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PROSPECT ASSESSMENT

1981 RECONNAISSANCE PROGRAM

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Summary

The purpose of this project was to evaluate the geothermal potential of known mercury, sulfur and alunite deposits in the western United States. The success of this exploration philosophy has been demonstrated by our discovery of the Alum and Fishlake properties and the heat anomalies associated with the Gilbert Junction, Rast, and Pershing prospects. The project, initiated in August, 1980, is now complete.

Five prospects identified in 1981 were targeted for detailed assessment work (Figure 1). All have been geologically mapped over an area of approximately 41 square kilometers. One to three shallow gradient holes (50 to 100m) were drilled at each prospect in order to determine heat flow.

The thermal anomalies associated with the prospects indicate fault control. Mineralization is Quaternary - Tertiary in age and the following heat flow values have been measured:

Prospect	Max. Heat Flow (HFU)	Rating
Needles	3.5	average
Crater	1.4	average
Noquez	7.6	excellent
Poinsettia	4.0	good
Cina	1.8	average

As a result of the geological and heat flow assessment work conducted on the above prospects during November and December, 1981, we recommend the following:

1. Detailed geologic mapping should be completed at the Noquez prospect.
2. Based on the linearity of the gradient logs at Noquez, 8 to 10 fifty meter gradient observation holes should be drilled to identify the extent and configuration of the anomaly.

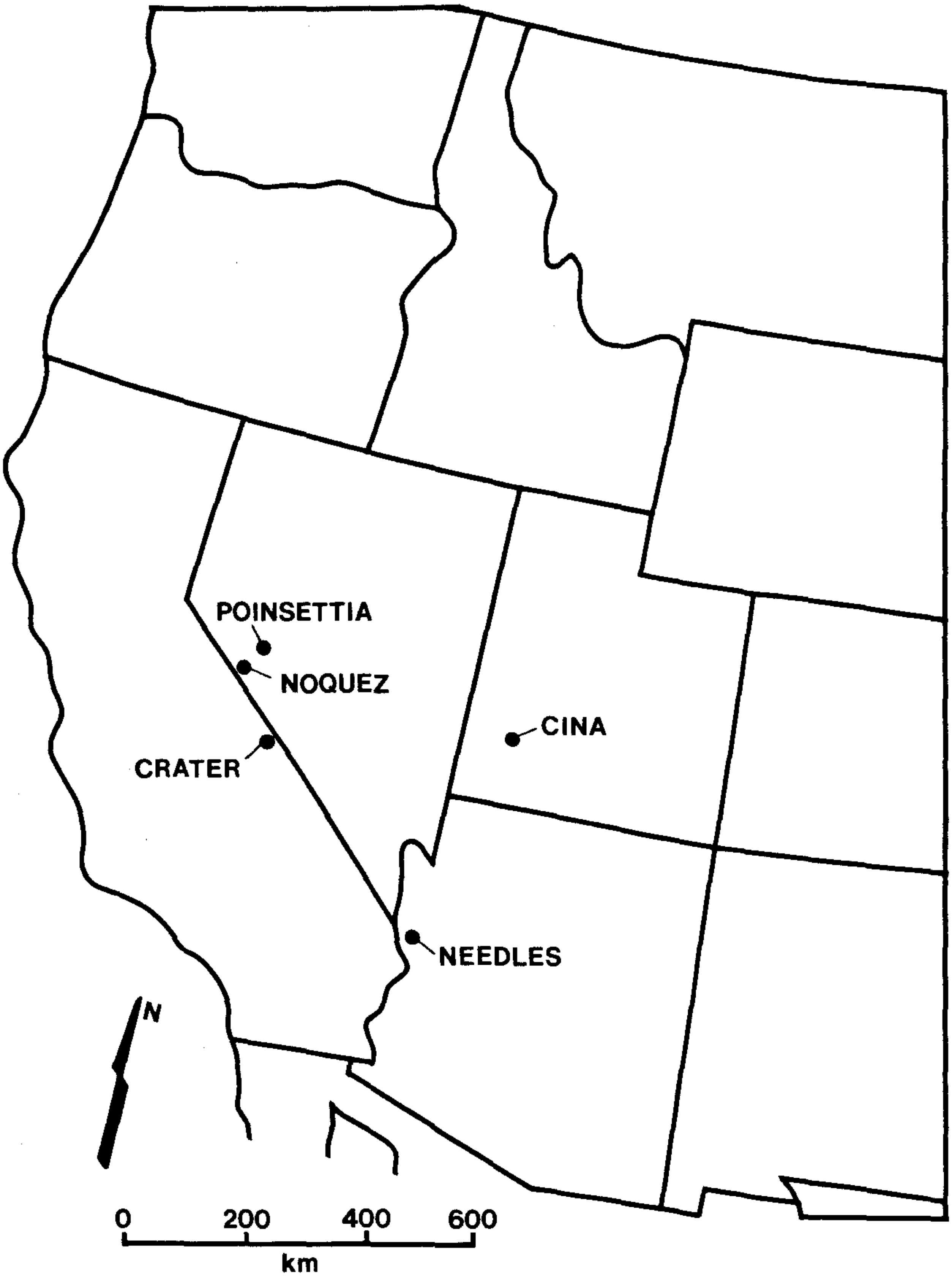


Figure 1. Prospect Location Map. 1981 Program.

Introduction

O'Brien Resources Corporation undertook a geothermal exploration program during 1980-1981 based on field evaluation of known mercury/sulfur/alunite deposits in the western United States. This program led to the identification of thirteen geothermal prospects warranting further investigation. Eight of the thirteen prospects were identified during the 1980 exploration program described in Mercury and Sulfur Reconnaissance Program, August 1980 to January 1981 by Garry Maurath and William Teplow, February 9, 1981 (Table 1).

Table 1. Geothermal prospects identified during the 1980 exploration program.

Program	County	State
Alum	Esmeralda	Nevada
Fishlake	"	"
Gilbert Junction	"	"
Pershing	Pershing	"
Rast	Lander	"
Silver Cloud	Elko	"
Horsehead	Harney	Oregon
Opalite	Malheur	"

This report presents the results of preliminary assessment work performed on five additional prospects identified during the 1981 field season (Table 2). The exploration program leading to these discoveries is described in Mercury/Sulfur/Alunite Reconnaissance Program, August 1980 to October, 1981 by Frank Dellechaie, Garry Maurath and William Teplow, October 26, 1981.

Table 2. Geothermal prospects identified during the 1981 exploration program.

Prospect	County	State
Needles	Mohave	Arizona
Crater	Inyo	California
Noquez	Mineral	Nevada
Poinsettia	"	"
Cina	Iron	Utah

The assessment work for each prospect consisted of geologic mapping and shallow gradient drilling. Each prospect description in this report contains a detailed geologic discussion accompanied by a geologic map and cross-section, thermal gradient curves, lithologic drill logs and interpretation of thermal data.

The geologic mapping for each prospect covered an area of 42 square kilometers (16 sections). The prospects were mapped at a scale of 1:24,000 using U.S.G.S. 7½' quadrangles for base maps. The Crater, California prospect was an exception to this format since only 1:62,500, 15' quadrangles were available for this region. Emphasis in mapping was placed on extent, intensity and mineralogy of hydrothermal alteration and on structures that may control hydrothermal activity.

One to three shallow holes, from 50 to 126 meters deep, were drilled at each prospect. Holes were cased with 3/4 inch PVC pipe which was filled with water and allowed to equilibrate for at least 72 hours before thermal gradients were determined. Temperature and depth measurements were made using an Enviro-Labs thermal probe equipped with an Olympic wire counter. Where possible, existing mineral holes, water wells and windmills in the vicinity of the prospects were also probed.

Recommendations for further assessment work and continuation of the exploration program are given at the conclusion of the report.

Needles Prospect

Introduction

The Needles kaolinite prospect is in Section 35 of Township 17 North, Range 19 West, Mohave County, northwestern Arizona (Figure 2). The prospect is located forty kilometers east of Needles, California. Access is by graded road from Franconia Siding on Interstate 40.

The prospect lies at an elevation of 488 to 640 meters in an area of moderate relief at the southern terminus of the Black Mountains. Erosional remnants of Cenozoic and Late Mesozoic volcanic flows form the host rocks. One large open face cut and several small prospect pits comprise the workings. The drainage divide between the Sacramento Valley to the east and Mohave Valley to the west is approximately 3 kilometers northeast of the prospect. The prospect lies in the Mohave Valley drainage basin which drains into the Colorado River, 24 kilometers to the west.

The arid climate supports only sage and cacti. No permanent human habitation or other cultural activities exist in the immediate vicinity at this time. The Oatman mining district lies 24 kilometers to the northwest. The Topock-Kingman trunk line of the Arizona power grid passes within 13 kilometers of the prospect.

Regional Geology

The Black Mountains are a block faulted mountain range of the Basin and Range Province. Rocks ranging in age from Precambrian to Recent

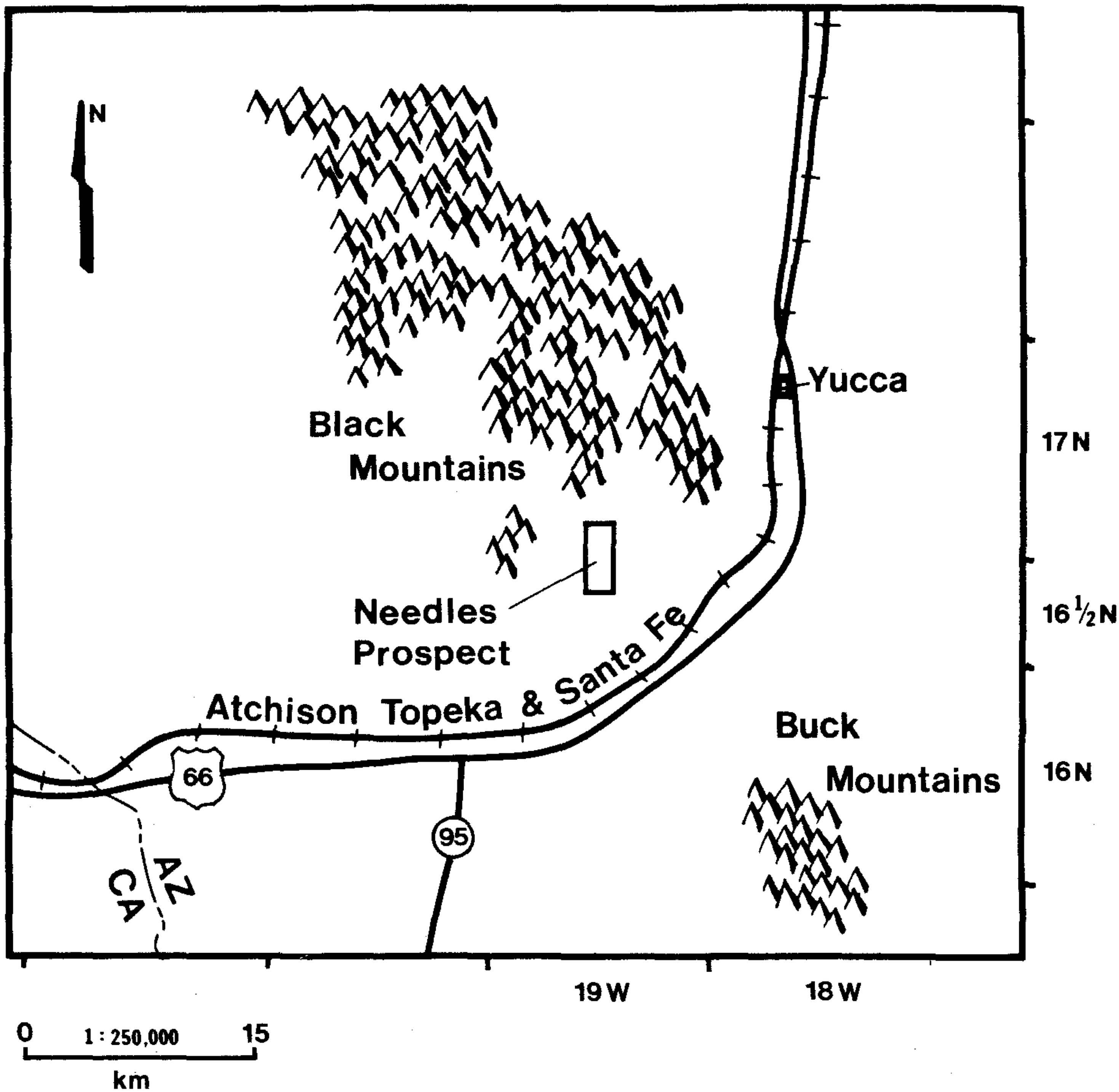


Figure 2. Location Map. Needles Prospect. Mohave County, Arizona.

outcrop within the range. Granite, granite-gneiss and schist form the majority of Precambrian rocks. Approximately five percent of the surface exposures within the Black Mountains are Precambrian. The Hualpai and Mohave Ranges to the east and south are composed almost entirely of Precambrian rocks. These rocks are unconformably overlain by the Gold Road Volcanics, which consist of Cretaceous andesite.

Cenozoic rhyolites, tuffs, and basalts overlie the Gold Road Volcanics. The extrusive volcanic deposits in the southern portion of the Black Mountains generally dip to the west and southwest. Granitic stocks associated with the Larimide orogeny are located forty kilometers to the northwest, on the far side of the Oatman mining district.

Range front faulting associated with the uplift of the Black Mountains has a vertical displacement of at least 910 meters. Several photolinears, striking northeast and southeast cross the prospect.

<u>Rock Units</u>

Silicic to basic pyroclastic and flow units comprise the majority of outcrops within the map area (Figure 3). Basement consists of Precambrian granite. Approximately 914 meters of Cretaceous rocks unconformably overlie the granite. The base of this unit is not exposed within the map area. A Tertiary silicic pyroclastic unit, approximately 50 meters thick overlies the Cretaceous units and is conformably overlain by Quaternary rhyolite and basalt flows.

The Precambrian basement (p€g) is composed of a medium grained, light pink granite. The granite weathers to reddish brown angular blocks.

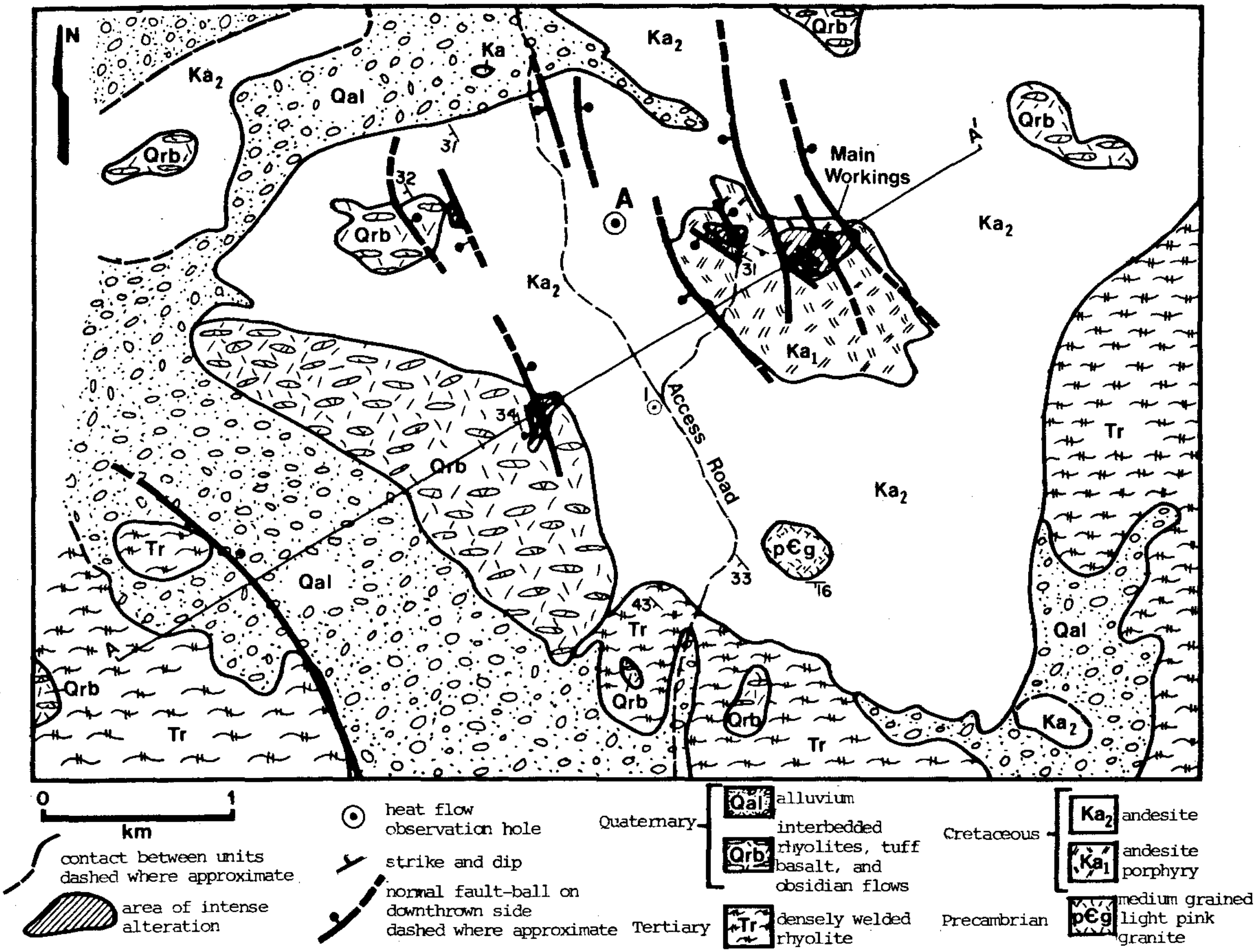


Figure 3. Geologic Map. Needles Prospect. Mohave County, Arizona

Near the contact with younger units the granite weathers to rounded hummocky surfaces and is very friable. There is a moderate amount of hematite staining. Siliceous veins up to a few millimeters wide are common.

The predominant unit in the map area consists of a series of Cretaceous andesite (Ka_2) flows, which overlie the granite. Flows vary in thickness from 1 to 10's of meters. The andesite is reddish gray in color with abundant subhedral sanidine in a gray to dark red glassy groundmass. The unit is locally brecciated and veined with secondary calcite. A 20 meter thick, poorly consolidated, light gray andesitic air fall tuff is interbedded with the andesite. The Ka_2 unit represents several cycles of eruption. The unit gradually becomes more silicic and the percentage of groundmass decreases towards the top of the unit. Some minor flow banding is evident.

