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RADIOACTIVE MINERAL OCCURRENCES, MT. PRINDLE AREA, YUKON-TANANA UPLANDS, ALASKA

A

THESIS

Presented to the Faculty of the University of Alaska

in Partial Fulfillment of the Requirements

for the Degree of

MASTER OF SCIENCE

By

P. Jeffrey Burton, B.S.

Fairbanks, Alaska

September 1981

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RADIOACTIVE MINERAL OCCURRENCES

MT. PRINDLE AREA

YUKON-TANANA UPLANDS, ALASKA

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ABSTRACT

Lithologies in the Mt. Prindle area, east central Alaska, consist of a late Precambrian-Cambrian low grade metasedimentary assemblage intruded by the Mesozoic Mt. Prindle area alkaline complex and Tertiary granites. Palinspastic reconstruction of late Cretaceous Tintina Fault displacement juxtaposes the Mt. Prindle area alkaline complex with the lithologically similar and possibly genetically related Tombstone Mountains, Yukon Territory, Canada.

Uranium exploration and development in the Mt. Prindle area is focused on radioactive mineral occurrences within syenite and surrounding altered quartzite. Fissure veins contain anomalous concentrations of the uranium, thorium, and rare earth element minerals: allanite, bastnaesite, britholite, monazite, thorianite, thorite, uraninite, and xenotime. A possibly new mineral species, tentatively identified as the cerium group rare earth mineral neodymian phosphate, has been determined using energy dispersive X-ray analysis. Geophysical studies utilizing surface magnetic methods are the most effective guide to radioactive mineralized fissures in the Mt. Prindle area.

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INTRODUCTION

Purpose and Scope

The objectives of this study are to map the bedrock geology, study the petrology, and investigate the radioactive mineral occurrences in the Mt. Prindle area alkaline intrusive complex. A program of detailed and regional geologic mapping, extensive rock sampling, mineralogic studies, and petrographic analysis has been undertaken to accomplish these objectives.

Location and Physiography

The Mt. Prindle area alkaline instrusive complex (Longitude 147° 05'W, Latitude 65° 29'N) is centered 95 km (59 miles) north-northeast of Fairbanks, Alaska, within the White Mountain National Recreation Area (previously the Yukon Flats National Wildlife Monument). The study area is bounded to the west by O'Brien Creek and contains the headwater ridges of Roy Creek (Plate 1 and Plate 2).

Two unimproved roads provide winter access to the area. One road leaves the Elliott Highway at Mile 25.5 (41 km) and follows Wickersham and O'Brien Creeks. The other road leaves the Steese Highway at Mile 56 (90 km) and follows Nome, Beaver, and Roy Creeks. Winter access to the study area via the Steese Highway road was granted for the 1980 field season by the Monument Manager. Summer access to the study area has been restricted to helicopters.

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Topographic map coverage of the Mt. Prindle area is provided by the United States Geological Survey Livengood and Circle Quadrangle 1:250,000 sheets.

The Mt. Prindle area lies within the Yukon-Tanana Uplands which have evolved into a mature landscape of rolling hills and creeks with broad flood plains (Mertie, 1937). An altiplanation terrace has formed by differential frost attack and solifluction. Valley side slopes have a low angle and are covered with a mantle of slope detritus. A thick soil horizon has resulted in the extensive development of valley and slope vegetation cover. Rock exposures are rarely found. Ridge crests and peaks are usually covered with talus. Prominent tors up to 33 m (100 ft) high occur along ridge crests in granitic terranes. A few isolated monadnocks, usually of intrusive rocks, rise above the altiplanation terrace. Alpine-type glaciation occurred on the northern and, sporadically, on the western flanks of these higher mountains. North-facing hillsides on monadnocks are undergoing active snow patch erosion, producing deep hollows.

The prominent dome within the study area is informally known as "Dromedary Dome" (Plate 2). The talus covered ridge extending north of Dromedary Dome has been informally named "Snake Schist Ridge" (Plate 2).

The climate is typical of interior Alaska. Winter is long and dry with maximum low temperatures to -54°C (-66°F). Summer is sunny, hot, and of short duration. Precipitation in Fairbanks averages 28 cm (11 inches) a year, with most falling during short summer storms.

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The Mt. Prindle area is uninhabited. Grizzly and black bear, moose, wolf, mountain sheep, and caribou have all been recognized in the Mt. Prindle area.

Previous Work

The first geologic mapping done in the Yukon-Tanana Uplands was by Spurr, a U.S. Geological Survey geologist, in the period 1895-1898. Spurr (1898) first described the geology of the metamorphic basement in the Yukon-Tanana Uplands which he named the Birch Creek Schist.

L. M. Prindle started systematic geologic mapping for the U.S. Geologic Survey in the area bearing his name during 1910-1913. Prindle (1913) gives the first recorded description of the Mt. Prindle area alkaline complex ... "a porphyritic rock with trachytic structure, composed chiefly of tabular orthoclase and pyroxene with a little biotite." This description appears to correlate with the porphyritic biotite aegirine-augite syenite (Kpbs, Plate 2).

A definitive U.S. Geologic Survey study of the Yukon-Tanana Uplands was completed by Mertie (1937). Mertie did little work in the Mt. Prindle area and merely reiterated the earlier description and mapping of the Mt. Prindle area alkaline complex.

R. E. Church and M. C. Durfee (1961), two University of Alaska graduate students, jointly wrote a thesis on their study of Fossil Creek, located 14 km (8 miles) northwest of the Mt Prindle area alkaline complex (Plate 1). These authors stressed the importance of thrust faulting in

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the structural development of the White Mountains, northwest of the Mt. Prindle area (Plate 1).

A geologic map of the Livengood area covering the western half of the Mt. Prindle area was published by the U.S. Geological Survey in 1971 (Chapman et al., 1971). The syenite was described as "a medium-light gray, mostly weathered to yellow, orange, and brown, coarse to very coarse grained, porphyritic, deeply weathered [syenite]" (Chapman et al., 1971.

University of Alaska graduate student Bjarne Holm studied the Mt. Prindle intrusion in 1973 (Holm, 1973). Holm mapped the Mt. Prindle pluton and, with U.S. Geological Survey support, determined early Tertiary age dates for the Mt. Prindle and Cache Mt. granites.

The geology of the Yukon-Tanana Uplands was regionally remapped by the U.S. Geological Survey (Foster et al., 1973) with the Birch Creek Schist being redefined and renamed the Yukon-Tanana Undifferentiated Schist. Lithologic units similar to the Yukon-Tanana Undifferentiated Schist in the Yukon Territory were named the Yukon Crystalline Terrane (Tempelman-Kluit, 1976). The Yukon Cataclastic Complex is now the generally accepted name for the metamorphic basement of the Yukon-Tanana Uplands (Tempelman-Kluit, 1979).

Geometrics, Inc., under U.S. Geological Survey contract in 1974, determined the aeromagnetic residual intensity of the eastern half of the Livengood Quadrangle and all of the Circle Quadrangle (Brosge et al., 1970). The aeromagnetic coverage included the Mt. Prindle area and

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showed a pronounced magnetic high coincident with the alkaline intrusive complex.

Anomalous concentrations (400-500 parts per million) of uranium were found during 1977 in artesian spring sediments and stream sediments within the Mt. Prindle pluton by the U.S. Bureau of Mines (Barker and Clautice, 1977). This discovery of anomalous uranium values led to a claim staking rush in the Mt. Prindle area in the fall of 1977. Numerous companies have subsequently explored for uranium deposits in the area.

Mining History

Gold was discovered in the Mt. Prindle area on Nome, Hope, and Sourdough Creeks during a small rush in 1910 (Ellsworth and Parker, 1911). Dredging operations began on Nome Creek in 1926 and produced several thousand ounces of gold. Small placer operations were active on Nome, Hope, and Sourdough Creeks in the summer of 1980. The source of the placer gold may be several small Tertiary granitic bosses south of the Mt. Prindle pluton (Plate 1), since small lode occurrences of stibnite-gold bearing quartz veins are found in these granitic rocks (Berg and Cobb, 1967).

Project History

Initial uranium exploration was conducted in the Mt. Prindle area during August-September 1977 by Resource Exploration Consultants (REC) under contract to MAPCO. Aeroradiometric surveying, stream sediment

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sampling, and reconnaissance geologic mapping was conducted by REC over a 80 km^2 (50 $mile^2$) region encompassing all the intrusives within the Mt. Prindle area.

Numerous companies and individuals staked claims in the Mt. Prindle area following the September 22, 1977 USBM announcement of anomalous uranium concentrations associated with the Mt. Prindle pluton.

Regional exploration was undertaken by REC under contract to MAPCO during the summer of 1978. Exploration concentrated on the intrusive rocks and major faults in the Mt. Prindle area. Exploration methods included rock and soil geochemistry, radon detection, detailed geologic mapping, and hand-held scintillometer traverses. Jay Slivkoff, party chief during the summer of 1978, discovered radioactive mineralization in the Mt. Prindle area alkaline complex in mid-August 1978.

The Mt. Prindle area was included in the Yukon Flats Wildlife National Monument by Presidential decree on December 2, 1978. Subsequent to this action, MAPCO was required to file for a permit to conduct development and further exploration. Drilling was required to prove the discovery of anomalous mineralization.

A major program of investigation was undertaken by MAPCO and REC during the summer of 1979. Geological, geophysical, and geochemical techniques, as well as extensive drilling, were utilized in a detailed investigation of sites with anomalous concentrations of uranium. Further drilling was conducted by MAPCO field personnel during the summer of 1980.

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I have been associated with MAPCO's Mt. Prindle project since its inception in 1977; first, as a member of the REC claimstaking crew and, subsequently, in 1979 as Project Geologist for MAPCO. I was directly responsible for the regional and detailed mapping in the Mt. Prindle area (Plate 1 and Plate 2).

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GEOLOGIC SETTING

Regional Geology and Structure

The oldest exposed rocks in the Mt. Prindle area (pGs, Plate 1) are units of the polymetamorphosed Yukon Cataclastic Complex (Tempelman-Kluit, 1979). A Precambrian age is inferred because overlying rocks contain Oldhamia, a Precambrian-Cambrian trace fossil. Radiometric age dates rangeing from 509 m.y. to 256 m.y. from the Yukon Cataclastic Complex in Alaska record episodes of recrystallization within the polymetamorphic terrain (Chapman et al., 1971). The metamorphic facies increased from greenschist facies rocks in the east to a dominantly greenschist-amphibolite facies unit south of Beaver Creek (Chapman et al., 1971). The greenschist rocks are primarily quartz-mica schists consisting of an assemblage of quartz, muscovite, biotite, and feldspar. The greenschist-amphibolite unit consists of hornblende, quartz, and feldspar. Recrystallization generally decreases to the northwest in the Mt. Prindle area.

The west central region of the Mt. Prindle area contains low-grade, metasedimentary units (Gg, Plate 1) that are possibly in fault contact with the undifferentiated schist (F. Weber, personal communication, 1980). These metasedimentary rocks consist of three overlying units. The basal unit of the metasedimentary sequence is the informally named Wickersham Dome quartzite composed of quartzite, slate, and argillite (F. Weber, personal communication, 1979). A distinctive conglomerate informally known as the "grit unit" which characteristically contains

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pale blue quartz granules occurs within the Wickersham Dome quartzite. This granular conglomerate appears to correlate with a unit in the Selwyn Basin, Yukon (Roddick, 1967). The Wickersham Dome quartzite is the host rock for the Mt. Prindle area alkaline complex. The Wickersham Dome quartzite is complexly folded and is thrust-faulted to the northwest (Plate 1).

A fossil-bearing unit of argillite interbedded with slate, quartzite, siltstone, and limestone overlies the Wickersham Dome quartzite (Foster et al., 1973). The Precambrian-Cambrian fan shaped trace fossil Oldhamia was found in an olive slate within a distinctive formation of interbedded quartzite and argillite (Churkin and Brabb, 1965). Oldhamia is a sedimentary structure resulting from the activity of an animal, probably a sponge-like archaeocyathid, moving in or above the sediment at the time of deposition (Moore et al., 1952). No other fossils were found at the Oldhamia locality but the formation in which Oldhamia occurs can be correlated with an archaeocyathid-bearing formation on the Yukon River (Churkin and Brabb, 1965). Worldwide, Oldhamia is restricted to rocks of Cambrian or latest Precambrian age (Newman, 1962). The age determination of this trace fossil is used to assign a Precambrian-Cambrian age to the Yukon Cataclastic Complex which stratigraphically underlies the fossiliferous horizon in the Mt. Prindle area.

A thin exposure of metachert, slate, and phyllite caps the metasedimentary sequence (Chapman et al., 1971). These metasedimentary rocks are in thrust contact to the northwest with a diverse package of

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early Paleozoic rocks (Chapman et al., 1971) in the White Mountains (Plate 1).

The Paleozoic rocks in the White Mountains (Plate 1) consist of volcanic and volcanoclastic rocks, mafic and ultramafic intrusions, limestone, and quartzite. Chapman and others (1971) describe the volcanics as mafic tuffs, breccia, agglomerate, and minor basalt and diabase of Ordovician-Silurian age (OSv, Plate 1). Diorite, diabase, and gabbro (Dm, Plate 1) intrude the volcanics (Chapman et al., 1971). The Tolovana Limestone (SDl, Plate 1), a Silurian-Devonian aged finely crystalline limestone, unconformably overlies the mafic volcanics in the Mt. Prindle area (F. Weber, personal communication, 1980). An Ordovician aged vitreous quartzite (Oq, Plate 1) is overthrust by the Mt. Prindle area mafic volcanics and is in fault contact northwest of the Beaver Creek Fault with Mesozoic conglomerates and sandstones (KJc, Plate 1) (Chapman et al., 1971).

The Mt. Prindle area alkaline complex (Ks, Plate 1) consists of alkali syenites and a granite. These rocks are discussed in detail later. Potassium-argon age dates from biotite in the syenites give values of 86.7 ± 3.6 m.y. and 85.4 ± 6.4 m.y. (Z. Al-Shaieb, personal communication, 1979).

Biotite granite occurs in the Mt. Prindle area at four isolated plutons: the Cache Mt., Lime Peak, Quartz Creek, and Mt. Prindle plutons (Plate 1). The granites are predominantly medium-coarse porphyritic biotite granites with subordinate rock types being latite, andesite, and

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tourmaline granite. Age dates from the Cache Mt. and Mt. Prindle plutons cluster at 57 ± 2 m.y. (Holm, 1973). The Lime Peak and Quartz Creek plutons are undated but may be of similar early Tertiary age because of the lithologic similarities to the dated Mt. Prindle pluton.

Regional Tectonics

The Mt. Prindle area (Fig. 1) is located 32 km (20 miles) southwest of the Tintina Fault, which forms a border of the Cordilleran fold belt (Grantz, 1966; King, 1969; Lathram, 1973). The Cordilleran fold belt represents the Precambrian-early Paleozoic continental margin of the North American plate (King, 1969). The continental margin is defined as a transitional facies between continental and oceanic assemblages. The Cordilleran fold belt is bounded on the east by a continuous fault and its inferred extension consisting of the Rocky Mountain Trench, Tintina Trench, and the Tintina Fault (Grantz, 1966; Roddick, 1967; and King, 1969). This boundary also approximates the western margin of the Precambrian basement of the North American plate (King, 1969).

The North American continental margin may have developed as a result of Precambrian oceanic rifting followed by passive continental sedimentation from basement rocks to the east (Tempelman-Kluit, 1979). Fine-grained marine shales and sandstones and impure, coarse, continental detritus with minor limestones were deposited in the Precambrian-Cambrian transition on the North American continental margin. The sediments formed the protolith for the Yukon Cataclastic Complex (Tempelman-Kluit, 1979).

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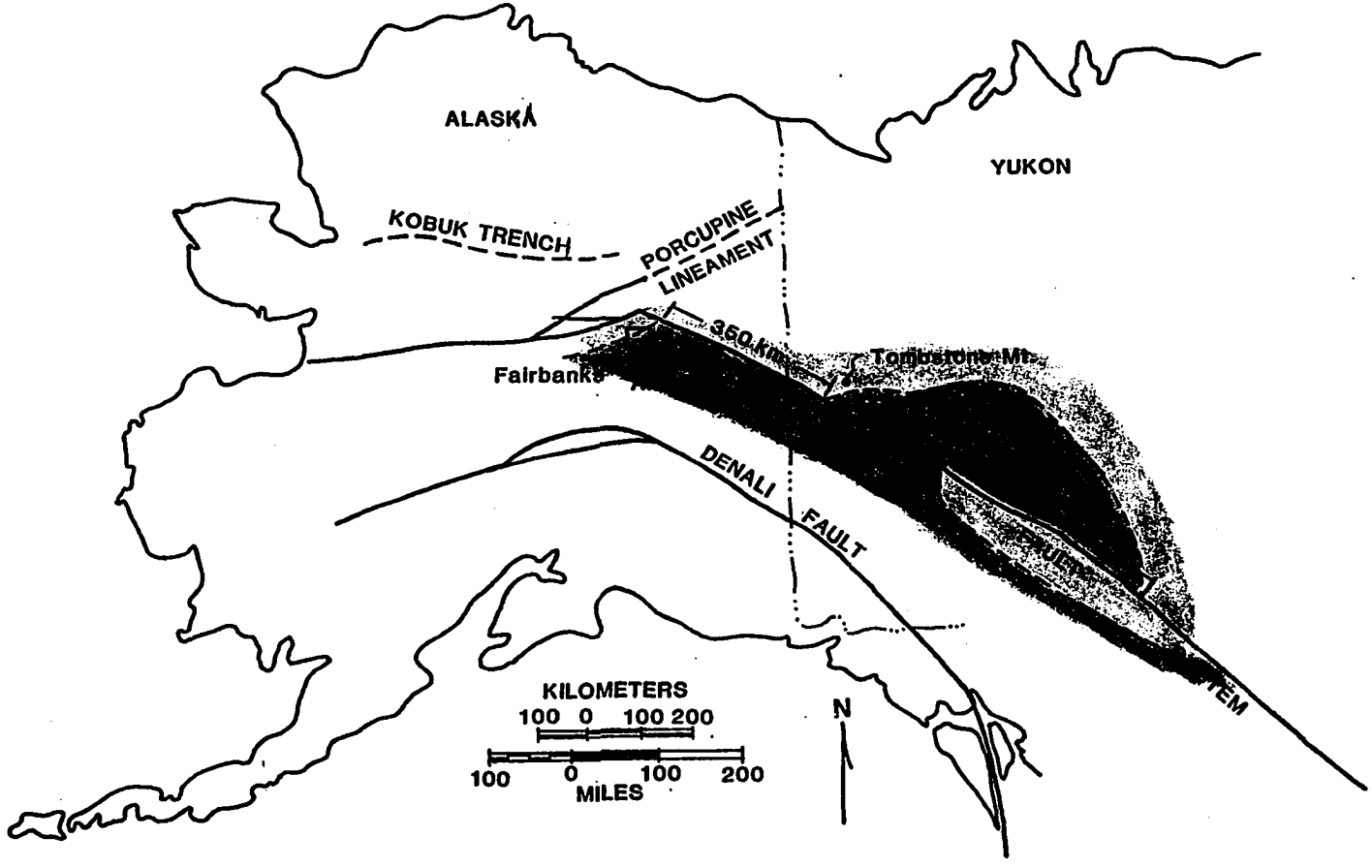

FIGURE 1 – Tintina Fault Displacement – Alaska and Yukon Territory.

Carbonate Platform Rocks **Clastic Rocks**

Diverse episodes of collision and accretion occurred in the early Paleozoic along the North American western continental margin (Churkin and Eberlein, 1977). Interpretations of the structurally complex history of the North American western continental margin are still being actively debated (Howell and McDougall, 1978).

Basalts were extruded from a southwestern source outboard of the Alaskan-Canadian Cordilleran fold belt in the early Paleozoic (Tempelman-Kluit, 1979; Churkin et al., 1981). This early Paleozoic volcanism is represented in the Mt. Prindle area by the White Mountain area volcanics of Ordivician-Silurian age (OSv, Plate 1). Tempelman-Kluit (1979) advocates an Andean-type island arc origin for the early Paleozoic volcanics. Churkin and others (1971), however, interpret the basalts as remnant oceanic crust with the Devonian ultramafic rocks (Dm, Plate 1) as tectonically emplaced mantle fragments within the oceanic crust.

Roddick (1967) documents 65 km (40 miles) of displacement on the Tintina Fault in the lower Paleozoic. Radiometric age dates from the Yukon Cataclastic Complex Schist record evidence of early Paleozoic tectonism. Wasserburg and others (1963) record a 509 m.y. (late Cambrian-early Ordivician) Rb/Sr age date from muscovite in schists just south of the Mt. Prindle area. A 470 m.y. (Ordivician) K-Ar age date (Forbes et al., 1968) is reported from schists near the locality of Wasserburg's sample. Early Paleozoic tectonism in the Mt. Prindle area resulted in regional metamorphism and the resetting of some of the radiometric ages.

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Carbonate shelf sedimentation occurred over volcanic rocks in the early Paleozoic along the western North American continental margin (Fig. 1). The Tolovana Limestone (SD1, Plate 1) in the White Mountains is an example of this carbonate shelf sedimentation.

Rifting in what is now British Columbia during the Pennsylvanian-Permian caused widespread faulting and metamorphism along the Alaskan-Canadian continental margin (Tempelman-Kluit, 1979). Oceanic crust was thrust to the east over the continental margin. Evidence of late Paleozoic tectonism in the Mt. Prindle area comes from a 256 m.y. (Permian) age for a sample of schist located just southwest of the study area (Chapman et al., 1971).

Ultramafic lenses were emplaced penecontemporaneous with steep, southwest-dipping faults along the Tintina Fault zone during the Triassic (Tempelman-Kluit, 1979). Faulting continued into the late Triassic-early Jurassic with the accretion of allochthonous terranes such as Wrangellia and Stikinia (Monger et al., 1972; Davis et al., 1978; and Tempelman-Kluit, 1979). In the late Jurassic to mid-Cretaceous, allochthonous terranes and island arcs were obducted onto an imbricating North American carbonate platform (Davis et al., 1978).

Large-scale dextral slip on the Tintina Fault in the late Cretaceous is well documented (Grantz, 1966; Roddick, 1967; Davis et al., 1978; and Tempelman-Kluit, 1979). Roddick (1967) has dated movement on the Tintina Fault between 66 m.y. and 100 m.y. The 100 m.y. Carmack volcanics in the central Yukon are displaced by the Tintina Fault; whereas, a nearby 66 m.y. granodiorite along the fault is unsheared.

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Palinspastic restoration for 360 km (225 miles) of late Cretaceous Tintina Fault displacement juxtaposes the Mt. Prindle area with the Selwyn Basin near the present position of Dawson, Yukon Territory. A distinctive Precambrian-Cambrian quartzite of the Mt. Prindle area correlates with a similar quartzite of the Selwyn Basin (Roddick, 1967; Brosge and Dutro, 1973; and Chapman et al., 1979). The correlation of the continental margin hinge line across the Tintina Fault in the Mt. Prindle area supports 360 km (225 miles) of Tintina Fault displacement (Fig. 1).

Tempelman-Kluit and Wanless (1975) identified a 90 m.y. episode of widespread metamorphism and plutonism in the Omineca Crystalline Belt. The Tombstone Mountains, an alkaline batholith, were emplaced 80-90 m.y. ago on the northeast side of the Tintina Fault, 50 km (31 miles) northeast of Dawson, Yukon Territory.

The Mt. Prindle area alkaline complex may be genetically related to the Tombstone Mountains (R. Swainbank, personal communication, 1979). The Mt. Prindle area alkaline complex displays many characteristics similar to the Tombstone Mountains using parameters of comparison developed by Murphy and others (1978) (Table 1).

The two alkaline bodies have similar petrology, mineralogy, tectonic settings, and age (D. Eaton, personal communication, 1980). Both are predominantly alkali syenite bodies which outcrop near the carbonate-clastic continental margin hinge line and after palinspastic reconstruction are separated by a mere 80 km (50 miles). Correlation of the Mt. Prindle area alkaline complex with the Tombstone Mountains would indicate movement on the Tintina Fault occurred less than 85-90 m.y. ago.

