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GEOLOGY AND METALLOGENY OF THE FAIRBANKS MINING DISTRICT

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Alaska Division of
Geological and Geophysical Surveys

1984

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The Fairbanks mining district is located in the western portion of the Yukon-Tanana Uplands and includes an area of approximately 800 square miles. Since the initial discovery of gold placers in 1902, the area has produced 7.6 million troy ounces of placer gold, 250 thousand troy ounces of lode gold, thus accounting for nearly 25 percent of Alaska's total production. The district has also produced several thousand tons of antimony and tungsten and significant amounts of building stone and aggregate.

Prindle and Katz (1913) were the first to provide a general description of the bedrock and surficial geology of the Fairbanks district as well as detailed descriptions of the gold placer deposits. Smith (1913), Chapin (1914, 1919), Mertie (1918) and Hill (1933) described the lode deposits of the district and noted the close spatial relationship of the placer deposits to the lode occurrences; much of the early work related lode occurrences to intrusive bodies in the district. Metz (1977) suggested the gold-antimony-tungsten lodes might have similarities to stratabound deposits known outside of Alaska.

Recent geologic mapping of the area (Smith and others, 1981; Robinson and others, 1982: Forbes and Weber, 1982, Bundtzen, 1981; Metz, 1981; Robinson, 1981) has shown that bedrock exposed in the district comprise three metamorphosed stratigraphic packages, which appear to be in thrust fault contact (Fig. ___4). The lowermost sequence, referred to as the Fairbanks Schist, consists dominantly of brown to gray quartzite and muscovite-quartz shist with local variants containing garnet, biotite and chlorite. Mineral assemblages in this 4,000 ft thick unit are indicative of greenschist facies metamorphism. Interstratified near the center of the Fairbanks Schist is a 400-800 ft thick sequence consisting of interlensing felsic schist, laminated white micaeous quartzite, chloritic or actinolitic greenschist, graphitic schist, minor metabasite and metarhyolite, calc-silicate beds, banded gray marble, and significant amounts of quartzite and muscovite-quartz schist indistinguishable from the Fairbanks Schist host rocks. These rocks, referred to as the Cleary Sequence, appear to be largely of distal volcanogenic origin and host most of the concordant and discordant lode mineral occurrences in the district; they are also exposed upstream from most significant placer deposits (Smith and others, 1981, Robinson and others, 1982).

Structurally above the Fairbanks Schist/Cleary Sequence is an interval of variable thickness containing dense banded amphibolite, tremolite marble, coarse-grained garnet muscovite schist, biotite-rich schist, micaceous calc-schist and pale green metachert (Chena River sequence). Mineral assemblages and textural advancement in these rocks suggest they were metamorphosed in the lower amphibolite facies (Forbes and others, 1982).

Metamorphic rocks occurring along the northern part of the district (Chatanika terrane) also overlie the Fairbanks Schist in presumed thrust contact, but consist of a different rock assemblage, including garnet- clinopyroxene eclogites, garnet amphibolites, black quartzite, marble and pelitic schist (Swainbank and Forbes, 1975).

Intrusive rocks in the district occur mainly as northeasterly-trending bodies of (1) dark, fine-or medium-grained homogeneous hornblende-bearing granodiorite exposed near Pedro Dome and (2) light colored, coarse-grained, multiphase porphyritic quartz monzonite/granodiorite present mainly on Gilmore Dome. Numerous small plutons or hypabyssal bodies of felsic to intermediate composition occur throughout the district. Field evidence suggests a mesozonal level of emplacement for the intrusives. Cross cutting relationships show the porphyritic quartz monzonite/granodiorite is younger than the hornblende-bearing granodiorite. Available K/Ar and Rb/Sr ages for the Pedro Dome and Gilmore Dome stocks range from 91 to 93 m.y. Petrochemical and mineralogical criteria suggest the porphyritic series may be S-type granitic rocks, whereas the hornblende-bearing granodiorite has characteristics of both S and I-type intrusive rocks. The initial $^{87}Sr/^{86}Sr$ ratio is 0.712, supportive of an S-type origin (Blum, 1983).

The regional structural evolution of the Fairbanks region was dominated by two fold episodes. The first resulted in synmetamorphic, overturned to recumbent, subisoclinal, northeast verging folds with wavelengths to about 1,000 ft and northwest trending axes. The second event folded the previously metamorphosed units into a series of broad northeast-trending open folds which control the distribution of rock types now exposed in the district. Local structures include small scale folds, faults, joints, shears, and "crush zones." the latter typically cluster in northeast and north-northeast trending sets and are variable in length to several miles; both sets have a close spatial and genetic relationship to discordant gold, antimony, and arsenic mineralization in the district. Northeast trending faults typically show reverse offset and southerly dips (fig. ___ B). Fault structures on Ester Dome strike generally north-south with steep dips and both normal and strike slip offset.

