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Compiled Geologic and Bouguer Gravity Map of the Nenana Basin Area, Central Alaska

by

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Two sheets accompany this pamphlet.

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INTRODUCTION

The purpose of this map is to show on one sheet the geology and simple Bouguer gravity of the Nenana basin area, a prospective petroleum province in central Alaska. Preparation of this map was part of a petroleum resource assessment project.

We compiled the geology of the Nenana basin area from published sources (Chapman and others, 1971, 1975a, 1975b, 1982; Chapman and Yeend, 1981; Csejtey and others, 1986; Jones and others, 1983; Péwé and others, 1966; and Reed, 1961), as shown on the accompanying index map. Map units are organized and presented according to the scheme of lithotectonic terranes proposed by Jones and others (1987) and Silberling and Jones (1984); we recognize, however, that this terrane scheme is controversial and likely to be revised in the future. Post-accretion cover deposits represent overlap assemblages that depositionally overlie accreted terranes. Plutonic igneous rocks shown on this map include several plutons that are clearly post-accretionary, on the basis of radiometric dates and (or) field relations. It is possible that some of the plutons predate accretion, but this has not been demonstrated. Each accreted terrane is fault bounded and distinguished from adjacent terranes by a distinctive geologic record. According to Jones and others (1982), the terranes in the area of our map were assembled during late Mesozoic or earliest Cenozoic time. References listed in brackets ([ ]) at the end of each map unit description are the principal ones used in preparing the description and showing the unit's distribution on the map. The contours of simple Bouguer gravity are from recent work by Valin and others (1991).

The most promising area for petroleum exploration is a prominent Bouguer gravity low in the area northwest of Nenana. This gravity low probably corresponds to the deepest part of a sedimentary basin filled by Cenozoic strata including nonmarine fluvial and lacustrine deposits of the Eocene to Miocene Usibelli Group. Gravity modelling suggests that the base of the Usibelli Group in this area is about 3,000 to 3,350 m beneath the ground surface (Barnes, 1961; Hite and Nakayama, 1980; Kirschner, 1988). Organic geochemical studies indicate that mudstones and coals in the Usibelli Group are potential sources of petroleum; calculations based on borehole temperatures suggest that, in the area of the gravity low, these rocks may have been buried deeply enough to generate oil and gas (Stanley and others, 1990). Two exploratory wells, the Union Nenana No. 1 and the ARCO Totek Hills No. 1, were drilled some distance away from the gravity low in areas where the Usibelli Group is thin (Grether and Morgan, 1988; Kirschner, 1988). Mudlogs show that both wells were dry holes that bottomed in schist, with gas shows associated with coal beds in the Usibelli Group but no reported signs of oil.

We thank Robert Chapman and Béla Csejtey, Jr., for their helpful reviews of this effort.

DESCRIPTION OF MAP UNITS

POST-ACCRETION COVER DEPOSITS

Qs **Surficial deposits (Quaternary)**--Mainly unconsolidated gravel, sand, silt, and clay. Includes lake deposits, swamp deposits, landslide debris (including blocks of bedrock), floodplain alluvium, stream gravel, alluvial fan deposits, dune sand, morainal deposits, glacial outwash, loess, tailings, and perennially frozen silt. [Chapman and others, 1971, 1975a, 1975b, 1982; Chapman and Yeend, 1981; Csejtey and others, 1986; Jones and others, 1983; Péwé and others, 1966; and Reed, 1961]

Qv **Volcanic rocks (Quaternary)**--Basaltic pyroclastic debris associated with cinder cones or maars located southwest of Buzzard Creek (T10S, R4-5W). Radiocarbon ages indicate that the debris erupted about 3000 ± 230 years ago. [Albanese, 1982; Péwé and others, 1966; Wahrhaftig, 1970a]

Tvs **Volcanic and sedimentary rocks (Tertiary)**--Rhyolitic lava, breccia, tuff, and welded tuff; flow banding, lamination, and spherulitic texture common. Gray cherty rocks are rare, occurring in thin beds or as nodules; tuffaceous siltstone, shale, and argillite are thin bedded to laminated. Tertiary age inferred from structural setting and lack of rock alteration; relationship to Upper Cretaceous to Miocene sedimentary rocks (unit **TKs**) is uncertain. Thickness unknown, probably at least 90 to 120 m. Unit **Tvs** occurs in T5-6N, R14-15W. [Chapman and others, 1982]

Thd **Hornblende dacite (Pliocene)**--Shallow intrusive rocks of Jumbo Dome (T11S, R6W). K-Ar age determination on basaltic hornblende yielded 2.79 ± 0.25 Ma. Apparently intrudes Nenana Gravel (unit **Tn**). [Csejtey and others, 1986; Wahrhaftig, 1970d]

Tn **Nenana Gravel (Pliocene and Miocene)**--Mainly buff to reddish-brown, poorly consolidated, pebble to boulder conglomerate and coarse sandstone, with minor interbeds of mudstone and lignite. These rocks occur in T8-16S, R1E-R18W. Unit **Tn** is more than 1300 m thick. Thickness and pebble size decrease northward; imbrication and crossbedding indicate deposition by northward-flowing streams. The Nenana Gravel rests unconformably on the underlying Tertiary Usibelli Group (unit **Tu**), is overlain by Quaternary surficial deposits (unit **Qs**), and appears to be deformed around an intrusion of Pliocene hornblende dacite (unit **Thd**). Because of the lack of diagnostic fossils, the age of the Nenana Gravel is uncertain, but it is younger than the underlying upper Miocene Grubstake Formation of the Usibelli Group and older than the Pliocene hornblende dacite intrusive of Jumbo