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Table 1 – Comparison of Mt. Prindle Area Alkaline Complex with the Tombstone Mountain Alkaline Complex.

PARAMETER	MT. PRINDLE	TOMBSTONE MOUNTAIN
Alkalinity	miaskitic–subalkaline	miaskitic–subalkaline
Petrology	alkali syenite granite	alkali syenite nepheline syenite quartz diorite
Mineralogy	aegirine–augite biotite	aegirine–augite biotite
Tectonic Setting	Tintina Fault	Tintina Fault
Age	85–88 m.y.	80–90 m.y.
Form of Emplacement	multiphase intrusion	multiphase intrusion
Country Rock	quartzite	quartzite
Pathfinder Elements	Thorium Rare Earths	Thorium Lead
Uranium Mineralization	Uraninite	Uraninite

References: Tempelman–Kluit, 1969; Currie, 1976; Goodfellow and Jonasson, 1977; Murphy et. al., 1978; and Eaton, personal communication, 1980.

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Greater right lateral slip for the Tintina Fault has been proposed in the Yukon, British Columbia, and Washington than in Alaska (Grantz, 1966; and Roddick, 1967). Roddick (1967) measures 450 km (280 miles) of right lateral displacement along the Tintina Fault in the central Yukon. Davis and others (1978) extend 450 km (180 miles) of late Cretaceous dextral movement along the Tintina Fault through the Fraser Fault system in British Columbia to the Straight Creek Fault in Washington. However, Grantz (1966) measures only 360 km (225 miles) right lateral displacement along the Tintina Fault in Alaska. Grantz (1966) believes that the unaccounted for displacement has been taken up by thrust faults in the Mt. Prindle area. Thrust faulting is widespread and of a regional scale in the Mt. Prindle area (Plate 1) (Church and Durfee, 1961). The Tintina Fault has also splayed into several faults in the Mt. Prindle area, resulting in partial offset of detached blocks (Chapman et al., 1979). Thus, the differences in calculated amounts of Tintina Fault displacement in the Mt. Prindle area can be accommodated by thrust faulting and splay faulting (Plate 1).

Churkin and others (1981) view the Mt. Prindle area as a pivot between the Tintina and Kaltag Faults. The Eurasian plate collided with the North American plate penecontemporaneously with late Cretaceous fault movement along the Tintina and Kaltag Faults (Churkin et al., 1981). Compressional stress resulting from plate collision may have triggered thrust faulting in the Mt. Prindle area. The Kobuk trench has been interpreted by some authors (Grantz, 1966; and Churkin et al.,

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1981) to be an extension of the Tintina Fault that was offset by the Kaltag Fault-Porcupine Lineament in the late Cretaceous (Fig. 1).

Approximately 760 m (2,500 feet) of normal movement on the Tintina Fault is documented in Canada and possibly Alaska during the Eocene-Oligocene (Grantz, 1966; Roddick, 1967; and Tempelman-Kluit, 1976). The Tintina Fault has been active since Tertiary time.

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PETROLOGY

Field Description and Relations

The rocks in the study area comprise a Cretaceous suite of syenites and a granite intruding a Cambrian argillitic quartzite. Mappable igneous rock types include: porphyritic biotite aegirine-augite syenite, biotite aegirine-augite syenite, aegirine-augite syenite, porphyritic biotite augite syenite, and alkali granite. There are minor occurrences of a magnetite biotite aegirine-augite lamprophyre.

The aegirine-augite syenite is the predominant intrusive rock forming the core of the alkaline complex. It is found in gradational contact with the other rock units. Fresh samples are dark green to gray. Weathering forms buff-colored, limonite-stained talus fragments that are smaller than any other rock type. The aegirine-augite syenite has fine-to medium-to coarse-grained hypidiomorphic-seriate with minor hypidiomorphic-granular textures. Very well-developed trachytic texture and porphyritic aegirine-augite syenite occur in widely scattered minor localities. Alkali feldspar generally constitutes about 83% of the aegirine-augite syenite, aegirine-augite averages 13%, with sphene, pyrite, and magnetite comprising a total average of 3%. Albite, biotite, apatite, zircon, and magnesioarfvedsonite are minor or rare accessories of the aegirine-augite syenite.

The biotite aegirine-augite syenite is located primarily along major lineaments within the aegirine-augite syenite apparent on airphotos,

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but also occurs in isolated dikes and small bodies. The biotite aegirine-augite syenite is dark gray and black in fresh specimens and weathers into blocky, light gray talus. The texture is fine- to medium-grained hypidiomorphic-granular and hypidiomorphic-seriate. The biotite aegirine-augite syenite averages 75% alkali feldspar, 13% aegirine-augite, and 7% biotite. The biotite content is variable and may exceed 30%. Sphene, apatite, pyrite, magnetite, and albite are common accessories. Eckermannite, rutile (?) , zircon, melilite, and sericite are rare accessories.

The porphyritic biotite aegirine-augite syenite is a map unit that is a textural variation of the biotite aegirine-augite syenite. The porphyritic rock occurs as a small body on the west flank of Dromedary Dome in contact with the hematite-stained argillitic quartzite and as scattered dikes. Phenocrysts of alkali feldspar up to 5 cm (2 inches) in length constitute about 60-80% of the porphyritic biotite aegirine-augite syenite. The porphyritic and phaneritic biotite aegirine-augite syenite differ only texturally and not in mineralogy.

An alkali granite occurs as a cupola on Snake Schist Ridge, as dikes within the hematite-stained argillitic quartzite, and in minor occurrences along the contact of the aegirine-augute syenite. Drill cores show the contact between the alkali granite and the aegirine-augite syenite to be gradational over a 1 to 1.5 m (3-5 ft) zone. The alkali granite is greenish-gray in fresh specimens with surface samples weathering buff due to limonite staining. The weathered granite appears similar in rubble size and color to the weathered aegirine-augite syenite. The

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quartz in the alkali granite is fine-grained and black due perhaps to metamict alteration and, without careful inspection, can be mistaken for aegirine-augite in hand specimen. The texture is generally medium-grained hypidiomorphic-seriate. The alkali granite is characterized by a high quartz content, averaging 30%. Alkali feldspar constitutes over 50% of the alkali granite with accessory aegirine-augite, sphene, and pyrite. The aegirine-augite content is highly variable from 1-10%. Biotite, eckermannite, apatite, and zircon are rare accessories.

Prophyritic biotite augite syenite is a minor rock unit occurring in gradational contact with the aegirine-augite syenite on the southwest flank of Dromedary Dome and the southern end of Snake Schist Ridge (Plate 2). The porphyritic biotite augite syenite also intrudes the host rock quartzite in isolated localities. The syenite is gray in fresh samples and weathers to form distinctive light gray blocks. The texture is fine-grained allotriomorphic-granular with phenocrysts of augite. Alkali feldspar constitutes about 60% of the rock, augite 15%, and biotite 10%. Pyrite, magnetite, albite, apatite, aegirine-augite, calcite, sericite, and sphene are minor or rare accessories.

An argillitic quartzite, informally named the Wickersham Dome quartzite, is the country rock surrounding the Mt. Prindle alkaline complex (F. Weber, personal communication, 1979). Variants of this argillitic quartzite include (in decreasing order of abundance): quartzite, argillite, and slate. The quartzite is gray, greenish-gray, or pale brown in fresh specimens and weathers with occasional iron staining. The quartzite

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is fine- to medium-grained, bedded, and rarely contains pebbles of blue translucent quartz. Milky white quartz occurs in veins and pods within the quartzite. The argillite and slate are very fine-grained with gray or pale green coloration. The slate is fissile; whereas, the argillite is well indurated.

The hematitic and/or hornfelsic quartzite occurs around all but the smallest intrusive bodies. The contacts with the intrusive rocks are sharp. Xenoliths and pendants of altered argillitic quartzite are common in the intrusive rocks. Hematite staining is pervasive in the altered quartzite. Hornfels are colored gray, olive, and purple. Textures vary from hornfelsic to porphyroblastic. Metasomatic porphyroblasts of alkali feldspar are found in some altered quartzite. Primary minerals in the altered quartzite and hornfels are alkali feldspar, biotite, quartz, eckermannite, white mica, and aegirine-augite. Accessory minerals in the altered quartzite include magnetite, albite, zircon, rutile, topaz (?), and chlorite.

Veinlets and replacement fillings of brucite (?), fluorite, titano-magnetite, fluorite-pyrite, fluorite-galena-pyrite, calcite-pyrite, calcite, quartz, and radioactive minerals are found in and around the Mt. Prindle area alkaline complex. Limonite and hematite staining are found along fractures.

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Petrographic Studies

Sixty-nine thin sections of rocks representing major rock units within the alkaline complex were prepared and examined. Mineralogy, texture, and order of mineral crystallization were determined for each thin section.

Table 2 tabulates the paragenetic sequence for each rock type within the Mt. Prindle area alkaline complex. There are three sequences of magmatism apparent in the alkaline complex (separated by dashed lines on Table 2).

The replacement of early minerals by later minerals is illustrated in Fig. 2, which shows an augite crystal from the porphyritic biotite augite syenite occurrence on Snake Schist Ridge. A relic augite crystal is partially replaced by, first, aegirine-augite and calcite, and, secondly, by biotite (Fig. 2).

Aegirine-augite has grown along fractures in quartz in alkali granite by penetration replacement (Fig. 3). Aegirine-augite fluids used pathways such as fractures or cleavages for migration through earlier formed crystals.

Aegirine-augite from the study area has a 2V of 85-90°, optically positive sign, and distinctive pleochroism with α = bright green, β = yellowish-green, and γ = brownish-green. The optical properties of the aegirine-augite are the same for all occurrences in the Mt. Prindle area rock types.

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Table 2 – Paragenetic Sequence, Mt. Prindle Area Alkaline Complex.

MINERAL	BIOTITE AUGITE SYENITE	ALKALI GRANITE	AEGIRINE – AUGITE SYENITE	RADIOACTIVE MINERALS	BIOTITE SYENITE
Apatite	X		X	X	X
Opaque	X	X	X	X	X
Augite	X				
Biotite	X				
Alkali Feldspar	X	X	X	X	X
Quartz		X			
Aegirine – Augite	(X)	(X)	X		X
Sphene	(X)		X		X
Calcite	(X)		(X)		(X)
Sodic Amphibole		(X)			
Radioactive Minerals			(X)	X	
Fluorite		(X)	(X)	X	
Biotite	(X)		(X)		X

X – mineral always present

(X) – mineral sometimes present.

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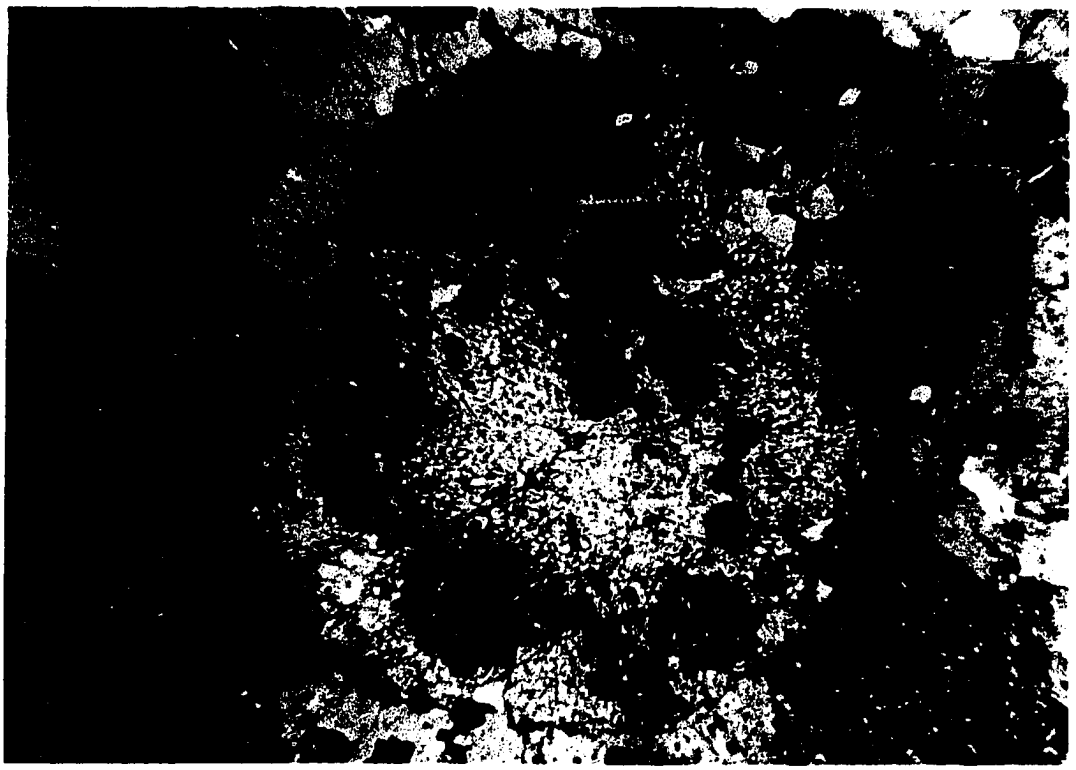

FIGURE 2 - Replacement of Augite Crystal, Mt. Prindle Area Alkaline Complex, 60x Magnification
A - augite
aa - aegirine-augite
b - biotite

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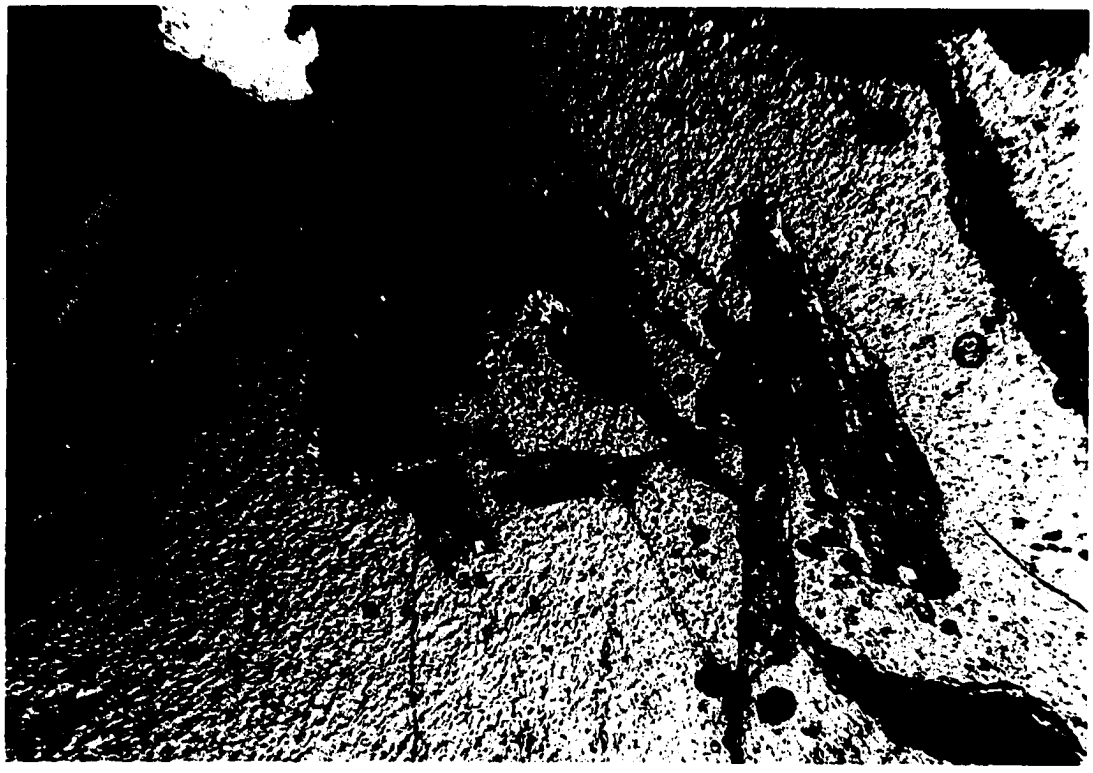

FIGURE 3 - Replacement of Quartz, 60x Magnification
Q - quartz
aa - aegirine-augite

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Two sodic amphiboles from the same solid solution series, eckermannite and magnesioarfvedsonite, also occur in the Mt. Prindle alkaline complex. Eckermannite is characterized by negative optic sign, high relief, pale blue-green color, strong absorption, extinction angle of about 30°, very strong dispersion, and second-order birefringence. Magnesioarfvedsonite, which has more iron and less magnesium than eckermannite, is characterized by positive sign, anomalous extinction, very strong dispersion, α = blue-green, β = lavender, and γ = blue-gray pleochroism, and second-order birefringence. Heinrich (1966) reports that eckermannite-magnesioarfvedsonite amphiboles commonly occur with quartz-rich rocks. These amphiboles are found in the Mt. Prindle area primarily in the alkali granite and the hematitic argillitic quartzite.

Allanite, a cerium-rich epidote family mineral, was the only radioactive mineral identified in thin section. Allanite is characterized by α = brown, β = brown, and γ = dark red-brown pleochroism, high relief, second-order birefringence, and common alteration to an isotropic hydrated state. Allanite commonly occurs in a metamict state due to crystal destruction by alpha particle bombardment from the disintegration of radioactive components. Alteration and hydration of allanite results in expansion, causing cracks to radiate into adjacent minerals (Fig. 4). The allanite forms a heterogeneous mixture of unaltered and altered material.

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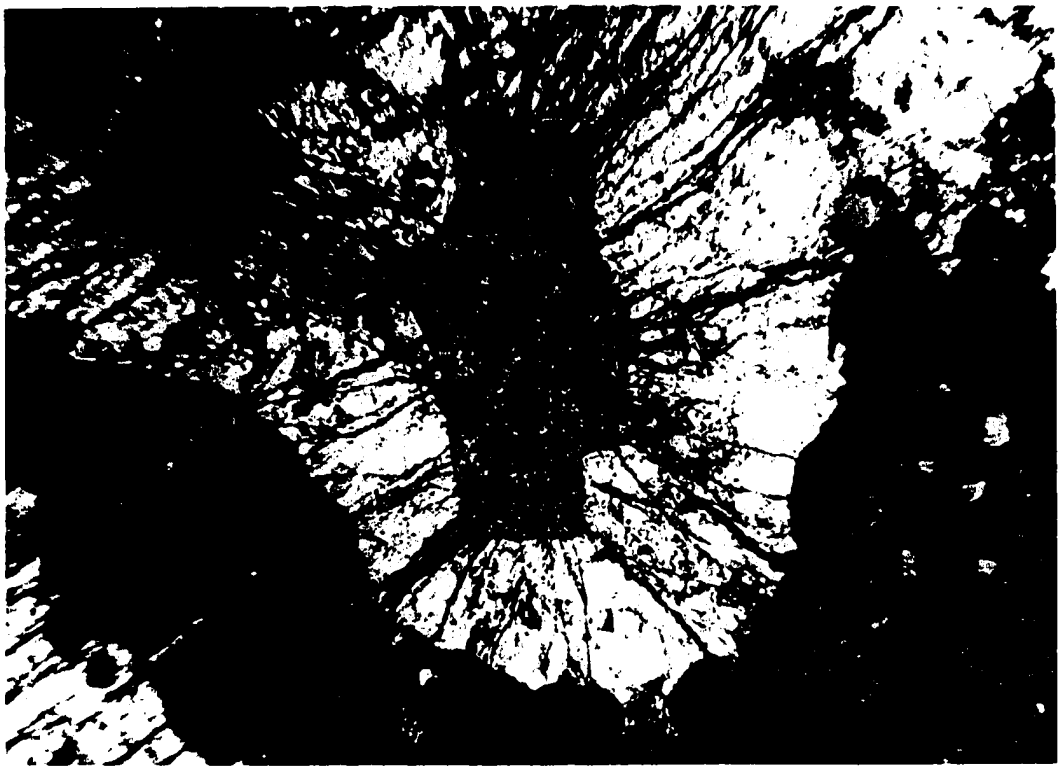

FIGURE 4 - Cracks from Hydrated Allanite, 60x Magnification

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Structural Geology

Joint directions, foliations, fault attitudes, and lineament trends were determined from aerial photographs, geophysical surveys, and the few bedrock outcrops. The results obtained from the limited recorded data show the strong influence of northeast-trending regional structures. The primary foliation of the quartzite determined from 13 values is N70°E, 15°SE (Fig. 5). Secondary foliation attitudes are N68°E, 60°NW, possibly indicating outcrops of rocks from the upper limb of the thrust plate (Plate II). Twenty-two joint attitudes were recorded with the dominant trend N60°E, vertical (Fig. 6).

High altitude black and white, high altitude false color infrared, and LANDSAT photographs were viewed stereoscopically to determine 98 lineaments (Fig. 7). The lineaments trend from N60°E to N110°E with the dominant trend N70°E. Many lineaments correlate to faults that were verified using VLF-electromagnetic and magneto-telluric geophysical methods.

A minor intraplate thrust fault striking N60°E outcrops three miles east of the alkaline complex (Plate 1 and Plate 2). The thrust in the study area has a parallel trend and a similar linear high magnetic value as the major thrusts located to the northwest (Brosge et al., 1970) (Plate 1).

The dominant fault in the study area cuts the granite on Snake Schist Ridge, then trends parallel to the ridge (Plate 2). The field relations of lithologic contacts and the Rule of V's indicate a high-angle reverse fault with the hanging wall block on the west.

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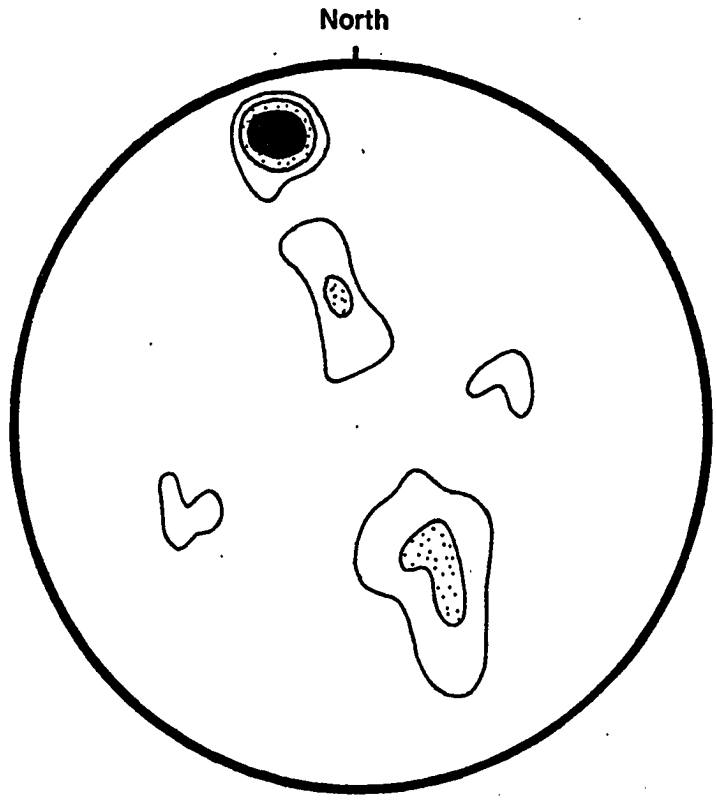
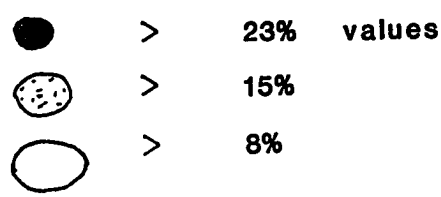


Figure 5 – Contour Diagram from Steriographic Projection of Joint Attitudes. Mt. Prindie Area Alkaline Complex.



