ALASKA DIVISION OF GEOLOGICAL AND GEOPHYSICAL SURVEYS

PROFESSIONAL REPORT 106
Robinson and others 1990, sheet 1 of 2
PR106-SH1

REGIONAL GEOLOGY AND TECTONIC HISTORY

The Yukon-Tanana Metamorphic Complex

The Fairbanks area is located in the northwestern part of the Yukon-Tanana Upland, an area underlain by crystalline rocks of the Yukon-Tanana metamorphic complex. The oldest rocks in the complex are crystalline schists and gneiss domes that were part of what was formerly known as the Birch Creek Schist Formation (Mertie, 1937). The metamorphic rocks range from greenschist and epidote-amphibolite facies to garnet-amphibolite facies. Although micaceous quartzite and pelitic schist are the most common rock types, the metamorphic complex also contains large gneiss dome complexes (Foster and others, 1977; and Dusel-Bacon and others, 1979) and subordinate amphibolite, marble, pelitic schist, calc-magnesian schist, and phyllite.

Intrusive rocks range from quartz diorite to granite intrude the Yukon Tanana Upland at many localities. Some of these masses, including the Charley River and Mt. Harper plutons, are of batholithic dimensions and encompass several hundred square kilometers. Small syenite bodies crop out in the Mt. Prindle and Mt. Harper areas. Mafic and ultramafic complexes, including diorite, gabbro, hornblendite, and peridotite, occur locally throughout the Yukon-Tanana terrane and are generally considered to be alpine ultramafics that are tectonic slices.

U-Pb-zircon dating of metamorphic rocks from the Yukon-Tanana terrane suggests that some of the protoliths may be as old as Late Precambrian (Aleinikoff and others, 1981; and Aleinikoff and Nokleberg, 1989). K-Ar ages from metamorphic and igneous rocks range between 639 m.y. and 55 m.y.

Structural and stratigraphic evidence indicates that greenschist-facies schists in the Circle and Livengood districts, northeast and northwest, respectively, of the Fairbanks district, include recrystallized Late Precambrian and lower Paleozoic sediments. Poorly preserved Paleozoic fossils have also been recovered from incompletely recrystallized calcschist and marble in the Big Delta and Eagle Quadrangles (Weber and others, 1978).

Mesozoic sedimentary rocks are relatively rare in the Yukon-Tanana Upland. However, Cretaceous argillaceous sandstone, graywacke, and conglomerate of the Wilber Creek unit (Weber, 1989) have been mapped in the Livengood district, northwest of Fairbanks.

Small areas of tholeiitic basaltic rocks, including pillow basalts, subaerial flows, and breccias, occur in the Fairbanks district (Birch Hill basalt). Whole-rock K-Ar age determinations indicate that the Birch Hill basalt is Tertiary. Silicified Metasequoia trunks and branches present in a fossil soil zone between the schists and overlying basalts on Birch Hill are also believed to be of early or middle Tertiary age.

Tertiary sedimentary rocks, including siltstone, sandstone, and conglomerate, occur in small, isolated basins throughout the Yukon-Tanana Upland. All occurrences are nonmarine, and some sections contain coal and minor basalt.

Large Cretaceous and Tertiary volcanic fields dominated by felsic volcanic rocks (including welded tuffs) have been mapped in the Tanacross and Big Delta Quadrangles by Foster (1970) and Bacon (1990, in press).

Regional Tectonic History

The regional tectonic setting of the Yukon-Tanana Upland is dominated by the Tintina and Denali faults. Both of these right-lateral strike-slip faults have large-scale displacements, bringing crustal blocks of contrasting geology into juxtaposition (fig. 1, sheet 2).

The Yukon-Tanana block (Yukon-Tanana terrane of Jones and others, 1987) is bounded on the northeast by the Tintina fault and on the southwest by the Denali fault (fig. 1, sheet 2). It is bounded to the northwest by the Manley terrane and on the southeast by the Stikine terrane (Jones and others, 1987; and Howell and others, 1985).