Dome. The Nenana Gravel represents a series of coalescing alluvial fans that developed on the north side of the Alaska Range as it rose during late Miocene and Pliocene time. [Csejtey and others, 1986; Wahrhaftig, 1987]

Tu **Usibelli Group (Miocene to Eocene)**--Poorly consolidated nonmarine conglomerate, sandstone, mudstone, subbituminous and lignite coal, and minor tuff. This unit crops out widely in the northern foothills of the Alaska Range (T8-16S, R1E-R14W) and also occurs in the subsurface of the middle Tanana basin, where it has been penetrated by two exploratory wells (both dry holes), the Union Nenana No. 1 and the ARCO Totek Hills No. 1. The Usibelli Group is generally less than 900 m thick. Locally, the Usibelli Group is divided into five formations; in ascending order, these are the Healy Creek, Sanctuary, Suntrana, Lignite Creek, and Grubstake Formations. Much of the Usibelli Group consists of repeated fining-upward sequences of conglomerate, sandstone, mudstone, and coal that were deposited by streams flowing southward across the present site of the Alaska Range, which then did not exist. Interstratified with these fluvial deposits are locally thick sequences of mudstone that probably accumulated in large, shallow lakes. Fossil plant leaves and pollen, along with a single radiometric date from an interbed of volcanic tuff, indicate that the Usibelli Group ranges in age from Eocene to Miocene. Coal has long been produced in commercial quantities from mines in the Healy Creek and Lignite Creek areas (T11-12S, R6-7W). Geochemical studies show that coals and mudstones in the Usibelli Group are potential source rocks of petroleum. [Buffler and Triplehorn, 1976; Csejtey and others, 1986; Stanley, 1987a, 1988; Stanley and others, 1990; Wahrhaftig and others, 1969; Wahrhaftig, 1987]

TKs **Sedimentary rocks (Miocene to Upper Cretaceous)**--Well-consolidated to friable nonmarine conglomerate, sandstone, mudstone, and coal. In places these rocks are arranged in repeated fining-upward sequences, suggesting deposition by streams. Fossil plant leaves and pollen indicate a range of ages from Late Cretaceous to Miocene. Thickness may be as much as 1500 m. Unit **TKs** occurs in T4-5N, R16-22W. [Chapman and others, 1982; Paige, 1959]

Tv **Volcanic rocks (Oligocene to Paleocene)**--Compositions range from rhyolite to basalt; includes extrusive rocks (flows, tuffs, and breccias) as well as dikes, sills, and shallow intrusive rocks. K-Ar age determinations range from 54.7 ± 2.4 Ma to 32.5 ± 1.0 Ma. These rocks occur in the vicinity of Sugar Loaf Mountain (T11-13S, R4-7W) and in T1S, R1E. [Albanese and Turner, 1980; Csejtey and others, 1986]

Tmg **Mount Galen Volcanics of Decker and Gilbert (1978) (Lower Oligocene and upper Eocene)**--Series of andesitic and basaltic lava flows, breccia, and tuff near Mount Galen (T16S, R14W). Thickness to 1000 m. K-Ar ages on plagioclase and hornblende range from 40.1 ± 1.2 Ma to 34.8 ± 1.4 Ma. [Decker and Gilbert, 1978; Jones and others, 1983]

Cantwell Formation (Paleocene)--Divided into:

Tcv **Volcanic rocks**--Unit **Tcv**, termed the "Teklanika Formation" by Gilbert and others (1976), is a moderately deformed sequence of andesite, basalt, rhyolite and dacite flows, felsic pyroclastic rocks, related intrusive rocks, and a few interbeds of sandstone and mudstone. The contact with the underlying sedimentary rocks (unit **Tcs**) is conformable in places but unconformable in others. Unit **Tcv** is reportedly more than 3700 m thick. Radiometric ages and field relations suggest that the volcanic rocks were erupted during Paleocene time. These rocks occur in T14-17S, R5-13W. [Csejtey and others, 1986; Gilbert and others, 1976; Wolfe and Wahrhaftig, 1970]

Tcs **Sedimentary rocks**--Mainly well-indurated nonmarine conglomerate, sandstone, mudstone, and bituminous coal; locally includes interstratified volcanic rocks resembling those in unit **Tcv**. In many places the sedimentary rocks are intruded by dikes and sills ranging in composition from basalt to rhyolite, and by granitoids of Cretaceous and Tertiary age (units **TKgr** and **Tgr**). The maximum reported thickness is about 3000 m. The Cantwell sedimentary rocks rest everywhere with pronounced angular unconformity on deformed and metamorphosed rocks of Precambrian(?) to Cretaceous age. Much of the conglomerate, sandstone, mudstone, and coal in the Cantwell Formation is arranged in repeated fining-upward sequences of fluvial origin. Intercalated with the fluvial deposits are thick sequences of mudstone that most likely were deposited in lakes. The age of the Cantwell Formation is based on the occurrence of Paleocene plant fossils and Paleocene radiometric dates from volcanic rocks. Geochemical studies indicate that some mudstones and coals are potential source rocks of petroleum. Unit **Tcs** occurs in T14-17S, R1E-R15W. [Csejtey and others, 1986; Gilbert and others, 1976; Stanley, 1987b; Wolfe and Wahrhaftig, 1970]