A Cretaceous fine to medium-grained andesite porphyry (Ka_1) intrudes the Ka_2 unit in the form of a small volcanic plug. The rock is buff to light red in color and weathers to dark reddish brown. The base of the unit is not exposed in the map area. The unaltered rock is well indurated and contains minor amounts of subhedral biotite. The rock is a resistant unit and displays some horizontal banding. A one meter thick quartz vein cuts the unit in the southeast quarter of Section 35.

In the southern portion of the map area a Tertiary rhyolite unit (Tr_1), approximately 50 meters thick overlies the andesite. The rhyolite is light gray, fine grained and contains silicic lenses which have been brecciated.

The unit is locally vesicular. The rhyolite was deposited unconformably on the Cretaceous andesite which had developed a surficial topography on the order of 10's of meters.

The rhyolite grades into a sequence of interbedded Quaternary rhyolite and basalt flows (Qrb). This unit consists of a series of silicic and basic flows ranging in thickness from 1/2 meter to greater than 20 meters. The basic member is a discontinuous light green to light gray, fine grained, vitric rhyolitic tuff which is interbedded with a light red to buff crystal tuff. The crystal tuff is thinly bedded with minor iron staining and abundant biotite crystals. The vitric tuff is massive and locally vesicular. It has a noticeably lower percentage of ferro-magnesium minerals than the crystal tuff. Lenses of an agglomeratic tuff with rhyolitic xenoliths are locally interbedded between the crystal and vitric tuffs. The crystal tuff weathers to a light gray color and the vitric tuff weathers to greenish gray rounded slopes. The agglomerate weathers to a light brown with dark gray to red clasts.

Overlying the tuffs is a buff to light tan rhyolite, interlayed with dark vesicular obsidian flows. The 2 - 5 meters thick obsidian flows are lenticular in shape and contain abundant subhedral feldspar crystals. A 1/3 to 1/2 meter thick discontinuous bed of nodules in a fine grained dark gray silicic matrix separates the rhyolite-obsidian sequence from a medium red, fine grained, vuggy quartz rhyolite. Overlying the quartz rhyolite is a vesicular basalt. This resistant unit caps most of the prominent hills within the map area.

The youngest unit is Quaternary alluvium (Qal) comprising the valley fill. The alluvium is composed of andesite, rhyolite and basalt cobbles and boulders in approximately equal proportions.

Structure

Thinning of the pyroclastic and flow units to the south and southwest indicates that the eruptive center was located northeast of the map area within the Black Mountains. Several high angle normal faults trend southeast through the map area (Figures 3 and 4). These faults create a horst - graben structure which is Late Quaternary in age. Displacement along these faults ranges from a few meters to more than 40 meters. The entire area has been uplifted and tilted to the southwest in conjunction with the uplift of the Black Mountains.

The Precambrian granite in Sections 20 and 21 appears to have been a topographic high when the Cretaceous rocks were deposited.

Alteration and Hydrothermal Activity

Alteration within the map area is confined to fault zones largely within Cretaceous rocks. The alteration consists of intense argillization resulting in massive, highly bleached, kaolinite in Sections 35 and 36. In the area of the mine workings, veins of opalite and chalcedony with minor amounts of alunite are associated with the fault zones. The veins are discontinuous and range from a few millimeters to 20 centimeters thick. Cinnabar deposition is closely associated with the secondary siliceous veining and decreases towards the surface. Fault zones outside the highly altered zones are characterized by partially silicified breccia. Age of

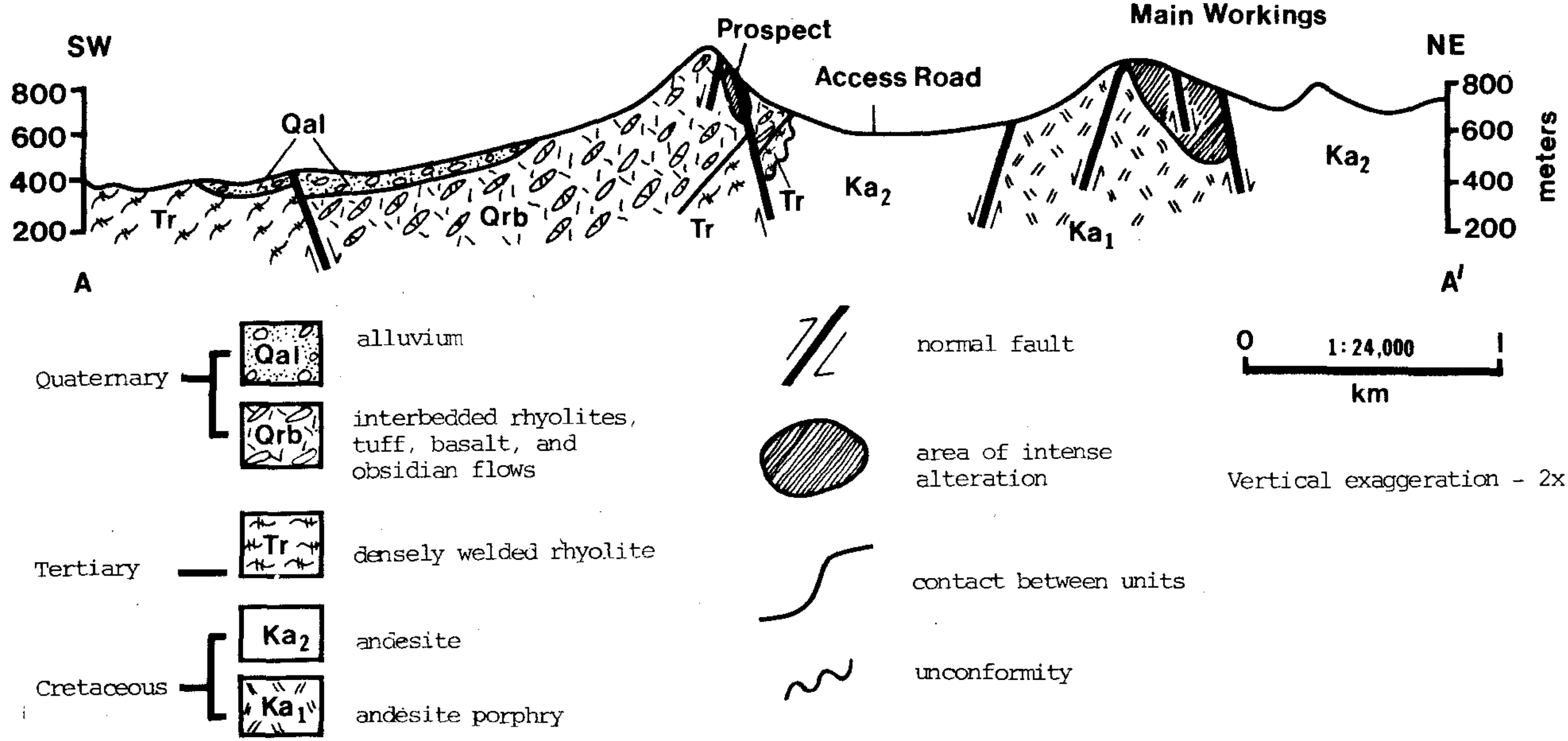


Figure 4. Geologic Cross Section A-A′. Needles Prospect. Mohave County, Arizona.

the alteration is probably Middle to Late Quaternary.

Heat Flow

A mineral exploration hole in Section 35 (Figures 3 and 5) has a geothermal gradient of 10°C/km and a bottom hole temperature of 26.34°C at 24 meters. The borehole is in andesite which results in an uncorrected heat flow of 0.6 HFU. The mean annual surface temperature in this area is between 25° and 27°C indicating that the high bottom hole temperature is probably due to environmental effects and is not indicative of a thermal anomaly.

A single 99 meter gradient observation hole was drilled near the center of the prospect (Figure 3). Lithologic and temperature logs of the hole are shown in Figure 6. The thermal gradient is approximately 46°C/km from 30 to 85 meters in depth and increases to 56°C/km from 85 to 99 meters. This yields a mean heat flow of 3.5 HFU with a bottom hole temperature of 28.93°C.

Extrapolation of the thermal gradient gives a mean annual surface temperature of 24.2°C which is slightly below normal. The uniformity of the lithology and thermal gradient suggest that conduction is the principle method of heat transfer.

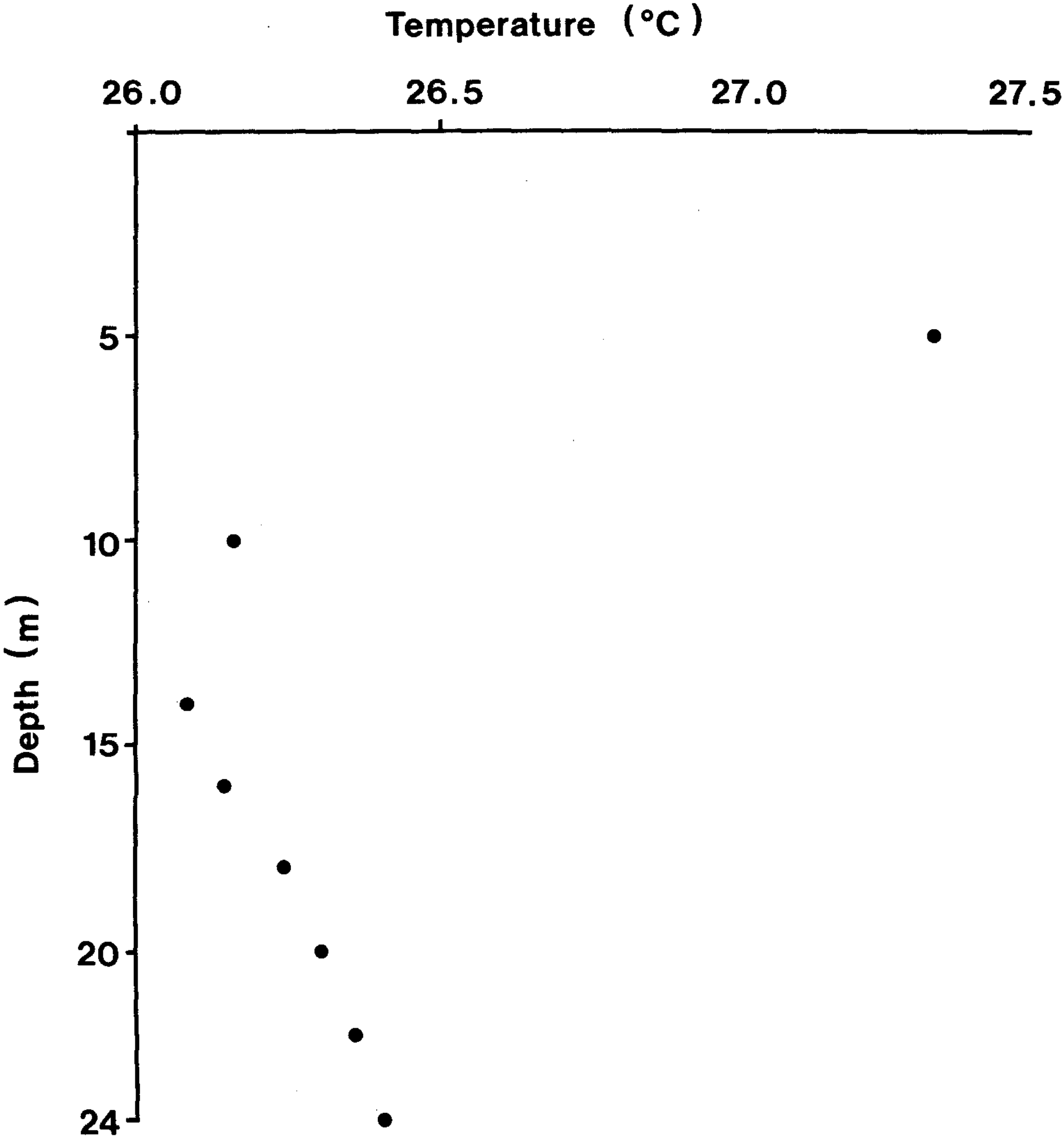


Figure 5. Thermal Gradient Curve Mineral Hole A. Needles Prospect Mohave County, Arizona. ΔT = 10°C/km; k - 6 T.C.U.; q = 0.6 H.F.U. Logged November 19, 1981.

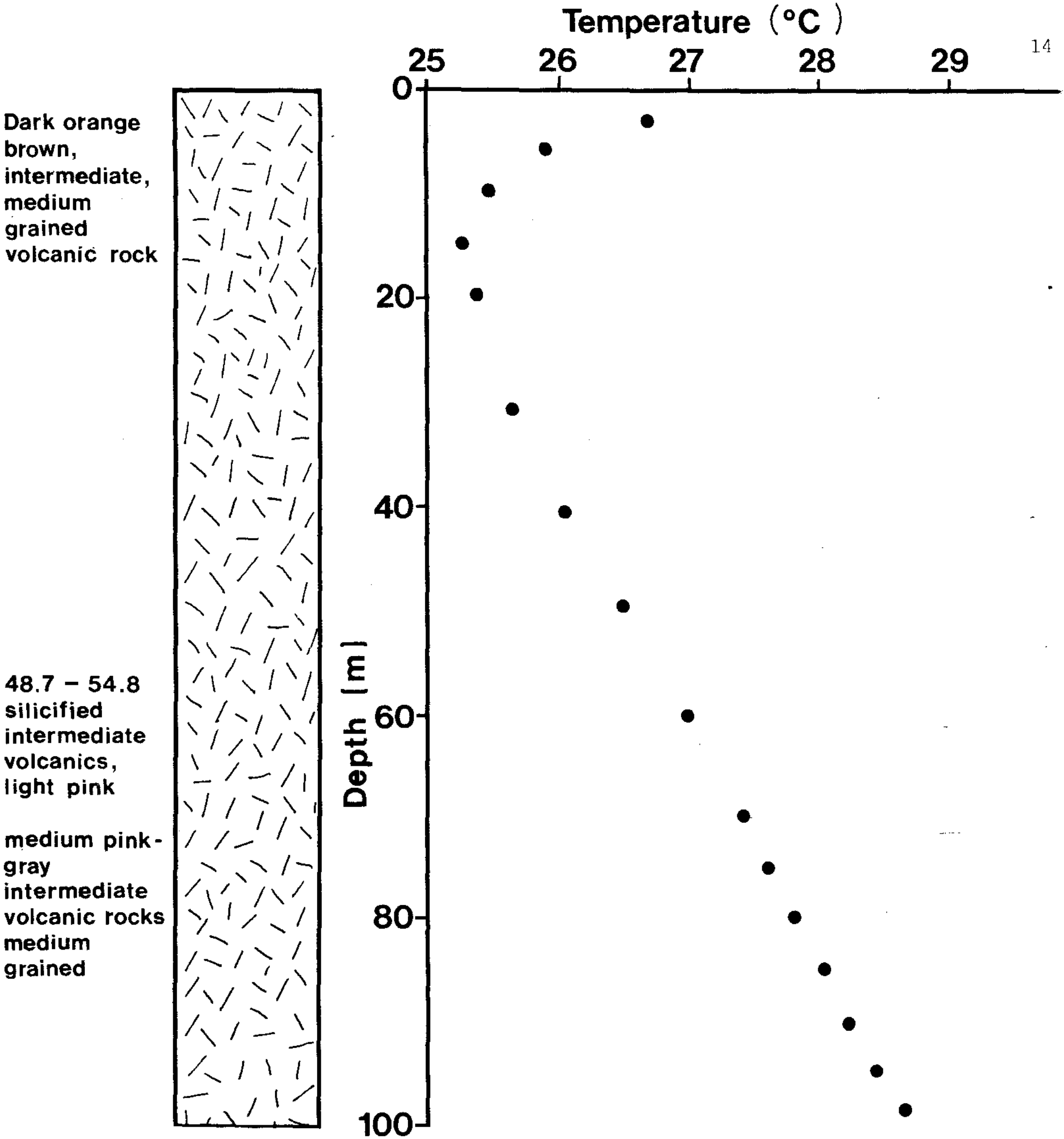


Figure 6. Lithologic Log and Thermal Gradient Curve D.H. #1.
Needles Prospect. Mohave County, Arizona.
ΔT = 46 °C/km; k = 7.5 T.C.U.; q = 3.5 H.F.U. 0–60 meters
ΔT = 56 °C/km; k = 6.3 T.C.U.; q = 3.5 H.F.U. 60–100 meters

Crater Prospect

Introduction

The Crater prospect is located at the Crater sulfur mine, Sections 27, 33 and 34, Township 8 South, Range 39 East in Inyo County, California. The prospect lies 55 kilometers east of Big Pine, California and is reached via the Big Pine - Death Valley Road which passes directly through the sulfur mine (Figure 7).

The Crater prospect is located in an intermontane basin near the crest of the Last Chance Range. The range trends north-northwest and is bounded by Eureka Valley on the west and Death Valley - Last Chance Canyon on the east. The basin lies at an elevation of 1590 to 1830 meters, trends northeast and is 3 kilometers long and 0.5 - 1.0 kilometer wide. The basin lies on a drainage divide and drains both eastward to Death Valley and westward to Eureka Valley. The climate is extremely arid and supports only a sparse growth of sage. Depth to ground water in the Eureka Valley is over 200 meters while in Death Valley a number of springs surface along the Furnace Creek Fault zone. Sparse growths of pinyon are found above 2000 meters. The region supports a small herd of open range cattle. The sulfur mine has been inactive since the 1930s, but the area is currently staked with mineral claims. No geothermal leasing has occurred in the area which is administered by the Bureau of Land Management.