The oldest structural grain in the Yukon Tanana block trends to the northwest, but a superimposed northeast trend becomes increasingly dominant to the northwest. Folds with north-vergent axial planes and northeast-trending axes transect the older structural grain at about 60°. The later deformational episode occurred about 90 to 120 m.y., in the Fairbanks area and was associated with the emplacement of mesozonal synkinematic plutons and the formation of epigenetic ore deposits (Blum, 1983; Metz and Hamil 1986; Metz and others 1987; and Metz, 1987).

Recent geologic mapping (Weber and others, 1978) and aeromagnetic studies show that the Yukon-Tanana block is transected by several northeast-trending faults. Several of these including the Shaw and Mansfield Creek faults, show left-lateral offsets and appear to be large-scale dislocations related to a possible shear couple between a locked or relatively slow-moving Tintina fault and more active displacement along the Denali fault system.

GEOLOGY OF THE FAIRBANKS MINING DISTRICT

The Fairbanks district is well known as one of the most important gold producing areas in Alaska. Since Felix Pedro's initial discovery in 1902, the Fairbanks mining district has produced over 7.6 million troy ounces of gold, mainly from placer deposits. This production accounts for 25 percent of Alaska's total production. The district has also produced significant amounts of antimony, tungsten, building stone, and aggregate.

Bedrock exposed in the district comprises three metamorphosed stratigraphic packages, all in apparent thrust-fault contact. From oldest to youngest they are the Chatanika terrane, Fairbanks schist unit, Chena River sequence, and the Birch Hill sequence.

The Chatanika terrane occurs in the northern part of the district and structurally overlies the Fairbanks schist unit in presumed thrust contact. It consists of eclogitic variants, garnet amphibolite, black quartzite, and pelitic schist of epidote-amphibolite- and garnet-amphibolite-facies metamorphic grade (Swainbank, 1970; Swainbank and Forbes, 1975; Brown and Forbes, 1984).

The Fairbanks schist unit is the dominant rock unit exposed in the Fairbanks mining district and consists of brown- to gray-quartzite and muscovite-quartz schist with local variants containing garnet, biotite and chlorite. Mineral assemblages in this 1,200 m-thick unit are indicative of greenschist-facies metamorphic grade. Interstratified near the center of the Fairbanks schist unit is a sequence of variable thickness that contains interlensing felsic schist, laminated white micaceous quartzite, chloritic and actinolitic greenschist, graphitic schist, minor metabasite and metarhyolite, calc-silicates, banded gray marble, and significant amounts of quartzite and muscovite-quartz schist. This unit, known as the Cleary sequence (fig. 2, sheet 2), may be largely of distal volcanogenic origin.

Structurally above the Fairbanks schist - Cleary sequence is the Chena River sequence, a unit of variable thickness containing dense banded amphibolite, tremolite marble, coarse-grained garnet muscovite schist, biotite-rich schist, micaceous calcschist and pale green metachert. Mineral assemblages and textural maturity indicate lower amphibolite facies metamorphic grade.

Stratigraphically overlying the Chena River sequence in the southern part of the distict is the Birch Hill sequence consisting of phyllitic siltstone, calc-schist, calc-amphibolite, quartzite and minor felsic tuff. The unit is intruded by and is overlain by basalts of Late Cretaceous or Tertiary age.

Table 1 (sheet 2) lists the results of major-oxide chemical analyses of samples of various metamorphic rock types in the Fairbanks district. These analyses reflect a wide range of chemical compositions contained within the individual metamorphic rock packages.

Table 2 (sheet 2) contains trace-element contcentrations for the same metamorphic rock samples contained in table 1. These data reveal the high

Economic Geology

Gold production from lode deposits in the Fairbanks district has been estimated at 225,000 to 300,000 troy ounces (Chapman and Foster, 1969; Koschmann and Bergendahl, 1968). The principal epigenetic lode deposits consist of gold-sulfide-quartz and gold-quartz veins and breccias hosted in faults, fractures, shear zones, and stockworks developed in the Cleary sequence and within intrusive complexes. The epigenetic deposits that are hosted within the metamorphic sequences are usually podiform and discontinuous and contain highly variable precious-metal values. Vein systems are best developed in areas with an appreciable quartzite component. Shears developed within the quartzite have well-defined walls, have open spaces, and are laterally continuous, whereas those developed within areas dominated by schistose rocks tend to be poorly developed, with diffuse walls and are generally restricted laterally.