Kv **Volcanic rocks (Upper Cretaceous)**--Gray to black porphyritic basalt; these rocks occur in a swarm of dikes limited to a small area in T13S, R4W. K-Ar age of 79.1 Ma. [Csejtey and others, 1986, p. 11]

PLUTONIC IGNEOUS ROCKS

Tgr **Granitic rocks (Oligocene to Paleocene)**--Wide variety of epizonal granitic rocks including granite, granodiorite, tonalite, and quartz monzodiorite. K-Ar dates range from about 62 to 37 Ma, and are interpreted to represent Paleocene to early Oligocene ages of intrusion. Unit **Tgr** occurs at Manley Hot Springs Dome (T2-3N, R15-16W) and in T15-17S, R1E and R1-5W. [Chapman and others, 1982, p. 11; Csejtey and others, 1986, p. 9]

TKgr **Granitic rocks (Paleocene and Cretaceous)**--Plutons, dikes, stocks, plugs, and breccia pipes, including granite, granodiorite, granite porphyry, monzonite, quartz monzonite, diorite, quartz diorite, aplite, dacite, syenite, rhyolite, andesite, and basalt. K-Ar dates range from about 71 to 59 Ma, and are interpreted to represent Late Cretaceous to Paleocene ages of intrusion. Unit **TKgr** occurs in T2-3S, R21-22W; T5-7N, R16-18W; T4-6N, R6-8W; T15S, R8W; and T1S-T2N, R1E-R4W. [Chapman and others, 1982, p. 11, 1975b; Chapman and Yeend, 1981, p. B31; Csejtey and others, 1986, p. 10; Péwé and others, 1966]

Kgr **Granitic rocks (Cretaceous)**--Tonalite, quartz monzonite, monzonite, granite, and some granodiorite, quartz diorite, diorite, and quartz monzodiorite. K-Ar dates range from about 106 to 49 Ma; however, the early Tertiary ages are suspected to represent a Tertiary reheating event as indicated by discordant ages on biotite-hornblende mineral pairs on some of the rocks (Csejtey and others, 1986, p. 34). Unit **Kgr** occurs at Roughtop Mountain (T4N, R16W), Elephant Mountain (T5-6N, R12-13W), and in T11-17S, R1E-R7W. [Chapman and others, 1982; Csejtey and others, 1986, p. 33]

ACCRETED TERRANES

BRY-RB: Baldry and Ruby terranes, undivided

PDa **Argillaceous rocks (Permian? to Middle or Upper Devonian?)**--Gray siltstone, slate, phyllite, and argillite, with minor sandstone. Contact relations, thickness, and age uncertain; apparently younger than unit **Oc** and older than unit **KJcs (MAN)**. Most probable ages are Middle or Late Devonian to Permian (Chapman and others, 1982, p. 7). Probably about 300 m thick. Mapped only near Boulder Ridge (T4N, R16-17W). These rocks were mapped as unit "Pzar" by Chapman and others (1982) and as unit "Pzcs" by Chapman and others (1975a). [Chapman and others, 1982, 1975a]

PDs **Schistose rocks (Permian? to Devonian?)**--Quartz-mica-garnet schist, with some quartzite schist, calcareous schist, marble and slate-phyllite; schistose chert, hornfels, and skarn occur locally. Pegmatite, quartz, and felsic dikes are common; some mafic dikes are present. A small body of gneissic granite and pegmatite at the head of Garnet Creek (T6N, R14W) is included. Ages and protoliths of rocks uncertain; age probably Devonian to Permian. Unit is apparently conformable with unit **DOl**, but contacts are poorly exposed. Thickness unknown but may be as much as 600 to 900 m. This unit is mapped only in the Russian-Ruby-Garnet Creeks area (T6-7N, R13-14W). These rocks were mapped as unit "Pzsr" by Chapman and others (1982, 1975a). [Chapman and others, 1982, 1975a]

Pzc **Clastic rocks (Middle to lower Paleozoic?)**--Upper part contains gray calcareous schistose siltstone and sandstone. Lower part contains poorly sorted sandstone, granule conglomerate, siltstone, and semischist with commonly 15 to 46 m of gray metachert near the top. Subordinate phyllite interbedded throughout upper and lower parts. Age uncertain; probably early Paleozoic and possibly Devonian (Chapman and others, 1982, p. 8). Thickness unknown, but probably at least 900 to more than 1200 m. Mapped only in Minook Creek area (T5-7N, R12-15W). These rocks were mapped as units "Pzc" and "Pzw" by Chapman and others (1982, 1975a). [Chapman and others, 1982, 1975a]