Regional Geology

The Last Chance Range consists of Lower Paleozoic quartzites,

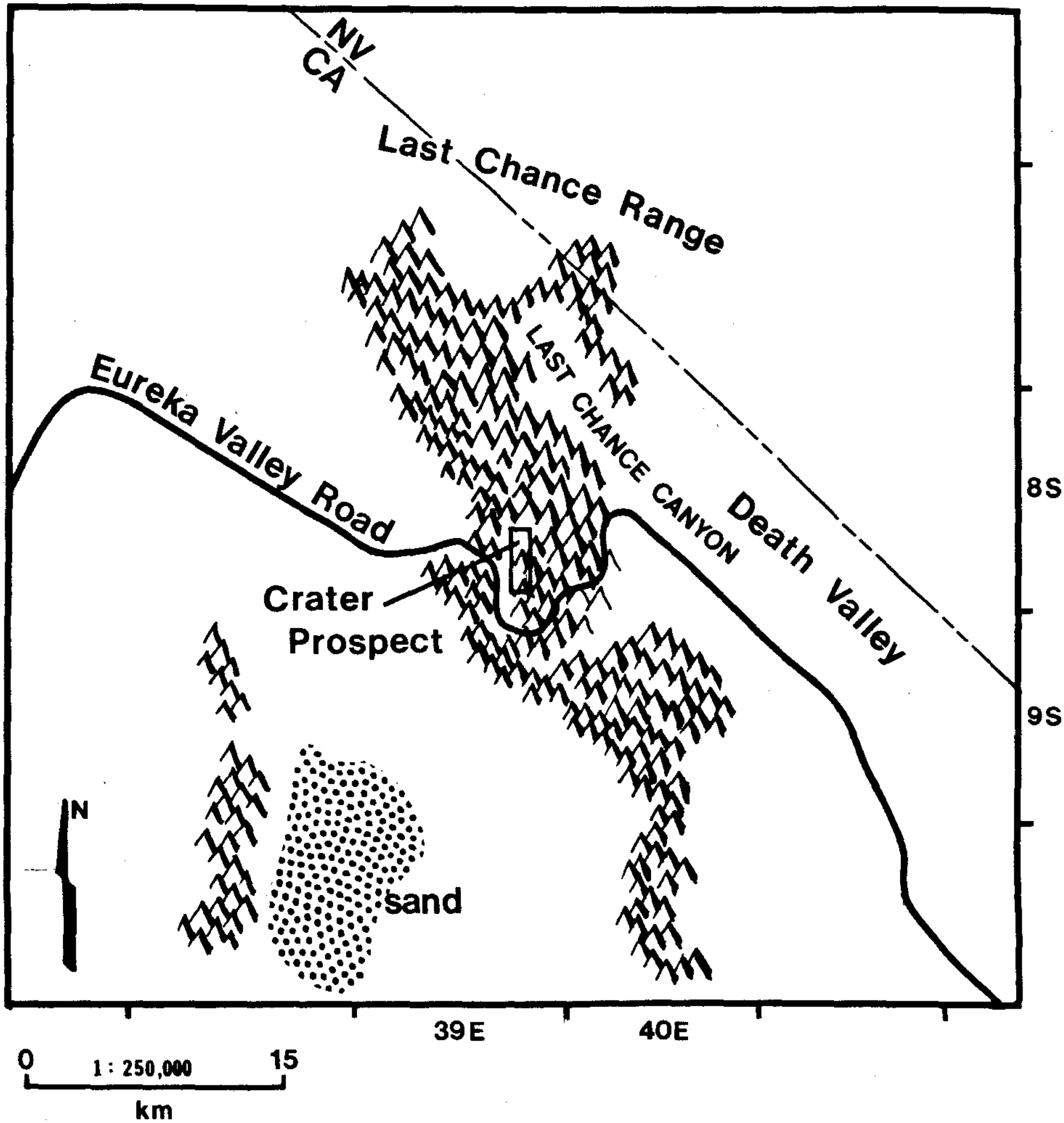


Figure 7. Location Map. Crater Prospect. Inyo County, California.

carbonates and fine grained clastic rocks. The Paleozoic section has been locally intruded by Cretaceous granitic rock and is overlain by Tertiary silicic and intermediate volcanics. Minor quantities of Quaternary basalts and tuffs are found along the western margin of the range.

The range is bounded on the east by the Furnace Creek Fault which is a right lateral strike slip fault with up to 50 miles of displacement. The western margin of the range is formed by high angle normal faults which offset late Quaternary fanglomerates. The Last Chance Thrust, probably Mesozoic in age, is well exposed west of the range axis.

Rock Units

A discontinuous sequence of Paleozoic carbonate and marine clastic units make up the bulk of the rock in the map area. Four of these units are Cambrian and one is Mississippian in age. These units are overlain by Late Tertiary tuffs and fanglomerates locally intruded by Quaternary basalt (Figure 8).

The lowest unit in the Paleozoic sequence is the Zabriskie Quartzite (€z). The quartzite is fine grained, massive and pink to light gray in color. It forms prominent light colored knobby outcrops with coarse talus aprons. Neither the top nor bottom of the unit is exposed, but the minimum thickness is at least 180 meters.

The Carrara Formation (€c) overlies the Zabriskie Quartzite but the contact is not exposed in the map area. The unit consists of thinly

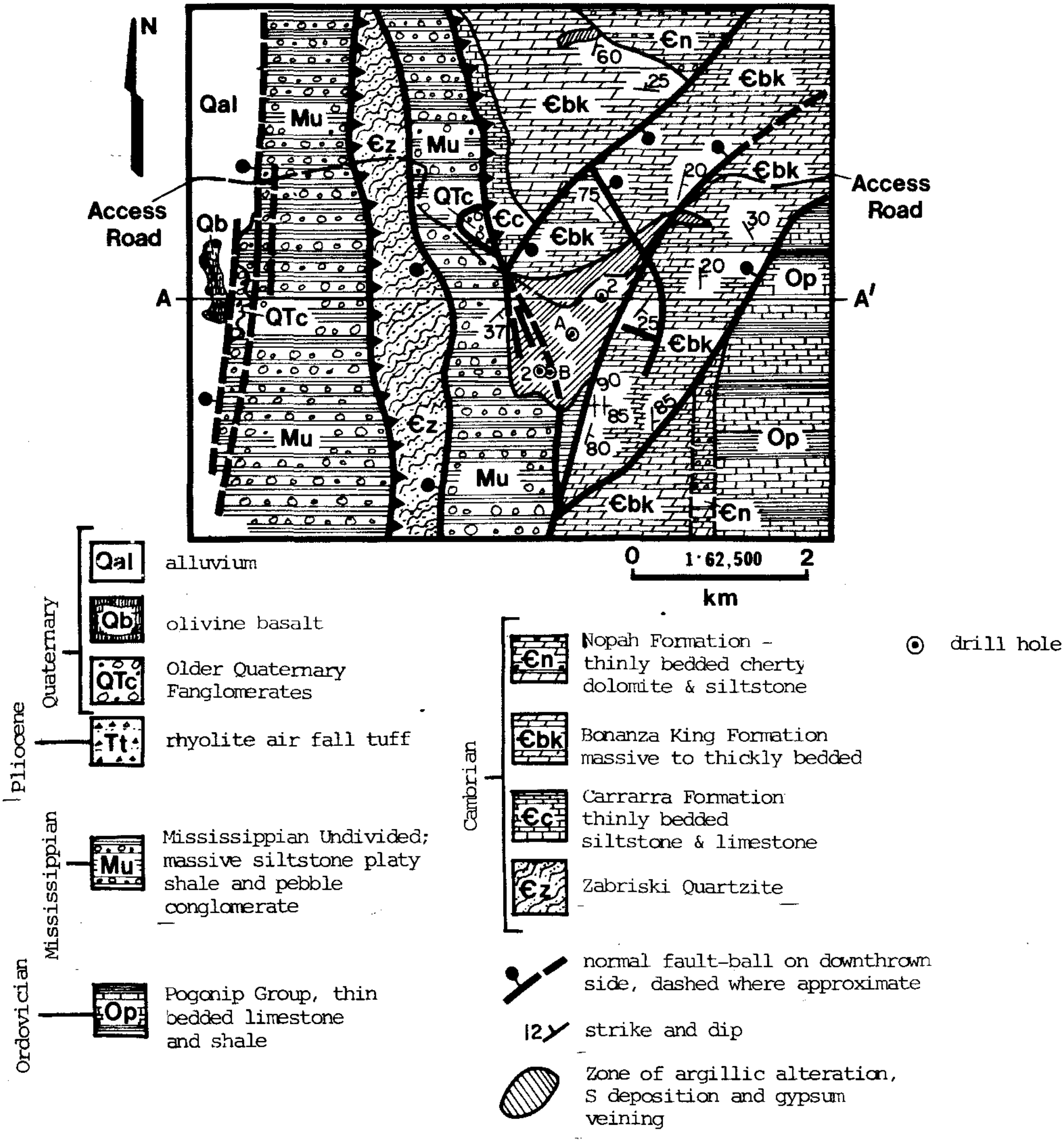


Figure 8. Geologic Map. Crater Prospect. Inyo County, California.

bedded to platy siltstones and interbedded orange limestone. A 120 meter thickness of the unit is exposed in the map area.

The Bonanza King Dolomite (Єbk) conformably overlies the Carrara Formation. It consists of massive to very thickly-bedded, dark gray dolomite. A complete section of the unit is exposed in the northern part of the map area and has a thickness of 1100 meters. The unit is very resistant and forms steep benched slopes with little debris cover.

The Nopah Formation (Єn) conformably overlies the Bonanza King Dolomite and consists of alternating limestone and siltstone beds with thicknesses of one to three centimeters. The top of the formation is not exposed but a minimum thickness of [illegible] meters occurs in the map area.

A thick sequence of undivided Mississippian (Mu) marine clastic rocks occur below the sole of the Last Chance Thrust which is well exposed in the map area. The unit consists of massive light gray siltstone with lenses of chert. The unit is poorly resistant and forms rounded, rubble covered, shallow slopes. Approximately 300 meters of the unit are exposed. The top of the unit is truncated by the Last Chance Thrust and the bottom is either faulted or covered by range front alluvial fans.

Three Late Tertiary - Early Quaternary units are recognized in the map area. A massive air-fall lithic tuff occupies the basin in the central part of the map area and is interbedded with Early Quaternary alluvial fan deposits which have been uplifted and dissected along the western flank of the Last Chance Range. The tuffs are massive but contain faint pebble horizons which indicate bedding orientation. The pebbles consist of quartzite and limestone from the surrounding Paleozoic sequence. The unit is white except where stained orange by limonite near the surface.

A Late Tertiary fanglomerate overlies the tuff and consists of very poorly sorted angular clasts of Paleozoic quartzites and carbonates.

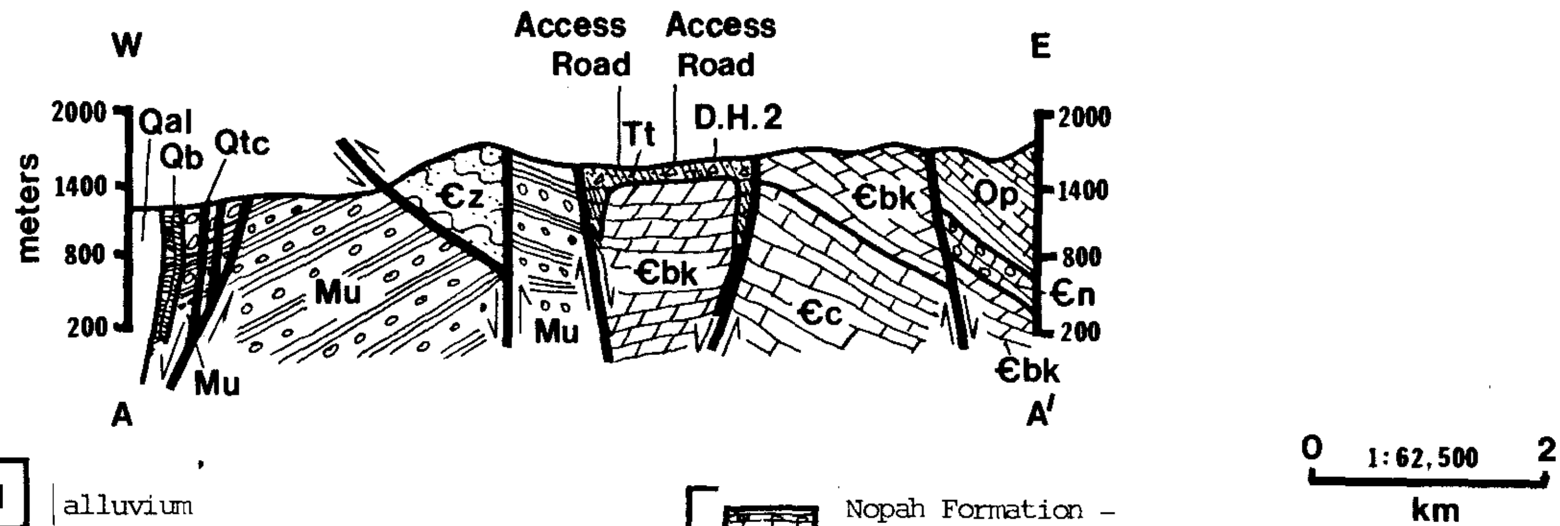
The Late Tertiary sequence is intruded by a fine grained dark gray olivine basalt along the western flank of Last Chance Range. The north-south orientation of the elongated outcrops indicates a dike structure.

Structure

Two major systems of Late Tertiary and Quaternary faults are recognized in the map area. These faults account for the major topographic features and for the distribution of hydrothermal alteration (Figure 9).

Numerous parallel north-south trending normal faults cut Plio-Pleistocene fanglomerates along the western flank of the Last Chance Range within the map area. Several exposed faults exhibit 10-30 meters vertical displacement. The total vertical displacement over the entire fault zone is probably several hundred meters. The closely spaced faults are probably consolidated at depth into one range front fault system. Quaternary olivine basalt dikes have penetrated the fanglomerates along this fault zone.

The central portion of the map area contains two opposing normal faults which form a northeast trending graben. The Crater sulfur mine



Quaternary
- Qal — alluvium
- Qb — olivine basalt
- QTc — Older Quaternary Fanglomerates

Pliocene
- Tt — rhyolite air fall tuff

Mississippian
- Mu — Mississippian Undivided; massive siltstone platy shale and pebble conglomerate

Ordovician
- Op — Pogonip Group, thin bedded limestone and shale

Cambrian
- €n — Nopah Formation - thinly bedded cherty dolomite & siltstone
- €bk — Bonanza King Formation massive to thickly bedded
- €c — Carrarra Formation, thinly bedded siltstone & limestone
- €z — Zabriski Quartzite

Zone of argillic alteration, S deposition and gypsum veining

normal fault

contact, dashed where approximate

Figure 9. Geologic Cross Section A-A'. Crater Prospect. Inyo County, California.

and the surrounding area of hydrothermal alteration occupy the intermontane basin formed by the graben. Vertical displacement may be as much as 300 to 400 meters.

Alteration and Hydrothermal Activity

The Crater sulfur mine is located near the center of an intense fumarolic alteration halo. The alteration is characterized by intense argillization and local massive silicification. Most of the alteration is confined to the poorly consolidated air-fall tuff that occupies the graben basin. Abundant native sulfur is disseminated throughout the altered tuff and forms massive tubular bodies in fault breccias.

Massive veins of gypsum 2-10 meters thick are dispersed through the area. They often contain significant amounts of massive and disseminated cinnabar.

The massive sulfur deposition along both the eastern and western boundary faults of the graben indicates that both faults served as conduits for rising acid-sulfate hydrothermal solutions. The intervening tuff beds were saturated from both the east and west sides thereby leading to complete alteration of rocks within the graben basin.

Heat Flow

Two existing mineral exploration holes (Figures 8, 10 and 11) yielded thermal gradients of 25°C/km and 38°C/km. It was assumed that topographic and ground water influences had lowered the gradient in the obviously fumarolic environment. A 200 meter gradient hole near the center of the

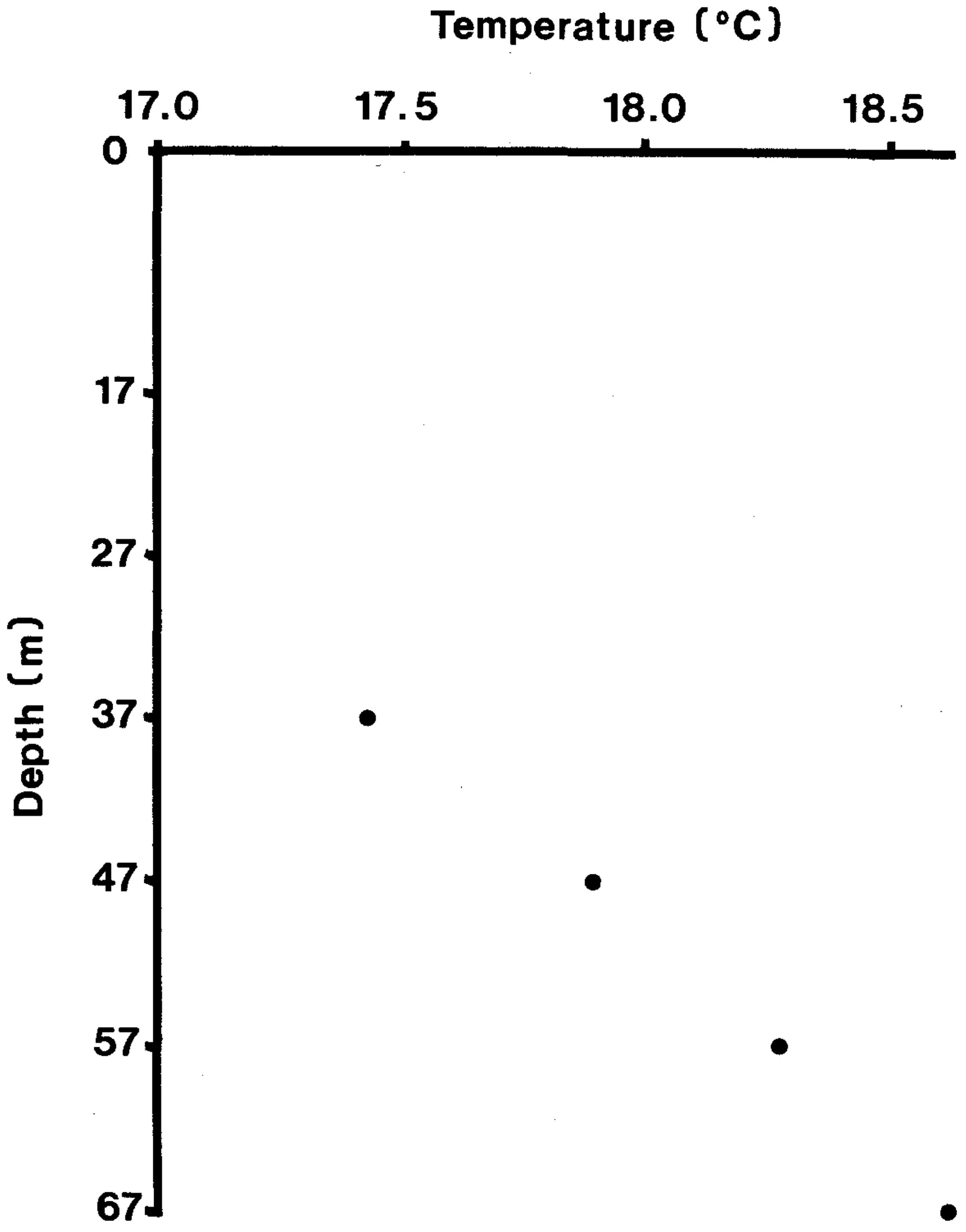


Figure 10. Thermal Gradient Curve Mineral Hole A.
Crater Prospect. Inyo County, California.
$\Delta T = 38^{\circ}C/km$; k = 5 T.C.U.; q = 1.9 H.F.U.
Logged October 11, 1981.