The economic vein systems in the Fairbanks district developed from at least four episodes of volatile transport within a retrograded upper-greenschist metasedimentary-volcanic assemblage (Metz and Hamil, 1986). These episodes include:

1) Early barren, coarse-grained quartz lenses formed within ductile shear zones in transition to brittle deformation. An increase in the abundance and thickness of concordant metamorphic segregation quartz lenses toward the vein zones in the hanging and footwalls of most productive vein systems suggests a metamorphic derivation.

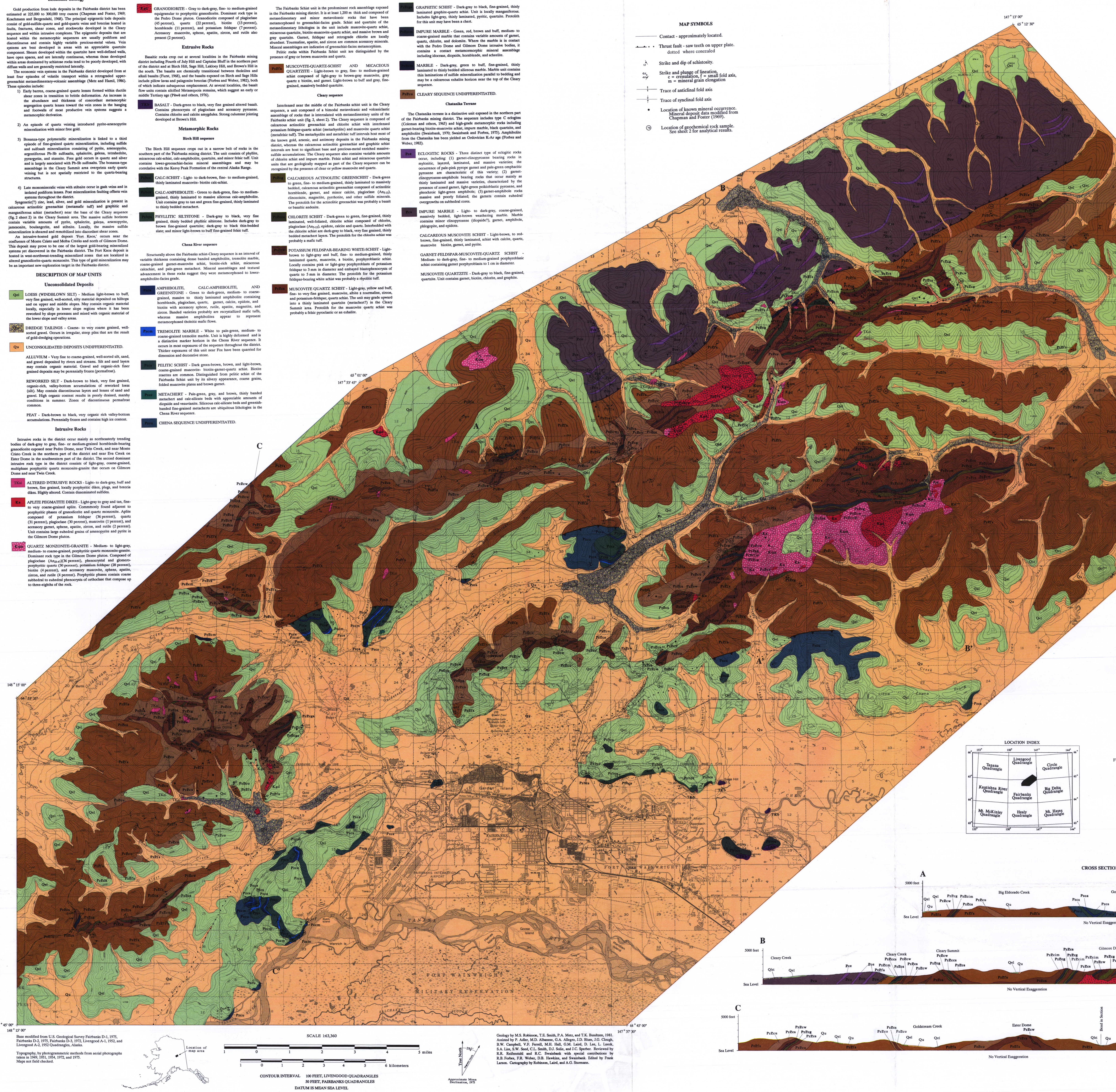
2) An episode of quartz veining introduced pyrite-arsenopyrite mineralization with minor free gold.