DSl **Limestone, dolomite, greenstone, schist, and chert (Devonian to Silurian)**--Limestone, dolomite, basaltic greenstone and chloritic schist. Mapped only along and north of the Yukon River (T4-7N, R16-22W), but rocks are similar to those in unit **DOl**. Minor amounts of phyllite, calcareous schist, quartz-mica schist, quartzite, and chert are included. Poorly preserved colonial rugose corals from Raven Ridge (T7N, R16-17W) are identified only as in age range of Silurian to Permian;

however, field relationships suggest that Silurian to Devonian age is most probable (Chapman and others, 1982, p. 9). Unit is presumed to correlate in part with unit **DSt (WHM)** (Chapman and others, 1982, p. 9). Upper and lower contacts poorly defined; hence, thickness unknown, but probably at least 460 m. These rocks were mapped as unit "Pzlc" by Chapman and others (1982, 1975a). [Chapman and others, 1982, 1975a]

DOl **Limestone, dolomite, greenstone, and schist (Devonian, Silurian, and Ordovician?)**--Dominantly light gray crystalline limestone and dolomite; cherty in part. Interbedded basaltic greenstone and chloritic schist. Some argillite, phyllite, quartz-mica schist, quartzite, and metachert are included. No fossils or continuous sections. Interpreted to include rocks of Ordovician(?), Silurian, and Devonian age. Apparently overlies unit **Oc**. Several thin chert-pebble conglomerate beds in basal 30 to 60 m; upper contact not seen. Mapped only south of the Yukon River (T4-6N, R13-21W). May be correlative in part with unit **DSl** north of the Yukon River, and in part with units **DSt (WHM)** and **Op€d (LIV)**. Thickness uncertain; probably at least 150 m to as much as 460 m. These rocks were mapped as unit "Pzl" by Chapman and others (1982, 1975a). [Chapman and others, 1982, 1975a]

SOvs **Volcanic and sedimentary rocks (Silurian or Ordovician)**--Foliated basaltic lava, tuff, slate, slaty shale, phyllite, and some limestone and chert. Volcanic rocks are partly altered and include some diabasic rocks. Sedimentary rocks are generally thin bedded. Sequence apparently lies between and is gradational with units **Oc** and **DOl**, and is assigned an Ordovician or Silurian age (Chapman and others, 1982, p. 10). Lithologically similar to unit **Ovs (WHM)**. Mapped only in the area between Rock and Minook Creeks (T5-6N, R13-14W) and just north of Roughtop Mountain (T4N, R16W). Thickness unknown, but probably at least 70 to 100 m. These rocks were mapped as unit "Pzvs" by Chapman and others (1982). [Chapman and others, 1982, 1975a]

Oc **Chert (Upper Ordovician)**--Gray chert and minor interbedded slaty shale, chert breccia, and quartzite. Chert is thin to medium bedded, sheared, and fractured. These rocks occur in T4-7N, R12-19W. Nature of upper and lower contacts uncertain; probably grades upward into unit **SOvs**. Interpreted to be correlative with the Livengood Dome Chert (Chapman and others, 1980), which occurs just north of the mapped area, and is therefore assigned a Late Ordovician age (Chapman and others, 1982, p.10). Thickness unknown, possibly 300 to 600 m. [Chapman and others, 1982, 1980, 1975a]

Pzp€sq **Schist, quartzite, phyllite, and slate (Lower Paleozoic and Precambrian)**--Quartz-mica schist, quartzite, phyllite and slate with minor amounts of chert, shaly limestone, siltstone, and graywacke. Unit is mapped only north of the Yukon River (T4-6N, R17-22W). Relationship to unit **€p€sl (WS)** unknown. Underlies unit **DSl**, but the contact is poorly defined. Age uncertain; unit is generally correlative with pelitic schist units of the Melozitna, Bettles, and Beaver quadrangles (Chapman and others, 1982, p. 11). Thickness unknown, possibly 600 to 900 m. These rocks were mapped as unit "Pzsq" by Chapman and others (1975a). [Chapman and others, 1982, 1975a]

DL: Dillinger terrane

DOsa **Sandstone, argillite, and limestone (Middle Devonian to Ordovician)**--Gray sandstone and black argillite with thin gray limestone interbeds, and a 200 m thick gray massive crystalline limestone interbed near the top of the section. Complexly folded and faulted, regionally metamorphosed, and stratigraphically upward-shallowing marine sequence of slope and basinal turbidites and hemipelagic deposits with lesser amounts of shelf deposits. These rocks occur north of the McKinley fault in T16-17S, R9-10W. Gastropod fossils in one of the thin limestone interbeds provided Ordovician to Devonian ages; Middle Devonian fossils were reported from a massive limestone interbed near the headwater area of the Sanctuary River (T16S, R9W). Limestone pebbles that occur in the overlying Cantwell Formation (**Tcs**) were probably derived from unit **DOsa** and contain conodont fossils ranging in age from Ordovician to Early Devonian. On the basis of the above fossil data, unit **DOsa** is considered to range in age from Ordovician to Middle Devonian. Csejtey and others (1986) correlate unit **DOsa** with the deep-water facies "shale out" beds of the Nixon Fork terrane. These rocks were mapped as unit "DOs" by Csejtey and others (1986) and as unit "Pzd" by Jones and others (1983). [Csejtey and others, 1986; Jones and others, 1983, 1982]