Of 188 known lode gold occurrences in the Fairbanks district, (Chapman and Foster, 1969) 65 have produced an estimated 240,000 ounces of gold with average ore values ranging from 0.28 to 2.3 ounces per ton (Thomas, 1973). The deposits are spatially concentrated in four areas: Cleary Summit, Ester Dome, Scrafford, and Gilmore Dome (fig___A.) Gold and tungsten lodes of the district are most numerous on Cleary Summit Gilmore Dome and Ester Dome and are hosted within various lithologies of the Cleary Sequence. The lode occurrences are classified as:

I. STRATABOUND VOLCANOGENIC(?) MINERALIZATION - in which intergrowths of arsenic-zinc-antimony-lead-and copper sulfides ± gold and scheelite occur in conformable laminae and lenses parallel to foliation and compositional banding in the metavolcanic host rocks with Au, Sb, As, Zn, and Pb associated with metafelsic rocks and Cu-W associated with metabasites.

II. LEAD SULPHOSALT-BEARING QUARTZ SULFIDE VEINS - with argentiferous galena, sphalerite, chalcopyrite, stibnite, arsenopyrite, and gold occurring within Cretaceous intrusives.

III. METASOMATIC TUNGSTEN SKARN MINERALIZATION - tungsten in local concentrations to 3 percent WO_3 as scheelite within prograde and retrograde calc-silicate skarn assemblages in close proximity to the Gilmore and Pedro Dome granitic stocks (Allegro, 1984, Byers, 1957, Robinson, 1976). Most occurrences are replacements of calcareous beds of the Cleary Sequence.

IV. GOLD-BEARING POLYMETALLIC QUARTZ SULFIDE VEINS - which cross-cut the metavolcanic host rocks of the Cleary sequence,

V. STIBNITE GASH VEINS AND FRACTURE FILLINGS - associated with axial plane shears in the metavolcanic host rocks.

A geochemical reconnaissance of selected rock chips from metamorphic rock units in the Fairbanks district indicates the following enrichments over crustal abundence: Antimony - 210 X, Arsenic - 83 X, gold - 50 X, and tungsten - 14 X. Samples from highly mineralized portions of the Cleary Sequence range up to several thousand times the crustal averages of these elements. (Albanese, 1982a, b, c; Metz, 1984)

Fluid inclusions from quartz in veins and selected rocks show contrasting compositions and homogenization temperatures as follows (fig.___C):

Type I Veins: 280-330°C, 5-6 wt. percent NaCl equivalent; CO_2 8 mole percent in samples with visible gold.

Scheelite also contains CO_2-rich fluid inclusions.

Types II and III Veins: 300-400°C, 12-14 wt. percent NaCl equivalent.

Type IV Veins: 290°-360°C, 2-3 wt. NaCl equivalent, CO_2 8 mole percent in samples with visible gold. Boiling conditions indicated.

Type V Veins: 190-220°C, 2-3 wt percent NaCl equivalent.

Intrusive Rocks: 550-600°C, 20 percent NaCl equivalent, occasional daughter minerals

Metamorphic Rocks: Similar to Type I veins

Sulfur isotope ratios of most polymetal vein types range from -1 to +4 per mil as indicated on fig.___D. Type V monomineralic stibnite veins range from -6 to -2 per mil S^{34}. None of the Sulfide pairs from the various vein types yield reasonable thermometric estimates, suggesting deposition or subsequent mobilization under disequilibrium conditions.

Lead isotopes of galena samples from "stratiform" and vein occurrences in the district are radiogenic in character, and cluster near the end of single stage growth curves (fig. ___E), similar to leads from continental rift environments (Smith and others, 1981).

The geologic setting as well as geochemical and isotopic data are consistent with an ore genesis model which includes: (1) bimodal volcanism in a late Precambrian(?) extensional environment accompanied by deposition of submarine volcaniclastics and exhalites enriched in Au-Sb-As-W (2) regional polymetamorphism in at least two compressional events, early mobilization of metals into veins may have accompanied metamorphism (3) emplacement of post-tectonic cretaceous anatectic(?) granitic rocks with concurrent development of contact metasomatic tungsten skarns and continued mobilization of metals into mineralized veins within favorable structural sites in the Cleary Sequence. Fluid-inclusion data and vein mineralogy suggest mobilizing fluids were enriched in CO_2, HS , antimonothio/arsenothio complexes; deposition of metals may have resulted from volatile release or boiling, a ph increase, and mixing with lower salinity meteoric water near the boiling interface.