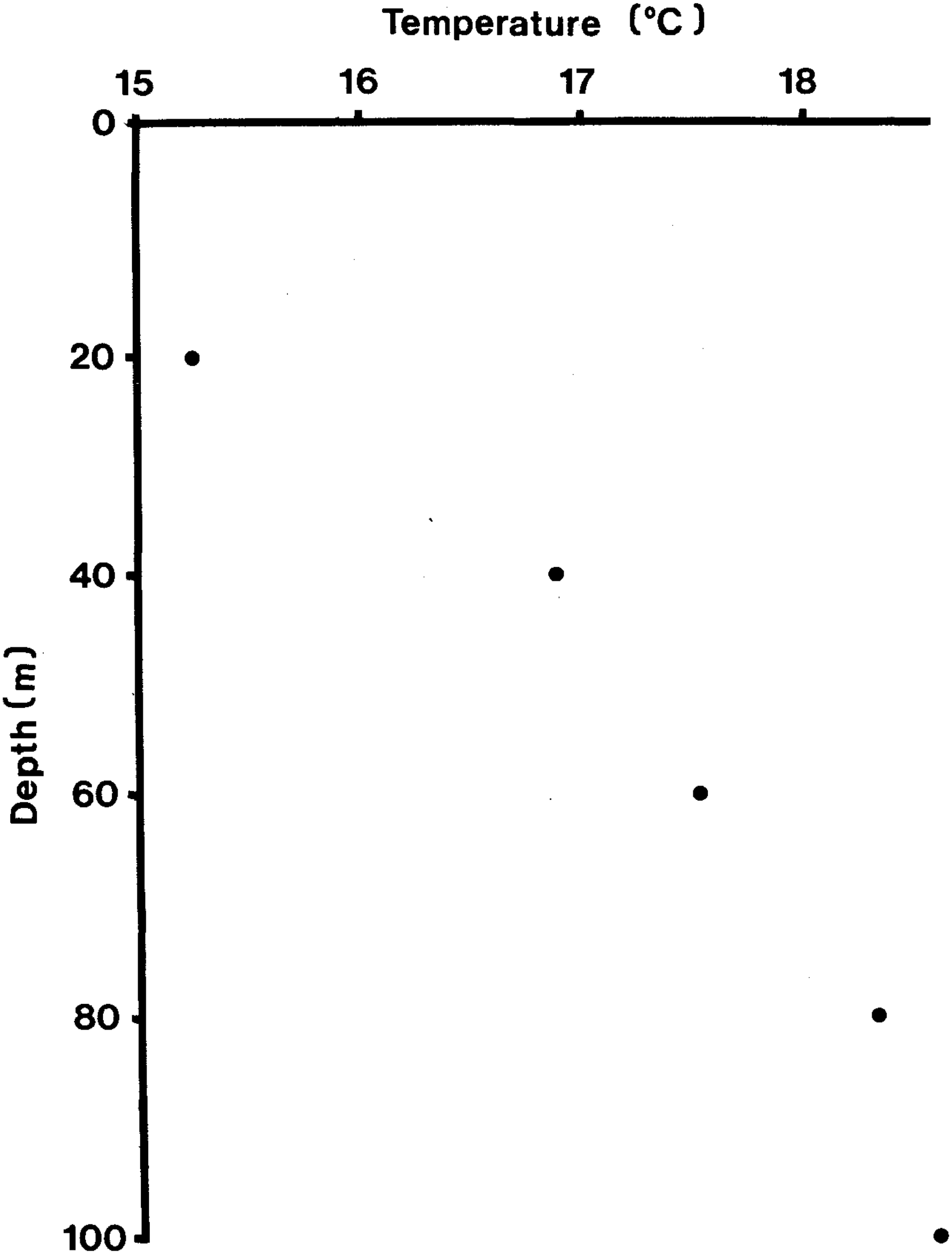


Figure 11. Thermal Gradient Curve Mineral Hole B.
Crater Prospect. Inyo County, California.
$\Delta T = 25^{\circ}C/km$; $k = 5$ T.C.U.; $q = 1.25$ H.F.U.
Logged October 11, 1981.

prospect (Figure 8) was planned to test this hypothesis, however lost circulation forced completion of the hole at 126 meters. Figure 12 shows the lithologic and temperature logs of the drill hole. The temperature gradient may be broken into three parts. The upper portion of the hole, 20 to 35 meters, displays a fairly straight line gradient of 102°C/km. This gradient is abnormally high due to the slightly warm conglomeratic aquifer at 43 meters. Extrapolation of this portion of the gradient indicates a mean annual surface temperature of approximately 14°C. When corrected for the effects of the aquifer, the extrapolated temperature is approximately 14.5°C which is normal for this area.

The 50 to 80 meter portion of the drill hole below the aquifer has a thermal gradient of 24°C/km. Assuming a thermal conductivity of 5.9 TCU, the heat flow is 1.4 HFU. This is the same heat flow measured in the 80 to 120 meter portion of the drill hole which has a thermal gradient of 28.5°C/km. The bottom hole temperature is 20.49°C at 126 meters.

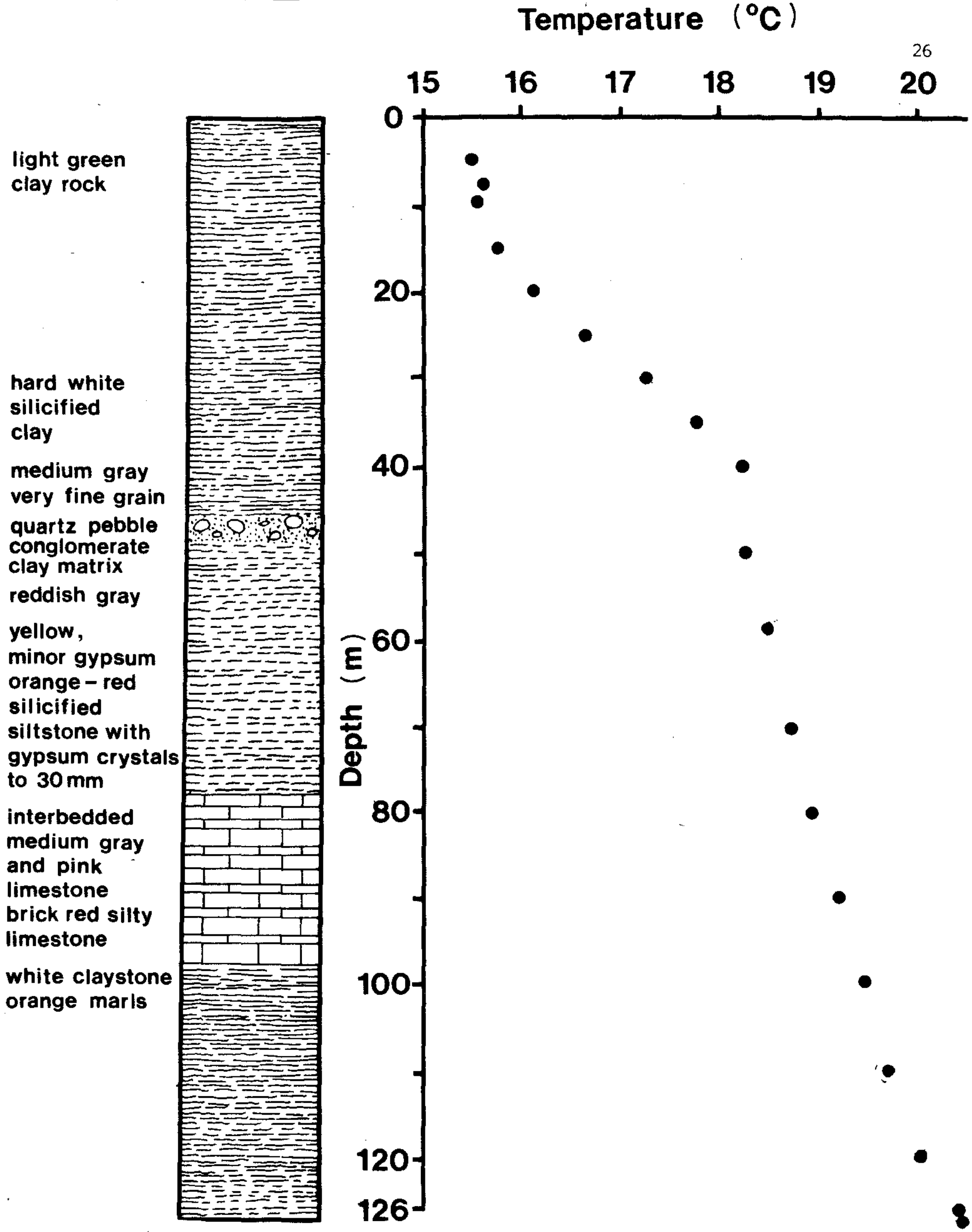


Figure 12. Lithologic Log and Thermal Gradient Curve D.H. #2 Crater Prospect. Inyo County, California. 0–40 meters $\Delta T = 102^{\circ}C/km$; $k = 1.9$ T.C.U.; $q = 1.9$ H.F.U. 40–100 meters $\Delta T = 24^{\circ}C/km$; $k = 5.9$ T.C.U.; $q = 1.4$ H.F.U. 100–126 meters $\Delta T = 28.5^{\circ}C/km$; $k = 5.0$ T.C.U.; $q = 1.4$ H.F.U. Logged October 11, 1981.

Noquez Prospect

Introduction

The Noquez mercury prospect is located in Section 36, Township 3 North, Range 32 East, Mineral County, Nevada. The prospect lies 40 kilometers east of Mono Lake, California and 60 kilometers south of Hawthorne, Nevada. The prospect is reached via 12 kilometers of graded road from Nevada State Highway 10 which runs from Mina to Basalt (Figure 13).

The prospect lies at an elevation of 2040 meters near the southwest terminus of the Candelaria Hills. The region consists of northeast trending hills with relief of 200 - 300 meters. The area receives moderate amounts of precipitation and supports dense pinyon - juniper forests above 2000 meters. The area is used for open range cattle grazing. There is no surface water in the vicinity and the water table is below a depth of 120 meters.

The Noquez mercury mine consists of over 200 meters of underground workings and a small retort which has been removed. The mine is currently abandoned but active gold-silver exploration took place in the summer of 1980 and consisted of five 75-110 meter rotary drill holes surrounding the mine. The prospect is entirely on federal land which has no geothermal leases at this time.

Regional Geology

The southern end of Mineral County is characterized by extensive

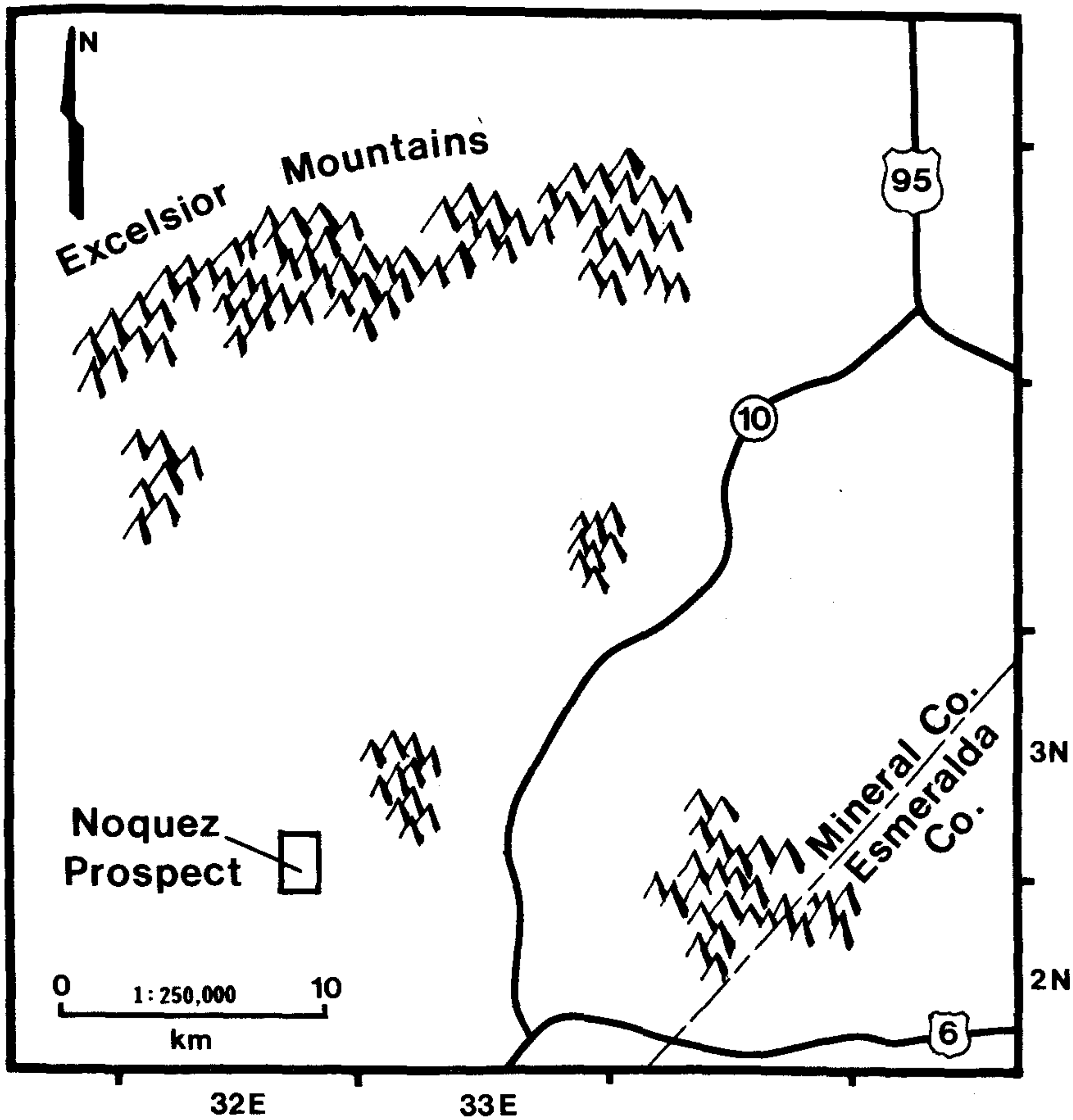


Figure 13. Location Map. Noquez Prospect. Mineral County, Nevada.

Pliocene flows and welded tuffs of rhyolitic to andesitic composition. These units lie directly on Ordovician silicic marine clastic rocks. This sequence is covered to the west by Quaternary olivine basalt flows. The units are truncated to the south by the uplifted granodioritic White Mountain Batholith of Cretaceous age.

The region contains numerous northeast trending normal faults which were probably active throughout the Quaternary. These faults account for the northeast trend of the ridges and moderate tilting of the Pliocene volcanics.

Rock Units

Three main rock units, ranging in age from Ordovician to Pliocene, outcrop in the map area (Figure 14). The Ordovician (Ou) unit consists of a sequence of orthoquartzites, siliceous siltstone and argillaceous sandstone. The thickly bedded light gray to pink quartzite consists of well-sorted, well-rounded 0.5 to 1.0 mm quartz grains with vitreous quartz cement. The siliceous siltstone is thinly bedded to laminated and light buff to light gray in color. The unit locally grades into dark gray to black chalcedony. The medium grained sandstone consists of well-rounded, well-sorted quartz grains with an orange clay matrix. Neither the top nor bottom of the Ordovician sequence is exposed in the map area and therefore no thickness measurements could be made.

A series of Pliocene welded tuffs and flows overlay the Ordovician basement. The lower part of the series consists of rhyodacitic welded tuffs (Tvf). The tuffs contain abundant collapsed pumice lapilli and

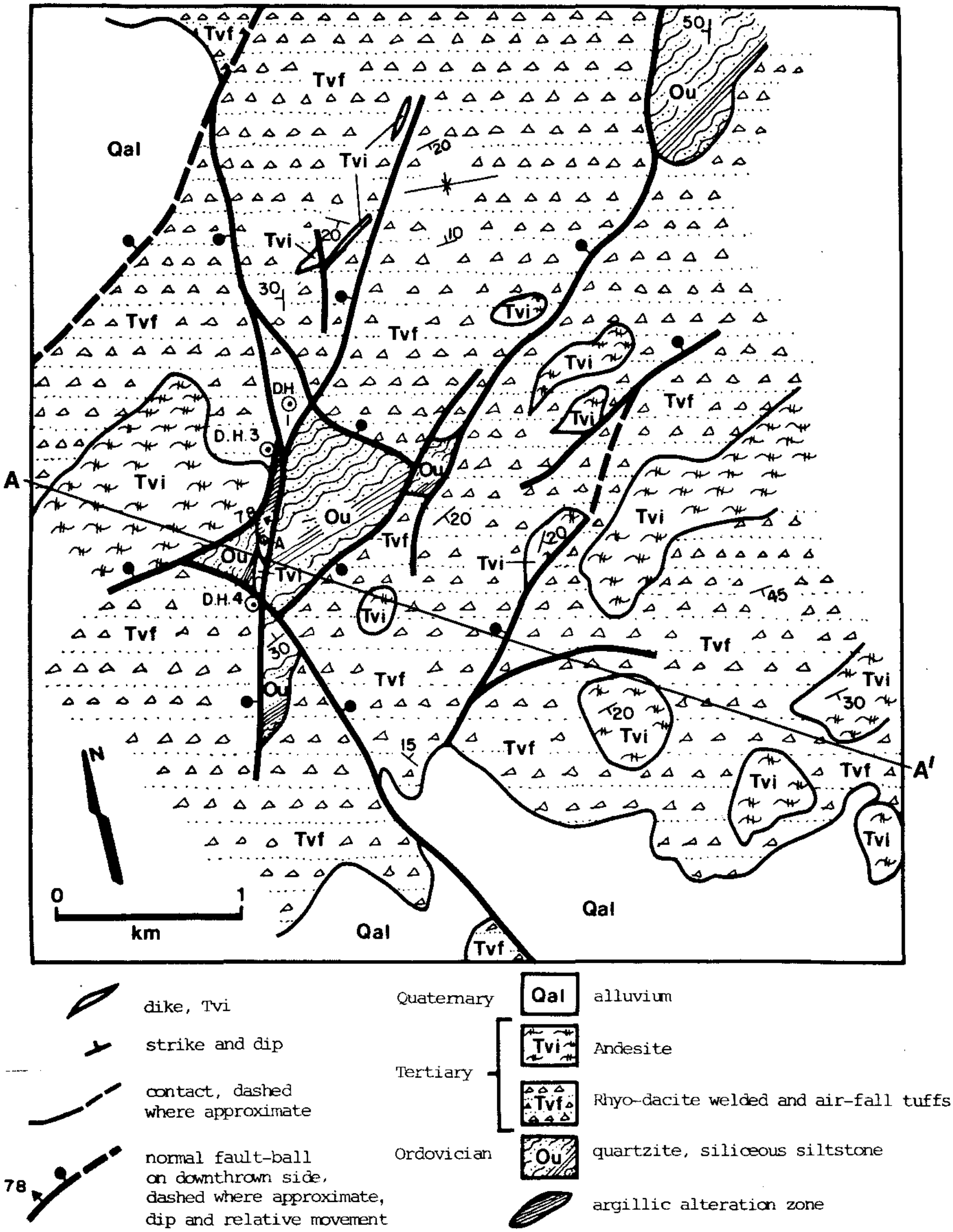


Figure 14. Geologic Map. Noquez Prospect. Mineral County, Nevada.

quartz and biotite phenocrysts. Poorly consolidated air-fall tuffs are interbedded with the welded tuffs. An exposed section of this unit at the north end of the map area indicates a minimum thickness of 250 meters. The thickness varies locally because of the considerable topographic relief of the Ordovician basement at the time of deposition.