3) Bonanza-type polymetallic mineralization is linked to a third episode of fine-grained quartz mineralization, including sulfide and sulfosalt mineralization consisting of pyrite, arsenopyrite, argentiferous Pb-Sb sulfosalts, sphalerite, galena, tetrahedrite, pyrargyrite, and stannite. Free gold occurs in quartz and silver and is largely associated with Pb-Sb sulfosalts. The bonanza-type assemblage in the Cleary Summit area overprints early quartz veining but is not spatially restricted to the quartz-bearing structures.

4) Late monomineralic veins with stibnite occur in gash veins and in isolated podiform lenses. Post mineralization faulting offsets vein systems throughout the district.

Syngenetic(?) zinc, lead, silver, and gold mineralization is present in calcareous actinolitic greenschist (metamafic tuff) and graphitic and manganiferous schist (metachert) near the base of the Cleary sequence (fig. 2 sheet 2) in the Cleary Summit area. The massive sulfide horizons contain variable amounts of pyrite, sphalerite, galena, arsenopyrite, jamesonite, boulangerite, and stibnite. Locally, the massive sulfide mineralization is sheared and remobilized into discordant shear zones.

An intrusive-hosted gold deposit 'Fort Knox,' occurs near the confluence of Monte Cristo a[illegible]



Base modified from U.S. Geological Survey Fairbanks D-1, 1975, Fairbanks D-2, 1975, Fairbanks D-3, 1972, Livengood A-1, 1952, and Livengood A-2, 1952 Quadrangles, Alaska.

Topography, by photogrammetric methods from aerial photographs taken in 1949, 1951, 1954, 1972, and 1975.
Maps not field checked.