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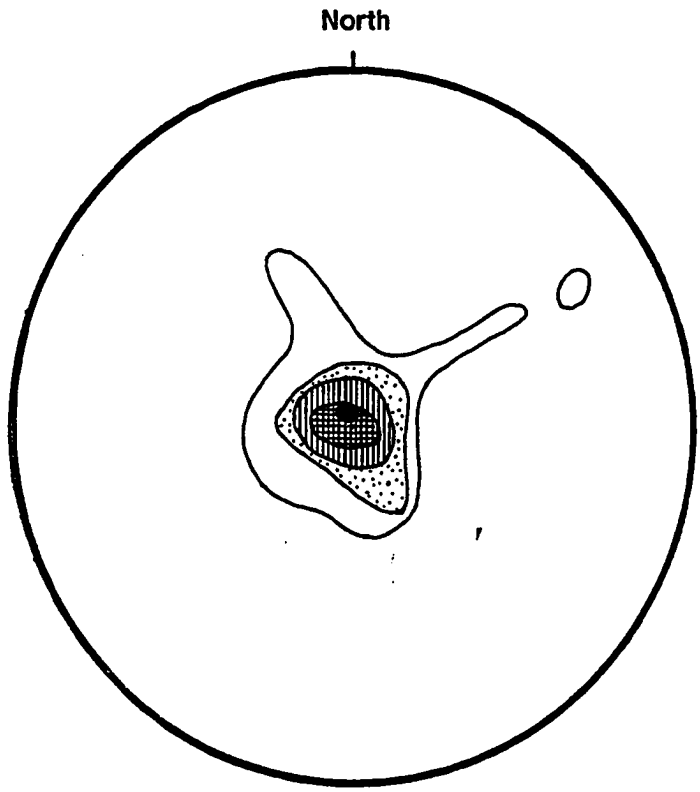
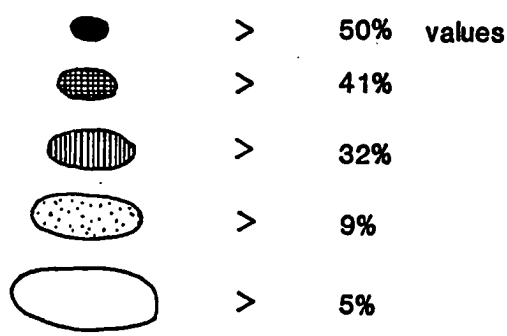


Figure 6 – Contour Diagram from Steriographic Projection of Joint Attitudes. Mt. Prindle Area Alkaline Complex.



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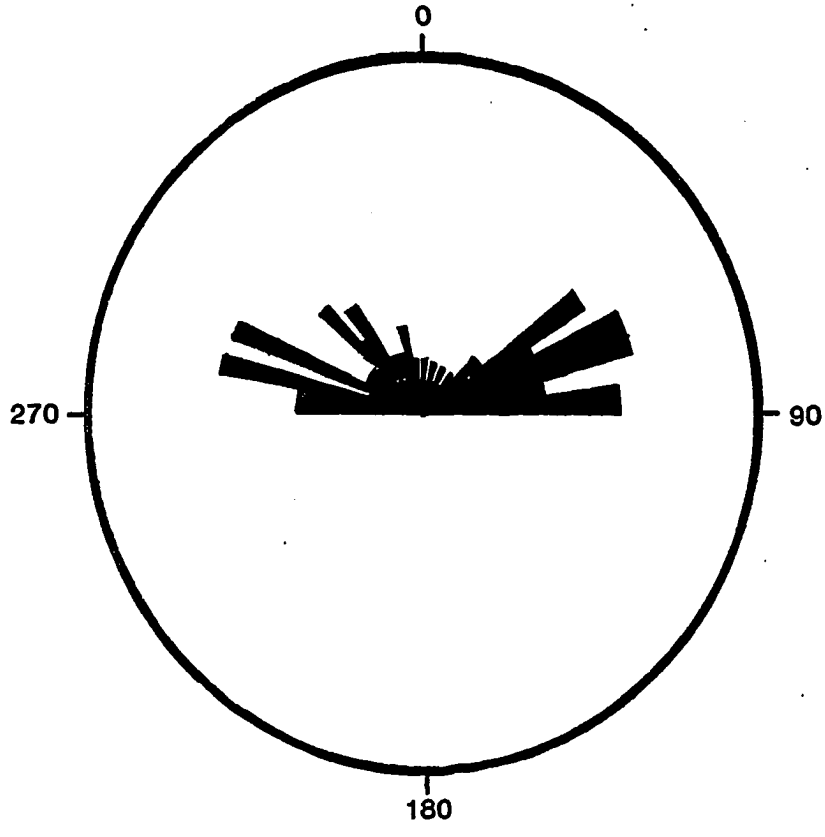

Figure 7 – Rose Diagram of Lineaments Northern Hemisphere Plot. Mt.Prindle Area Alkaline Complex.

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An almost east-west trending fracture on Snake Schist Ridge is mineralized with radioactive mineralization. This fracture was determined from air photos and verified by magneto-telluric and magnetic geophysical methods. The mineralized fracture is discussed in more detail in the Economic Geology section of this report.

The presence of abundant xenoliths and apophyses of intrusive rock in the study area indicates that the Mt. Prindle area alkaline complex was emplaced by piecemeal stoping of country rocks by a magma (Billings, 1972). The aureole of contact metamorphism and occasional miarolitic cavities give evidence for an upper crustal depth of emplacement (Billings, 1972).

Major Oxide Geochemistry

Twenty rock samples which were examined petrographically were also analyzed for major oxides by X-ray fluorescence (Uranium West-Lab, Pacific Palisades, Calif., 1979). Modal analyses, variation diagrams, and ternary plots were constructed to illustrate the geochemical character of the rocks in the study area.

The rocks of the Mt. Prindle area alkaline complex are alkali basalt family syenites and subalkaline granites (Fig. 8 and Fig. 9). The two classes of rocks have distinctly different chemical nature.

The plot of Thorton and Tuttle's (1960) Differentiation Index (D.I.) vs. weight percent SiO_2 clearly shows a distinct difference between the granite and the syenites. The Differentiation Index is

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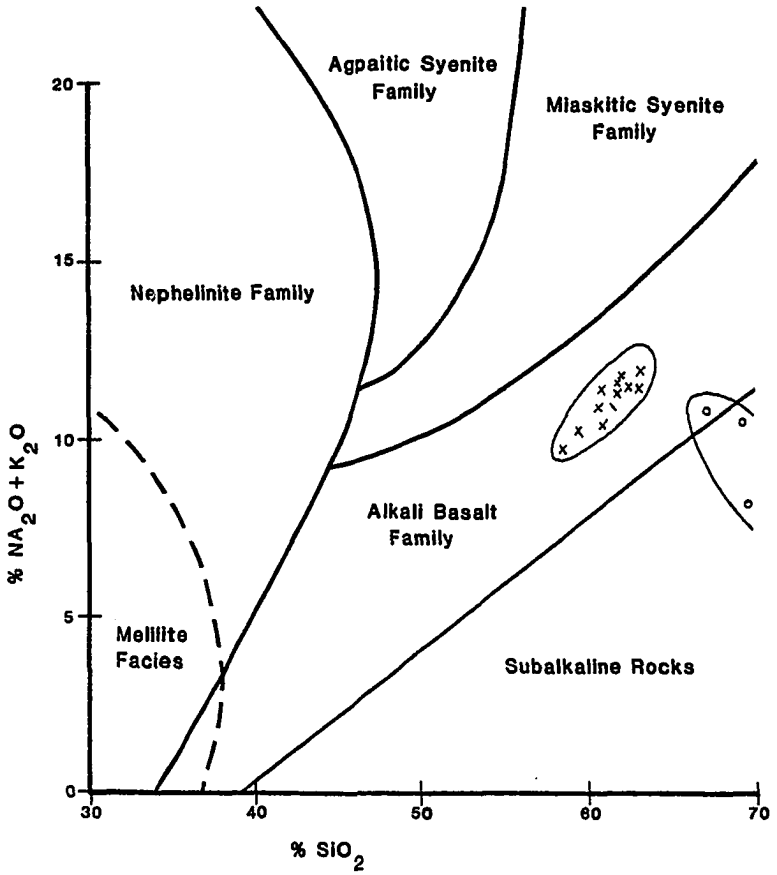

Figure 8 - Alkali - Silica Diagram for Alkaline Rocks. Plot of Mt. Prindle Area Alkaline Complex.

o granite

× syenite

Adapted from Nockolds (1954)

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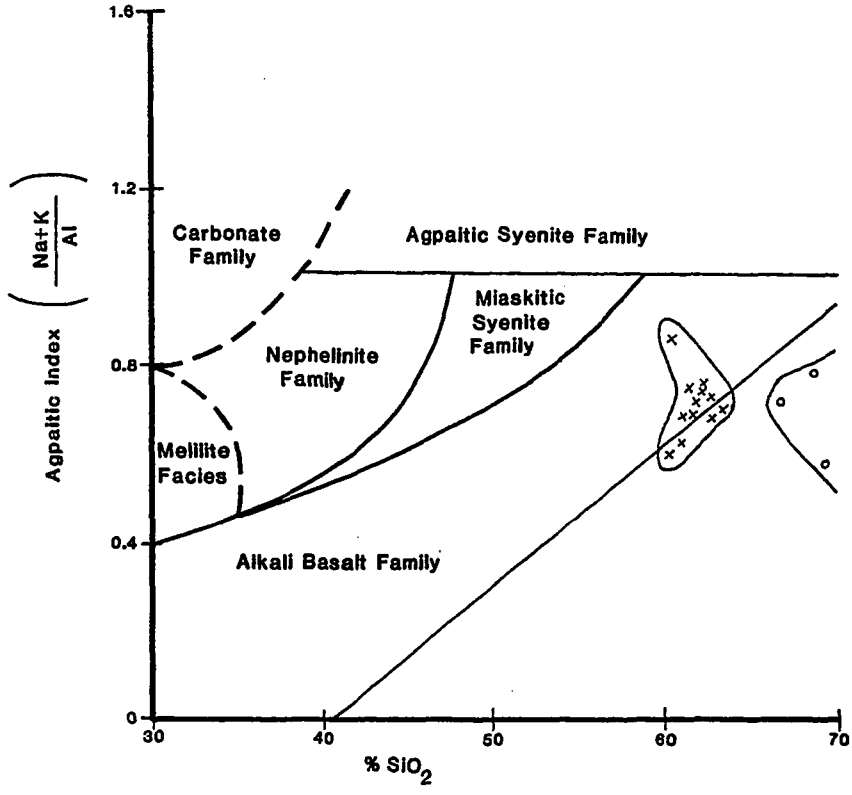

Figure 9 – Agpaitic index – Silica Diagram of Alkaline Rock Families with Plot of Mt. Prindle Area Alkaline Complex Samples.

o granite

x syenite

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a measure of the differentiation of an igneous rock, and a plot of the D.I. vs. SiO_2 shows a populations of saturated syenites and oversaturated granites having two different trends (Fig. 10).

Different trends for the syenites and granites result from a plot of total alkali vs. SiO_2 (Fig. 11). Silica and alkalis are proportional in the syenites but inversely proportional in the granites.

The diversity of the two rock types is further evidenced by a Harker Diagram (Fig. 12). The major oxides follow different trends for the granite with respect to the syenites from the Mt. Prindle area. Calcium content varies markedly between the granite and the syenites (Fig. 12).

Ternary diagrams of the syenites and granite also show a difference. A plot of the normative orthoclase-quartz-albite shows the granite with more quartz (silica) and less orthoclase (potassium) than the syenites (Fig. 13). A plot of Na_2O-K_2O-CaO reveals a calcium enrichment and sodium deficiency in the syenite with respect to the granite (Fig. 14).

The conclusion from the geochemical evidence is that the granite and the syenites are not co-magmatic. The exact relationship between the two rock types is not known, however the paragenetic sequence of minerals indicates that the granite is an earlier forming rock type (Table 2).

All the rocks studied petrographically were also analyzed for uranium and thorium by X-ray fluorescence (Z. Al-Shaeib, personal communication, 1979). The alkali granite averaged 36 parts per

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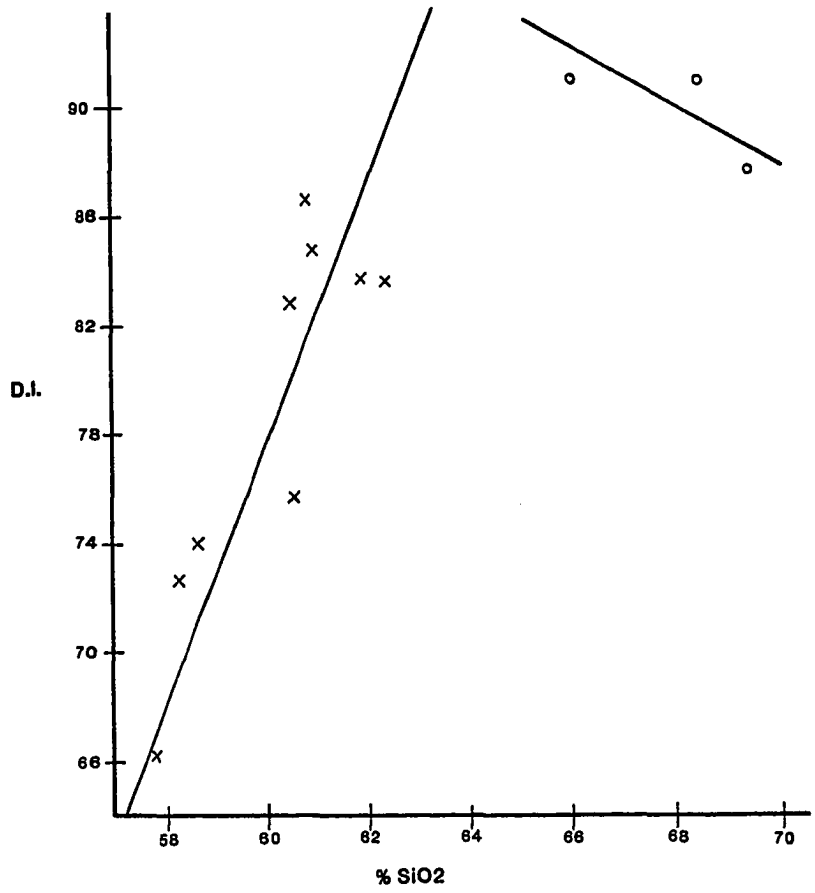

Figure 10 - Plot of Differentiation Index (D.I.) vs. Percentage Silica, Mt. Prindle Area Alkaline Complex.

o granite

× syenite

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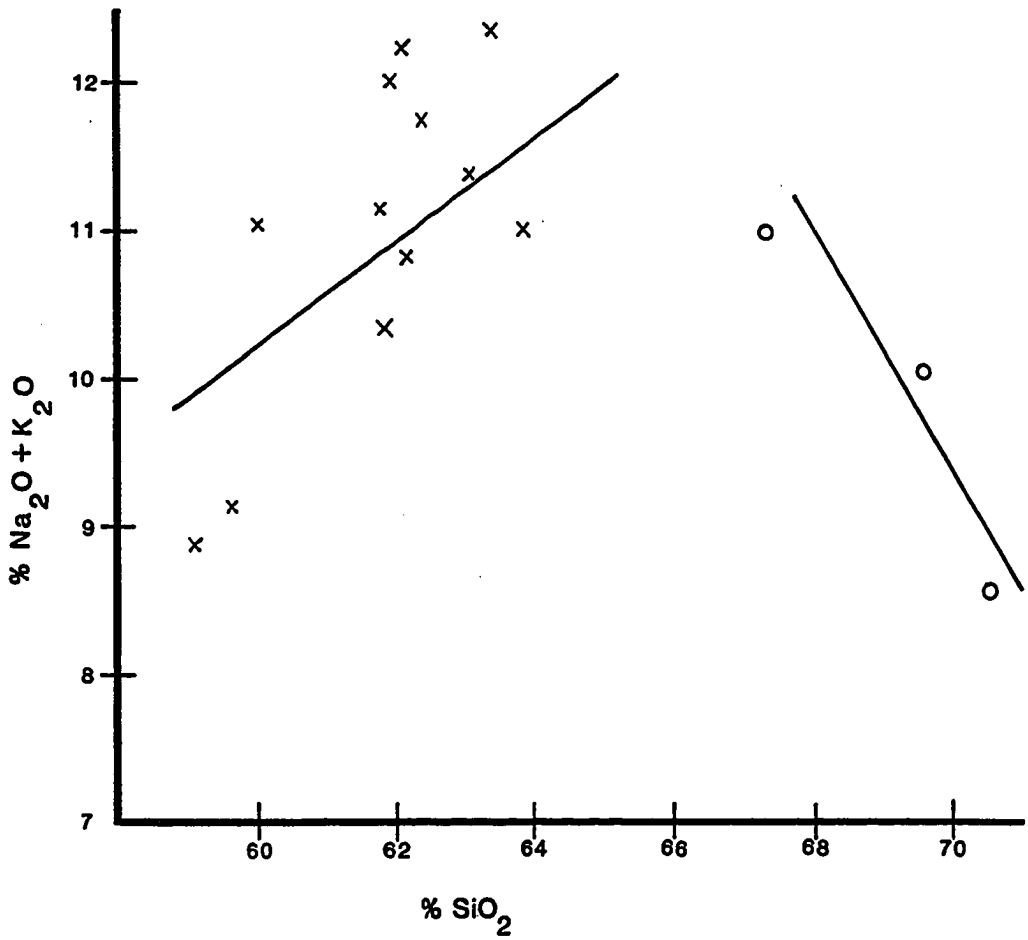

Figure 11 - Plot of Alkalis versus Silica. Mt. Prindle Area Alkaline Complex.

o granite

x syenite

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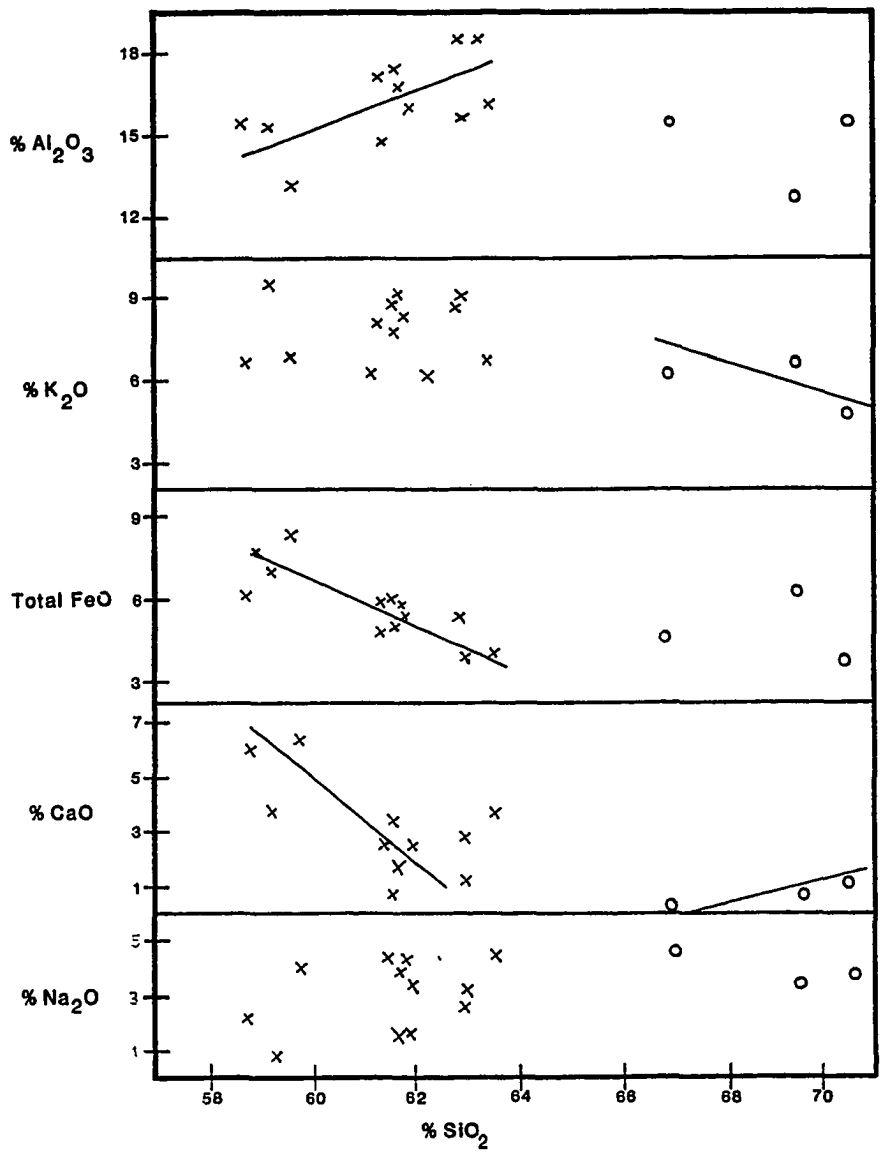

Figure 12 – Harker Diagram of the Major Oxides versus Silica for the Mt. Prindle Area Alkaline Complex.

o granite

x syenite

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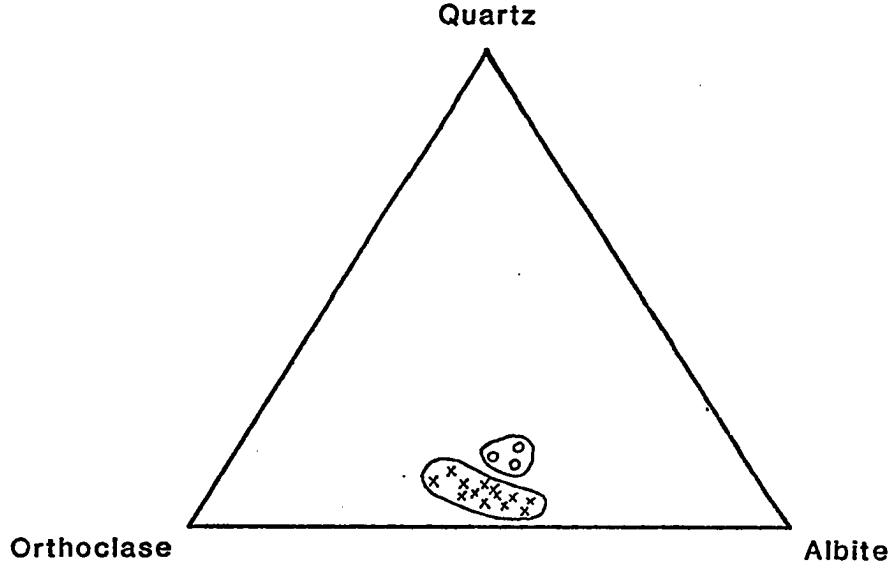

Figure 13 – Ternary Diagram Plotting Normative Quartz vs. Norm Orthoclase vs. Norm Albite, Mt. Prindle Area Alkaline Complex.

o granite

× syenite

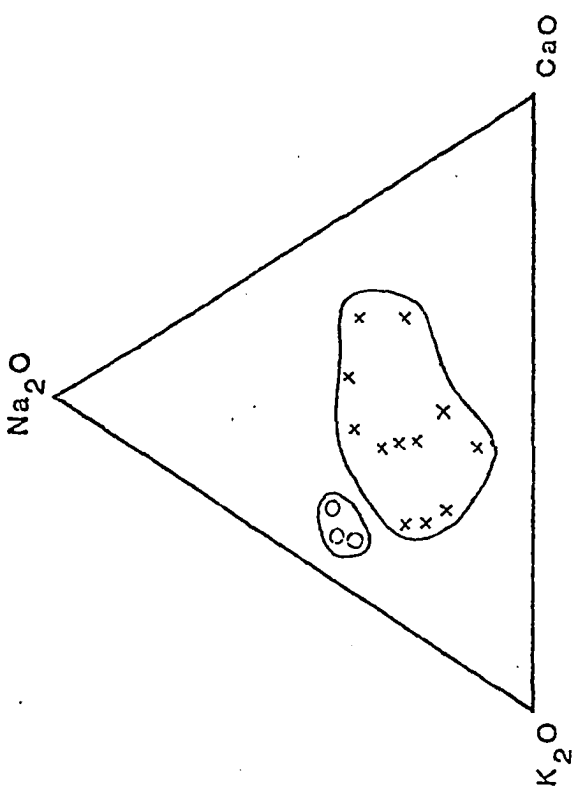

Figure 14 – Ternary Diagram Plotting Sodium vs. Calcium vs. Potassium, Mt Prindle Area Alkaline Complex.

O granite

x syenite.