An andesitic flow unit overlies the felsic welded and air-fall tuff. This unit is dark orange-brown, fine grained and generally non-vesicular. The rock contains abundant equant and prismatic brown clay and limonite pseudomorphs which may be remnants of plagioclase and pyroxene phenocrysts. The flow is massive to coarsely foliated with minor vesicularity in its upper portion. The upper surface is either not exposed or has been eroded away but the unit is probably not more than 30 to 40 meters thick.

Structure

Structure in the map area is dominated by two high-angle, normal fault systems (Figure 15). The major system consists of northeast trending faults with a regular spacing of approximately 1.5 kilometers. These faults show considerable topographic expression along steep escarpments which bound parallel systems of hills. The blocks formed by the faults are tilted to the southeast 10-30 degrees. The faults dip 70 to 80 degrees to the northwest and have vertical displacements of up to 230 meters as evidenced by the topographic offset of the Tvf-Tvi contact. The Ordovician basement is exposed along major fault scarp running through the mine site.

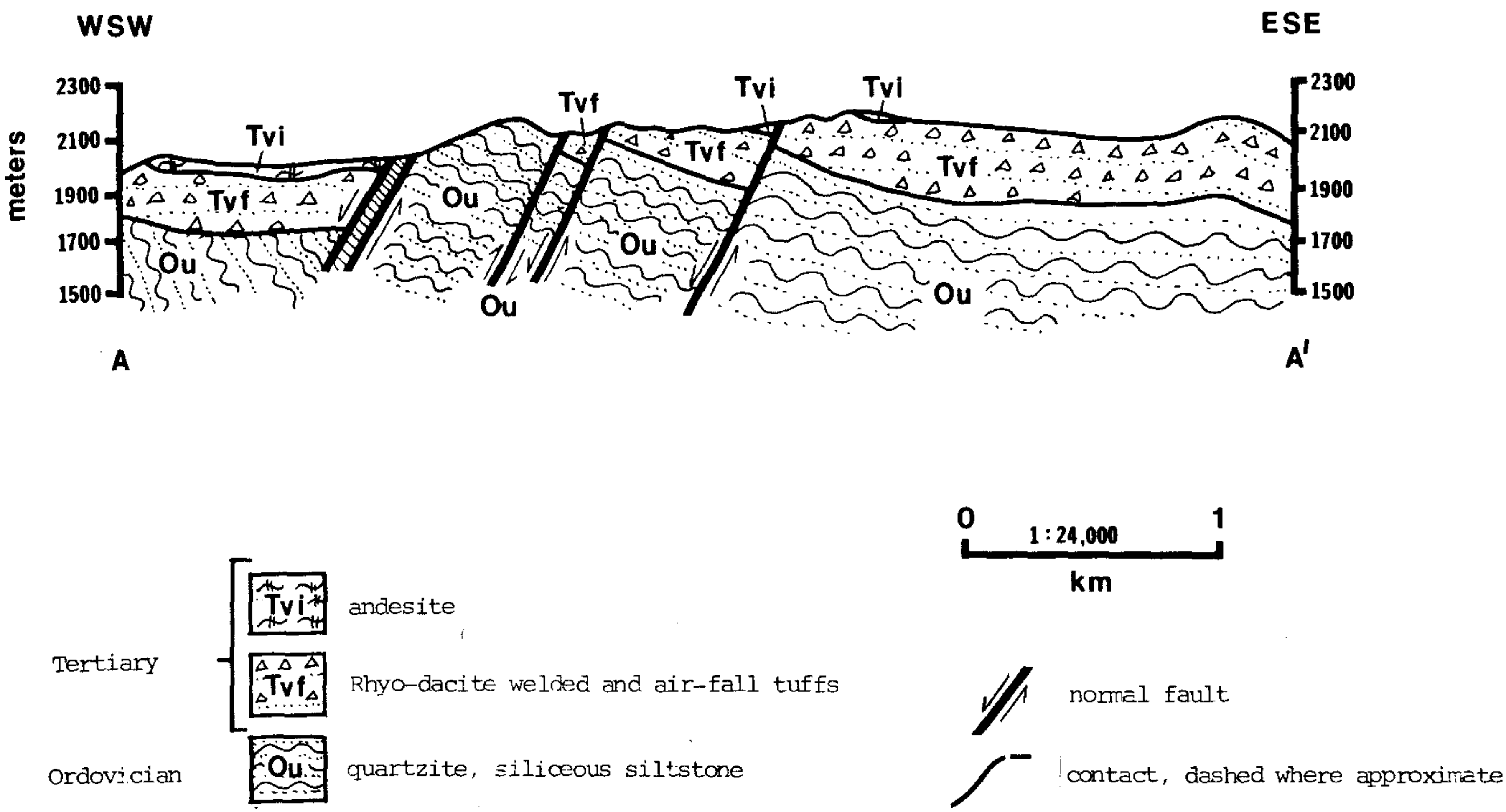


Figure 15. Geologic Cross Section A-A'. Noquez Prospect, Mineral County, Nevada.

A secondary set of faults intersects the main fault system at right angles. These high angle faults of small displacement show up as northwest trending gullies and lines of low hills. The mild topographic expression indicates small vertical displacement.

Alteration and Hydrothermal Activity

Hydrothermal alteration is confined to a narrow band of argillized tuff which extends in a northeast direction along the base of the escarpment on which the mercury mine is situated. The band is 25 - 75 meters wide and approximately 500 meters long. The band lies adjacent to the west side of a major northeast trending fault which bisects the mine site. The altered tuff is white to light buff, extremely friable and is heavily stained with orange limonite.

Cinnabar mineralization is confined to the quartzite on the southeast side of the fault. The cinnabar appears as thin fracture coatings in brecciated fault zones. The vitreous quartzite may represent a silicified alteration product of the argillaceous sandstone encountered in drill hole number 4.

Heat Flow

A 110 meter deep mineral exploration hole at the mine site displayed a geothermal gradient of $100^{o}C/km$. (Figure 16). Three confirmation gradient observation holes were drilled (Figure 14). Holes 1 and 4 are 74 meters deep and hole 3 is 83 meters deep. Lithologic and temperature logs for holes 1, 3 and 4 are shown in Figures 17, 18 and 19 respectively. Hole 1 displays a straight line gradient of $95^{o}C/km$ between 15 and 74 meters,

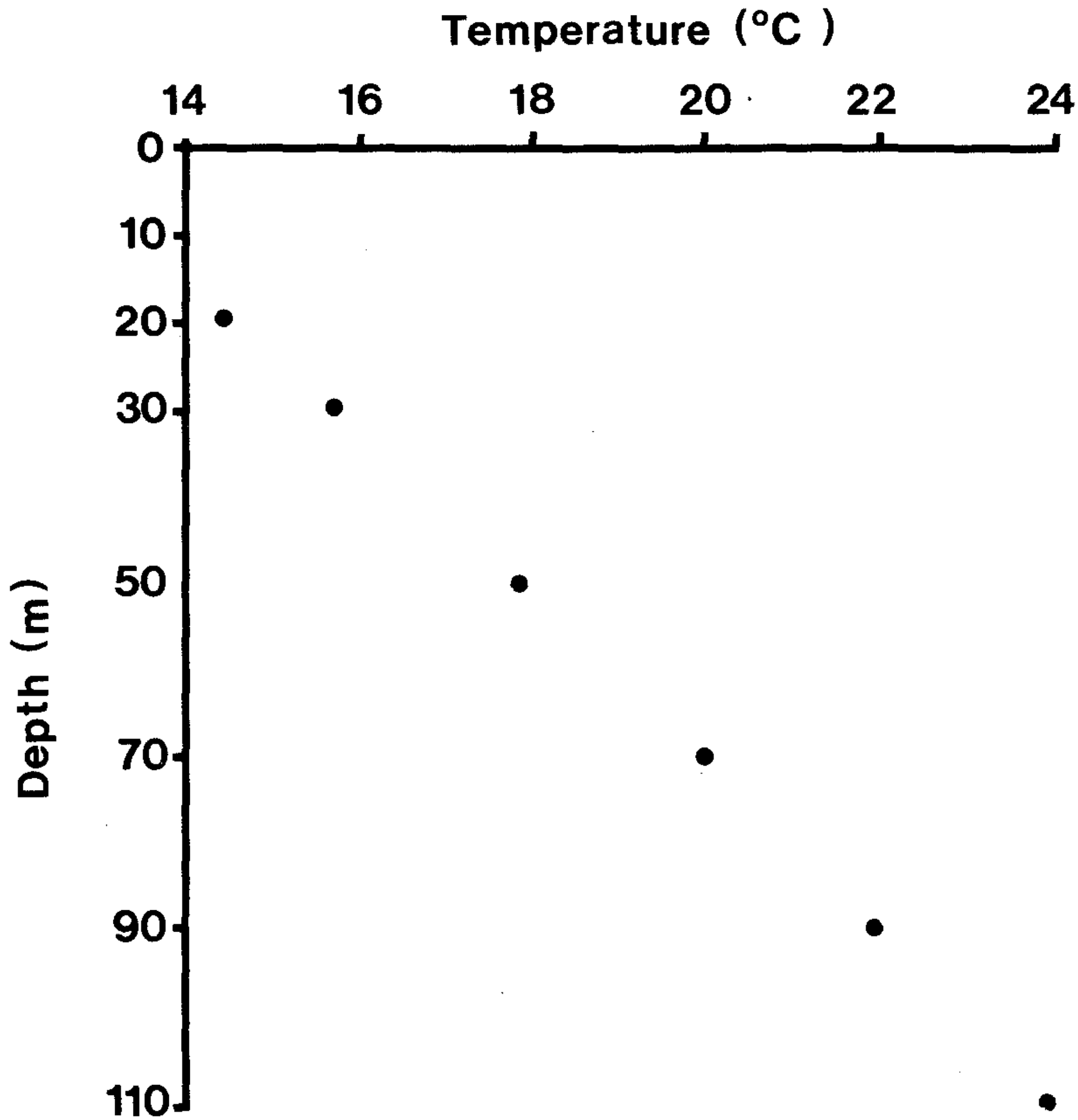


Figure 16. Thermal Gradient Curve Mineral Hole A. Noquez Prospect. Mineral County, Nevada. $\Delta T = 100^{o}C/km$; k = 10 T.C.U.; q = 10 H.F.U. Logged October 20, 1981.

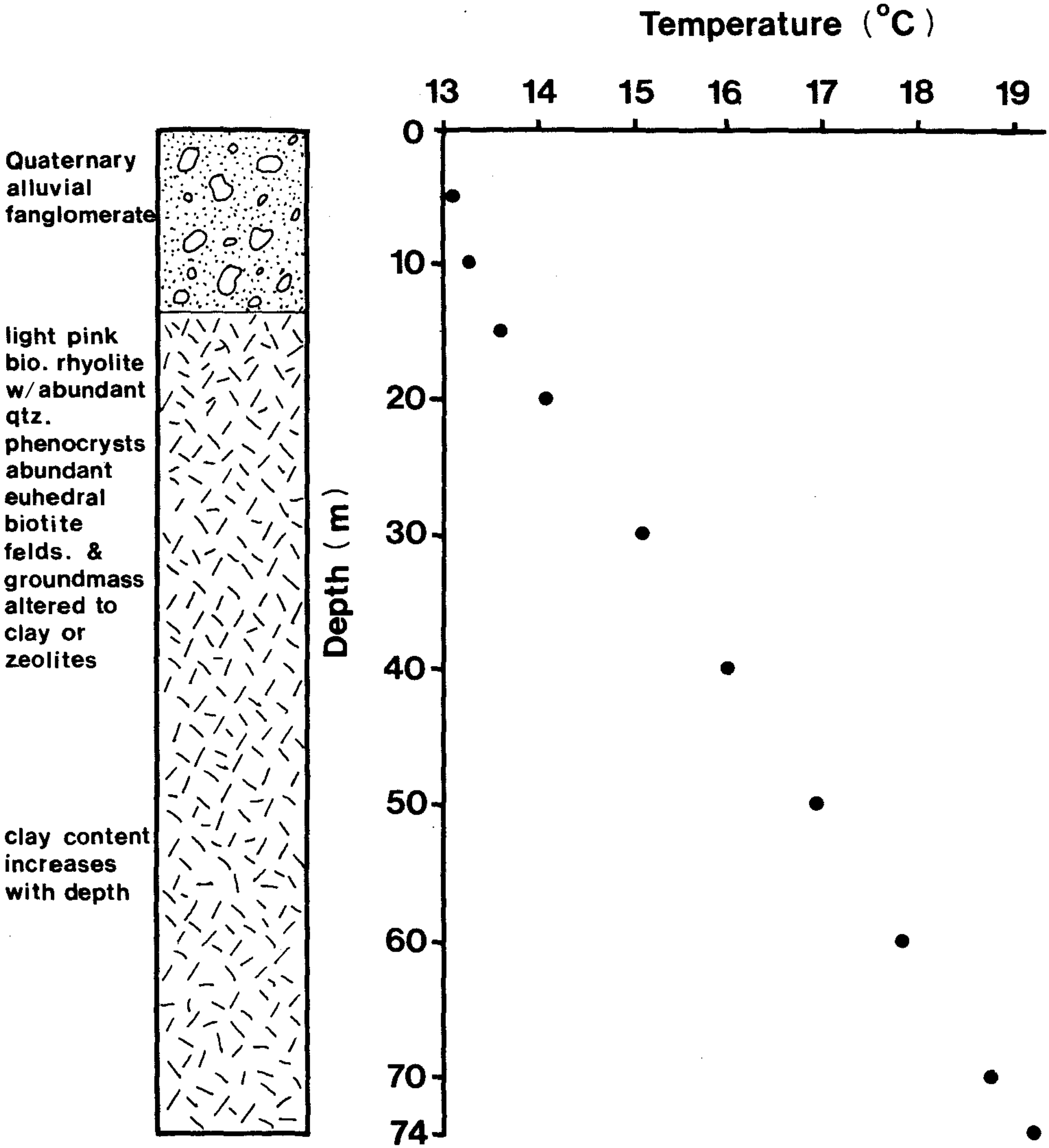


Figure 17. Lithologic Log and Thermal Gradient Curve D.H. #1. Noquez Prospect. Mineral County, Nevada. $\Delta T = 95^{o}C/km$; $k = 7.7$ T.C.U.; $q = 7.3$ H.F.U. Logged October 20, 1981.

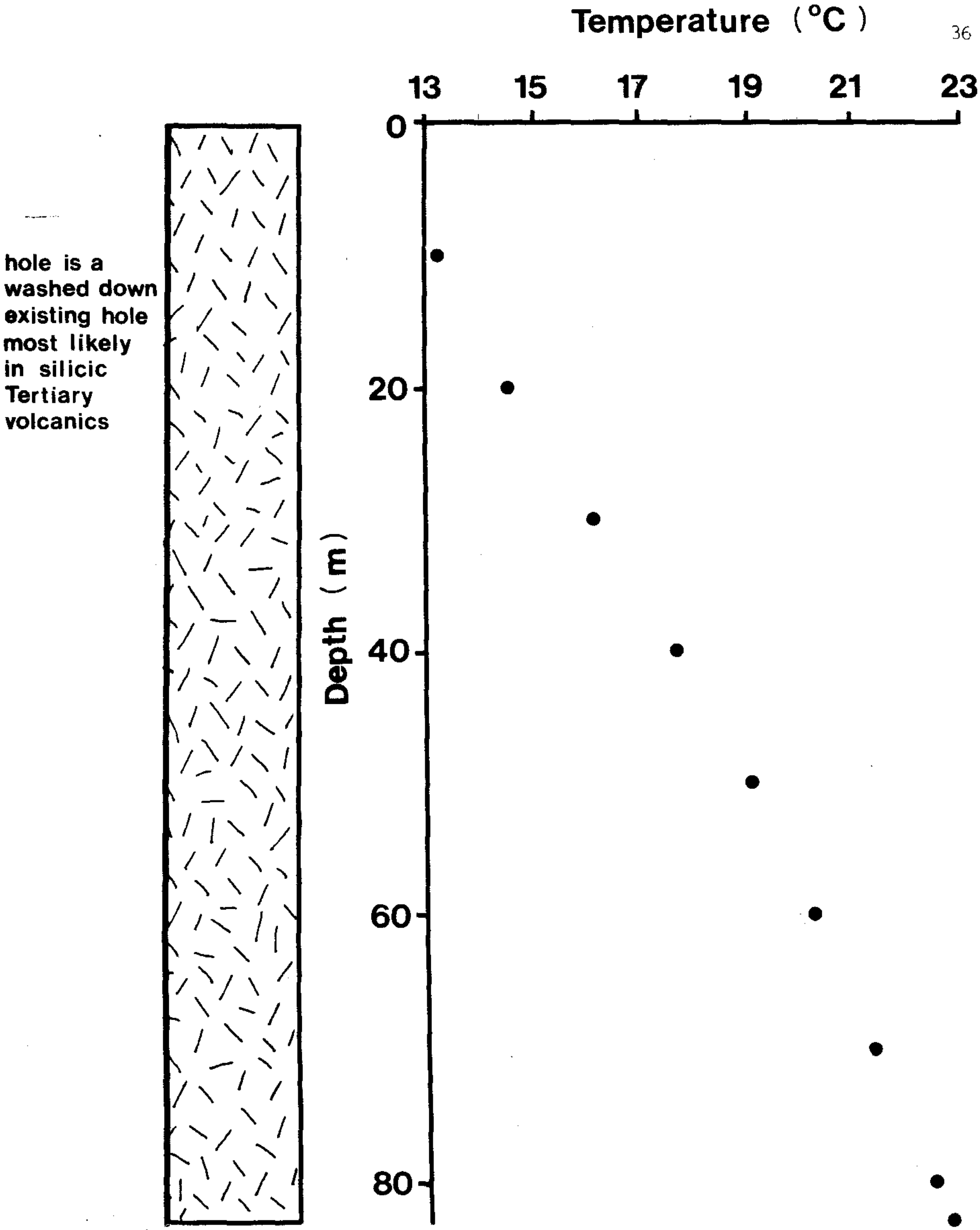


Figure 18. Lithologic Log and Thermal Gradient Curve D.H. #3.
Noquez Prospect. Mineral County, Nevada. 0–60 meters
$\Delta T = 171.5^{o}C/km$; k = 7.4 T.C.U.; q = 12.7 H.F.U.
60–83 meters T = $103^{o}C/km$; k = 7.4 T.C.U.; q = 7.6 H.F.U.
Logged October 20, 1981.