LG: Livengood terrane

Pc **Chert, clastic rocks, limestone, and minor associated volcanic rocks, undivided (Permian)**--Chert is gray, black, green, red, yellow, or tan, and thin bedded. Clastic rocks, including shale, slaty shale, siliceous slate, siltstone, argillite, sandy shale, graywacke, tuffaceous rocks, tuff, volcanic breccia, and agglomerate, are generally thin bedded and siliceous, calcareous, or micaceous in parts. Rare gray limestone beds are thin bedded. Unit **Pc** occurs near Sawtooth Mountain (T6-7N, R8-11W). Fossils from clastic rocks indicate Early Permian age; bryozoans and pelecypods from clastic limestone have been identified as of probable Permian age. Thickness unknown. These rocks were mapped as unit "Pzu" by Chapman and others (1971). [Chapman and others, 1971]

Dcg Conglomerate, graywacke, and shale (Upper to Middle Devonian)--Conglomerate, graywacke, shale, and siltstone grading to argillite; some quartzite occurs in thin beds. Rare gray limestone beds are locally very fossiliferous with corals, stromatoporoids, bryozoans and pelmatozoan debris. Pelecypods and some gastropods, brachiopods, corals, echinoderm debris, and plant fragments are locally abundant near Livengood (T8N, R5W; just off map area) in shale-siltstone units and indicate a late Middle Devonian to early Late Devonian age. These rocks are included in the Middle Devonian "Cascaden Ridge unit" of Weber (1989). Unit **Dcg** occurs north of the Beaver Creek fault in the area of Sawtooth Mountain (T7N, R10W) and along Cascaden Ridge (T7N, R6-7W). Correlated by Chapman and others (1971) with unit **Dc (WHM)** south of the Beaver Creek fault near the confluence of Beaver and Wickersham Creeks (T7N, R1-2W). Thickness unknown. These rocks were mapped as unit "Dcl" by Chapman and others (1971). [Chapman and others, 1971; Weber, 1989]

Op€d Dolomite, limestone, silicified carbonate rocks, and chert (Ordovician to Precambrian)--Dolomite and limestone are finely crystalline and silicified to various degrees. Beds are massive or medium bedded and rarely thin bedded, brecciated in part, and commonly veined with quartz and some calcite. Interbedded chert is generally highly fractured and brecciated in parts, with associated thin beds of slaty shale and siliceous argillite or siltstone that are tuffaceous in part and gradational to chert. Includes some mafic volcanic rocks occurring as flows, dikes, and sills. Correlative, at least in part, with the Precambrian(?) to Ordovician "Amy Creek unit" of Weber (1989). Unit **Op€d** occurs in a belt between Livengood Dome (T9N, R5W) and Sawtooth Mountain (T7N, R10W) and is spatially associated with unit **€Zsp**. Thickness unknown. These rocks were mapped as unit "DOd" by Chapman and others (1971). [Chapman and others, 1971; Weber, 1989]

€Zsp Serpentinite and mafic and ultramafic rocks (Cambrian to Upper Proterozoic)--Tectonically emplaced Proterozoic(?) serpentinized mantle peridotite intruded by Late Proterozoic to Cambrian dioritic-gabbroic rocks. Includes some basalt, metabasalt, and greenstone. Always spatially associated with unit **Op€d**. Serpentinite is sheared and foliated to massive. Rocks are generally green and dark green to black, and are commonly overlain by barren to thinly vegetated soil and rubble patches on upper slopes and hilltops. Unit **€Zsp** occurs north of the Beaver Creek fault (T7N, R8W and T7N, R11W). These rocks were mapped as unit "Pzsp" by Chapman and others (1971) and as part of the "Mafic and ultramafic complex" by Weber (1989). [Chapman and others, 1971; Loney and Himmelberg, 1987; Weber, 1989]

MAN: Manley terrane

Ksp **Serpentinite and mafic rocks (Upper Cretaceous?)**--Serpentinite, diabase-gabbro, and some metadiorite and rodingite; including some thin layers of slaty to schistose rocks, phyllite, and mafic volcaniclastic rocks. Serpentinite and mafic rocks apparently intrude sedimentary rocks of unit **KJcs**. Chapman and others (1982) interpret the age of these rocks to be Late Cretaceous. Unit **Ksp** occurs in T3N, R15-17W. [Chapman and others, 1982]

KJcs **Clastic sedimentary rocks (Cretaceous and Jurassic)**--Graywacke sandstone, quartzose sandstone, quartzite, siltstone, shale, slate, argillite, and conglomerate. Sandstone beds preserve sole marks and are commonly normally graded. Quartzites and conglomerates are more common in lower half of unit; graded sandstone beds with turbidity current features are more abundant in upper half of unit. Bedding is generally thin to medium, and thick to very thick. Rarely fossiliferous; however, invertebrate and plant fossils indicate Late(?) Jurassic and Cretaceous ages. Thickness poorly known; probably not less than 1000 m and may be as much as 2700 m. Unit **KJcs** occurs in T1-7N, R3-19W. Mapped as unit "KJgs" by Chapman and others (1975b), and as units "KJs" and "KJc" by Chapman and others (1971). [Chapman and others, 1982, 1975a, 1975b, 1971]