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million (ppm) uranium (Table 3) which is nine times the average for granites worldwide (Rogers and Adams, 1967). Values of uranium concentration of the syenites fell within the normal range of alkaline intrusives (Rogers and Adams, 1967).

Nishimori and others (1977) developed a technique using thorium-uranium (Th/U) ratio to roughly determine the origin of the igneous rock. The utility of the Th/U ratio is due to greater crustal mobility of uranium (Gableman, 1977). A Th/U ratio greater than four indicates a mantle derivation (Nishimori et al., 1977). The biotite aegirine-augite syenite and biotite augite syenites both have Th/U ratios over four (Table 3). The alkali granite, hematite-stained quartzite, and aegirine-augite syenite have Th/U ratios between four and one which Nishimori and others (1977) interpret to indicate a metasomatic origin. A Th/U ratio very much less than one occurs in epigenetic uranium deposits (Nishimori et al., 1977). A plot of Th/U ratio vs. K_2O shows a directly proportional relationship for both the granite and syenite (Fig. 15) which indicates that uranium is not as closely related to the magmatic residuum as thorium (Lyons, 1964). The K_2O content is regarded as a measure of the degree of petrogenetic evolution and the increased thorium with increased potassium indicates that uranium is more volatile (Lyons, 1964).

Geochronology

Biotites from aegirine-augite syenite and porphyritic biotite aegirine-augite syenite were age dated by K-Ar techniques at 85.4 ± 6.4 m.y. and 86.7 ± 3.6 m.y., respectively (Plate 2) (Z. Al-Shaieb, personal

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Table 3 – Uranium, Thorum and Thorium / Uranium Ratio.
Mt. Prindle Area Alaska
Values Determined by Uranium West Labs.

ROCK TYPE	Uppm	Thppm	Th / U
Argillitic Quartzite, Hematitic	33	45	1.8
Alkali Granite	36	95	2.6
Aegirine – Augite Syenite	20	60	3.0
Biotite Aegirine – Augite Syenite	12	52	4.7
Biotite Augite Syenite	7	41	5.8

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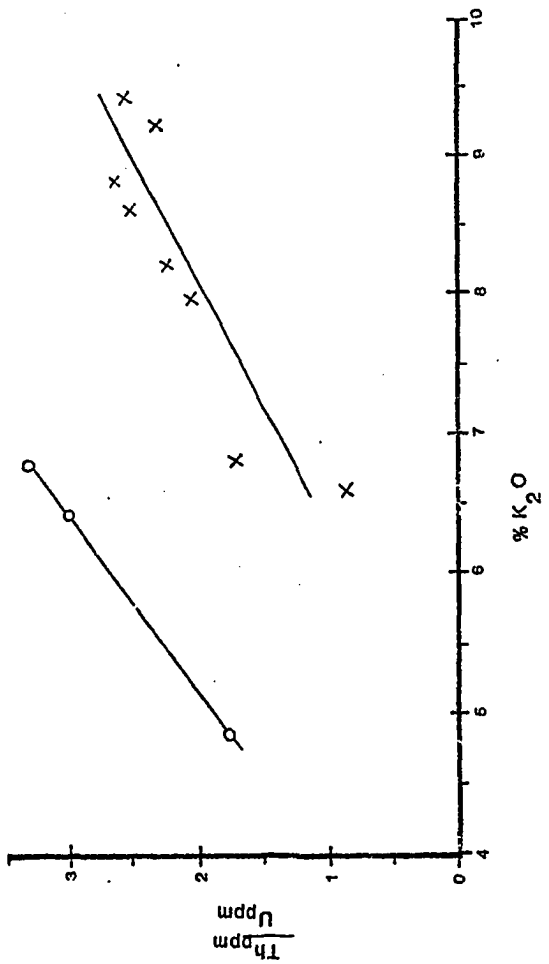

Figure 15 – Plot of Thorium / Uranium Ratio versus Potassium oxide.
Mt. Prindle Area Alkaline Complex.
o granite
X syenite

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communication, 1979). This late Cretaceous age for the crystallization of the Mt. Prindle area alkaline complex is a minimum age due to possible argon loss.

Petrogenesis

A petrogenetic model for the Mt. Prindle area alkaline complex is proposed (Fig. 16) based on pargenetic sequence (Table 2), field relations, and major oxide geochemistry following stages outlined by Hibbard (1978). Investigators of magmatic crystallization have developed a plethora of terminology to describe magmatic processes (Jahns and Burnham, 1969). Hibbard (1980) offers a general model with terminology devoid of implied views of genesis. Hibbard's stages are as follows: main stage magmatic, late magmatic, early post magmatic, and late post magmatic.

The main magmatic stage in Hibbard's model corresponds to rock-forming crystallization from the silicate melt, whereby the major portion of the intrusive crystallizes. The late magmatic phase corresponds to the stage when early formed crystals are resorbed and replaced by later formed crystals in the presence of a silicate melt. Post magmatic processes are derived from a water rich residual liquid.

The alkali granite and augite syenite are deduced to be the first magmatic products of the Mt. Prindle and alkaline complex due to the extensive replacement of late magmatic phase mineralization visible petrographically in thin sections (Fig. 2 and Fig. 3). Both rock types are found in altered and unaltered form (Table 2).

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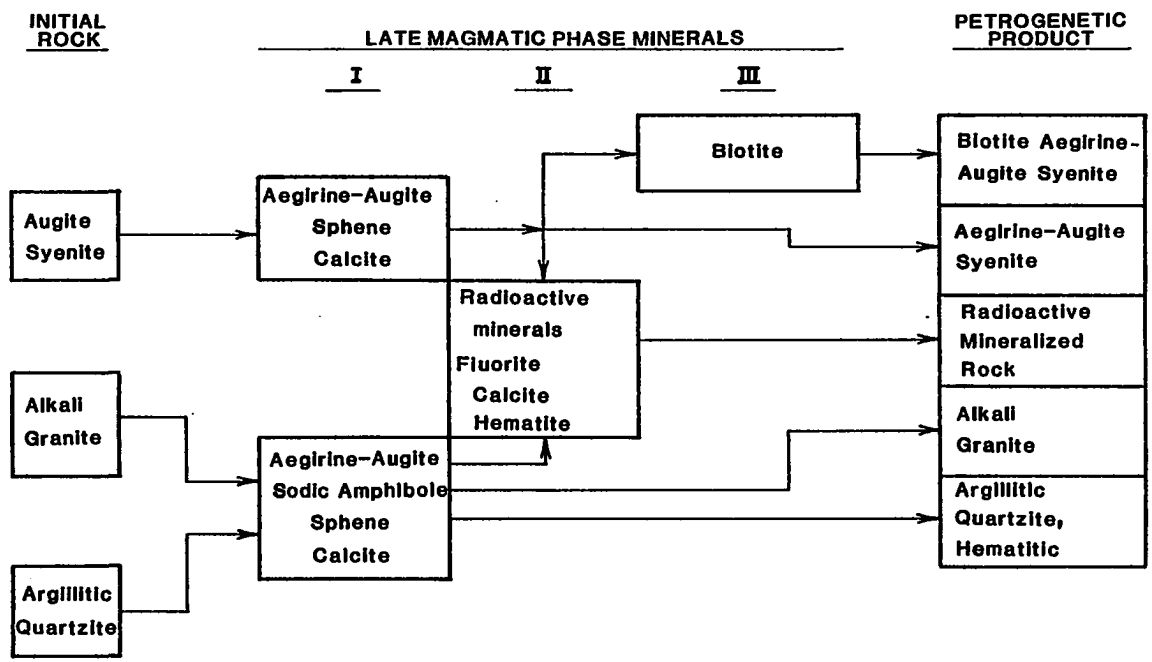

FIGURE 16 – Petrogenetic Model, Mt. Prindle Area Alkaline Complex

The aegirine-augite syenite was formed in the first phase of late magmatic processes (Fig. 16, Table 2). The aegirine-augite formed by the extensive replacement of the earlier formed granite and augite syenite (Plate 2) and was accompanied by widespread calcite veining.

Fluorite and radioactive mineralization were deposited along fissures in the second phase of late magmatic processes (Fig. 16, Table 2). The wall rocks of these fissures were altered by pervasive hematite staining during the second phase.

The final phase of late magmatic processes in the Mt. Prindle area alkaline complex resulted in biotite replacing aegirine-augite. Zones of biotite replacement appear to be concentrated along airphoto lineaments.

Post magmatic processes resulted in hydrothermal veining and alteration within and around the Mt. Prindle area alkaline complex. Galena, pyrite, and magnetite were deposited in veins and veinlets after emplacement of the intrusion. Secondary potassic alteration and lamprophyre dikes occurred penecontemporaneously with hydrothermal veining in a few isolated localities within the alkaline complex (Plate 2).

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ECONOMIC GEOLOGY

Uranium Concentration in Alkaline Rocks

Recent exploration in the Mt. Prindle area has centered on searching for an igneous-hosted uranium deposit. Uranium has three modes of occurrence within igneous rocks: discrete uranium minerals, molecular ionic disseminations, and isomorphic uranium substitution within crystal structures (Adler, 1977).

The primary mode of uranium occurrence in economic igneous uranium deposits is discrete uranium minerals (DeVoto, 1978). Uranium minerals--such as uraninite, betafite, coffinite, and brannerite--occur in igneous uranium deposits as minor accessories disseminated in the rock or concentrated in veins. These uranium minerals are readily leached in an oxidized environment, forming potentially valuable secondary mineral deposits.

Uranium commonly occurs as molecular ionic disseminations within rock-forming minerals (Rogers and Adams, 1967). The uranium ions are disseminated along grain boundaries, structural defects, fractures, cleavage planes, and within fluid inclusions. Twenty to sixty percent of the uranium ionically disseminated in rock-forming minerals is readily leachable for economic recovery (DeVoto, 1978). At present (1981), only one disseminated uranium deposit (Rossing, Namibia) is being mined.

A refractory and, therefore, uneconomic mode of uranium occurrence is isomorphic uranium substitution within the crystal structure. Uranium (valence +4) may substitute for thorium, calcium, zircon, tungsten,

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molybdenum, niobium, tantalum, and yttrium (DeVoto, 1978) (Table 4). Uranium so commonly substitutes for thorium that the primary uranium and thorium minerals often have the same X-ray pattern.

The mode of occurrence of uranium in igneous rocks depends upon the geochemical properties of uranium (Adler, 1977), chemical properties of the magma, and the conditions of emplacement and crystallization (Sorensen, 1977).

Uranium is a lithophile element occurring in a reduced environment with a +4 valence and in an oxygenated environment with a +6 valence. The average crustal abundance of uranium is 2 parts per million (ppm) (Rogers and Adams, 1967). Uranium is an incompatible element that, due to its large atomic radius, generally low concentration, and high valence, is concentrated in residual fluids and late-stage magmas (Carmichael et al., 1974).

Uranium shows a strong affinity for melts rich in the halogens (Bohse et al., 1974). Uranous halides form many soluble complexes in undersaturated magmas (Gableman, 1977).

High uranium concentrations in a magma can also be formed if a volatile phase is retained during crystallization of a water-saturated magma (Sorensen, 1977). Fractional crystallization of this hydrous residual melt concentrates uranium (Burnham and Ohmoto, 1979). Uranium is transported with volatile components such as NH_3, CH_4, CO_2, and H_2O (Gableman, 1977). Economic mineralization can occur upon precipitation of these uranium-enriched fluids.

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Table 4 - Isomorphic Cation Substitution of Uranium

ELEMENT	ATOMIC RADIUS (Å)	VALENCE
Tungsten	0.70	+4
Molydebnum	0.70	+4
Niobium	0.70	+5
Tantalum	0.73	+5
Yttrium	0.76	+4
Zircon	0.79	+4
URANIUM	0.97	+4
Calcium	0.99	+2
Thorium	1.05	+4

Reference : DeVoto, 1978

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The concentration of uranium in residual fluids from alkaline magmas is well documented (Sorensen, 1977). These residual fluids are enriched in uranium, thorium, sodium, potassium, and halogens.

Thus, the uranium content of igneous rocks generally increases with magmatic differentiation. Uranium (and thorium) are usually enriched in the youngest, most felsic, most silicic, and most potassic members of a comagmatic suite of igneous rocks (Bohse et al., 1974).

Mineralogic Studies

Radioactive mineralization in the Mt. Prindle area alkaline complex consists of a varied suite of uranium, thorium, and rare earth element (REE) silicates, phosphates, carbonates, and oxides (Table 5). Mineralogic studies by the U.S. Geological Survey, Mineral Industry Research Laboratory, and this writer have identified: allanite, bastnaesite, britholite, monazite, neodymian phosphate, thorianite, thorite, uraninite, and xenotime. A variety of analytical techniques have been used to identify these minerals: ore microscopy, optical petrography, energy dispersive X-ray analysis, and X-ray diffraction. Uranium, thorium, and cerium-group or light rare earth elements have been identified from anomalously radioactive samples.

An unusual mineral, neodymian phosphate, was discovered by energy dispersive X-ray analysis utilizing a scanning electron microscope

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Table 5 – Radioactive Minerals, Mt. Prindle Area Alkaline Complex.

MINERAL	FORMULA
Allanite	$H(Ca,Fe)(Al,Fe,REE)_3Si_3O_{13}$
Bastnaesite	$(REE)FCO_3$
Britholite	$(Ca,Ce)_5[(Si,P)O_4]_3(OH)F$
Monazite	$(REE)PO_4$
Neodymian Phosphate	$NdPO_4$
Thorianite	$(Th,U)O_2$
Thorite	$ThSiO_4$
Uraninite	$(U,Th)O_2$
Xenotime	YPO_4

Minerals identified by: Mortimor Staatz, USGS; Mark Robinson MIRL, and Jeff Burton.

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(Fig. 17). The mineral is tentatively identified using a Kevex 700 Microanalyzer at the Geophysical Institute, Fairbanks, Alaska (Fig. 18). Murata and others (1953) divide the cerium group or light rare earth elements into two subgroups: The Lanthanum Subgroup and the Neodymian Subgroup. Rare earth elements occur in extensive solid solution with one another due to similar chemistry and crystal chemical properties (Vlasov, 1968). Neodymian phosphate may be the end member representative of a solid solution between monazite, a Lanthanum Subgroup Phosphate and a Neodymian Subgroup Phosphate.

Nature of Radioactive Mineralization

Inferred grade and tonnage of the Mt. Prindle area mining claims is unavailable for this report. However, the general nature of the occurrences can be described.

Radioactive mineralization appears to be controlled by fissure veins. The fissures are highly inclined with pinches and swells forming openings. Faulting is evidenced by slickensides and bands of gouge.

The mineralization appears to have filled openings by precipitation with only minor replacement of wall rock. Open vugs occur within the radioactive mineralization. Hematitic alteration of the wall rocks occurred in association with radioactive mineralization resulting in the leaching of magnetite around radioactive mineralized fissures. This megnetite loss is measurable using surface magnetic methods (Fig. 19).

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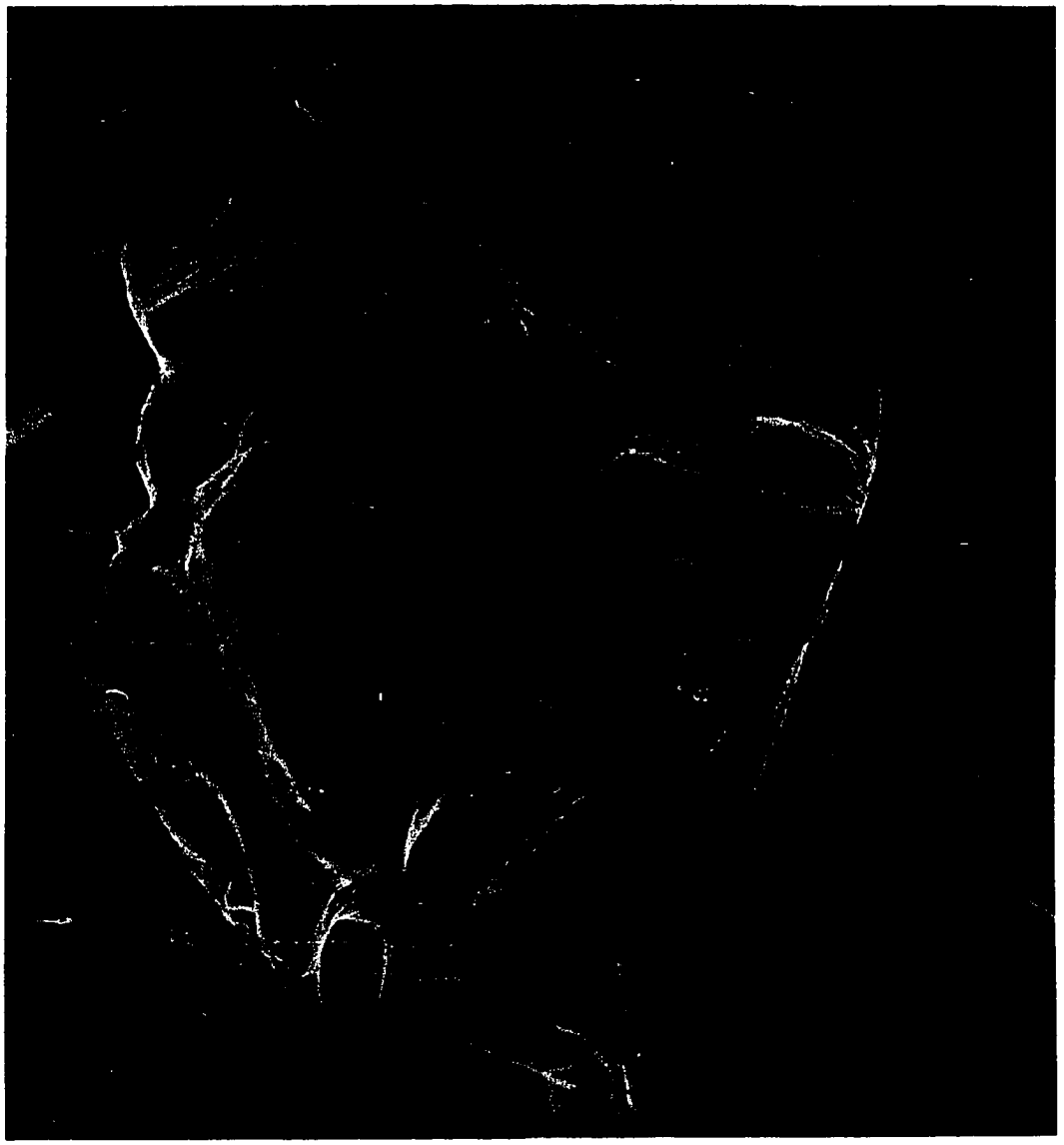

FIGURE 17 - Neodymian Phosphate,
Scanning Electron Microscope
Photography 20,000x Magnification

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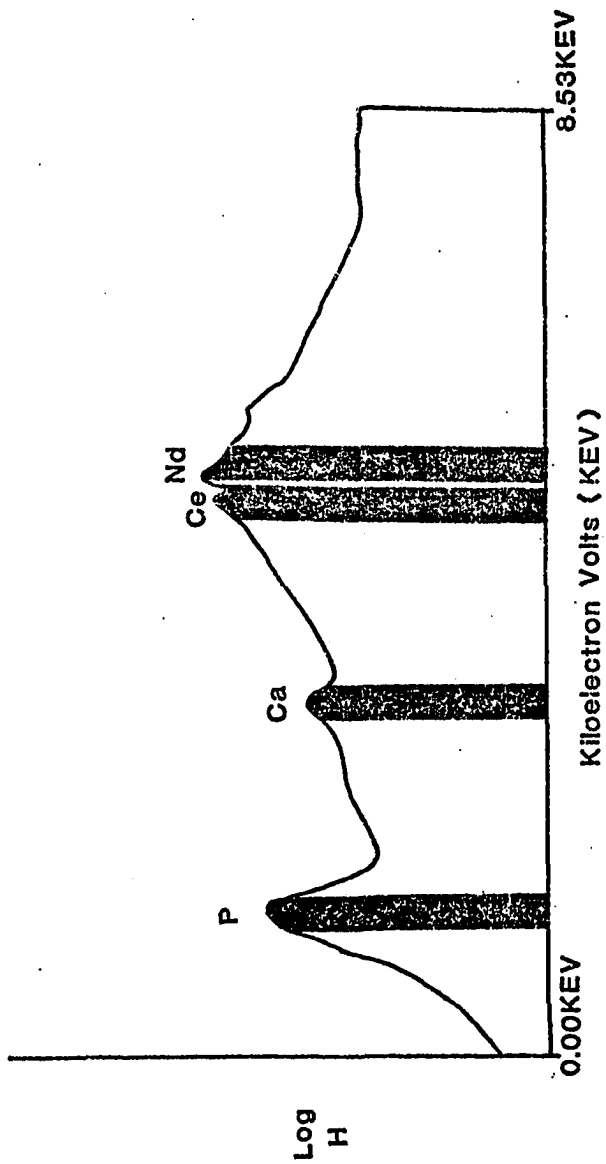

Figure 18 X-Ray Analysis of Heavy Mineral Separate,
Radioactive Mineralized Rock, Mt. Prindle Area, Alaska.

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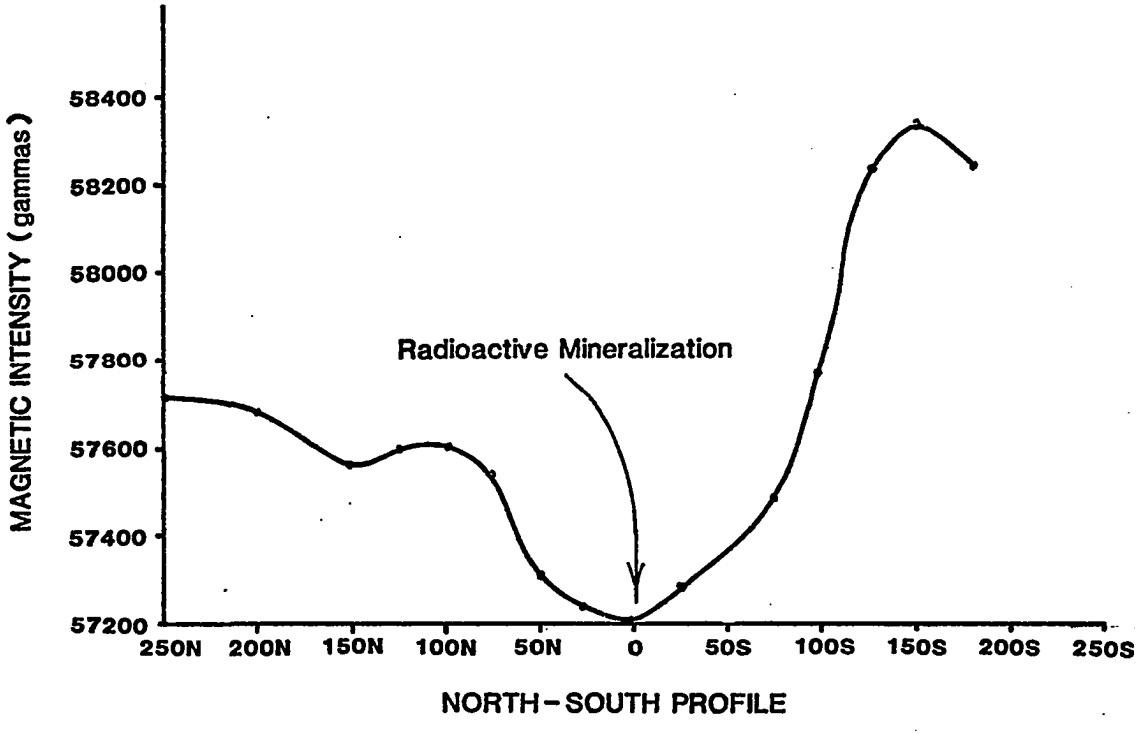

Figure 19 - Ground Magnetic Data over 'P' Pit. Mt.Prindie Area Alkaline Complex.
(Data is smoothed using a 1-2-1 weighted running average.)

There is an uneven distribution of values along the fissures with the highest grade mineralization occurring in or along contacts with pendants of altered country rocks (Plate 2).