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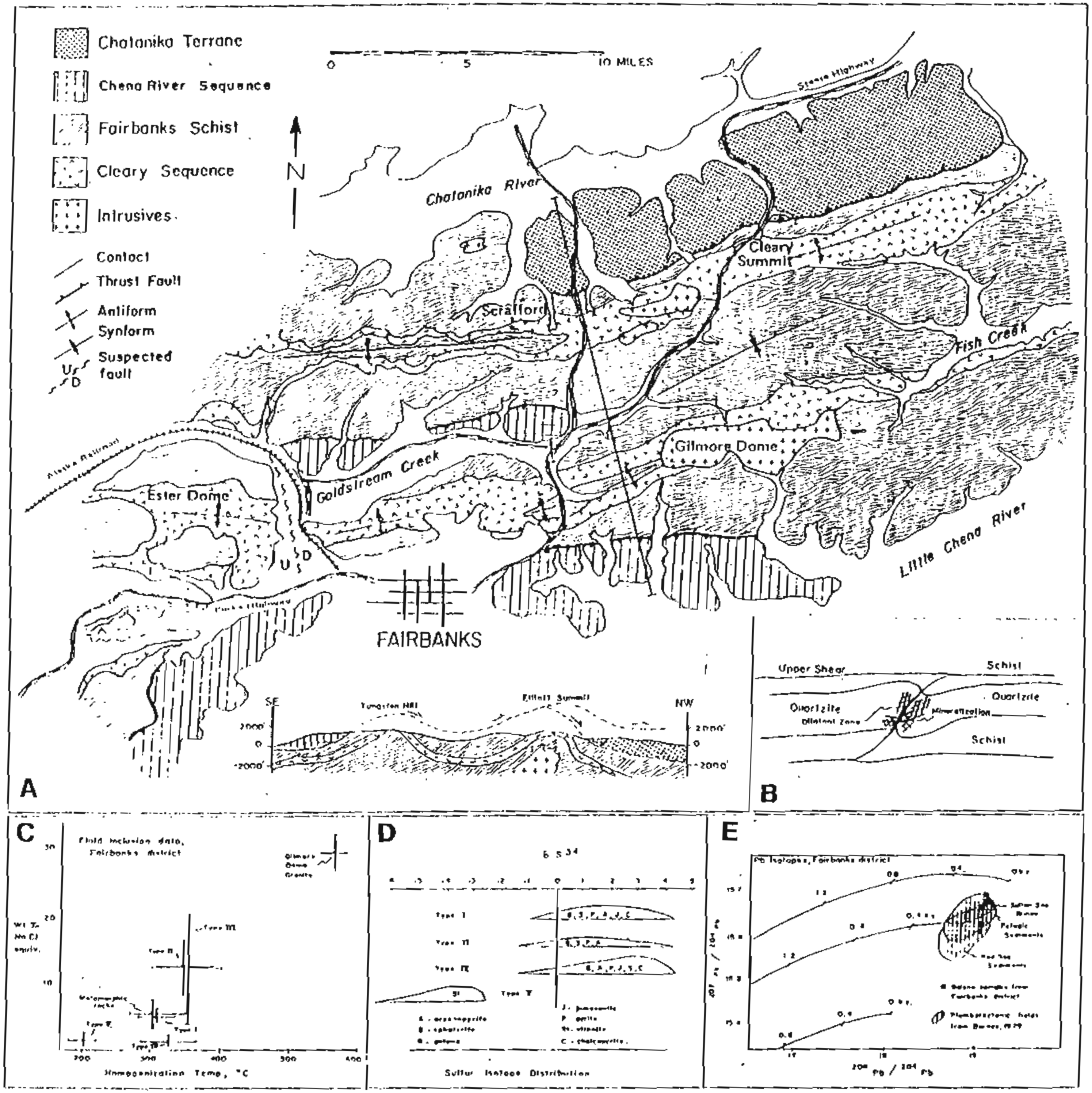
Figure _____ A-E. (A) Generalized bedrock geologic map of the Fairbanks mining district showing distribution of metalliferous Cleary Sequence along anticlinal ridge crests and location of four principal mineralized areas. Most lode gold mines and prospects (about 180) are localized on vein systems developed within or just above the Cleary Sequence. (B) Model of typical mineralized shear zone in district (Hall, oral. Comm., 1981) Sigmoidal shears form crush zones where they intersect competent quartzite units; shears and associated crush zones were later infilled with vein material; multiple stages of shearing and vein emplacement common. (C) Homogenization temperature and NaCl equivalent ranges for fluid inclusions in quartz from vein types and selected rocks from the district. Type I and IV veins also contain fluid inclusions with CO_2 contents in excess of 8 mole percent. (D) Sulfur isotope ranges of sulfide minerals from vein types showing contrast between late(?) monomineralic stibnite veins and earlier polysulfide veins. (E) Lead isotope ratios of galena from stratiform and discordant mineralization in Fairbanks district compared with those from continental rift settings and deep sea sediments.


Chatanika Terrane
Chena River Sequence
Fairbanks Schist
Cleary Sequence
Intrusives
Contact
Thrust Fault
Antiform
Synform
Suspected fault
U
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0
5
10 MILES
N
Steese Highway
Chatanika River
Cleary Summit
Scrafford
Fish Creek
Gilmore Dome
Goldstream Creek
Ester Dome
Little Chena River
FAIRBANKS
SE
NW
2000'
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A
Upper Shear
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Quartzite
Mineralization
Schist
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Sulfur Isotope Distribution