MK-PN: McKinley and Pingston terranes, undivided

KJf **Flysch (Lower Cretaceous and Upper Jurassic)**--Monotonous, very thick (probably several thousands of meters) turbidite sequence, including argillite, graywacke, conglomerate, and a few thin interbeds of chert and some thin beds of limestone. The entire sequence has been compressed into tight folds and complexly faulted, including thrust faults. These rocks unconformably overlie unit **TRbg** east of the Nenana River; elsewhere the contact is tectonic or covered by surficial deposits. Depositional age span is well established based on fossils; age of metamorphism is about mid-Cretaceous, but may span from Late Jurassic to early Tertiary based on K-Ar age determinations on mineral separates (Csejtey and others, 1986, p.25). Unit **KJf** occurs in T15-16S, R1E-14W. These rocks were mapped as unit "KJf" by Csejtey and others (1986) and as unit "Ks" by Jones and others (1983). [Csejtey and others, 1986; Jones and others, 1983, 1982]

TRbg **Basalt, gabbro, diabase, and subordinate interbedded sedimentary rocks (Upper Triassic; Karnian and Norian)**--Several hundred to several thousand meters thick submarine sequence of mostly pillow basalts with gabbro and diabase sills and dikes that also cut the underlying unit **ŦIPs**; subordinate interbedded sedimentary rocks are gray to green sandstones, siltstones, and argillites. This unit probably represents a series of subaqueous basalt flows with minor intercalated clastic and pelagic sedimentary materials that were deposited in a deep marine environment. Fossils are rare, but a bivalve of Late Triassic (Karnian and Norian) age and radiolarians of Late Triassic (late Norian) age were identified. These rocks occur in a narrow, discontinuous, fault-bounded, east-west trending belt between Panorama Mountain (T16S, R6W) and the Toklat River (T16S, R13W). Metamorphic grade is prehnite-pumpellyite. Depositionally overlies unit **ŦIPs**. These rocks were mapped as unit "Ŧbd" by Csejtey and others (1986) and as unit "Ŧbg" by Jones and others (1983). [Csejtey and others, 1986; Jones and others, 1983, 1982]

ŦIPs **Flysch-like sedimentary rocks (Upper Triassic to Pennsylvanian)**--Conglomerate, sandstone, siltstone, argillite, a few thin interbeds of limestone, and chert intercalated with argillite near the top. These rocks are intensely folded, several hundred meters thick, and massive to thin bedded. The depositional environment of this unit may have been slope to base-of-slope. Age based on abundant fossils of marine macroinvertebrates, conodonts, and radiolarians. Metamorphic grade is prehnite-pumpellyite. Depositionally underlies unit **Ŧbg**. Unit **ŦIPs** occurs in T16S, R7-13W. [Csejtey and others, 1986; Jones and others, 1983, 1982]

Ŧcs **Calcareous sedimentary rocks (Upper Triassic; Karnian and Norian)**--Thin-bedded calcareous marine shale, argillite, sandstone, siltstone, and argillaceous limestone, including numerous dikes, sills, and small plugs of altered diabase and gabbro that are constrained by cross-cutting relations to range in age from Jurassic to Early Cretaceous. These rocks are intensely and penetratively deformed, and locally metamorphosed to greenschist and amphibolite facies. Unit **Ŧcs** is interpreted to represent a marine regressive sequence with deep continental slope deposits at the base, overlain by progressively shallower slope deposits, then by outer shelf deposits, and finally by inner shelf deposits. The age range is based on conodonts and pelecypods. Unit **Ŧcs** overlies unit **Dy** with slight angular unconformity as indicated in a good exposure south of the Wood River (T14S, R1-2W); the top of the sequence is nowhere exposed. Correlated with unit **Ŧsc** (NN) south of the McKinley fault by Csejtey and others (1986). Preserved thickness uncertain, but estimated to be several hundred meters. These rocks occur in T14-16S, R1E-9W. Mapped as unit "Ŧs" by Jones and others (1983). [Csejtey and others, 1986; Jones and others, 1983, 1982]

Dy **Yanert Fork sequence of Csejtey and others (1986) (Upper Devonian)**--Intensely deformed metasedimentary and metavolcanic rocks, including mudstone, argillite, shale, slate, phyllite, and quartzite with thin chert interbeds, and interbeds of metatuff and metabasalt, as well as marble; also contains diabase and gabbro intrusive rocks lithologically similar to those in units **₸cs (MK-PN)** and **₸sc (NN)** and presumably of the same age. Crops out mainly in the headwater region of Yanert Fork (T14-15S, R2E-5W). Overlain with slight angular unconformity by unit **₸cs**; basal contact is nowhere exposed. Thickness unknown, but estimated to be at least 1000 m. Metamorphic grade is lower greenschist facies; metamorphism probably occurred during mid-Cretaceous time. Age span imperfectly known, but conodont fossils occurring in a marble interbed yielded Late Devonian (Famennian) age. Lithologies, depositional environment, metamorphic grade, age, and structural style are the same north and south of the Hines Creek fault. These rocks were mapped as unit "Pzy" by Csejtey and others (1986). [Csejtey and others, 1986; Jones and others, 1983, 1982]