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SUMMARY

The Mt. Prindle area alkaline complex lies within the Yukon-Tanana Uplands at the northern terminus of a major continuous fault system which includes the Tintina Fault, the Tintina Trench, and the Rocky Mountain Trench. This fault system represents the late PreCambrian-early Paleozoic North American continental margin.

Greater right lateral slip for the Tintina Fault has been proposed in the Yukon, British Columbia, and Washington than in Alaska (Grantz, 1966 and Roddick, 1967). Grantz (1966) believes that the unaccounted for displacement in Alaska has been taken up by thrust faulting in the Mt. Prindle area. Geologic mapping has revealed thrust faulting as well as splay faulting of widespread extent in the Mt. Prindle area.

Palinspastic restoration of late Cretaceous Tintina Fault displacement juxtaposes the Mt. Prindle area with the Selwyn Basin near the present position of Dawson, Yukon Territory. The Mt. Prindle area alkaline complex may be genetically related to the lithologically similar Tombstone Mountains northeast of Dawson.

The rocks in the Mt. Prindle area consist of a late Precambrian-Cambrian metasedimentary assemblage intruded by a late Mesozoic alkaline complex and numerous early Tertiary granitic plutons. The Mt. Prindle area alkaline complex was geologically mapped and the petrogenetic history determined in the course of this study. An augite syenite was emplaced during the late Cretaceous in an argillitic quartzite within the Mt.

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Prindle area. Late magmatic processes altered pre-existing rock resulting in an aegirine-augite syenite. After formation of aegirine-augite, radioactive mineralization was deposited in fissures within the syenites and associated quartzites. Biotite replacement occurred along lineaments as a final magmatic phase. Secondary potassic alteration, metalliferous hydrothermal veining, and lamprophyre dikes occurred in the post magmatic stage of activity in the Mt. Prindle area alkaline complex.

Radioactive mineralization in the Mt. Prindle area alkaline complex consists of numerous occurrences of a varied suite of uranium, thorium, and rare earth element minerals. One of these minerals, tentatively defined as neodymian phosphate, may represent a new mineral species. Detailed investigations revealed that radioactive mineralization filled fissures by open space filling. These fissures are detected geophysically as magnetic lows which result from late magmatic radioactive mineralizing fluids oxidizing orthomagmatic magnetite to hematite. The most notable occurrences of radioactive mineralization are found in fissures within or along the contacts of altered country rocks.

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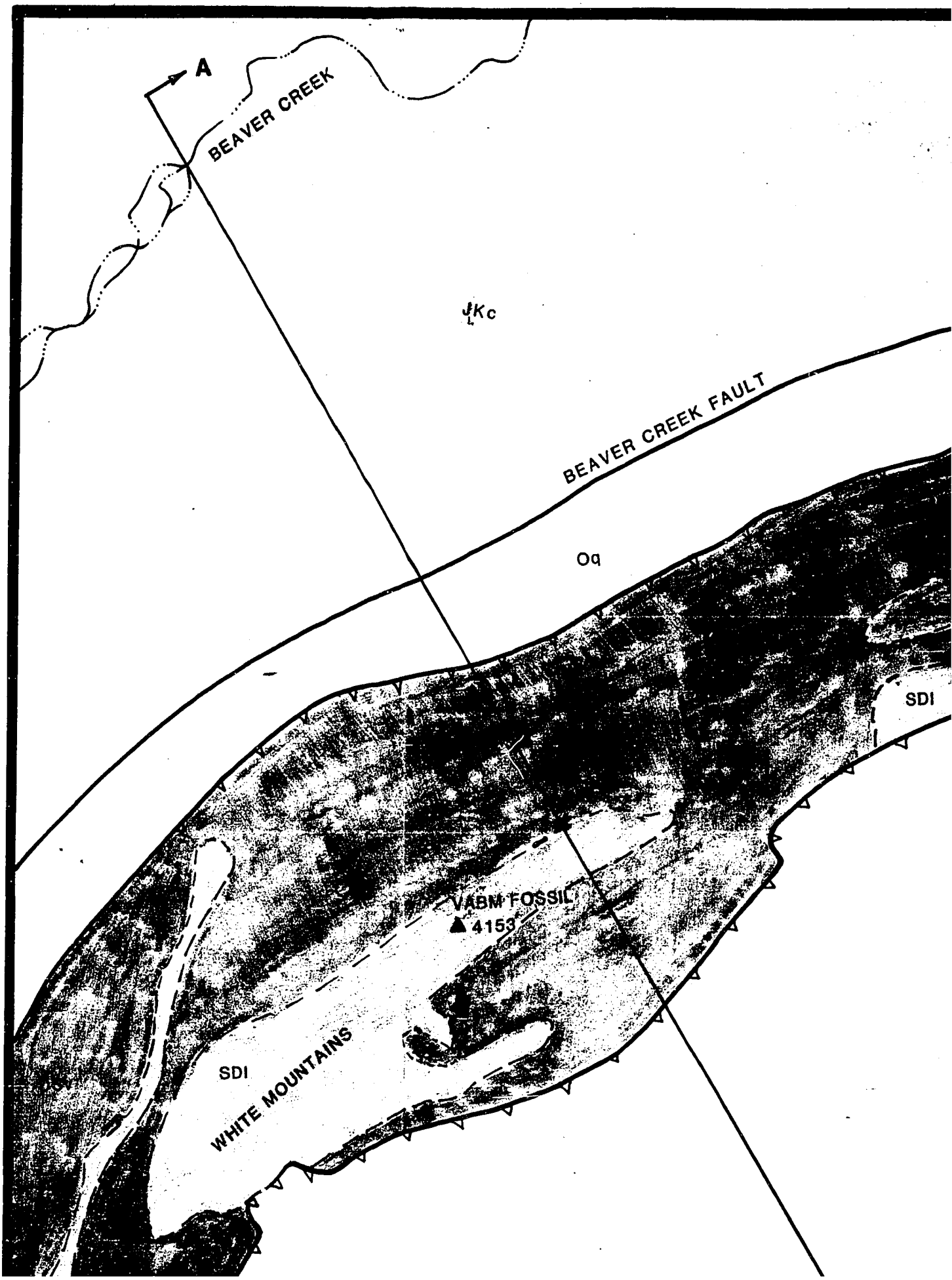

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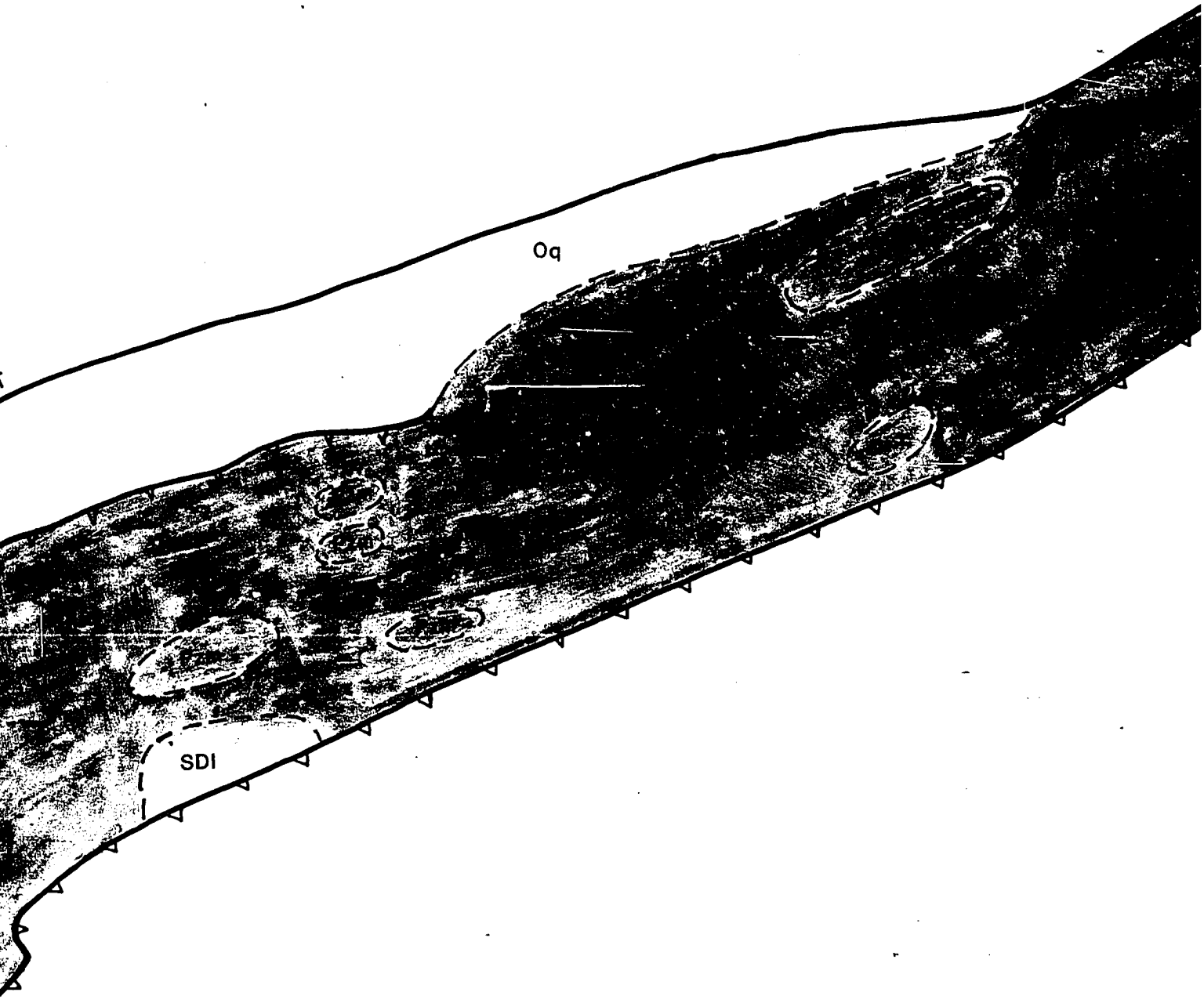

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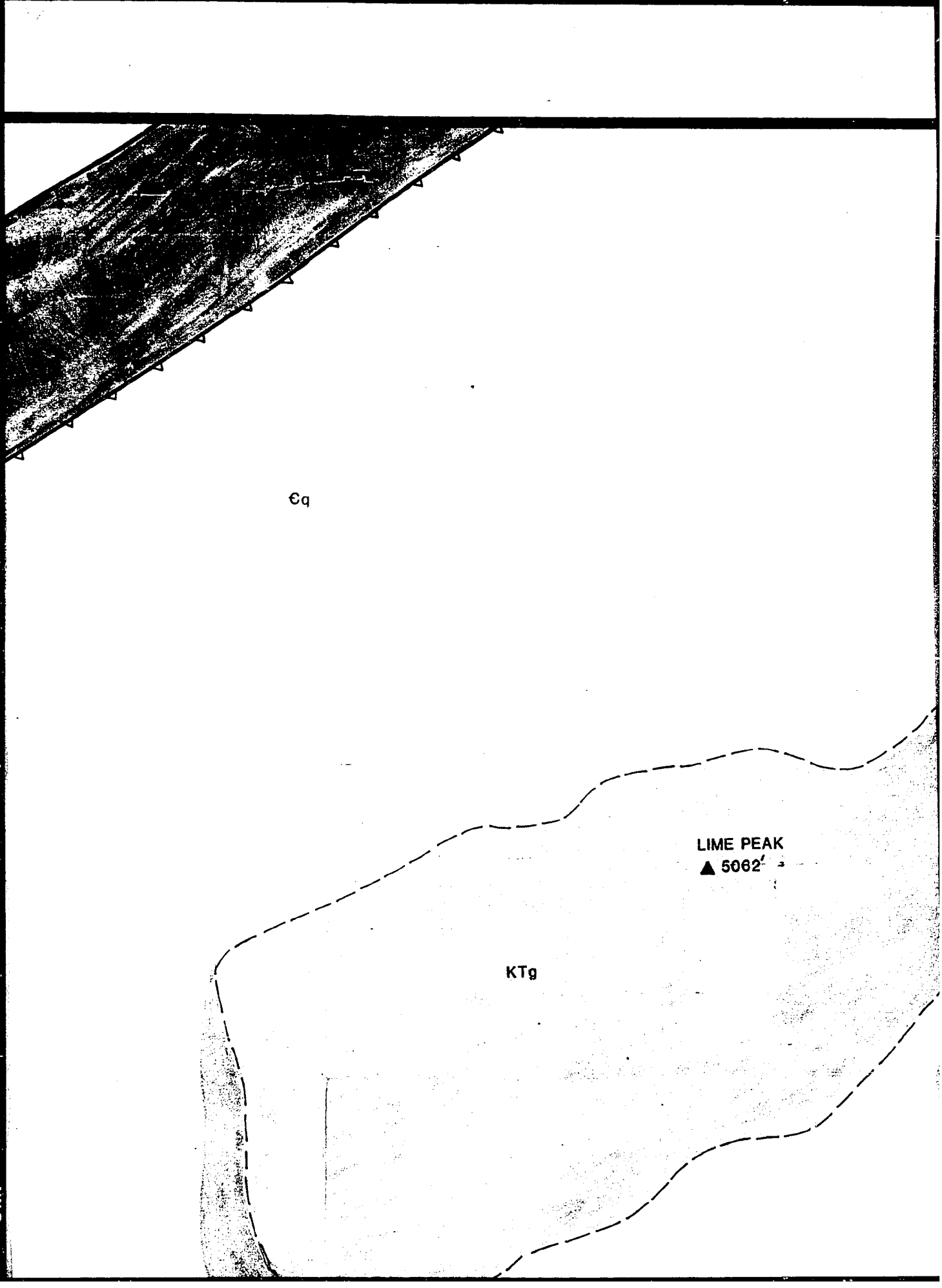

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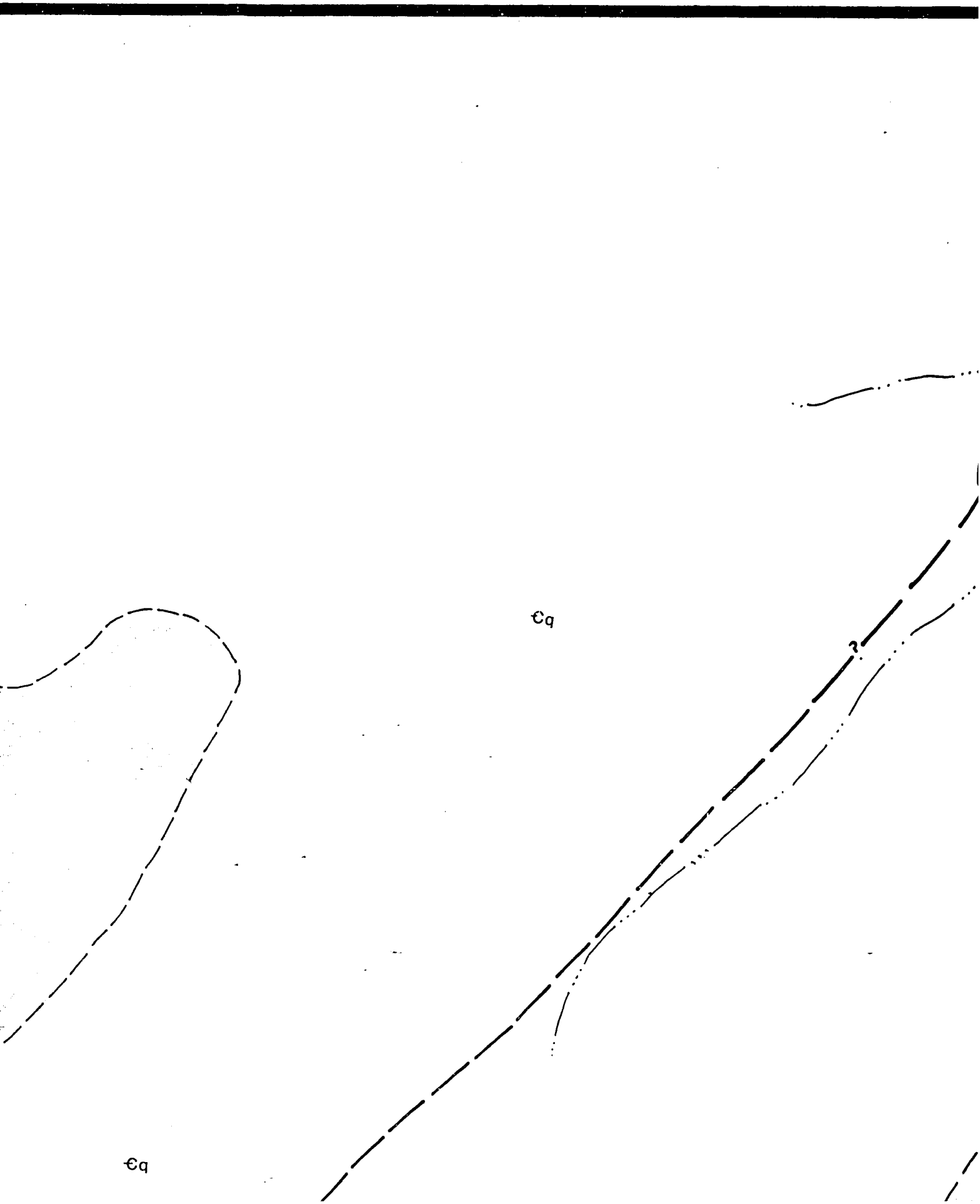

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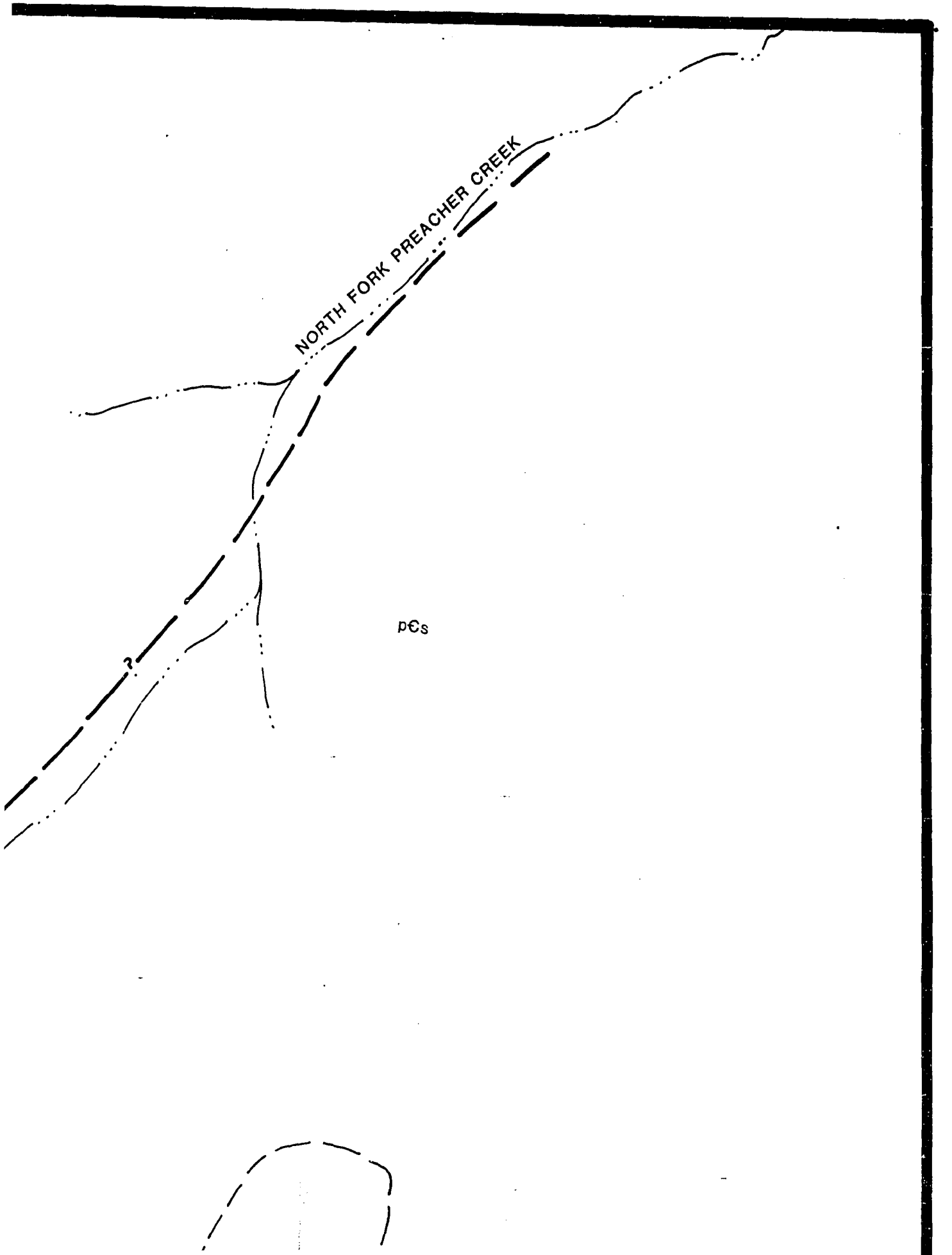

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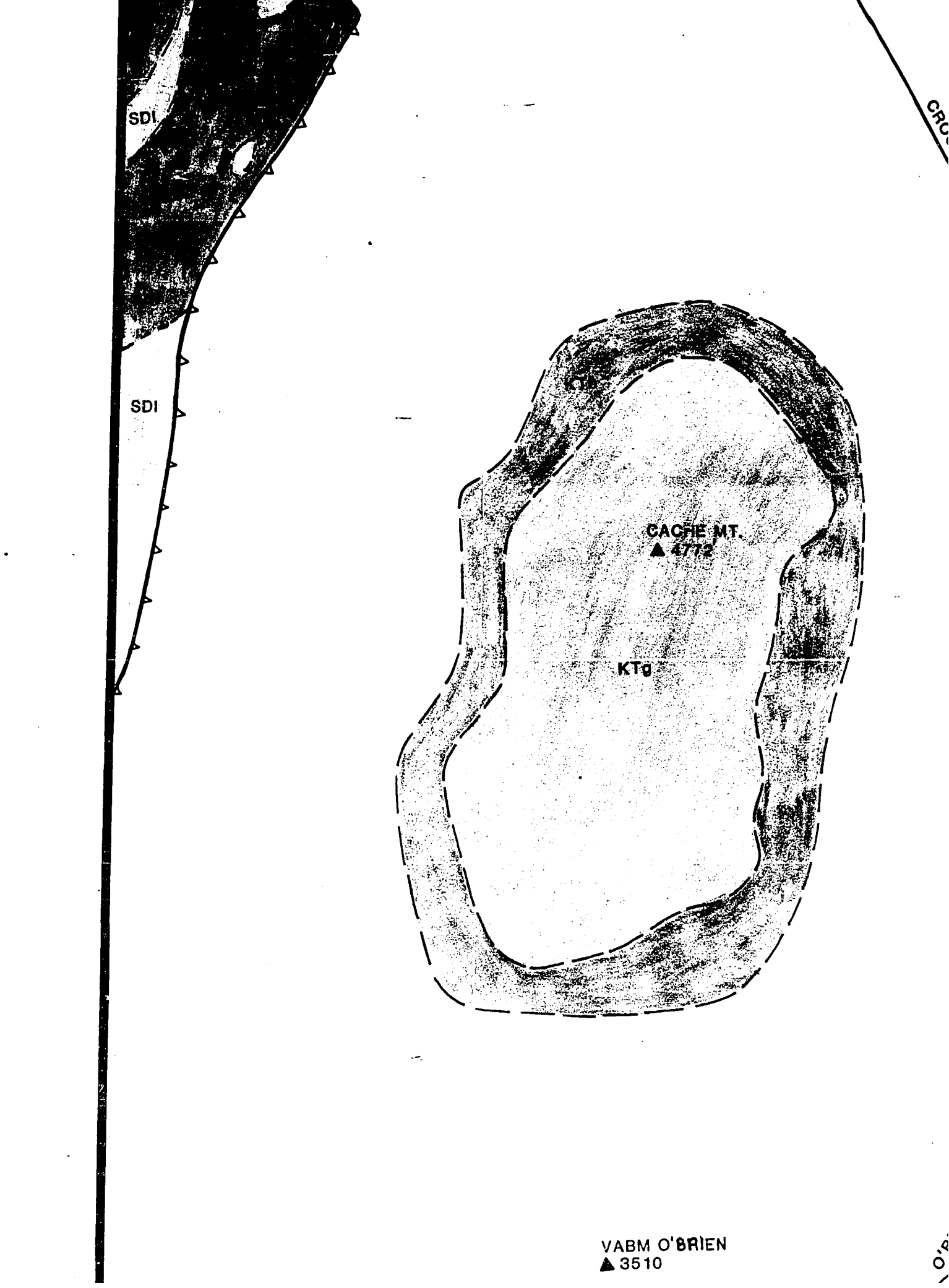