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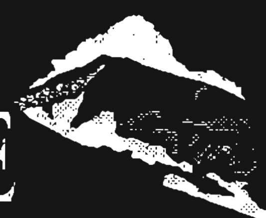
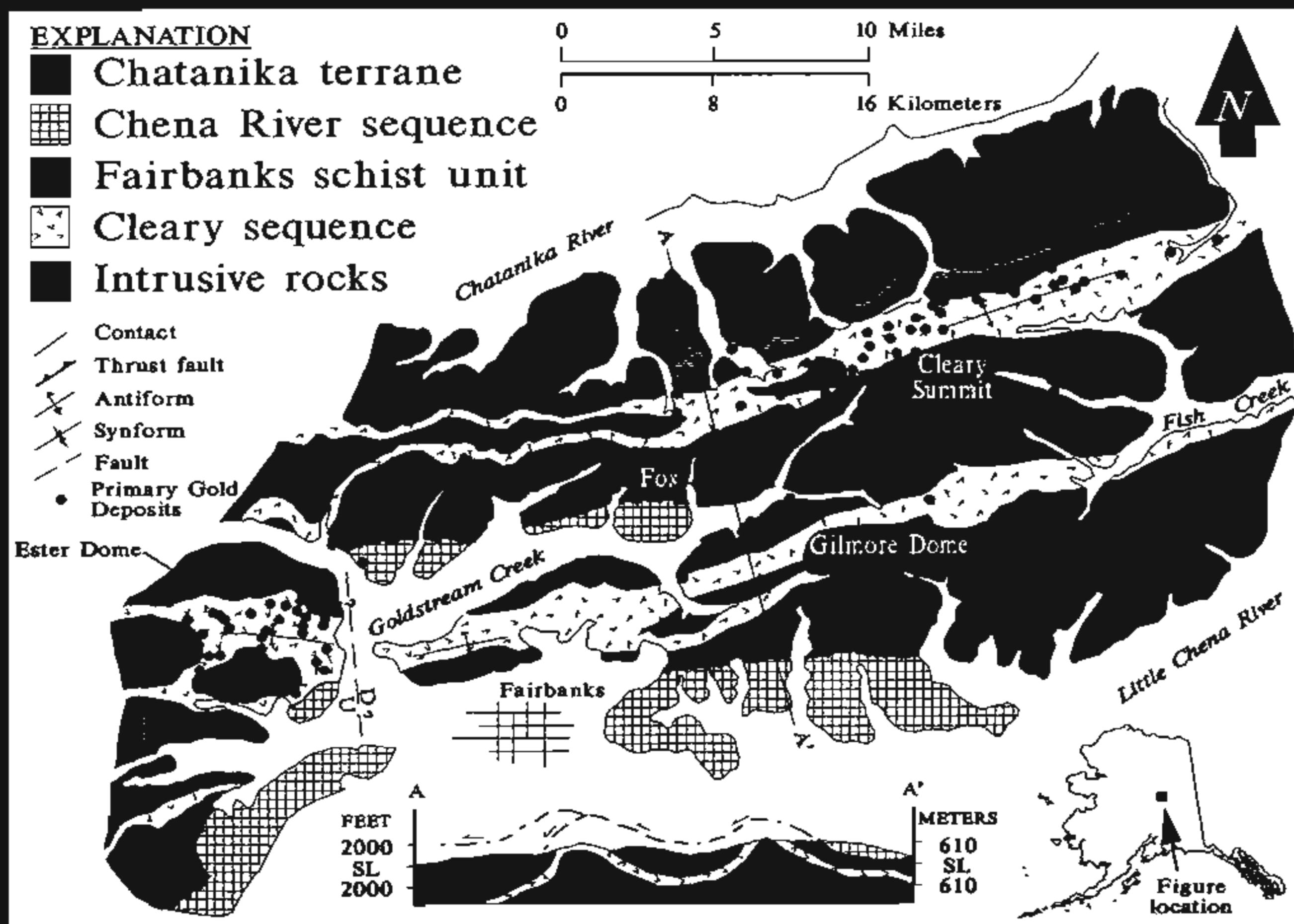