MNK: Minook terrane

Ps **Slaty shale, siltstone, graywacke, and conglomerate (Permian)**--Shale, foliated to slaty, and in part phyllitic; siltstone, in part argillite; graywacke and pebble-to-granule conglomerate. Graded bedding is common in sandstones; siltstones are interbedded with shales and phyllites; minor interbedded unfossiliferous chert also occurs. Sparsely fossiliferous clastic limestone occurs rarely in thin discontinuous beds. A Permian age is based on the association of crinoidal and bryozoan debris with a distinctive foraminifer. Thickness unknown, but probably at least 300 m in the Minook-Hoosier Creeks area (T6-7N, R12-13W). Contact with unit **KJcs (MAN)**, which is lithologically similar, is a poorly exposed unconformity or possibly a fault. These rocks were mapped as unit "Ps" by Chapman and others (1982, 1975a) and as unit "Pzc" by Chapman and others (1971). [Chapman and others, 1982, 1975a, 1971; Patton and others, 1989]

NN: Nenana terrane

₸sc **Sedimentary calcareous rocks (Upper Triassic)**--Lithologically similar to unit **₸cs (MK-PN)**, but occurs only south of the McKinley fault (T16S, R1-4W). Correlated by Csejtey and others (1986) with unit **₸cs (MK-PN)**. [Csejtey and others, 1986]

NX-MN: Nixon Fork and Minchumina terranes, undivided

Dls **Limestone and siltstone (Upper? Devonian)**--Dominantly gray limestone; forms prominent ridges; minor siltstone is gray, shaly to phyllitic and calcareous in part. Unit **Dls** occurs in T1-2S, R22W. The only known fossil locality (8 miles south of Redlands Lake, T3S, R24W, just off map area) yielded early Late Devonian (Frasnian) ages. Thickness unknown; probably at least 150 m. [Chapman and others, 1975b]

DOc **Chert (Lower Devonian to Ordovician)**--Gray thin to thick bedded chert with thin interbeds of siliceous siltstone, shaly to slaty mudstone, and shaly tuffaceous argillite. Overlies unit **DOs**; contact may be gradational. Radiolarians of early Paleozoic (Ordovician to Early Devonian) age occur in both chert and argillite, and Ordovician graptolites were found in thin shale beds at one site. May be correlative in part with unit **Pzcs** in the Dugan Hills area (T2N-1S, R11-13W). Correlated with the "Livengood Dome Chert" by Chapman and others (1981, p. B33; 1975b). These rocks occur in T4-9S, R19-23W, and were mapped as unit "Oc" by Chapman and others (1975b). [Chapman and Yeend, 1981; Chapman and others, 1981, 1975b]

DOs **Shaly rocks (Lower Devonian to Ordovician)**--Mudstone, argillite, grit, quartzite, calcareous quartz-chert arenite, sandy limestone, and minor amounts of chert, and quartz-mica schist. Age range based on the occurrence of Ordovician graptolites and an Ordovician coral, and a coral of "probable Early or Middle Devonian" age in a lakeshore cobble (Chapman and others, 1981). Probably underlies unit **DOc**. These rocks occur in T7-13S, R19-22W. May be correlative in part with unit **Pzma** at Mooseheart Mountain (T2-3S, R17-18W) and the Bitzshtini Mountains (T5-6S, R22-23W), and in part with units **Pzsr (NX-MN)** and **€p€sl (WS)** in the Dugan Hills area (T2N, R11-13W). [Chapman and others, 1981; Chapman and Yeend, 1981]

Pzcs **Chert and siliceous shale (Lower Paleozoic)**--Thin to thick bedded chert with thin interbeds of siliceous slaty shale. These rocks occur in the Dugan Hills area (T2N-1S, R11-13W). Age is inferred from lithologic similarity to unit **DOc (NX-MN)**, which contains Ordovician and Devonian fossils. This unit was mapped as unit "DOc" by Chapman and Yeend (1981), unit "Oc" by Chapman and others (1982, 1975a), and unit "nc" by Péwé and others (1966). [Chapman and others, 1982, 1975a; Chapman and Yeend, 1981; Péwé and others, 1966]

Pzsr **Shaly rocks (Lower Paleozoic)**--Siltstone-mudstone-argillite, shaly-slaty-phyllitic mudstone, maroon and green slaty argillite, grit, quartzite, calcareous quartz-chert arenite, sandy limestone, and minor amounts of chert and quartz-mica schist. These rocks are lithologically similar to, and perhaps correlative with, unit **DOs (NX-MN)**, which contains Ordovician and Devonian(?) fossils. Unit **Pzsr** occurs in the Dugan Hills area (T2N-1S, R11-13W), where it is mapped as unit "DOs" by Chapman and Yeend (1981), unit "Ꞓal" by Chapman and others (1982, 1975a), and as unit "ng" by Péwé and others (1966). [Chapman and others, 1982, 1975a; Chapman and Yeend, 1981; Péwé and others 1966]

Pzma **Mudstone, argillite, grit, quartzite, calcareous quartz-chert arenite, sandy limestone, and minor chert and quartz-mica schist (Lower Paleozoic?)**--Lithologically similar to unit **DOs**. Lithology at Mooseheart Mountain (T1-2S, R17-18W) comprises hornfels, brown slates and quartzites. Unit **Pzma** occurs northwest of unit **DOc** in the Bitzshtini Mountains (T5-6S, R22-23W). The same rocks were mapped as units "Ꞓqs" and "OꞒsl" by Chapman and others (1975b), and as unit "DOs" by Chapman and others (1981). [Chapman and others, 1981, 1975b]