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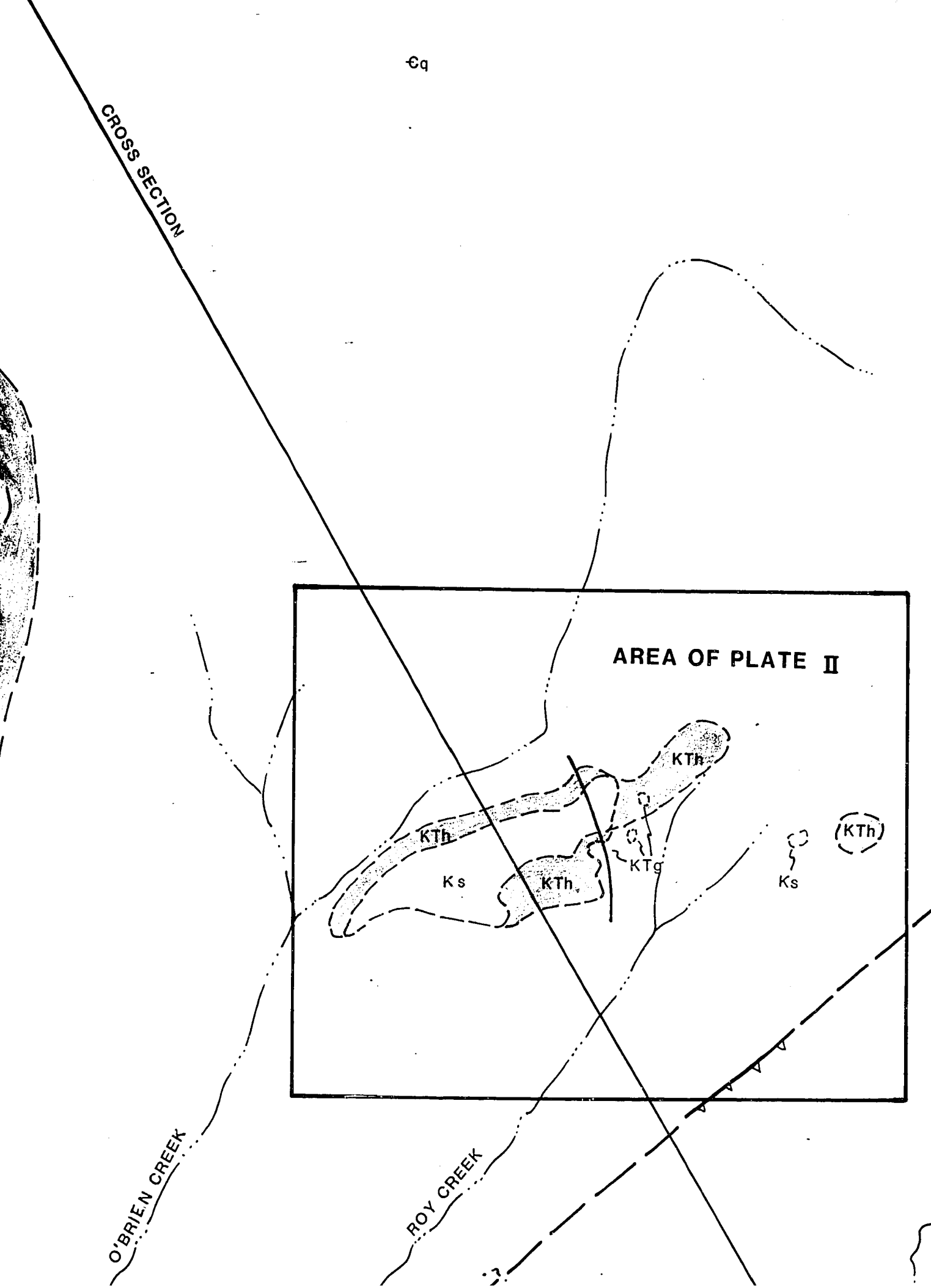

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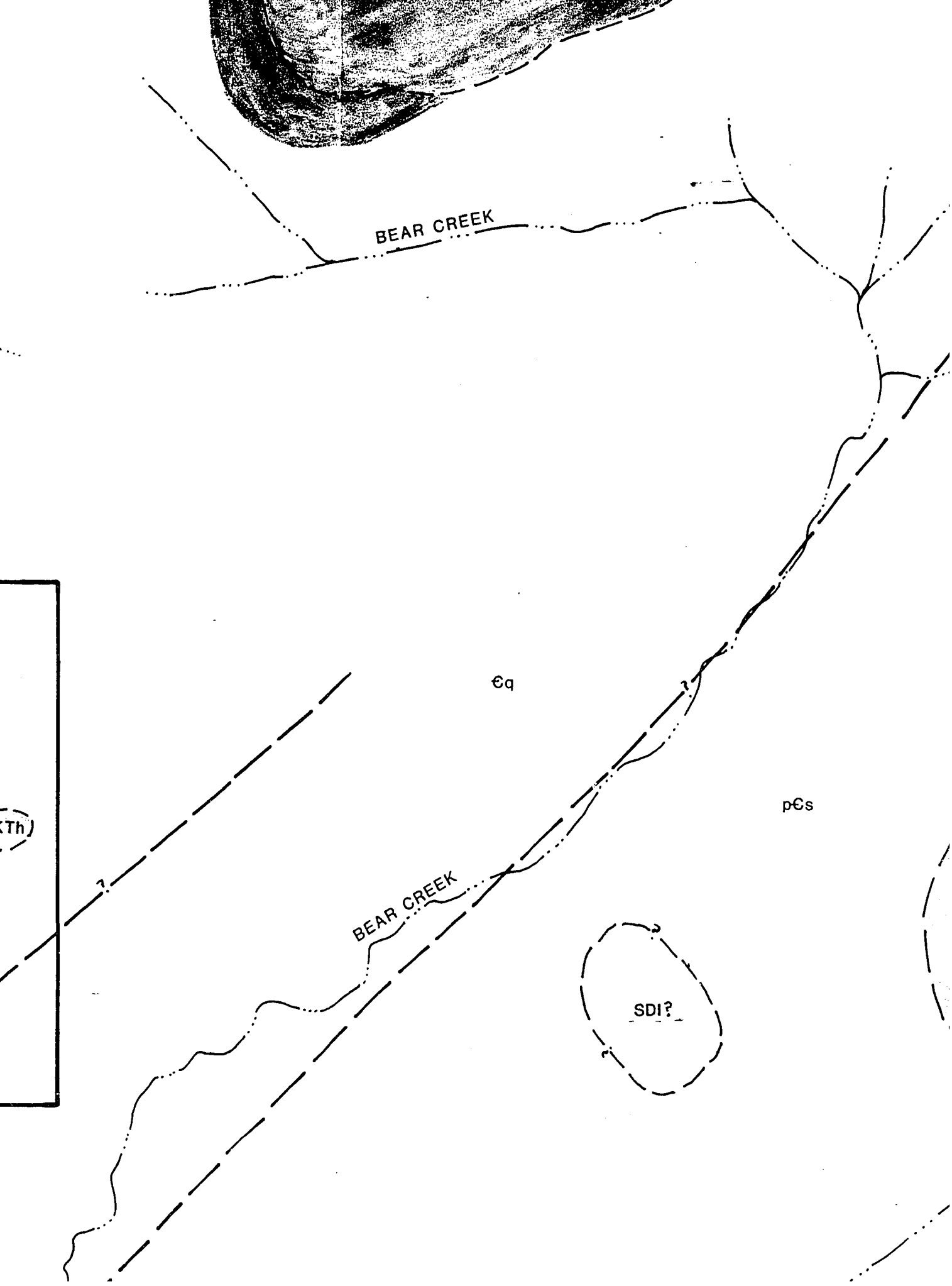

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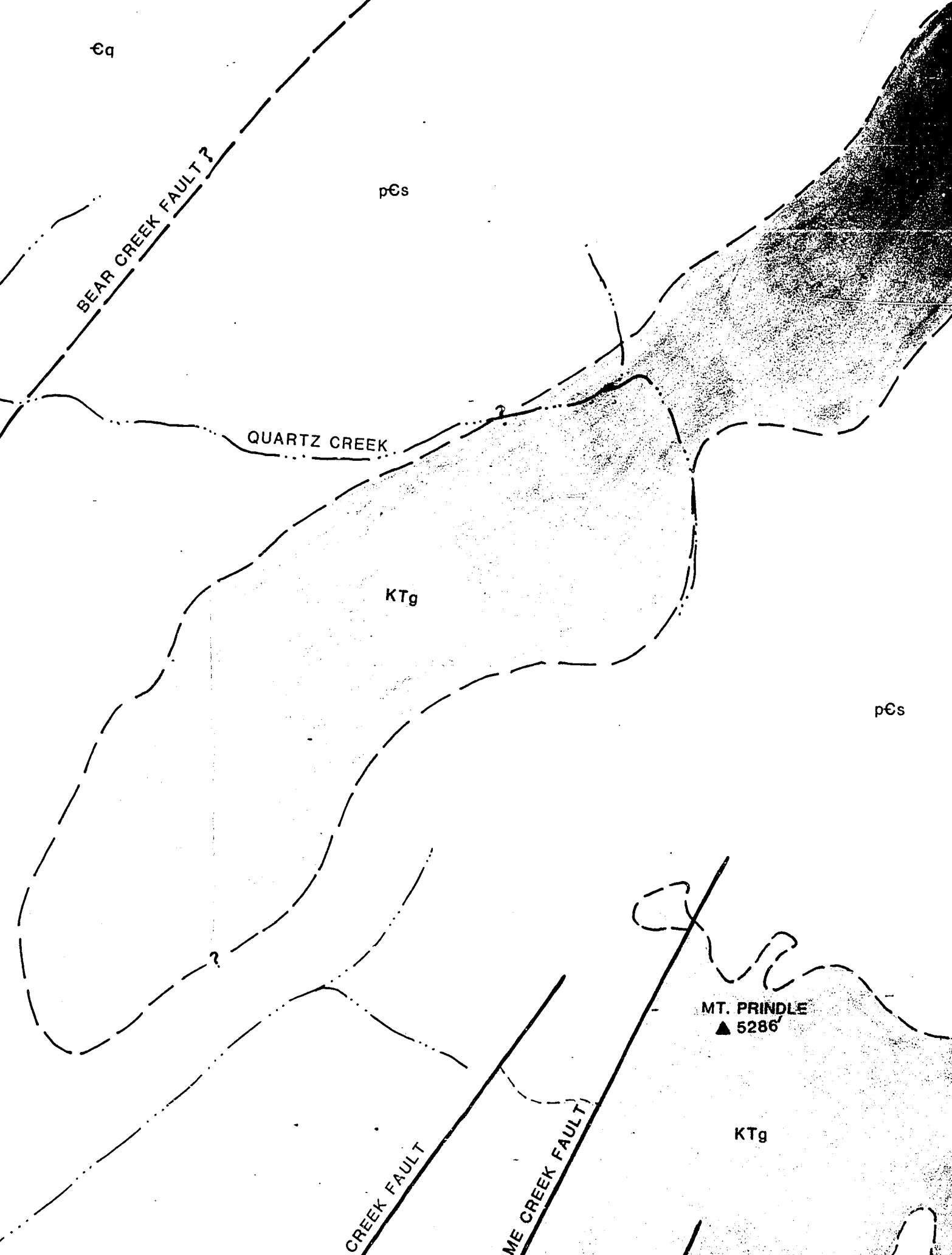

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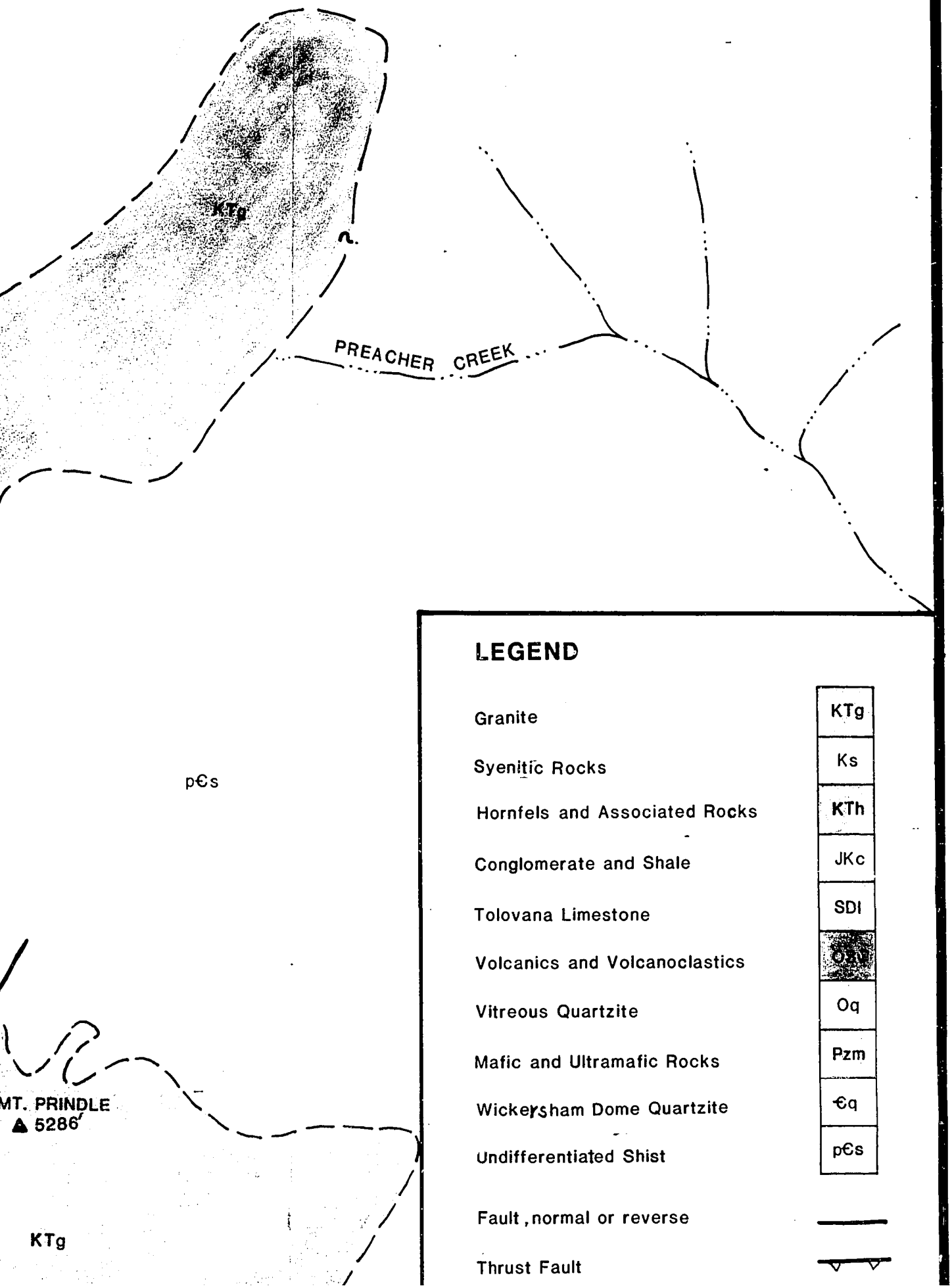

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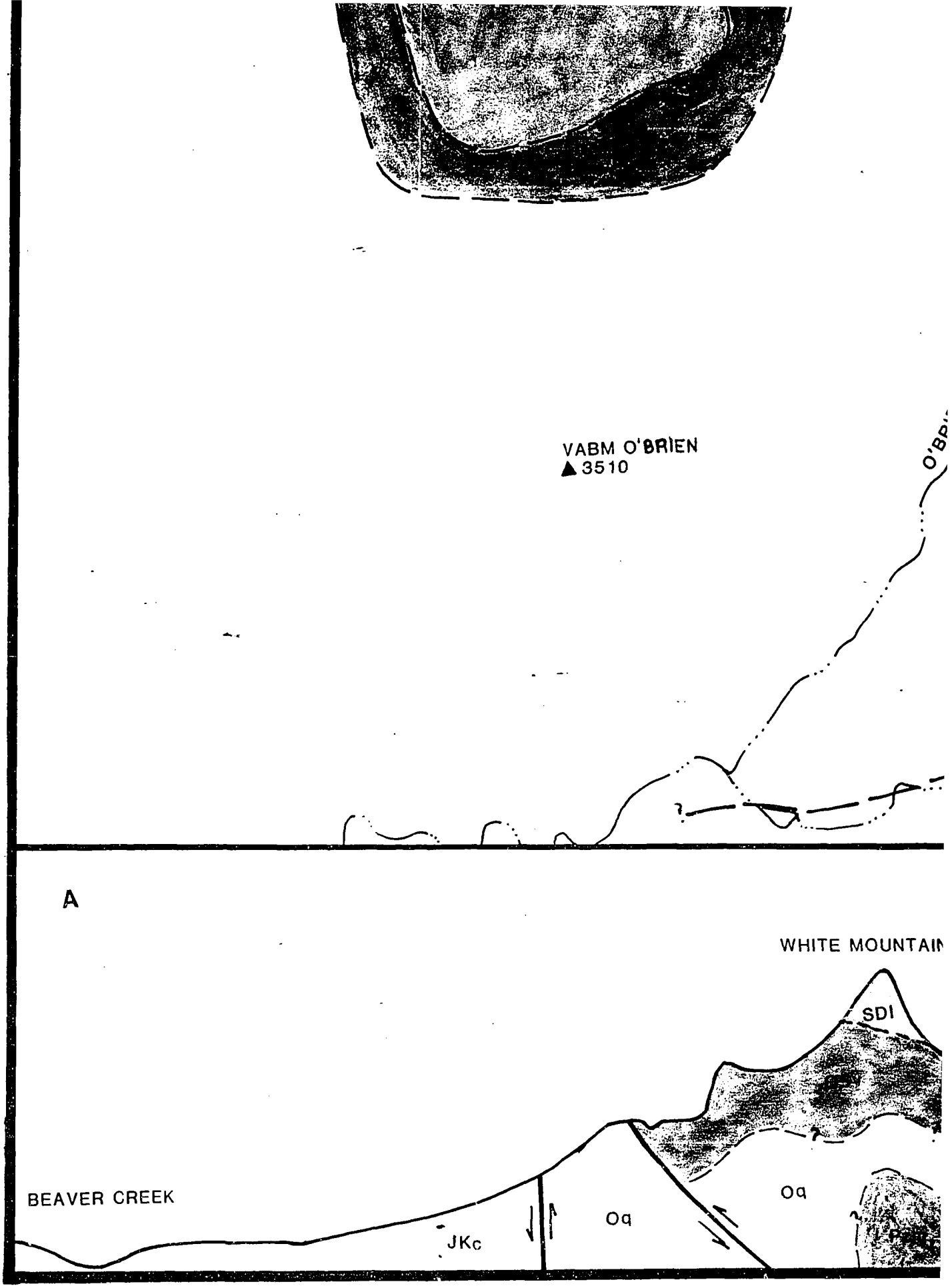

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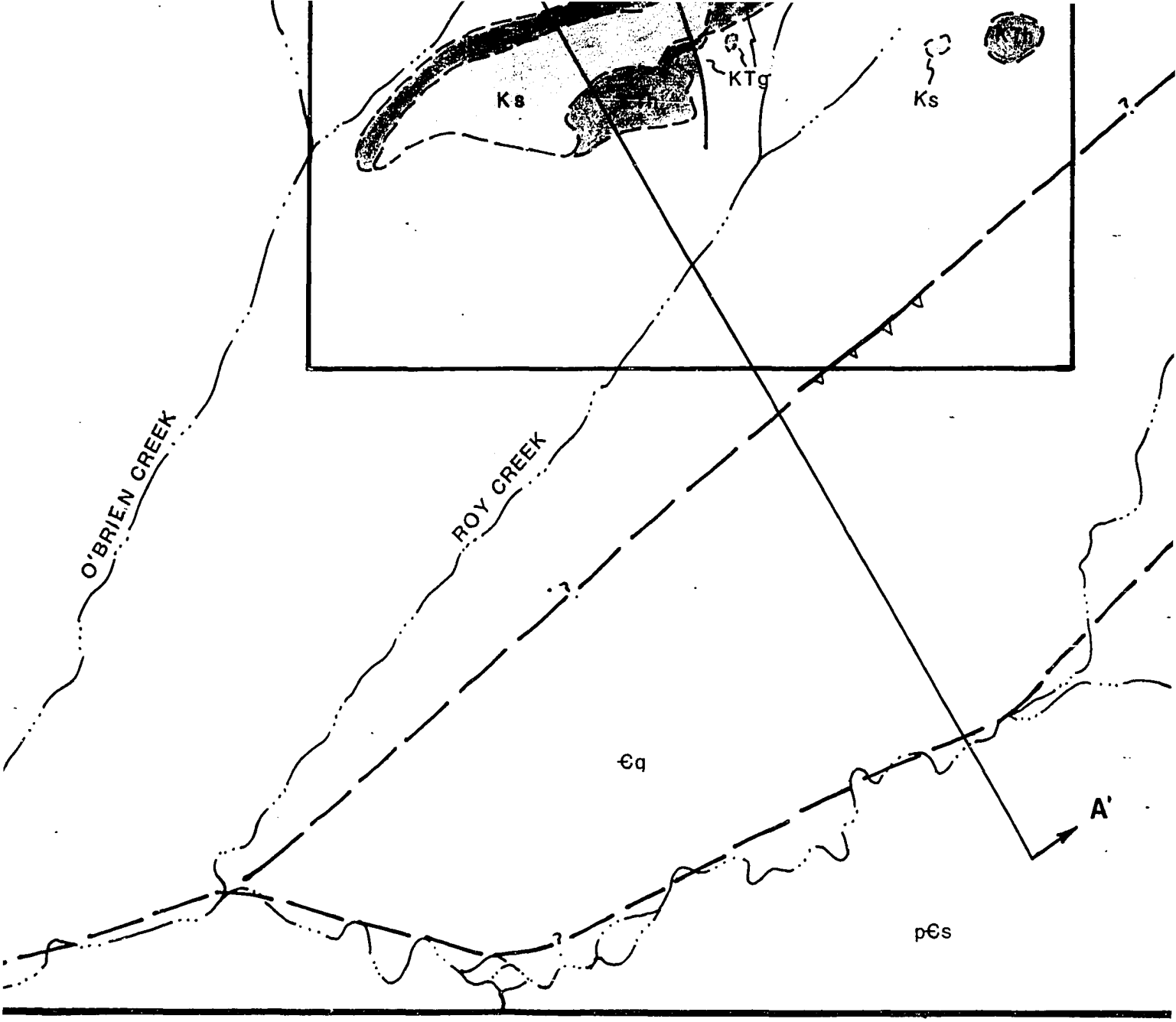