YUKON - TANANA BLOCK IN ALASKA

INTRO.IMG

Fairbanks Gold

LOCATION OF 94 PRIMARY GOLD DEPOSITS



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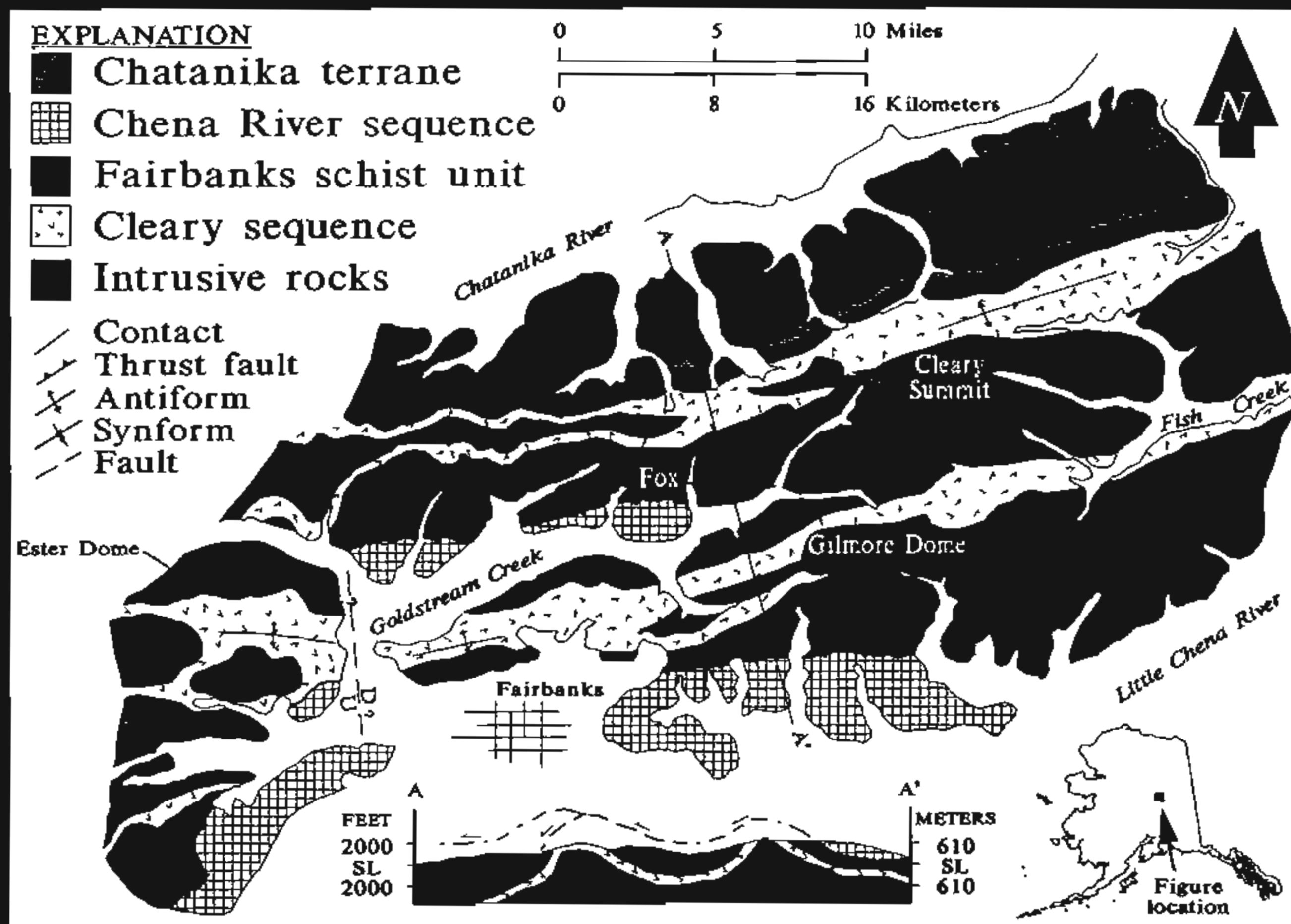
BEDROCK GEOLOGY FAIRBANKS MINING DISTRICT