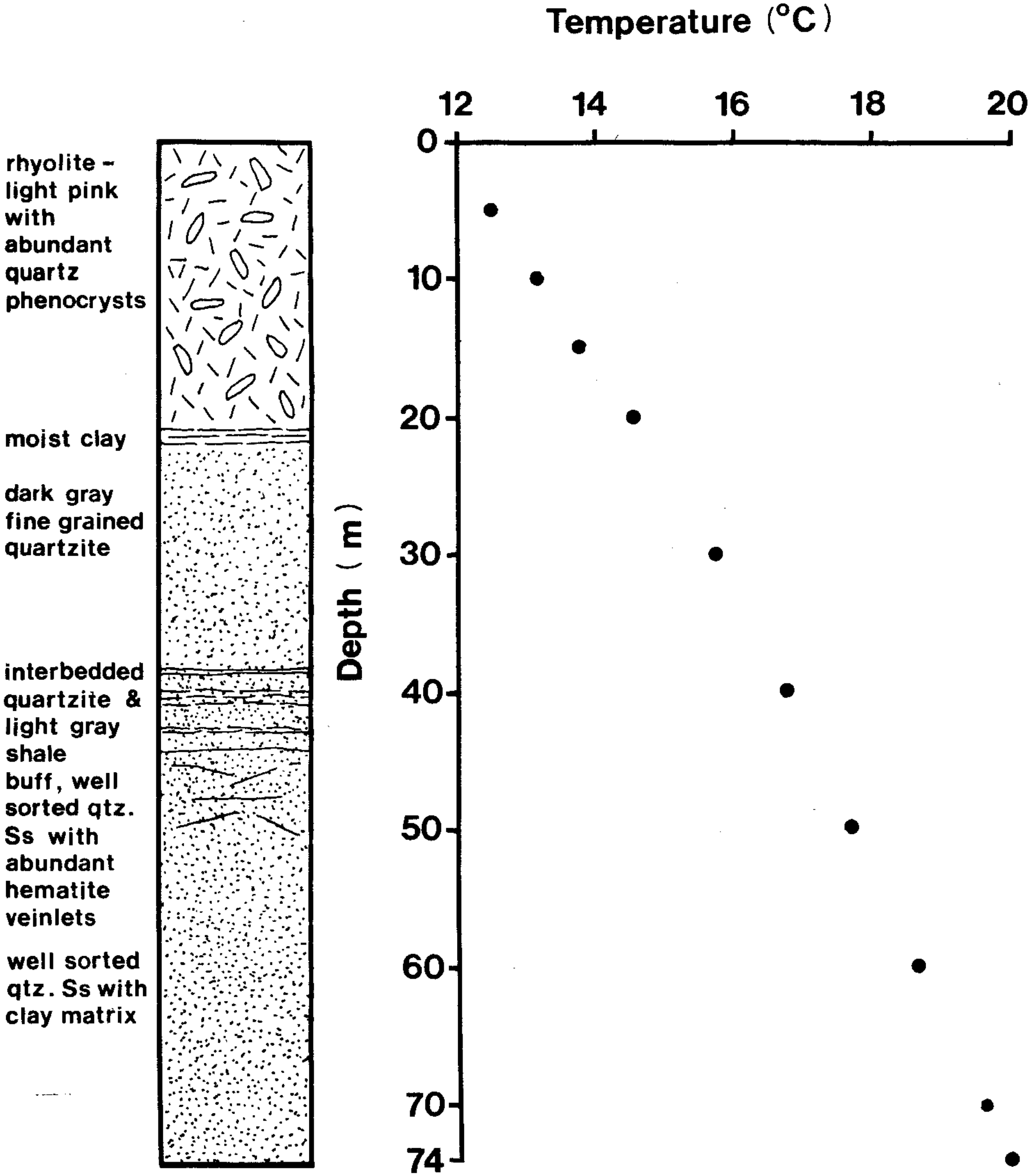


Figure 19. Lithologic Log and Thermal Gradient Curve D.H. #4. Noquez Prospect. Mineral County, Nevada. $\Delta T = 90^{o}C/km$; k = 10 T.C.U.; q = 9.0 H.F.U. Logged October 20, 1981.

yielding a heat flow of 7.3 HFU. Hole 3 has a thermal gradient of 171.5°C/km from a depth of 20 to 40 meters and decreases to 103°C/km between 50 and 83 meters. This yields a heat flow of 7.6 HFU. The change in gradient is probably due to a change in conductivity and ground water content. This hole is a reoccupied mineral exploration hole and therefore no lithologic information was obtainable. Changes in lithology of drill hole 4 result in an irregular thermal gradient above a depth of 40 meters. The uniform gradient between 40 and 74 meters is 90°C/km. Thermal conductivity measurements made on quartz-sandstone cuttings from hole 4 and one core taken from representative hand samples, indicated a mean conductivity of 5.5 TCU.

Poinsettia Prospect

Introduction

Poinsettia mercury mine is located in Section 34, Township 11 North, Range 33 East, Mineral County, Nevada. The prospect lies 41 kilometers northeast of Hawthorne, Nevada at the northwest terminus of the Gabbs Valley Range. The prospect is reached by graded county road from either Highway 95 at Hawthorne or from Highway 23, 18 miles north of Luning (Figure 20).

The prospect is located at the western edge of a highly dissected Tertiary volcanic range. The area drains north into the closed basin of Gabbs Valley. Ground water, probably from a perched water table, surfaces at Poinsettia Spring 0.75 kilometers east of the mine. The water table at the mine is below 100 meters. The depth to the water table was 38 meters in a windmill 8 miles to the northwest in November, 1981. The area is sparsely vegetated with sage and supports open range cattle grazing.

The Poinsettia mercury mine consists of a tunnel and shaft with intact headframe. Several small wooden houses and remnants of a retort are also found at the mine site. Mineral assessment work is currently being done on the property.

Regional Geology

The Gabbs Valley Range consists of a continuous blanket of Pliocene rhyodacitic flows and tuffs overlain in the southwest by Pliocene andesite

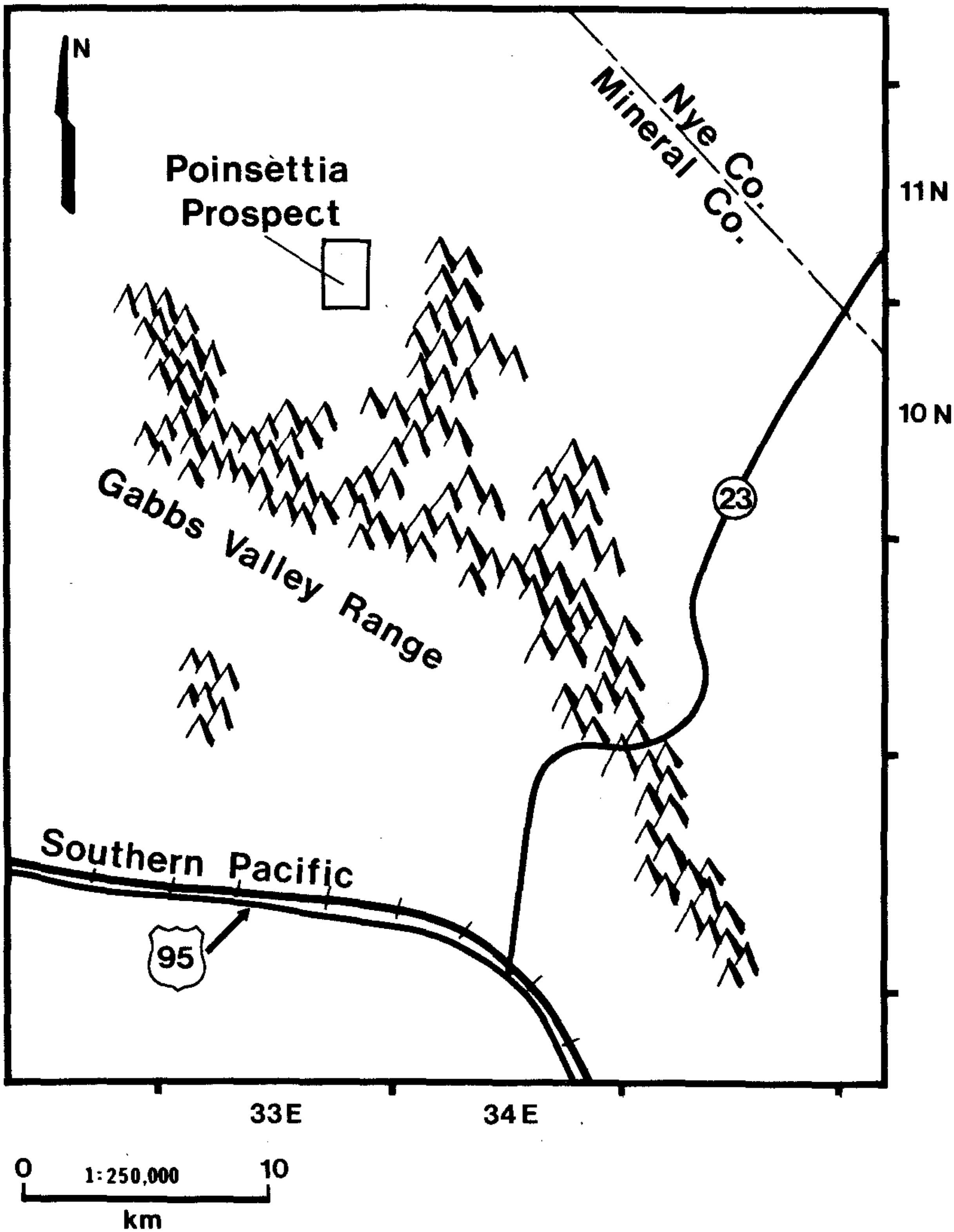


Figure 20. Location Map. Poinsettia Prospect. Mineral County, Nevada.

flows. The volcanics overlay a basement of Triassic marine carbonate and clastic sediments which have been extensively intruded by Cretaceous granitic rocks.

The Gabbs Valley and Gillis Ranges which are made up of these units trend northwest and are bounded on the northeast and southeast by parallel range front faults. Faulting has produced mild to moderate tilting of the Pliocene volcanic cover thereby indicating significant Quaternary tectonic activity.

Rock Units

Two major extrusive volcanic units dominate the map area (Figure 21). The lower unit (Tvf) consists of rhyodacitic flows with interbeds of welded tuffs of similar composition. The massive flow unit is very light gray to white and contains abundant phenocrysts of euhedral hornblende. The groundmass which may have originally been glassy is now argillized. The unit is at least 250 meters thick though its lower contact is not exposed in the map area. The overlying andesite flow is medium gray and locally vesicular. It contains abundant euhedral plagioclase phenocrysts with reaction halos. The groundmass is aphanitic and partially argillized.

Structure

Structure in the map area is dominated by northwest trending high angle normal faults (Figure 22). These faults cut the Pliocene volcanics and have distinct topographic expression in the elongated ridges with escarpments on their northeast side. Movement along the faults ranges

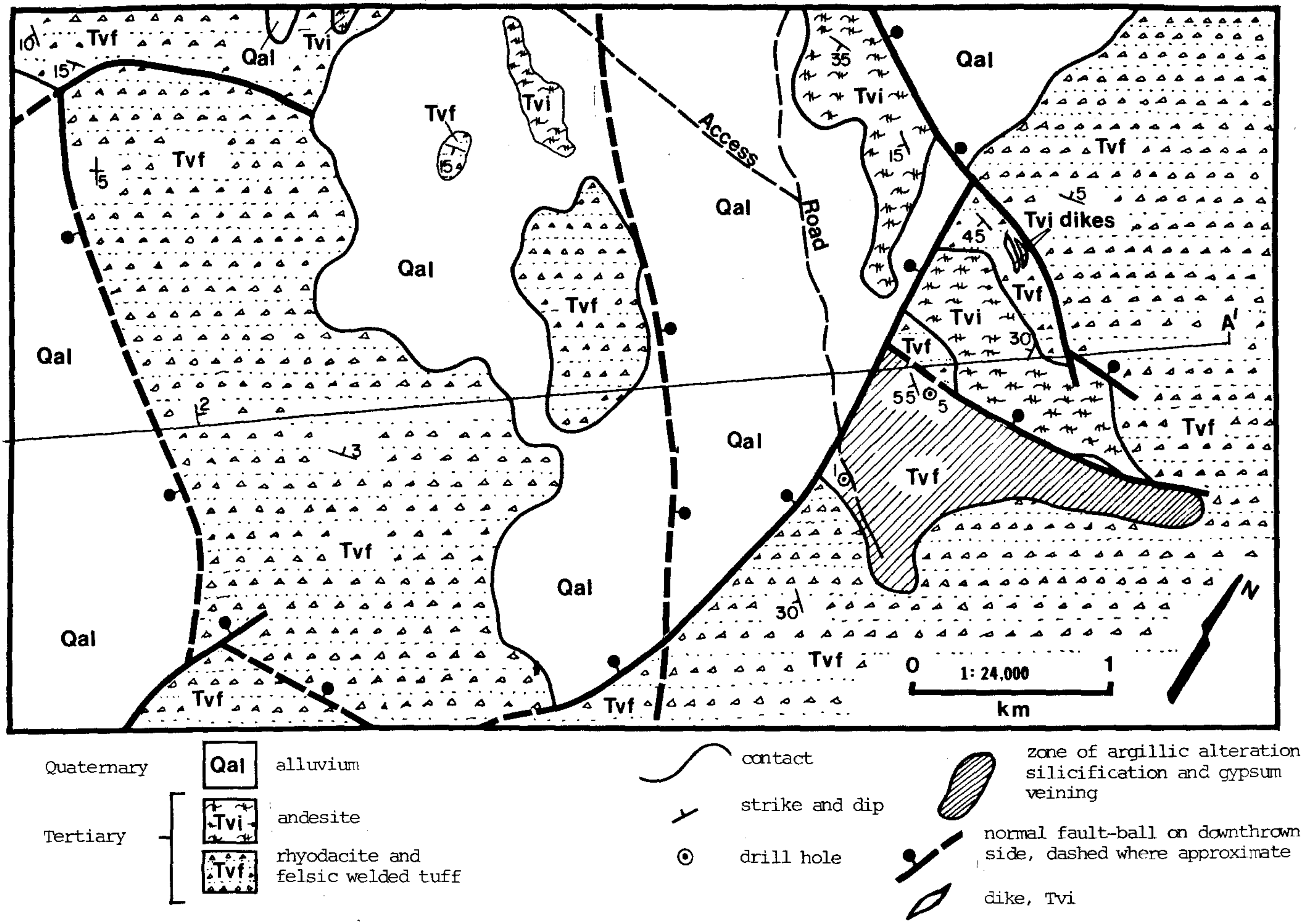


Figure 21. Geologic Map. Poinsettia Prospect. Mineral County, Nevada.

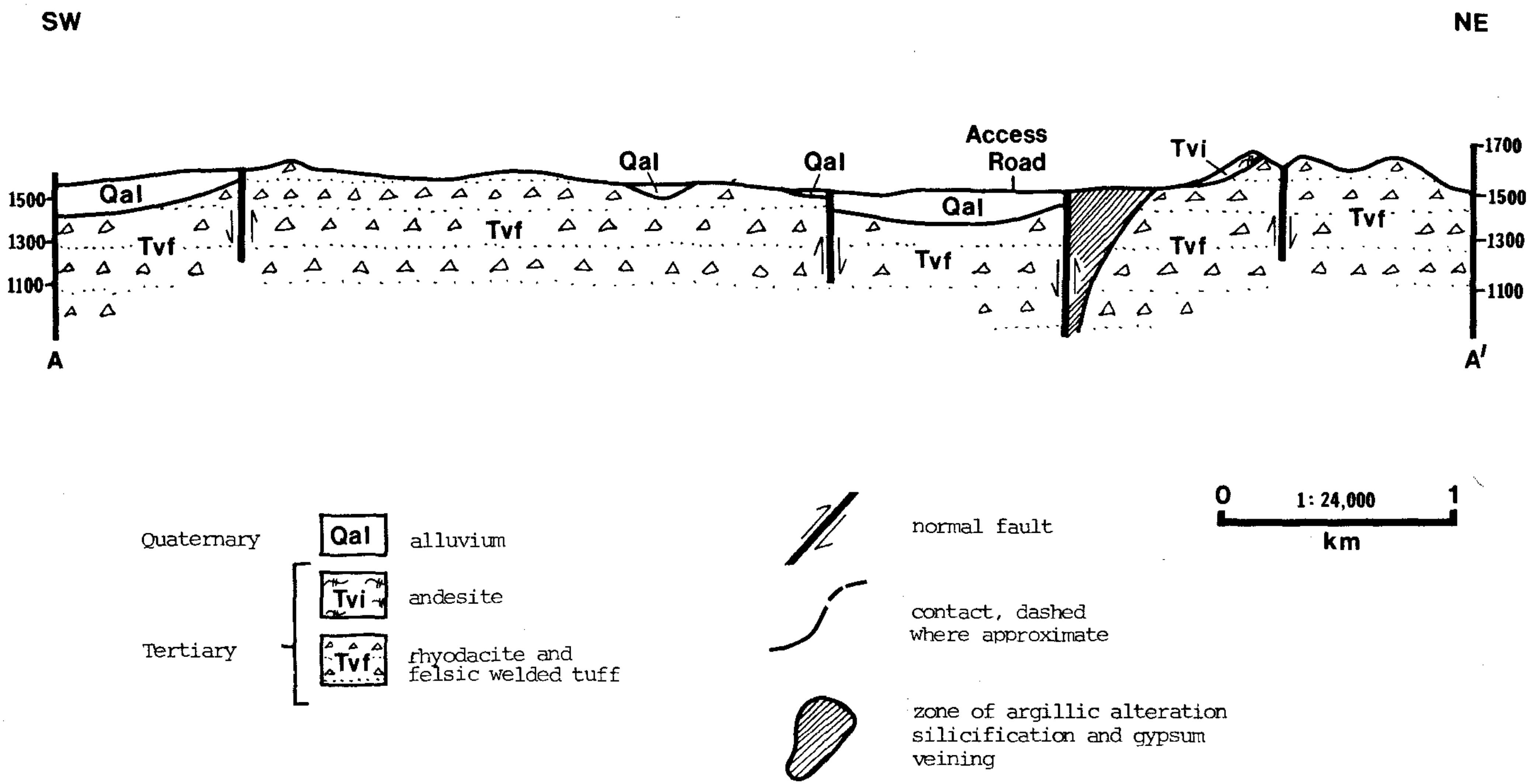


Figure 22. Geologic Cross Section A-A′. Poinsettia Prospect. Mineral County, Nevada.

between 10 to 80 meters.