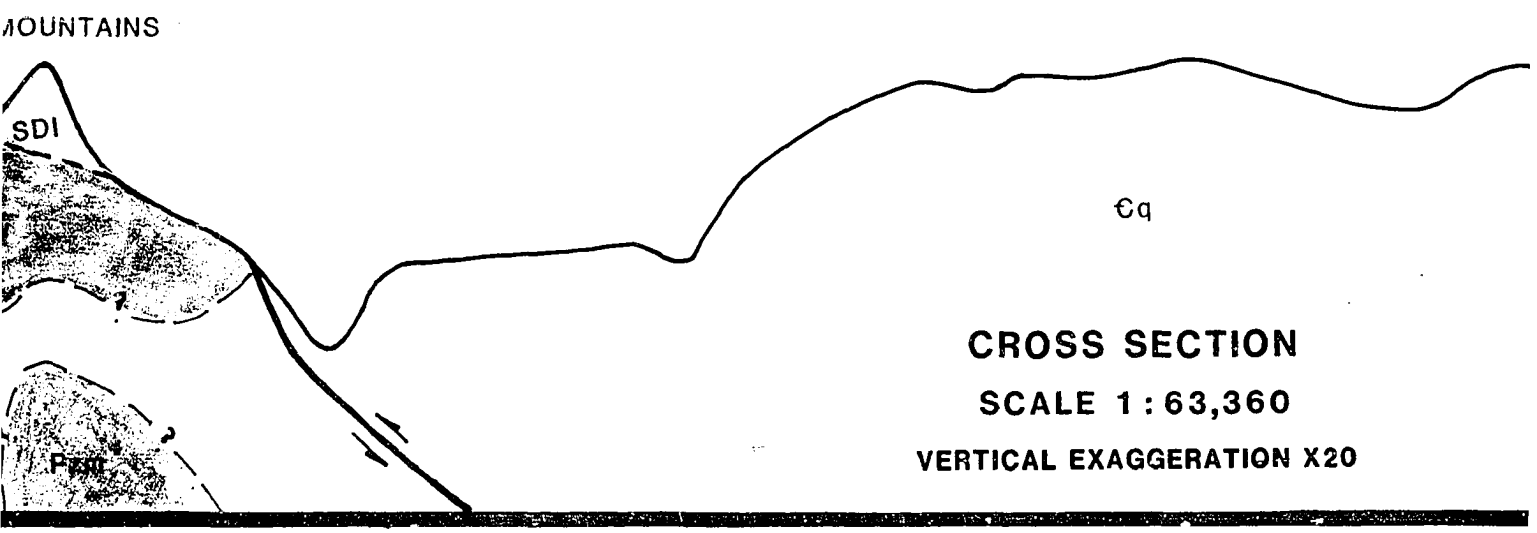

CROSS SECTION

SCALE 1 : 63,360

VERTICAL EXAGGERATION X20

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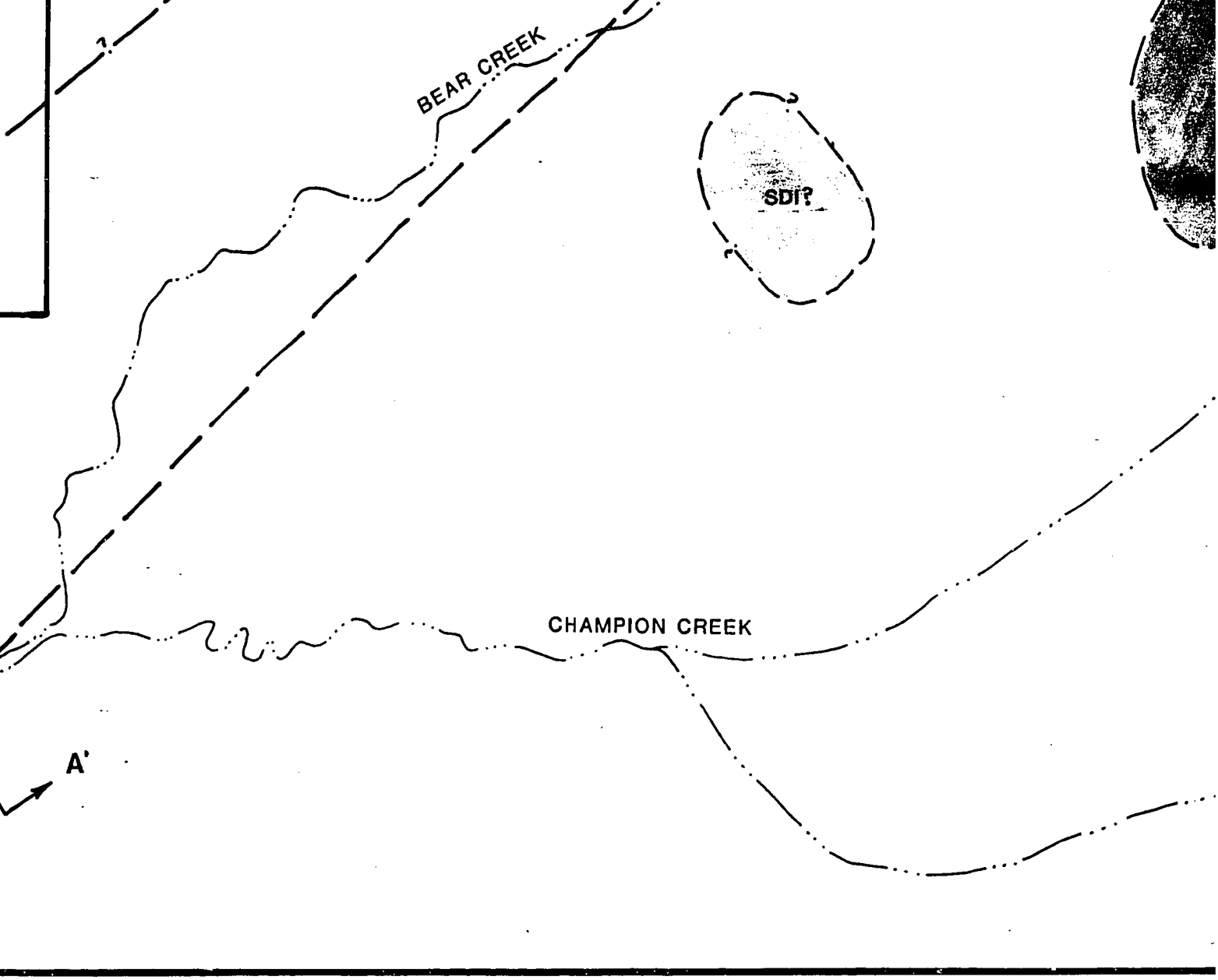

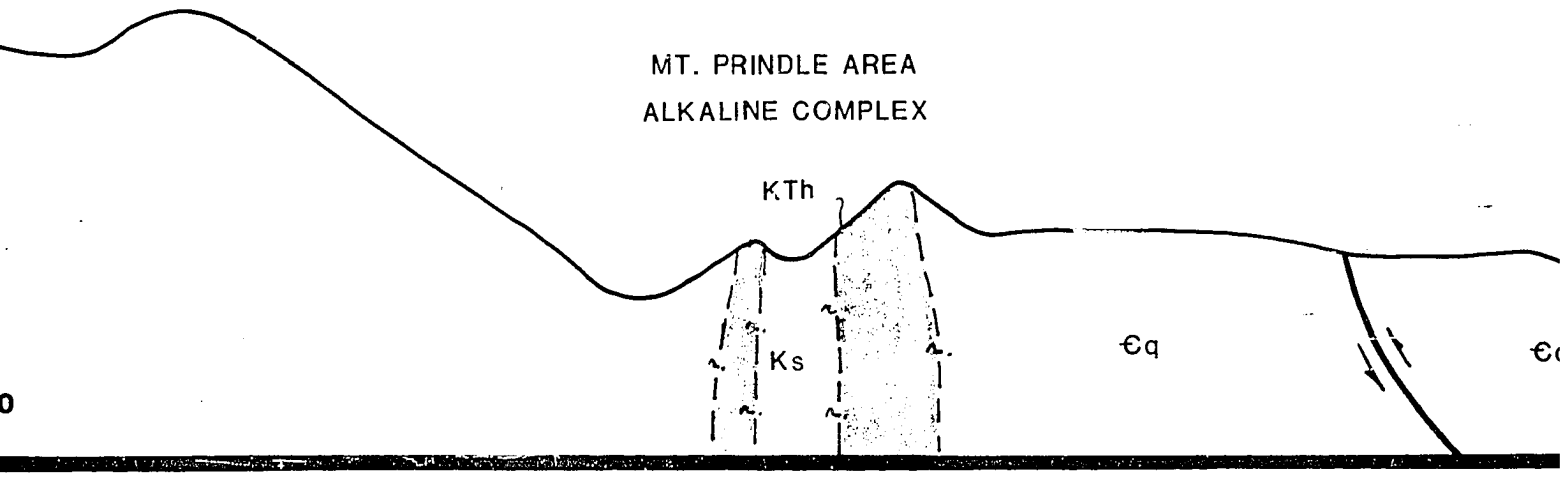

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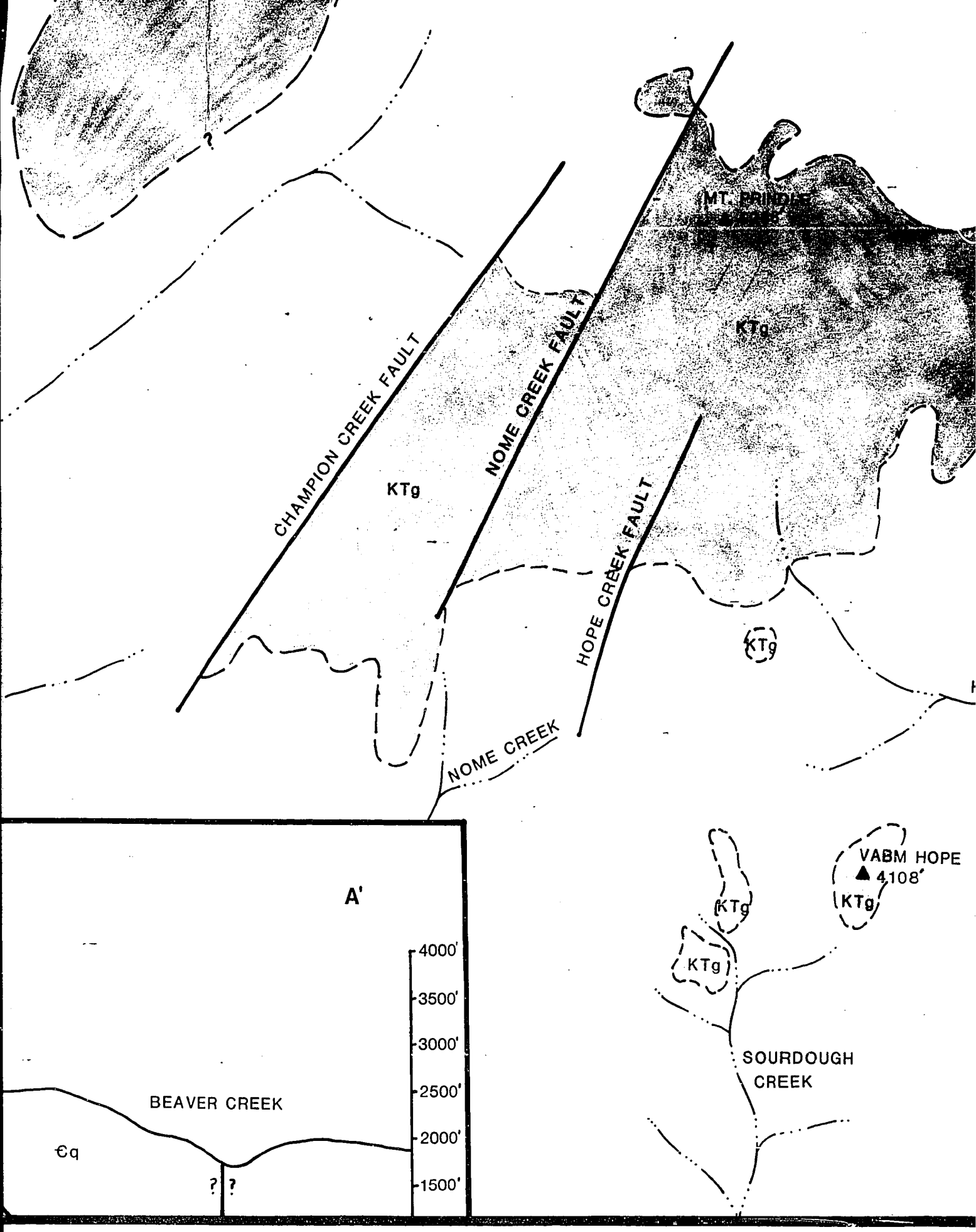

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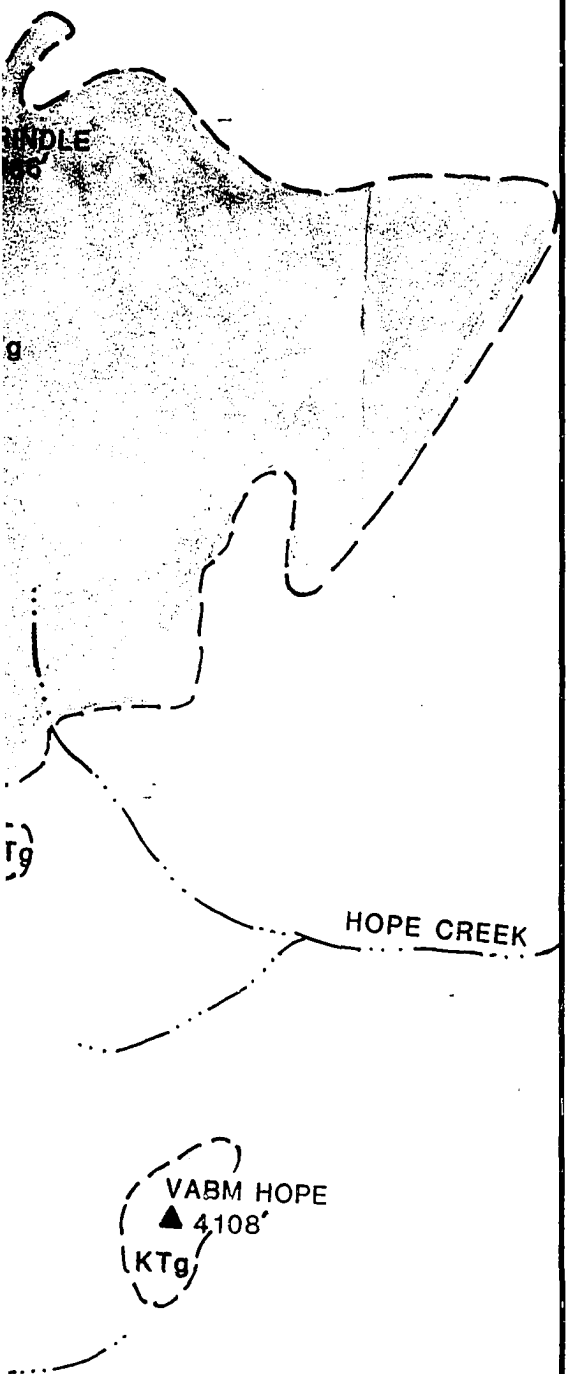


URDOUGH
REEK

Conglomerate and Shale	JKc
Tolovana Limestone	SDl
Volcanics and Volcanoclastics	
Vitreous Quartzite	Oq
Mafic and Ultramafic Rocks	Rzm
Wickersham Dome Quartzite	€q
Undifferentiated Shist	p€s

Fault, normal or reverse

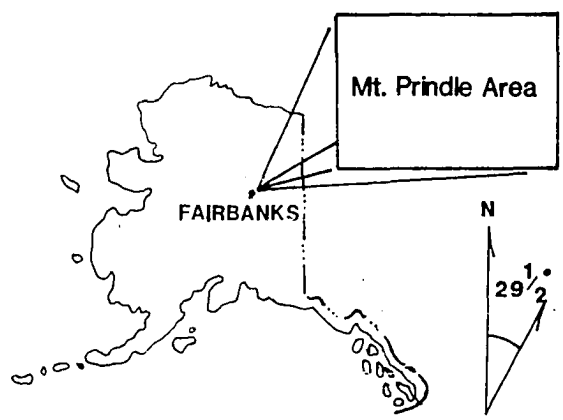
Thrust Fault

Inferred Fault

Contact, approximate

Contact, inferred

MAP LOCATION



SCALE 1:63,360

0 0.5 1 1.5 2 MILES

0 1 2 KILOMETERS

PLATE I

REGIONAL GEOLOGY
MT. PRINDLE AREA ALASKA

Jeffrey Burton, Summer 1978

Adapted from Chapman et.al. 1971, Holm, 1973.

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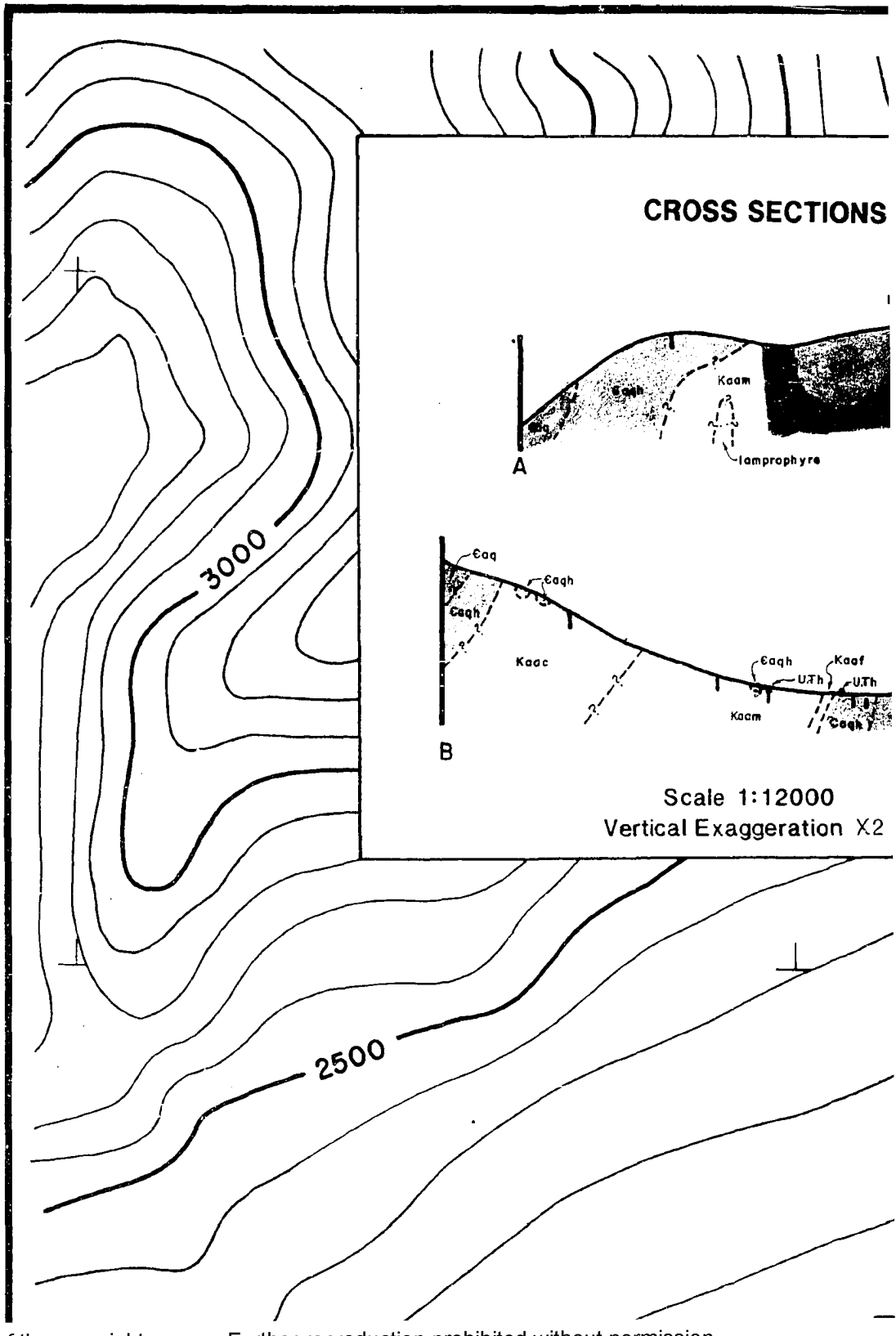

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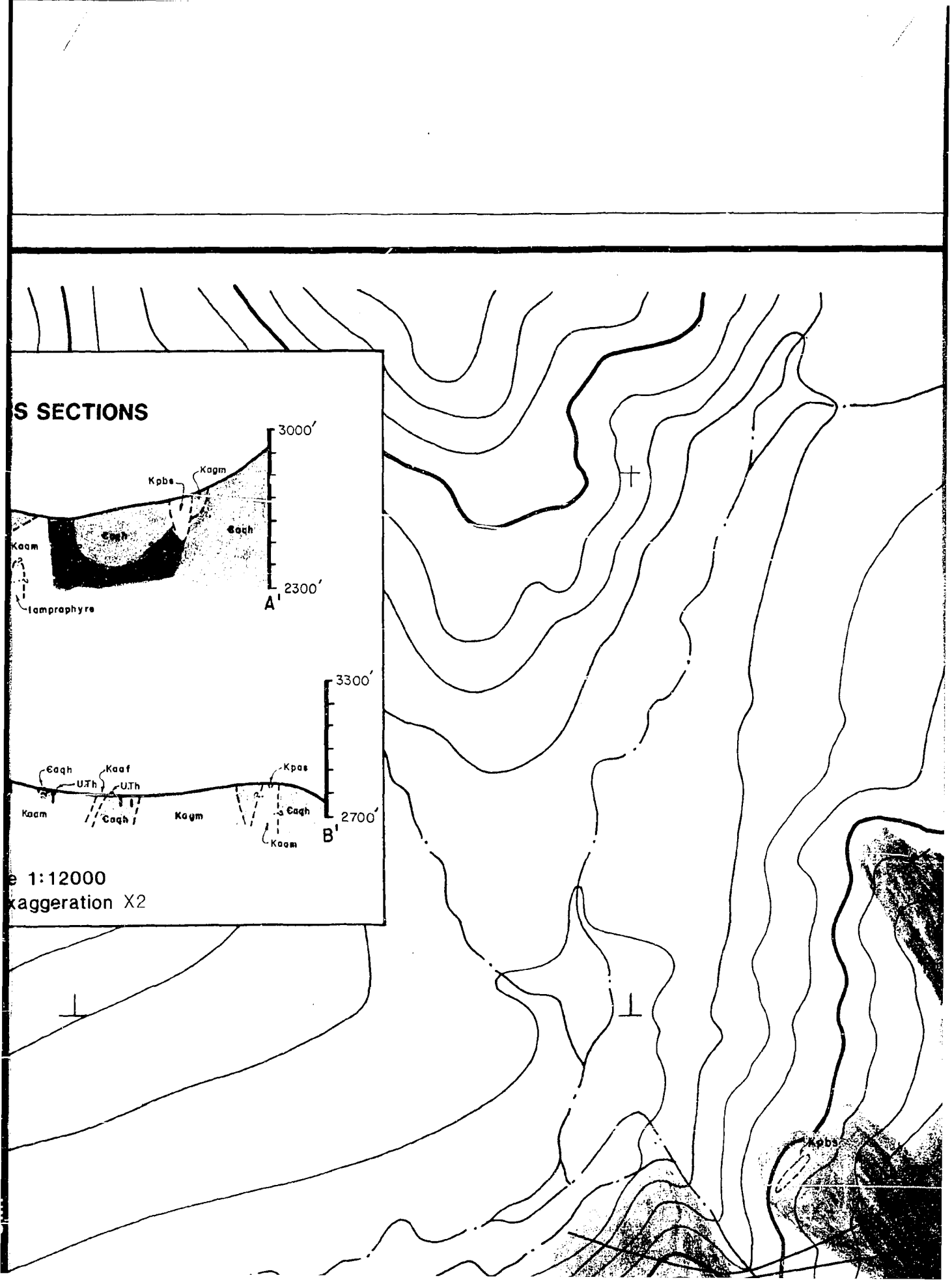