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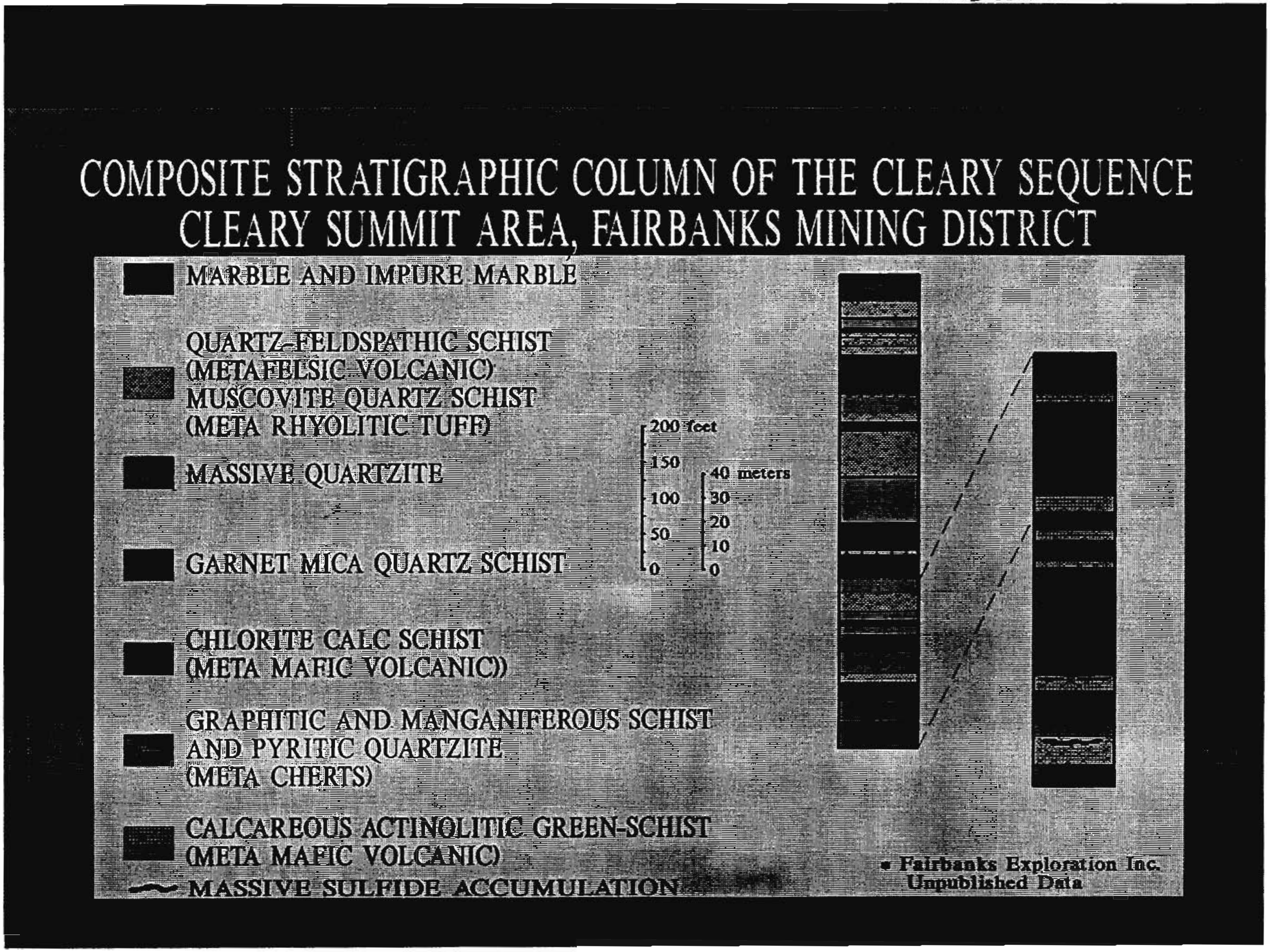