Alteration and Hydrothermal Activity

A large alteration zone with dimensions of 0.8 by 2.0 kilometers extends north and east of the mine site. The alteration consists of pervasive and intense argillization accompanied by opalite, chalcedony and anhydrite veining along fractures. Disseminated pyrite appears as 1-2 mm equidimensional anhedral blebs uniformly distributed to a depth of at least 100 meters in the alteration zone. The pyrite content of the drill cuttings ranges from 0.5 to 5.0 percent. Cinnabar mineralization is associated with silicification in the fractures and faults.

Heat Flow

Two gradient observation holes, one 50 and one 97 meters, were drilled near the Poinsettia mine (Figure 21). Figures 23 and 24 show the respective lithologic and temperature logs of these holes. Hole 1 displayed nearly linear gradients of 67°C and 57°C/km over the 10-50 and 50-90 meter intervals respectively. The decrease in gradient with depth is attributed to changes in thermal conductivity resulting from increases in the percentage of sulfides coupled with variations in the clay content of the material. The mean heat flow for hole 1 is 4.0 HFU. The bottom hole temperature is 20.93°C at 97 meters.

Hole 5 (50m) yielded results very similar to hole 1. The gradient was slightly more irregular and lower, 48°C/km, than that of hole 1. This is due to a higher percentage of sulfides and less ground water. Surface temperatures extrapolated from these gradients are between 14° and 15°C.

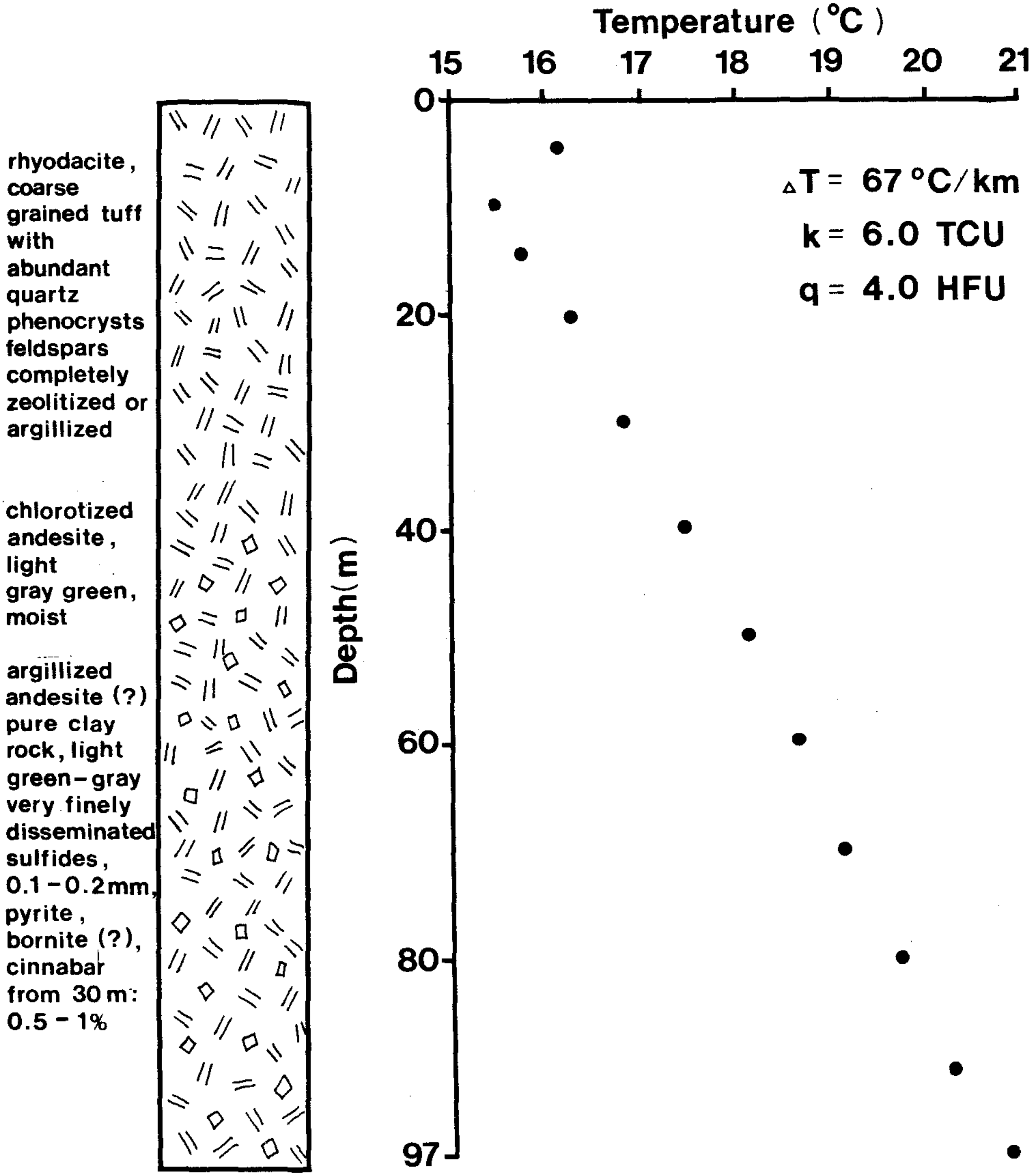


Figure 23. Lithologic Log and Thermal Gradient Curve D.H. #1. Poinsettia Prospect. Mineral County, Nevada.
0-20 meters $\Delta T = 67^{o}C/km$; k = 6.0 T.C.U.; q = 4.0 H.F.U.
20-97 meters $\Delta T = 57^{o}C/km$; k = 7.0 T.C.U.; q = 4.0 H.F.U.

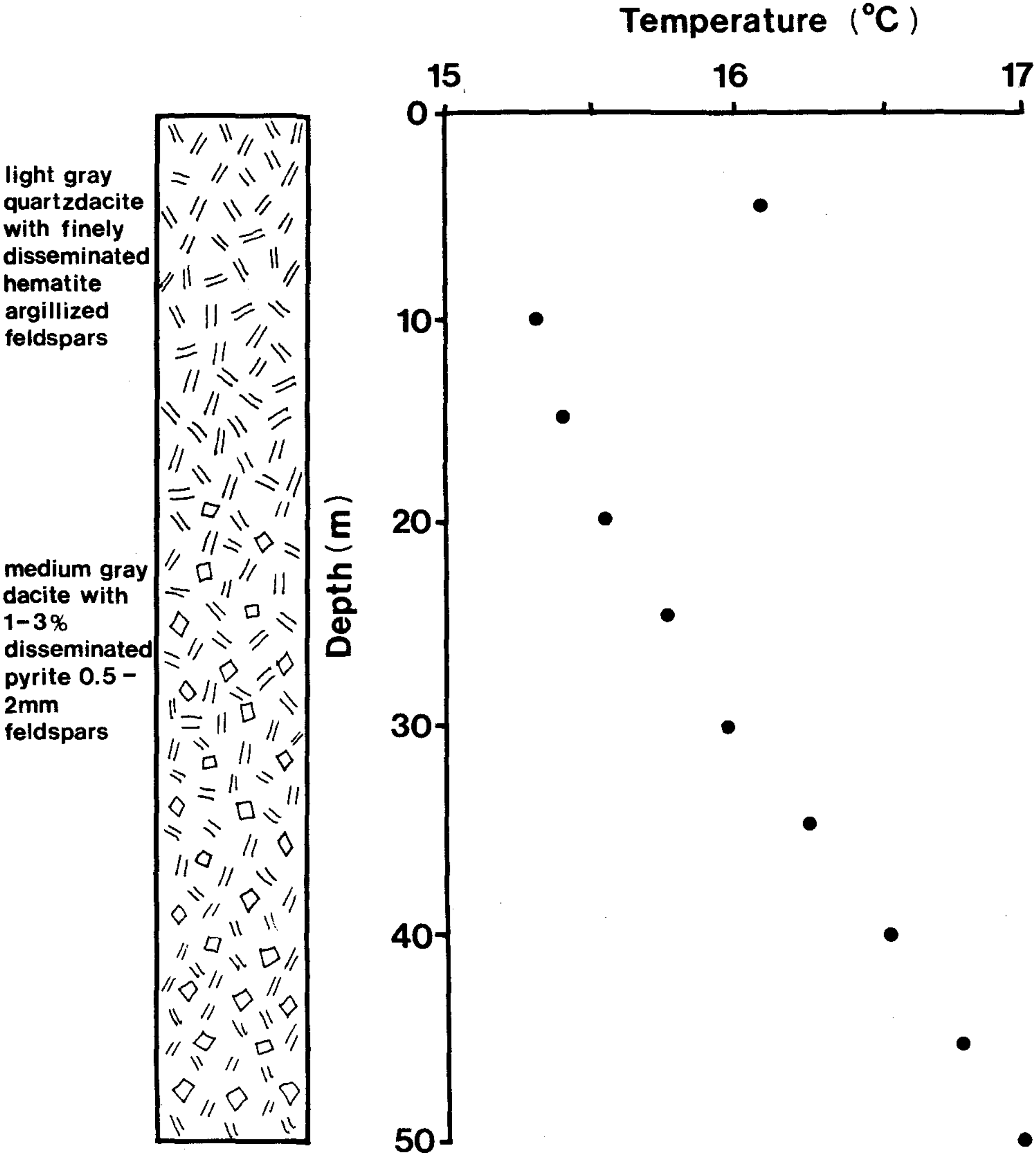


Figure 24. Lithologic Log and Thermal Gradient Curve D.H. #5. Poinsettia Prospect. Mineral County, Nevada. $\Delta T = 48^{\circ}C/km$; k - 7.5 T.C.U.; q = 3.6 H.F.U.

Cina Prospect

Introduction

The Cina mercury mine is in Section 5 of Township 31 South, Range 15 West, Iron County, Utah (Figure 25). The prospect is located 48 kilometers southwest of Milford, Utah. Access is by graded county road from either Lund or Milford.

The prospect lies at an elevation of 2043 meters in an area of moderate relief at the southern end of the Wah Wah Mountains. Bedrock consists of Lower Paleozoic carbonate and clastic units which are overlain by Cenozoic silicic pyroclastic and flow rocks. The Cina mine straddles a high angle normal fault contact between Paleozoic dolomite, and Tertiary rhyolite and water lain tuff. The prospect area lies within the Escalante Desert drainage basin near the drainage divide between Pine Valley and the Escalante Desert.

A semi-arid climate supports dense sage, juniper, pinyon and white pine. Assessment work on the Cina and other nearby mines is currently being conducted, however no permanent human habitation exists in the immediate vicinity.

Regional Geology

The Wah Wah Mountains are a typical Basin and Range block comprised of Paleozoic carbonate and clastic rocks overlain by Cenozoic volcanics. The southern Wah Wahs are composed largely of Tertiary volcanics with windows of Cambrian carbonates and overthrust

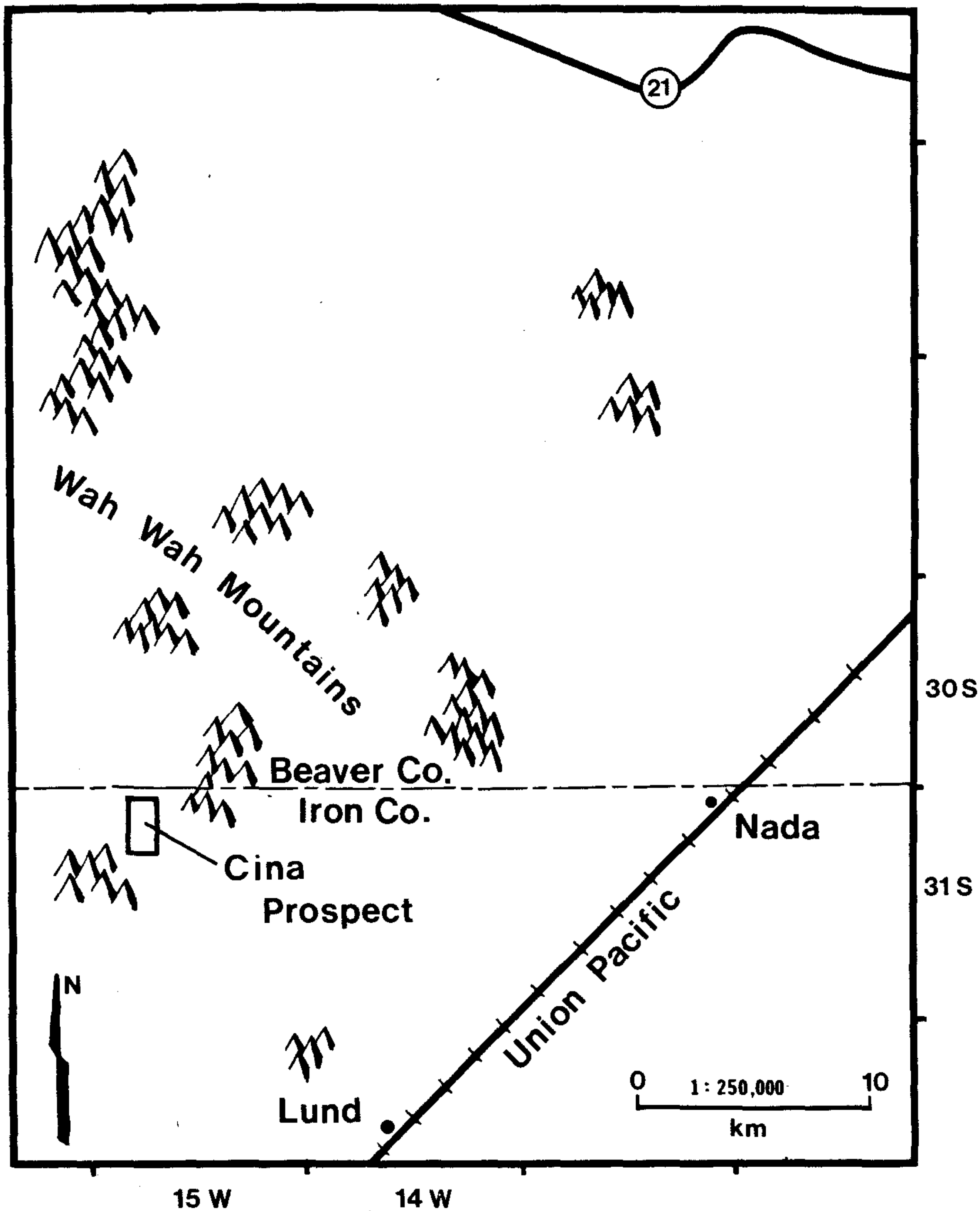


Figure 25. Location Map. Cina Prospect, Iron County, Utah.

remnants of Lower Mesozoic Navajo Sandstone.

Faulting throughout the range trends either east-west or parallel to the north-south range front fault zone. Displacement along the Wah Wah Range front fault zone is approximately 1 kilometer.

Sources of Cenozoic volcanism in this region lie within the Needle Range to the west, the Wah Wahs to the north and possibly the San Francisco Range to the northeast.

Rock Units

Cambrian dolomite and silicic extrusive volcanics comprise the majority of bedrock in the map area. The dolomite, which is exposed in the eastern portion of the map area, is in fault contact with Tertiary volcanics (Figure 26). The volcanic sequence is at least 300 meters thick.

The Cambrian basement (€d) is composed of very fine grained, light to dark gray dolomite. The dolomite varies from massive to very thinly bedded. Ripple marks and minor amounts of calcite veining occur in the upper portion of the section.

A poorly bedded Tertiary rhyolite (Tr_1) overlies the dolomite. This unit is probably Oligocene in age and is composed of at least 100 meters of interbedded rhyolite and water lain tuff.