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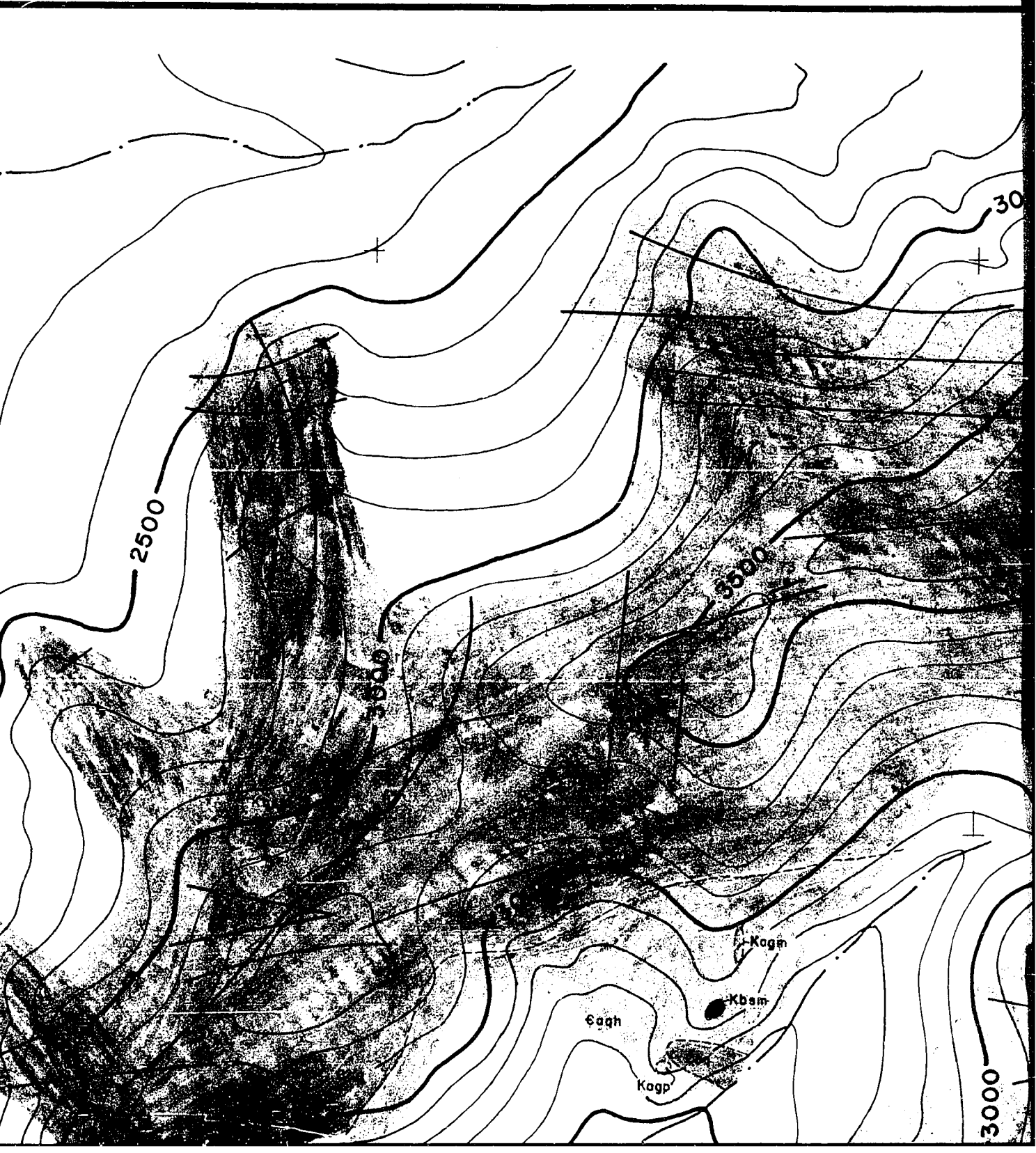

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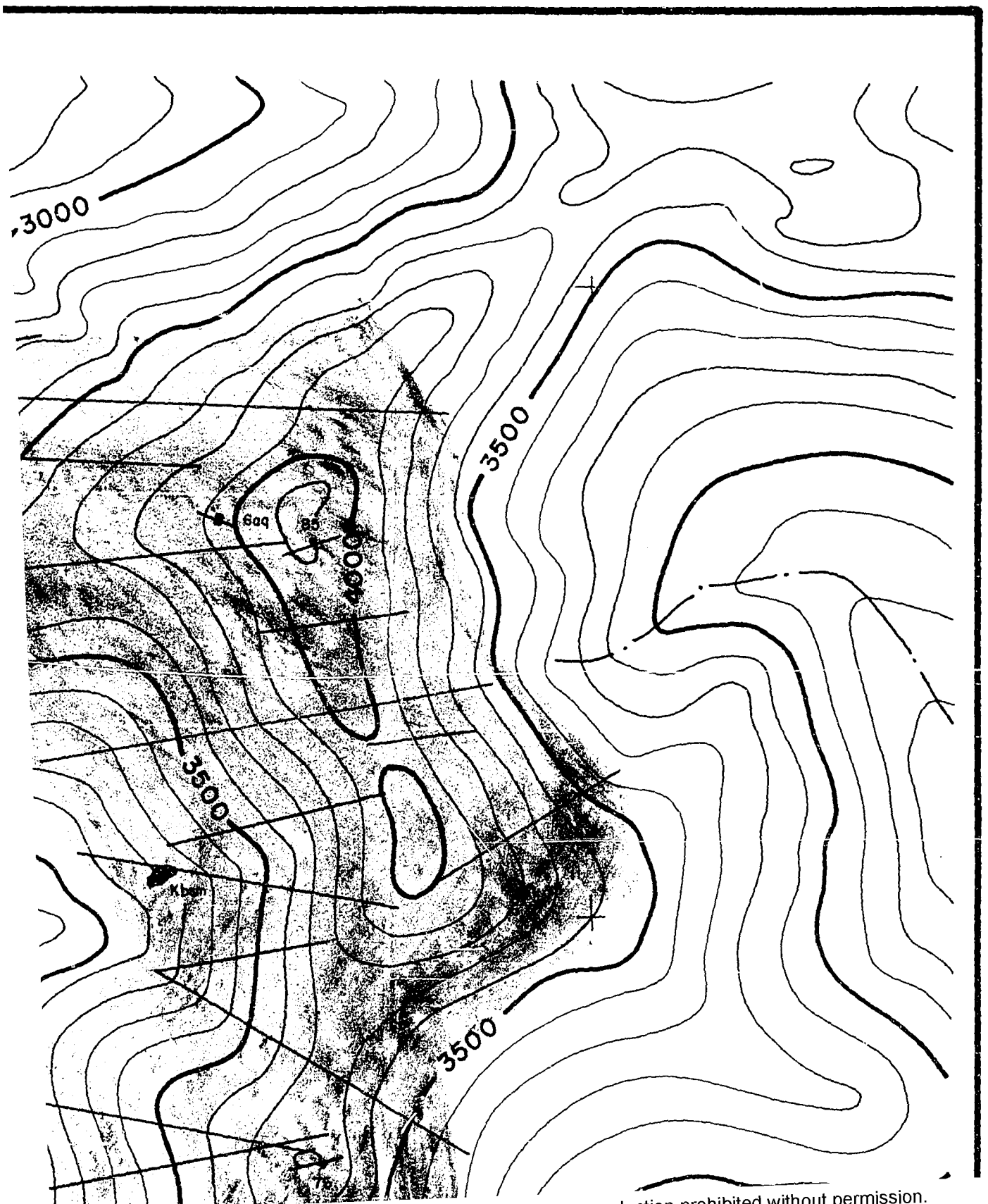

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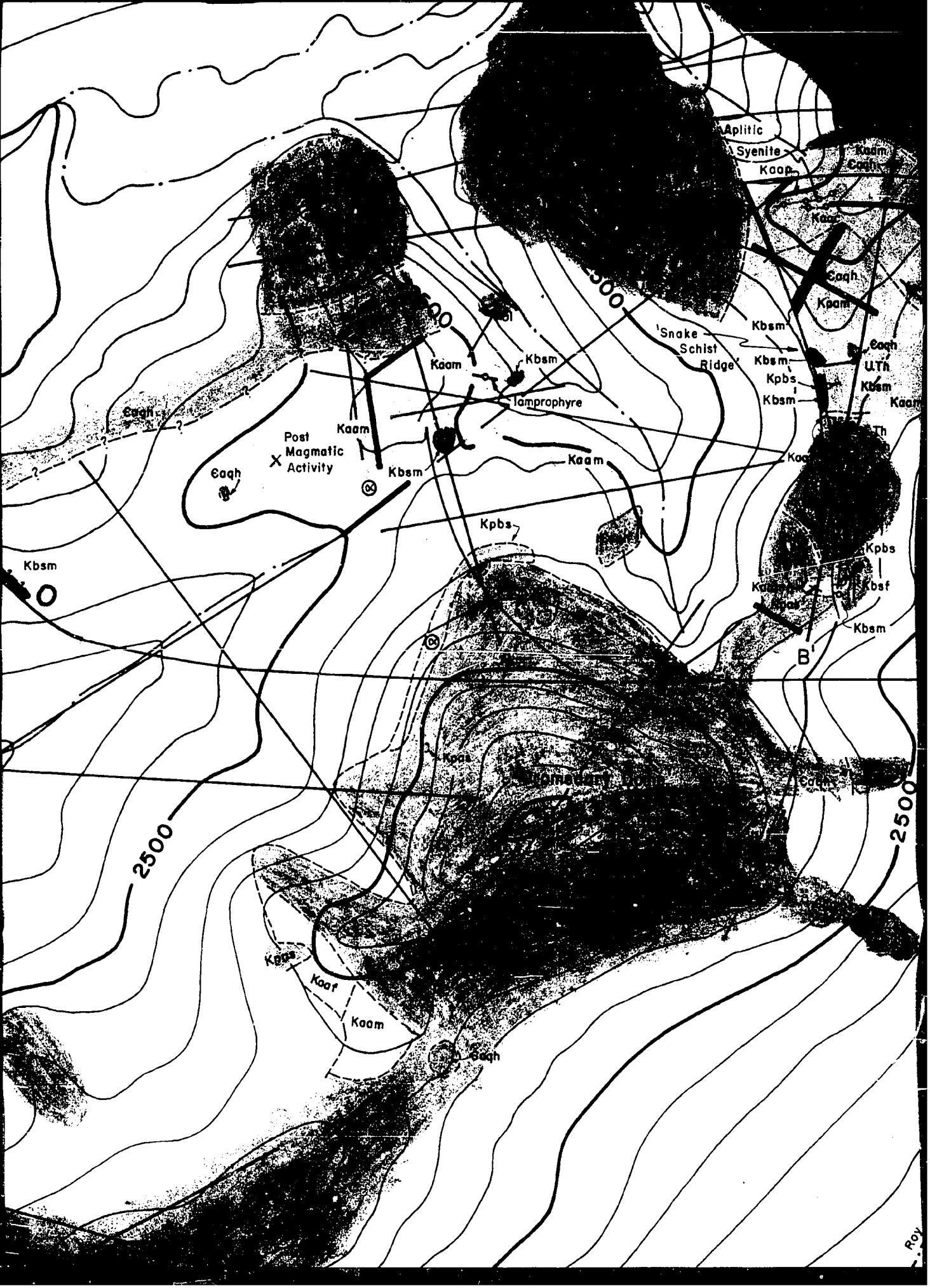

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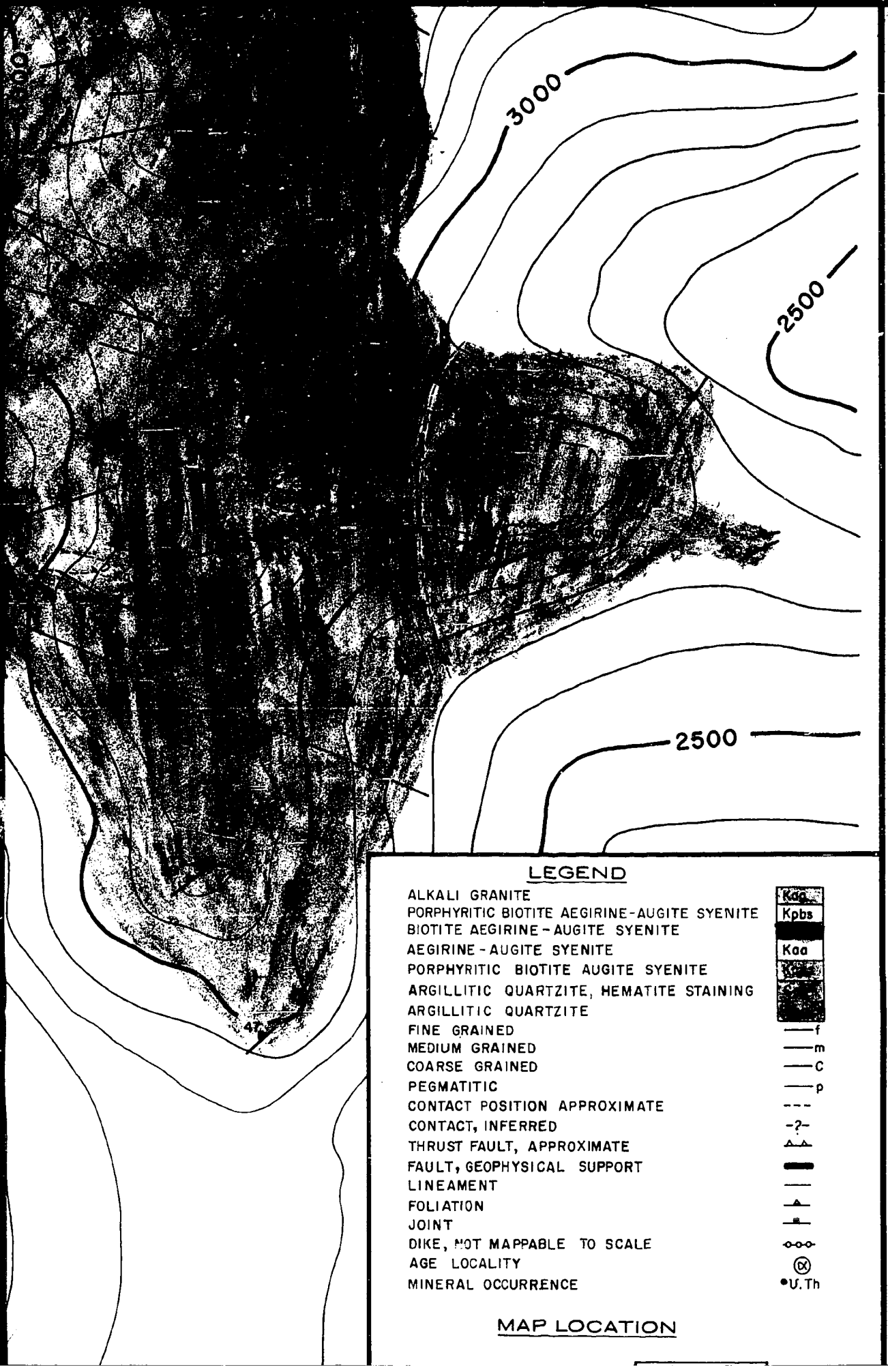

LEGEND

ALKALI GRANITE	Kag
PORPHYRITIC BIOTITE AEGIRINE-AUGITE SYENITE	Kpbs
BIOTITE AEGIRINE-AUGITE SYENITE	
AEGIRINE-AUGITE SYENITE	Kaa
PORPHYRITIC BIOTITE AUGITE SYENITE	
ARGILLITIC QUARTZITE, HEMATITE STAINING	
ARGILLITIC QUARTZITE	
FINE GRAINED	—f
MEDIUM GRAINED	—m
COARSE GRAINED	—c
PEGMATITIC	—p
CONTACT POSITION APPROXIMATE	---
CONTACT, INFERRED	-?-
THRUST FAULT, APPROXIMATE	
FAULT, GEOPHYSICAL SUPPORT	
LINEAMENT	
FOLIATION	
JOINT	
DIKE, NOT MAPPABLE TO SCALE	
AGE LOCALITY	⊗
MINERAL OCCURRENCE	•U.Th

MAP LOCATION

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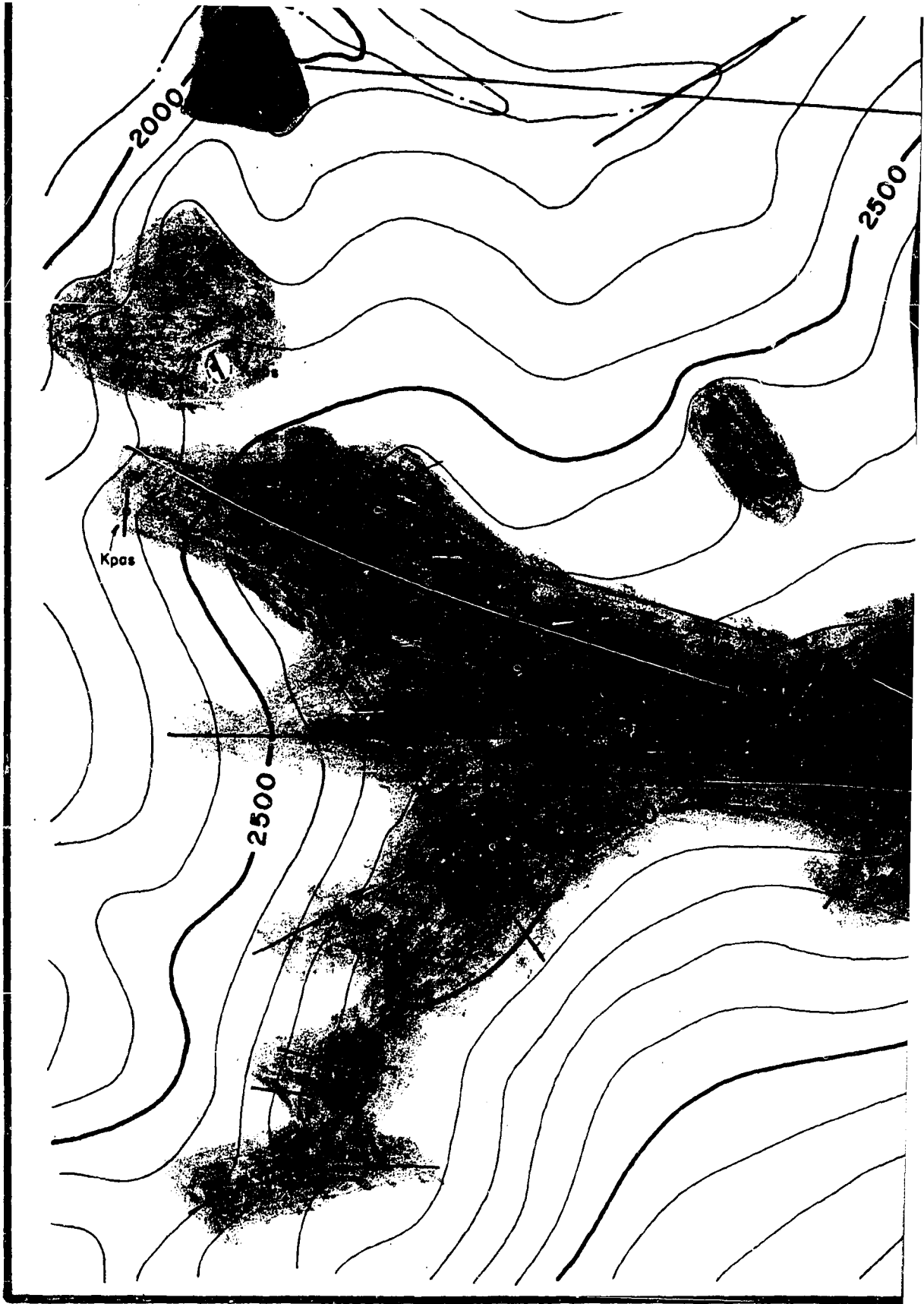

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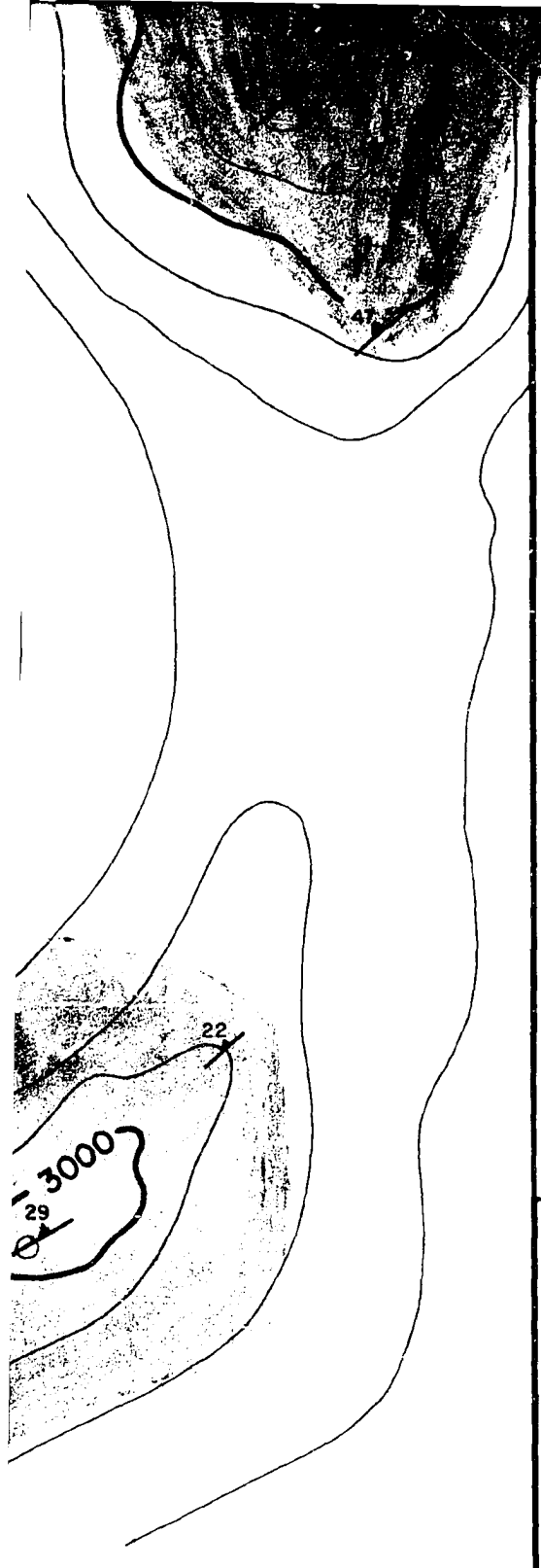
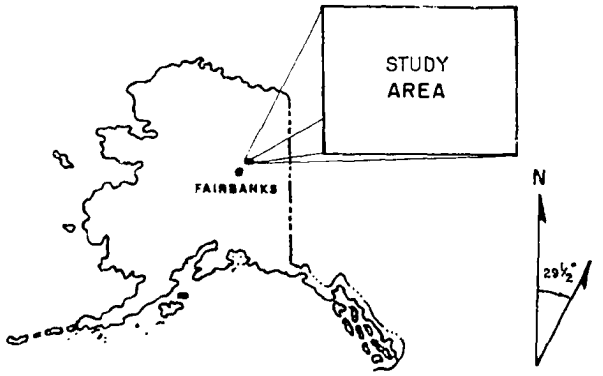


LEGEND

ALKALI GRANITE	
PORPHYRITIC BIOTITE AEGIRINE-AUGITE SYENITE	Kpbs
BIOTITE AEGIRINE-AUGITE SYENITE	
AEGIRINE-AUGITE SYENITE	Kaa
PORPHYRITIC BIOTITE AUGITE SYENITE	
ARGILLITIC QUARTZITE, HEMATITE STAINING	
ARGILLITIC QUARTZITE	
FINE GRAINED	—f
MEDIUM GRAINED	—m
COARSE GRAINED	—c
PEGMATITIC	—p
CONTACT POSITION APPROXIMATE	---
CONTACT, INFERRED	-?-
THRUST FAULT, APPROXIMATE	
FAULT, GEOPHYSICAL SUPPORT	
LINEAMENT	
FOLIATION	
JOINT	
DIKE, NOT MAPPABLE TO SCALE	
AGE LOCALITY	⊗
MINERAL OCCURRENCE	•U.Th

MAP LOCATION



SCALE 1: 12,000

0 1000 2000 FEET

0 100 200 300 400 500 METERS

Contour Interval 100'

PLATE 2

ALKALINE COMPLEX

MT. PRINDLE AREA, ALASKA

Jeff Burton Summer 1979

F#33

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