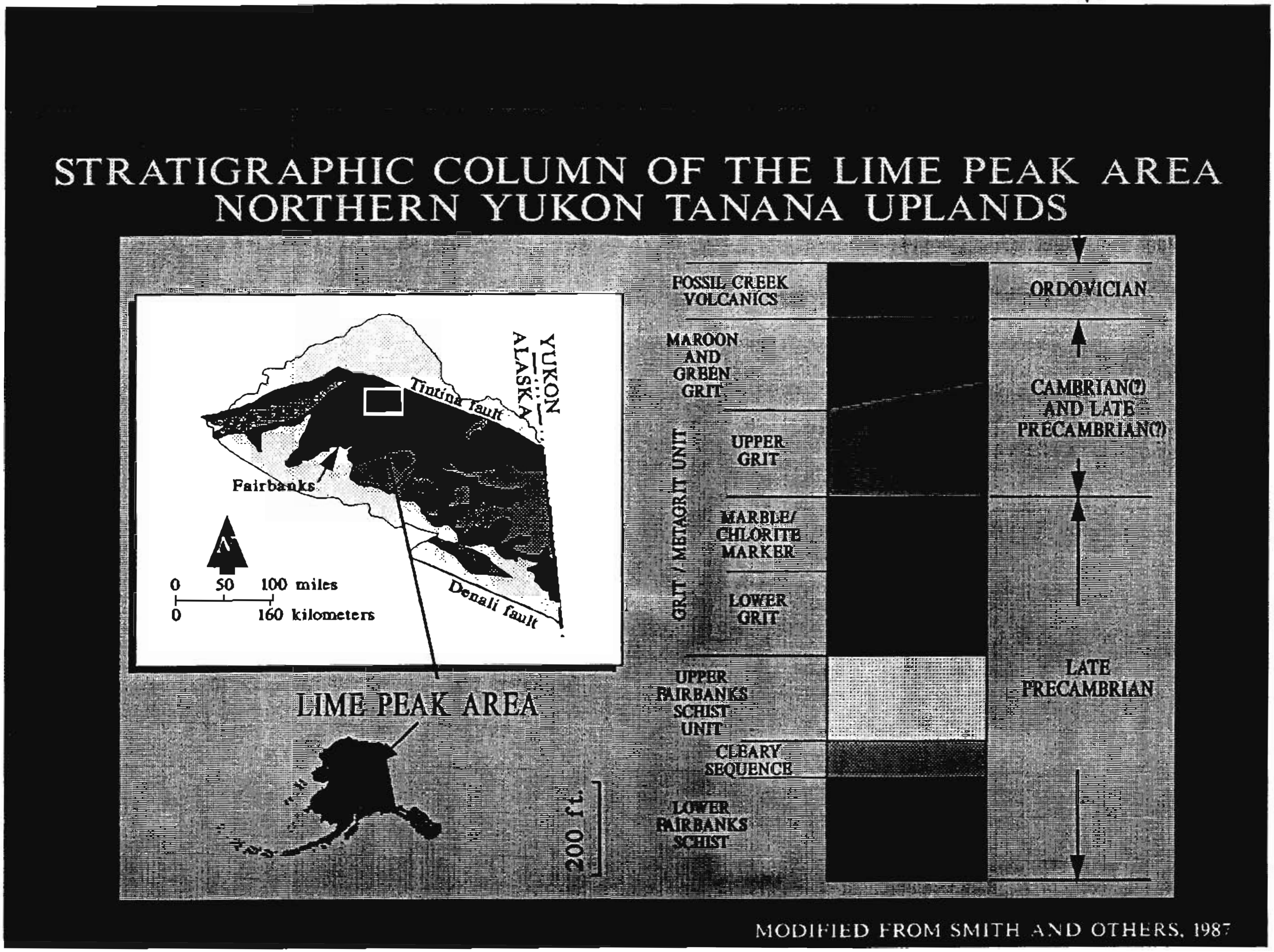
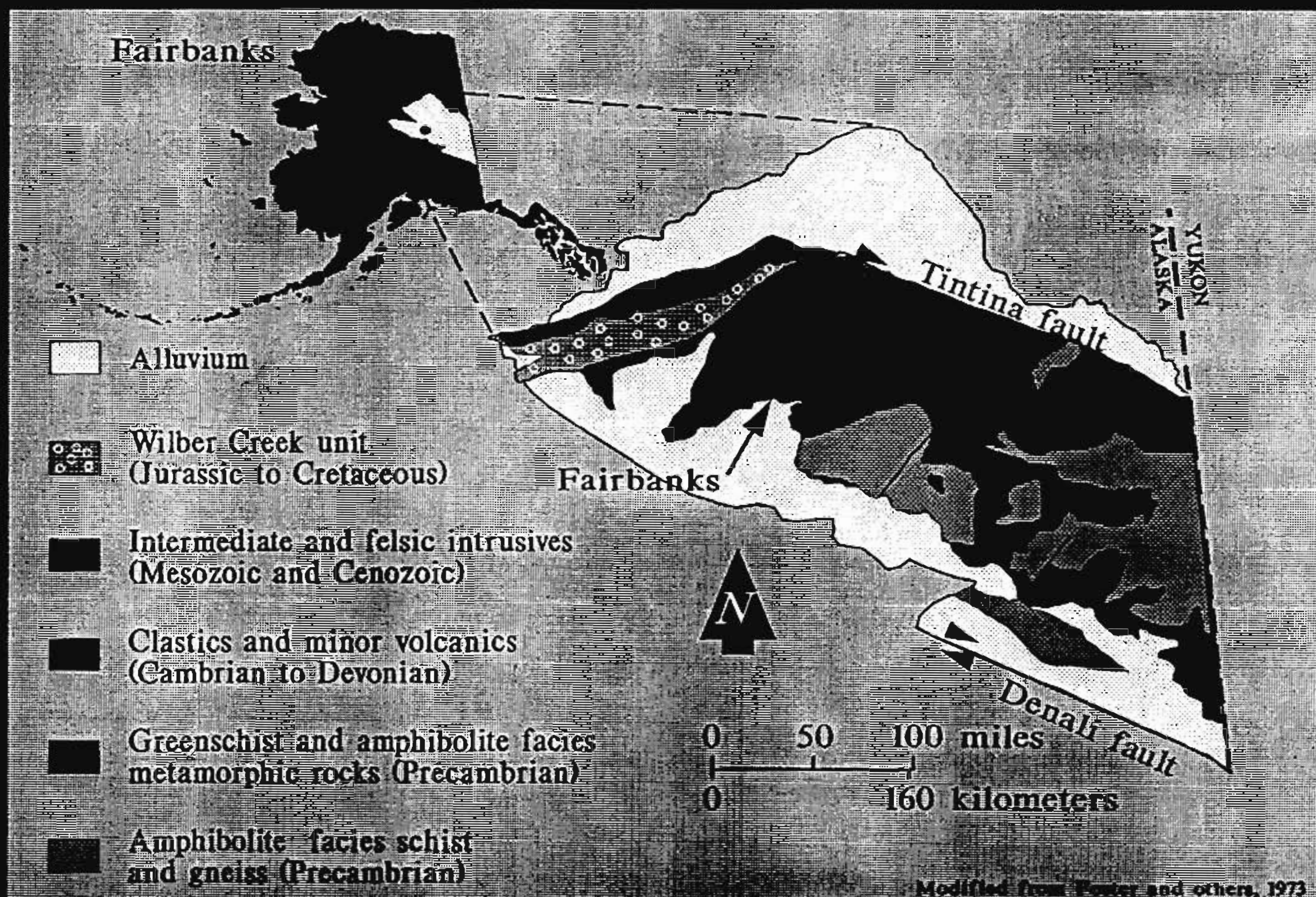