Location of map area

SCALE 1:63,360

1 0 1 2 3 4 5 miles

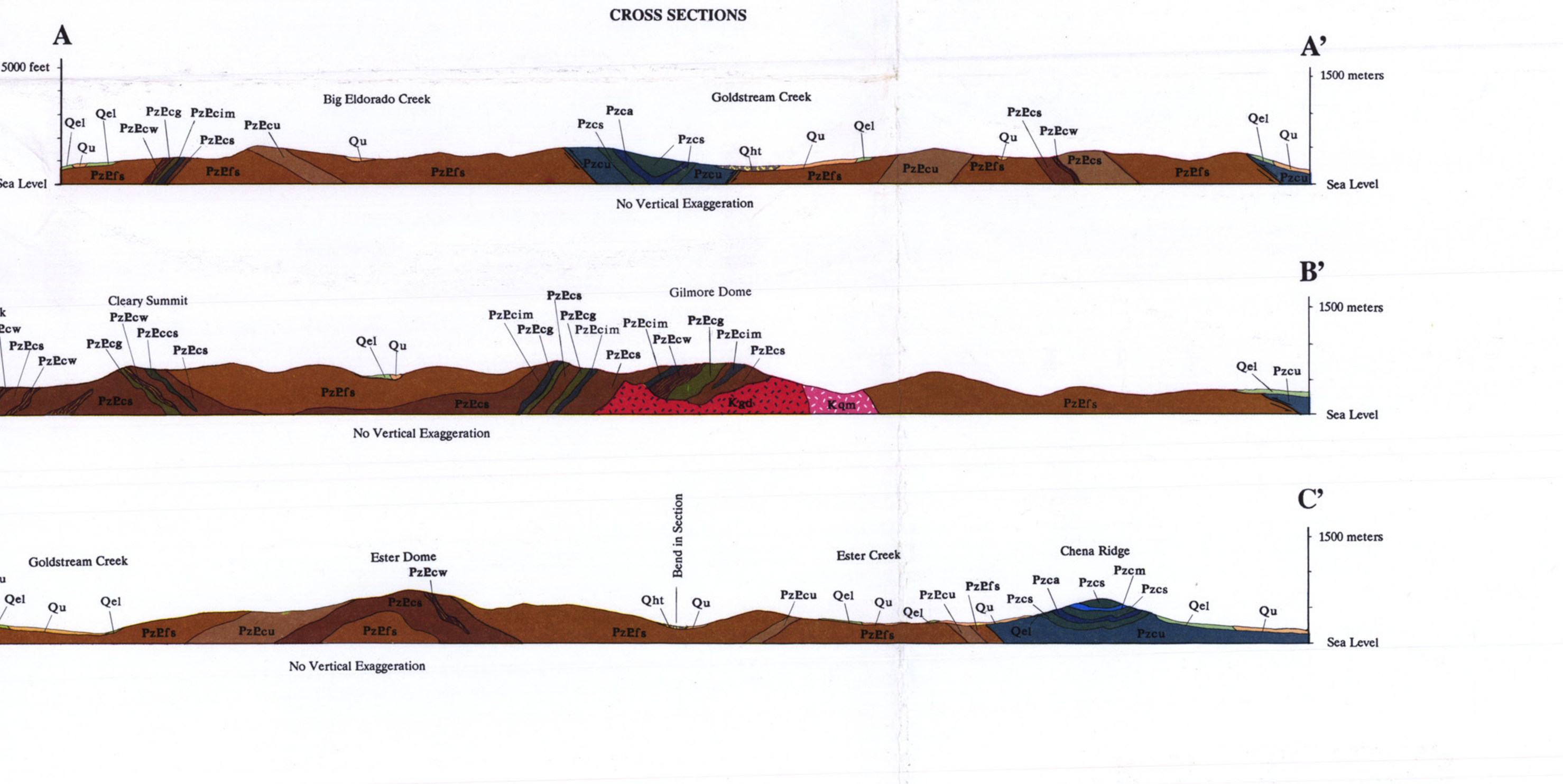
1 0 1 2 3 4 5 6 kilometers

CONTOUR INTERVAL 100 FEET, LIVENGOOD QUADRANGLES
50 FEET, FAIRBANKS QUADRANGLES
DATUM IS MEAN SEA LEVEL

True North — Magnetic North — 29½°
Approximate Mean Declination, 1975

Geology by M.S. Robinson, T.E. Smith, P.A. Metz, and T.K. Bundtzen, 1981. Assisted by P. Adler, M.D. Albanese, G.A. Allegro, J.D. Blum, J.G. Clough, B.W. Campbell, V.F. Ferrell, M.H. Hall, G.M. Laird, D. Lee, L. Lueck, S.A. Liss, S.W. Seed, C.L. Smith, D.J. Solie, and J.C. Sperber. Reviewed by R.R. Reifenstuhl and R.C. Swainbank with special contributions by R.B. Forbes, F.R. Weber, D.B. Hawkins, and Swainbank. Edited by Frank Larson. Cartography by Robinson, Laird, and A.G. Sturmann.

CROSS SECTIONS



BEDROCK GEOLOGY OF THE FAIRBANKS MINING DISTRICT

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1990

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Aleinikoff, J.N., and Nokleberg, W.J., 1989, Age of deposition and provenance of the Fairbanks Schist unit, Yukon-Tanana terrane, east-central Alaska: U.S. Geological Survey Bulletin 1903, p. 75-83.

Aleinikoff, J.N., Dusel-Bacon, Cynthia, and Foster, H.L., 1981, Geochronologic studies in the Yukon-Tanana Upland, east-central [illegible]