The rhyolite is light pink, poorly bedded and contains abundant

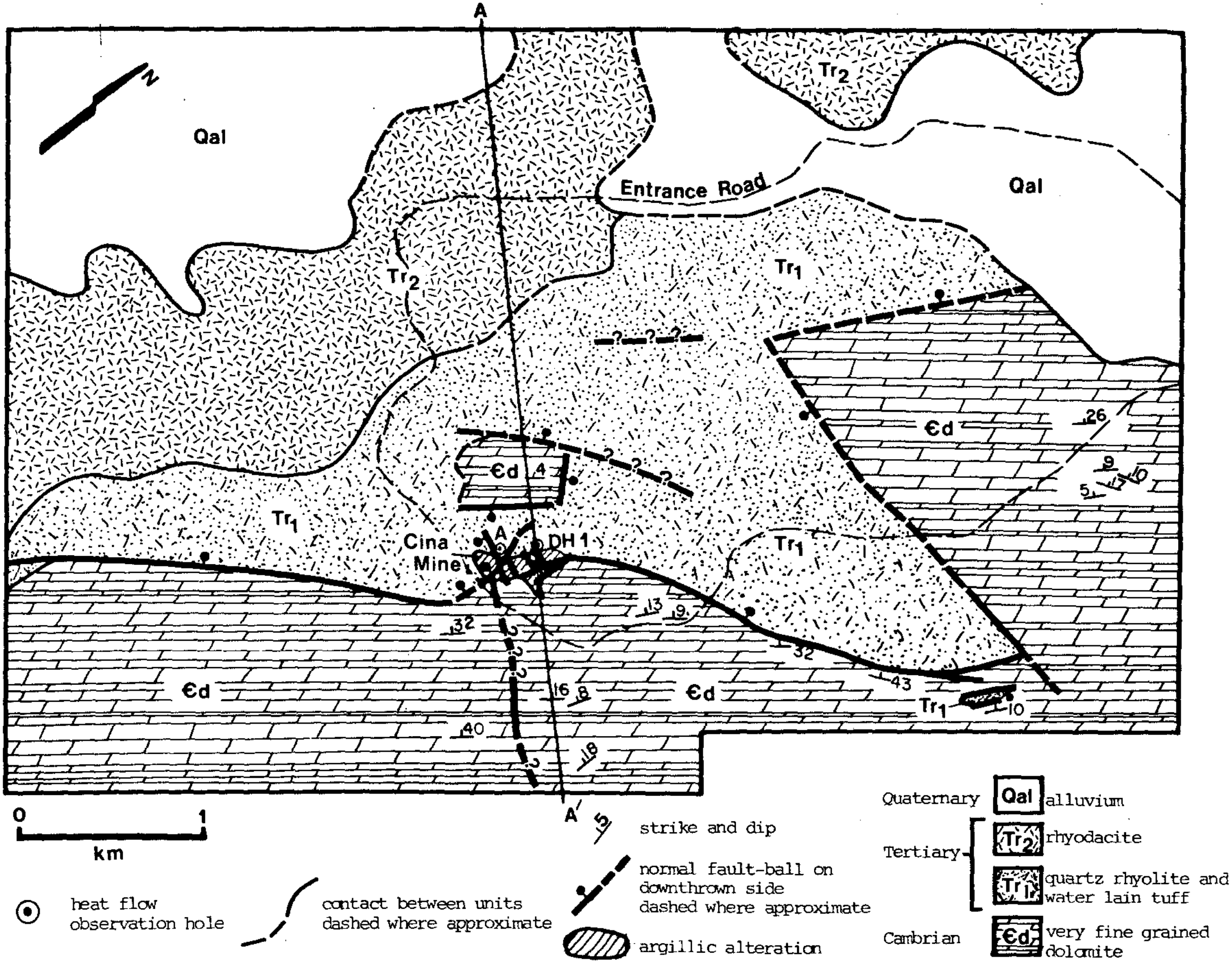


Figure 26. Geologic Map. Cina Prospect. Iron County, Utah.

quartz phenocrysts. It is highly silicified near fault zones. The silicified zones are white to dark gray in color, vuggy and generally conformable to bedding. The rhyolite weathers to a light pink to buff color and forms rounded slopes. The water lain tuff is not as silicified as the quartz rhyolite and contains minor amounts of lithic rhyolite fragments.

Tertiary rhyodacite (Tr_2) overlies the rhyolite and is approximately 200 meters thick. The rhyodacite is composed of subhedral to euhedral feldspar and quartz crystals in a dark red crystalline groundmass. The unit weathers to a dark red to reddish-brown and caps most of the prominent hills west of the Cina mine.

The youngest unit is Quaternary alluvium (Qal). The alluvium is composed of rhyodacite and rhyolite cobbles and boulders in approximately equal proportions with minor amounts of dolomite pebbles.

Structure

Structure within the map area is dominated by a high angle, northeast trending fault zone resulting in the uplift of Cambrian dolomite (Figures 26 and 27). The dolomite generally strikes northeast and dips 10° to the northwest. Dips as great as 43° to the northwest are found near fault contacts due to dragging of beds along the faults.

A second set of faults strikes east-west at approximately 120° to the major fault zone. Displacement along this second series of faults is generally less than 10 meters. Areas of closely spaced, small

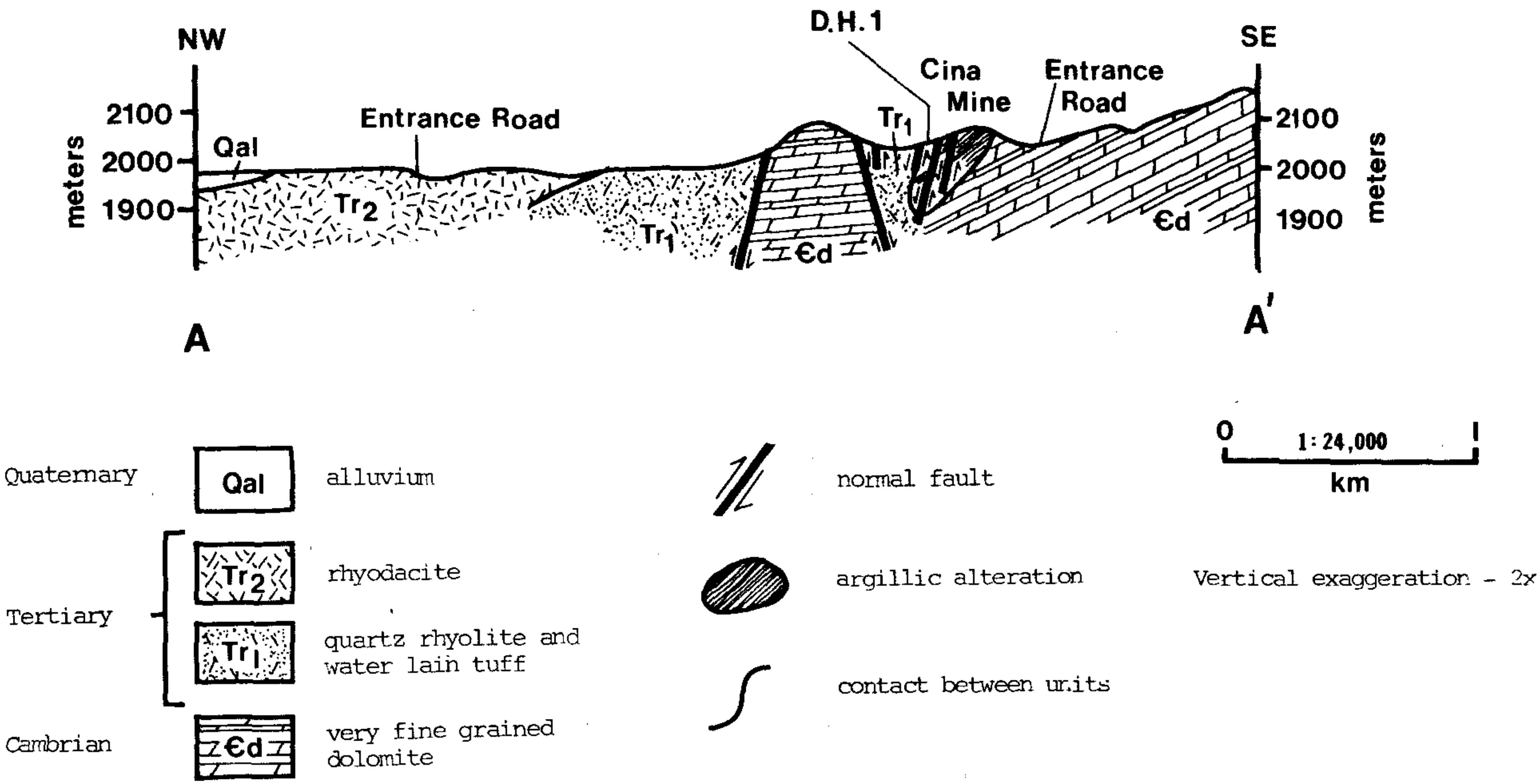


Figure 27. Geologic Cross Section A-A'. Cina Prospect. Iron County, Utah.

displacement faults correspond with areas of intense alteration. The faults are both pre- and post-mineralization in age.

Alteration and Mineralization

The Tertiary rocks in the vicinity of the Cina mine are highly friable, intensely bleached and argillized. Massive pods and irregularly shaped bodies of sulfur and alunite, up to 3 meters thick, are disbursed throughout the alteration zone. Replacement lenses of massive opalite and chalcedony roughly follow remnant bedding in the tuff. Irregular veins of chalcedony are associated with faults in the tuff. Pockets of less intense argillic alteration with minor silicification are associated with small displacement faults two to three kilometers northeast of the Cina Mine.

Cinnabar has been deposited as blebs and stringers in the alunite and is disseminated in opalite within fault zones. Cinnabar is also found as veins and fracture fillings along faults in the Cina mine. Sulfur deposition is generally not associated with cinnabar.

Heat Flow

The prospect is located within a 72 kilometer radius of the Newcastle, Beryl, Frisco, and Roosevelt Hot Springs geothermal anomalies. A mineral hole at the mine site (Figures 26 and 28) has a bottom hole temperature of 10.19°C at 20 meters. The measured thermal gradient, 36°C/km yields an uncorrected heat flow of 1.8 HFU.

The 98 meter gradient observation hole drilled at the Cina prospect is located on the northern side of the mine (Figure 26). Lithologic

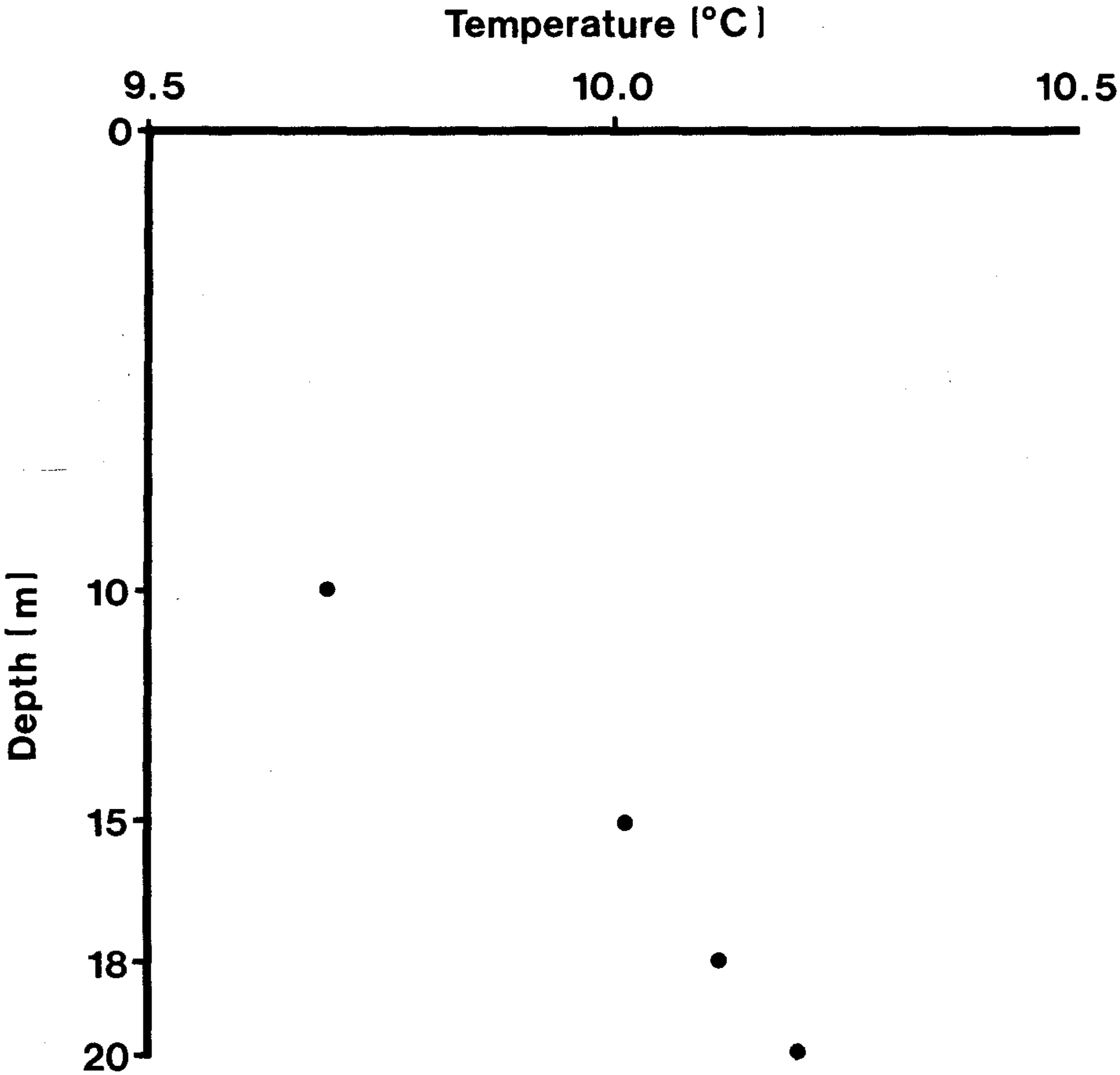


Figure 28. Thermal Gradient Curve Mineral Hole A. Cina Prospect. Iron County, Utah. $\Delta T = 36^{o}C/km$; k = 5 T.C.U.; q =1.8 H.F.U. Logged November 20, 1981.

and temperature logs of the hole are shown in Figure 29. The linear temperature gradient from 25 meters to the total depth is 38°C/km which yields a heat flow of approximately 3 HFU.

Extrapolation of the temperature gradient indicates a mean annual surface temperature of 9.6°C. This is within the expected regional norm for the area considering the elevation of the prospect.

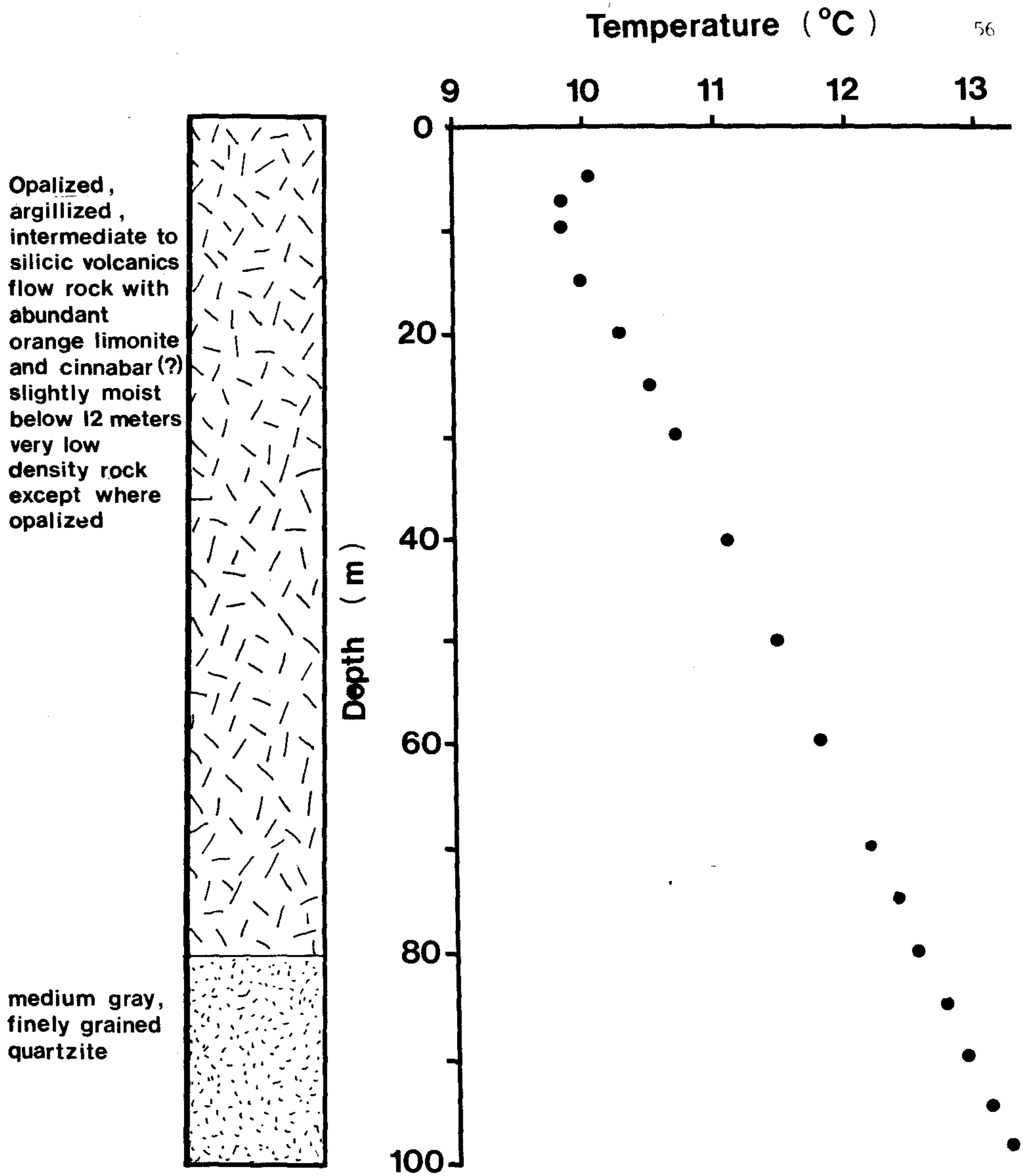


Figure 29. Lithologic Log and Thermal Gradient Curve D.H. #1. Cina Prospect. Iron County, Utah.
$\Delta T = 38^{o}C/km$; k = 8 T.C.U.; q = 3 H.F.U.

Recommendations

Drilling

Gradient holes at the Noquez prospect yielded heat flows from 5.0 to 7.6 HFU in dense silicic rock. We recommend drilling ten additional shallow (50m) gradient holes within a radius of 4.0 kilometers of the Noquez prospect in order to define the size, shape and intensity of the heat flow anomaly. In addition, detailed geologic mapping at a scale of 1:12,000 should be undertaken to assist in correlating heat flow distribution with structure, lithology and alteration.

Prospect Generation

Our geothermal exploration program, based on known mercury/sulfur/alunite deposits, is complete. The program was successful in identifying five intense heat flow anomalies. We believe that additional heat flow anomalies will be located in the western United States by utilizing the correlation of argillic alteration with currently active hydrothermal systems. Numerous alteration zones with anticipated active hydrothermal systems were overlooked because they lacked commercially interesting quantities of mercury, sulfur or alunite and therefore did not appear in the literature. These alteration halos will be recognized by low flying aerial reconnaissance techniques, and then examined on-site during the ground based follow-up phase. Additionally, numerous mineral holes in areas of abundant hydrothermal alteration will be identified. These drill holes will be probed during the on-site phase of the program. These holes might otherwise be missed in a strictly ground-based program.

Procedural and budget details of the above program are contained in Geothermal Exploration Program and Budget, January through June, 1982 by Frank Dellechaie, November 16, 1981.