COMPOSITE STRATIGRAPHIC COLUMN OF THE CLEARY SEQUENCE
CLEARY SUMMIT AREA, FAIRBANKS MINING DISTRICT
MARBLE AND IMPURE MARBLE
QUARTZ-FELDSPATHIC SCHIST
(METAFELSIC VOLCANIC)
MUSCOVITE QUARTZ SCHIST
(META RHYOLITIC TUFF)
MASSIVE QUARTZITE
GARNET MICA QUARTZ SCHIST
CHLORITE CALC SCHIST
(META MAFIC VOLCANIC))
GRAPHITIC AND MANGANIFEROUS SCHIST
AND PYRITIC QUARTZITE
(META CHERTS)
CALCAREOUS ACTINOLITIC GREEN-SCHIST
(META MAFIC VOLCANIC)
MASSIVE SULFIDE ACCUMULATION
200 feet
150
100
50
0
40 meters
30
20
10
0
• Fairbanks Exploration Inc.
Unpublished Data

LIMPEAK.IMA


STRATIGRAPHIC COLUMN OF THE LIME PEAK AREA
NORTHERN YUKON TANANA UPLANDS
YUKON
ALASKA
Tintina fault
Fairbanks
Denali fault
0 50 100 miles
0 160 kilometers
LIME PEAK AREA
200 ft.
FOSSIL CREEK VOLCANICS
MAROON AND GREEN GRIT
UPPER GRIT
MARBLE/ CHLORITE MARKER
LOWER GRIT
GRIT / METAGRIT UNIT
UPPER FAIRBANKS SCHIST UNIT
CLEARY SEQUENCE
LOWER FAIRBANKS SCHIST
ORDOVICIAN
CAMBRIAN(?) AND LATE PRECAMBRIAN(?)
LATE PRECAMBRIAN
MODIFIED FROM SMITH AND OTHERS, 1987

Yuktands.ima

GEOLOGY OF THE YUKON-TANANA UPLANDS



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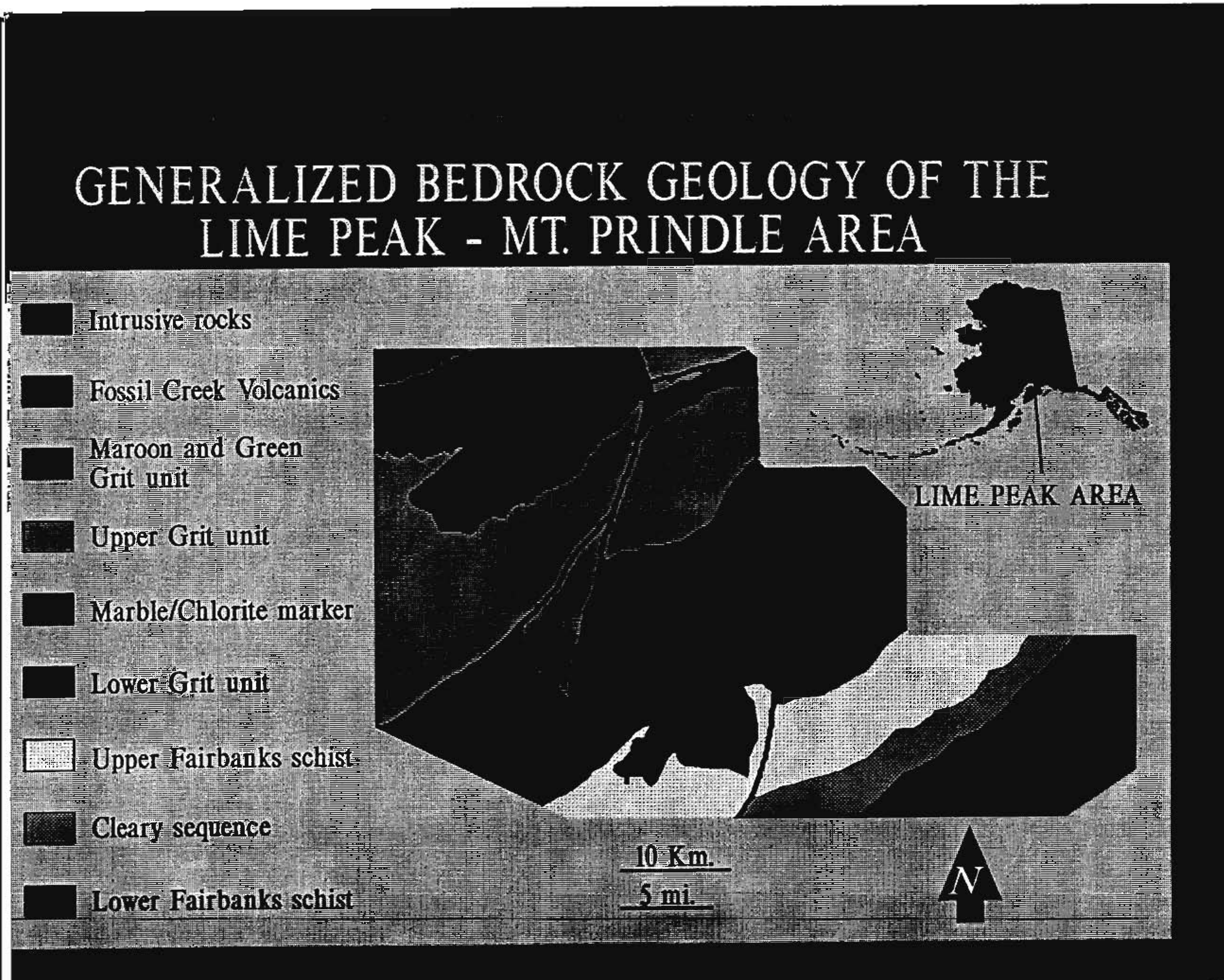
GENERALIZED BEDROCK GEOLOGY OF THE
LIME PEAK - MT. PRINDLE AREA
Intrusive rocks
Fossil Creek Volcanics
Maroon and Green Grit unit
Upper Grit unit
Marble/Chlorite marker
Lower Grit unit
Upper Fairbanks schist
Cleary sequence
Lower Fairbanks schist
LIME PEAK AREA
10 Km.
5 mi.
N