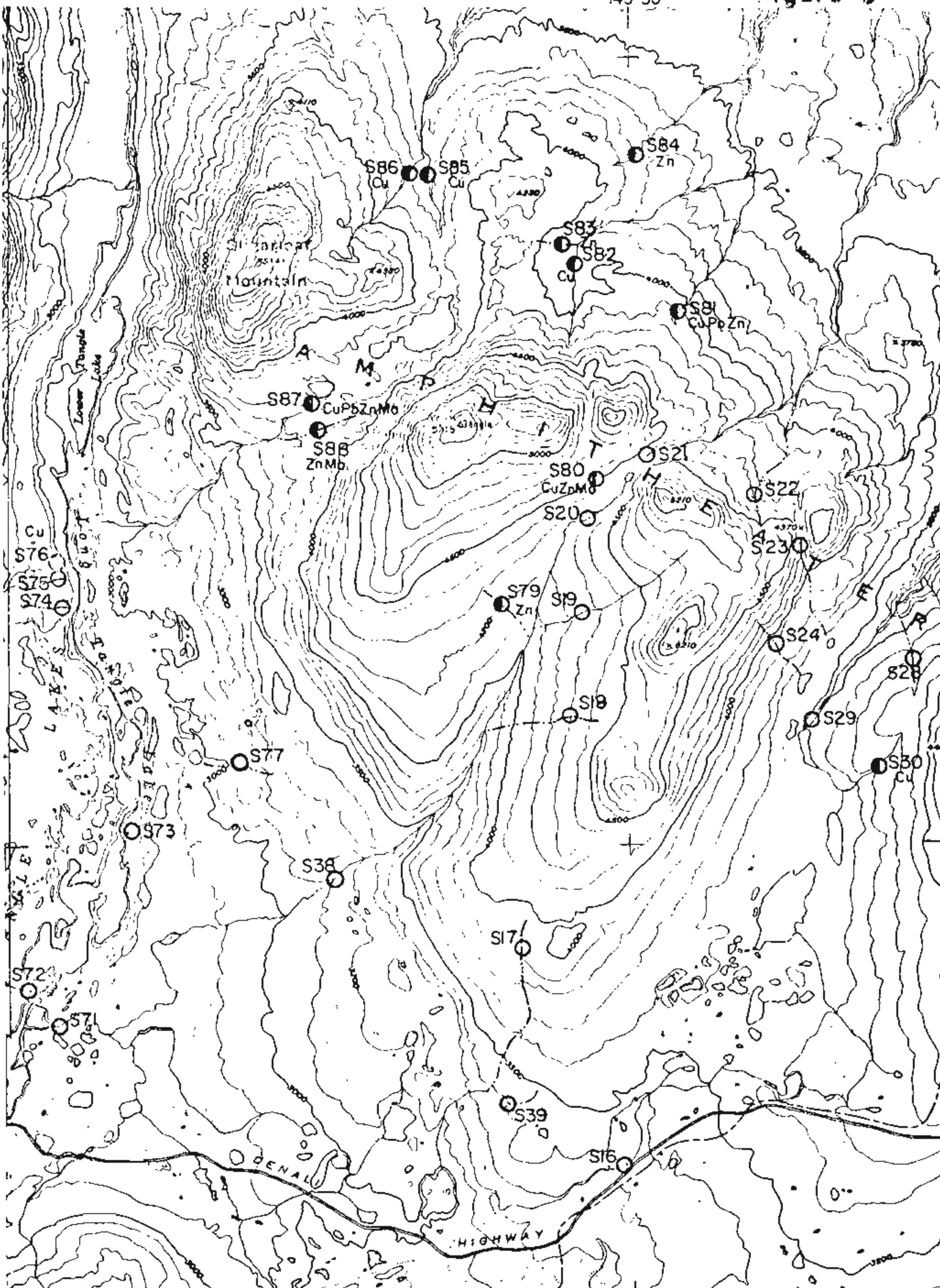


NORTHERN PAXSON MOUNAIN AND VICINITY

0 3 miles

Figure 8

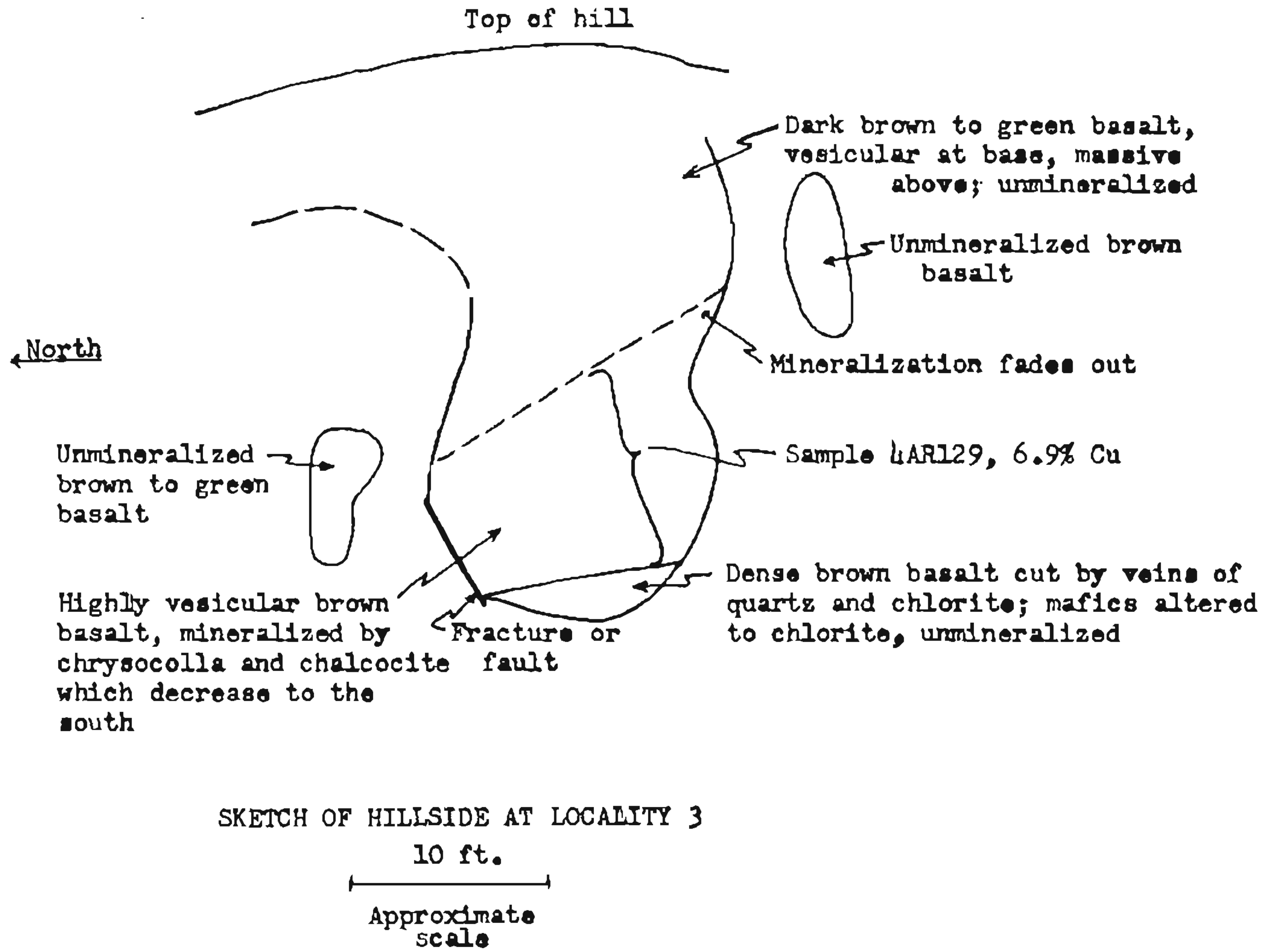
Figure 9



AMPHITHEATRE MOUNTAINS

0 — 3 miles

FIGURE 10



SKETCH OF HILLSIDE AT LOCALITY 3

Looking east

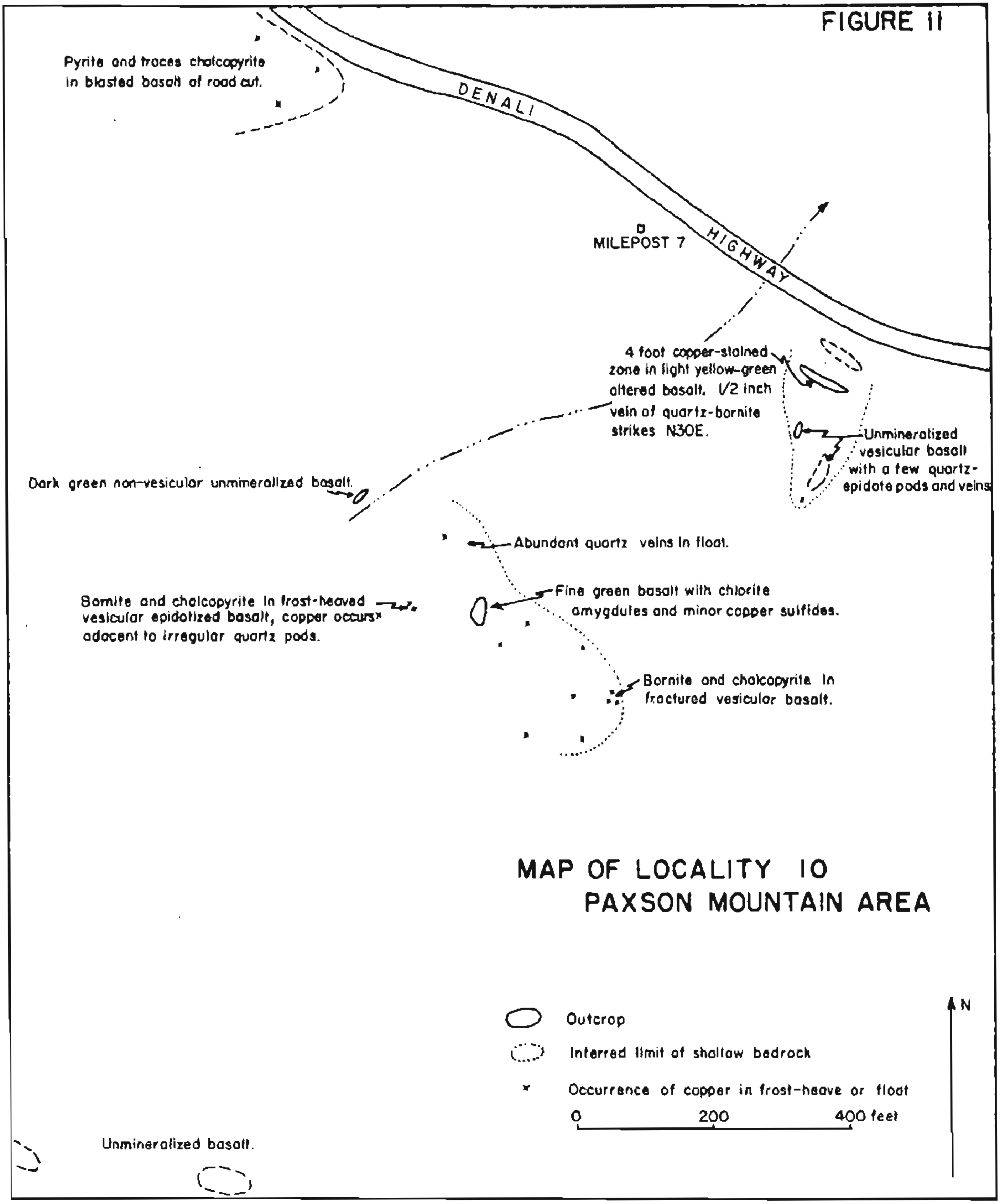


FIGURE 11
Pyrite and traces chalcopyrite in blasted basalt of road cut.
DENALI
HIGHWAY
MILEPOST 7
4 foot copper-stained zone in light yellow-green altered basalt. 1/2 inch vein of quartz-bornite strikes N30E.
Unmineralized vesicular basalt with a few quartz-epidote pods and veins
Dark green non-vesicular unmineralized basalt.
Abundant quartz veins in float.
Bornite and chalcopyrite in frost-heaved vesicular epidotized basalt, copper occurs adjacent to irregular quartz pods.
Fine green basalt with chlorite amygdules and minor copper sulfides.
Bornite and chalcopyrite in fractured vesicular basalt.
MAP OF LOCALITY 10
PAXSON MOUNTAIN AREA
Outcrop
Inferred limit of shallow bedrock
Occurrence of copper in frost-heave or float
0
200
400 feet
N
Unmineralized basalt.