SV: Seventymile terrane

PMum **Ultramafic and mafic rocks (Lower Permian? to Mississippian?)**--Diorite and serpentinized peridotite; these rocks occur at Wood River Buttes (T5S, R3W) and are lithologically similar to mafic and ultramafic rocks along the Salcha River in the Big Delta quadrangle to the northeast. An intense linear magnetic anomaly extends from the Wood River Buttes to the Salcha River outcrops, suggesting that the mafic and ultramafic rocks in the two areas are parts of a single belt (Péwé and others, 1966). In the Salcha River area and farther east, the mafic and ultramafic rocks are associated with slightly recrystalized cherts that contain radiolarians and conodonts of Early Permian age and radiolarians of Mississippian age (Foster and others, 1987, p. 42). The rocks at Wood River Buttes were mapped as unit "Dmu" by Péwé and others (1966). [Foster and others, 1987; Péwé and others, 1966]

TZ: Tozitna terrane

ꞦMms **Mafic and sedimentary rocks (Triassic? to Mississippian)**--Volcanic, sedimentary, and ultramafic rocks, including tuffs, greenstones, breccias, and basaltic, diabasic, and rarely andesitic lavas; pyroclastic tuffaceous rocks apparently grade into sedimentary tuffs and chert. Intrusive rocks are fine to coarse grained diabase-gabbro with some diorite, occurring chiefly in sills that are several meters to at least 90 m thick and commonly form prominent ridges, knobs, and bluffs. Serpentinized ultramafic rocks have been reported at a few locations (Chapman and others, 1975a, p. 6). Sedimentary and metasedimentary rocks are argillite, phyllite, chert, and slate, with some tuff, epiclastic tuffaceous rocks, and arkosic semischist, and rare clastic limestone. Argillite and slate are commonly maroon and subordinately gray and green. Chert and limestone are commonly gray. Referred to as the "Rampart Group" by Chapman and others (1975a) and by Jones and others (1984). Age range of Mississippian to Triassic(?) is based on fossils (radiolarians in chert and invertebrates in limestone) and a radiometric age of 210 ± 6 Ma on a gabbroic intrusive body. Lower contact may be an unconformity, thrust fault, or both. Thickness unknown but probably at least 900 to 1200 m. Unit **TRMms** occurs in T2-3S, R21-22W. Part of this unit may be correlative with unit **Ps (MNK)**; mapped as units "TRPv" and "TRm" by Chapman and others (1975a and 1975b, respectively). [Chapman and others, 1982, 1975a, 1975b; Jones and others, 1984; Patton and others, 1989]

WHM: White Mountains terrane

DSt **Tolovana Limestone (Middle Devonian to Lower? Silurian)**--Thick bedded to massive, finely crystalline, gray limestone, in places rich in peloids and ooids. Forms prominent ridge near Dugan Hills (T2N, R12-13W) and along the White Mountains (T8-10N, R1-2E). Contains crushed zones recemented by white calcite and quartz; chert is rare or absent. Rare fossils (conodonts, brachiopods, and associated megafauna) identified as Silurian and Middle Devonian in age. Disconformably overlies unit **Ovs**; contact is well exposed in a saddle on a north-south trending ridge spur 0.5 km east-southeast of VABM 4153 (T9N, R2E). Thickness exceeds 1200 m. [Blodgett and others, 1987; Chapman and others, 1971; Oliver and others, 1975; Péwé and others, 1966; Weber, 1989; Wheeler and others, 1987]

Dc **Clastic rocks (Devonian?)**--Conglomerate, graywacke, and shale; quartzitic in part. Age is uncertain; may be correlative with unit **Dcg (LG)**, which is lithologically similar. These rocks occur south of the Beaver Creek fault near the confluence of Beaver and Wickersham Creeks (T7N, R1-2W). Thickness unknown. Mapped as unit "Dcl" by Chapman and others (1971). [Chapman and others, 1971]

Ovs **Volcanic and sedimentary rocks (Ordovician)**--Lower part is composed primarily of sedimentary rocks, including slate, chert, and limestone, with a minor amount of mafic intrusive rocks; grades laterally and upward into a sequence of basalt, tuff, and agglomerate that is generally capped by a thin layer of volcanic-rich sedimentary rocks. Fossils indicate Early to Late Ordovician ages. Disconformably underlies unit **DSt**. Thickness exceeds 610 m. Unit **Ovs** occurs in a northeast-southwest trending belt along the Beaver Creek fault (T2-7N, R2-12W). This unit is mapped as the "Fossil Creek Volcanics" by Weber (1989) and as unit "SOvs" by Chapman and others (1971). [Blodgett and others, 1987; Chapman and others, 1975a, 1971; Péwé and others, 1966; Weber, 1989; Wheeler and others, 1987]

Pzq **Vitreous quartzite (Upper Paleozoic?)**--Quartzite; massive, fractured and very hard. Some slaty shale and silty sandstone occur as thin interbeds; minor chert, slate and phyllite also occur. Nonfossiliferous. Thickness unknown; probably relatively thin. These rocks occur only south of the Beaver Creek fault in T2-7N, R2-13W. Unit **Pzq** is included as part of the "Globe unit" of Weber (1989), which has a late Paleozoic(?) age based on correlation with the informally named "Keno Hill quartzite" of Tempelman-Kluit (1970). May be correlative with unit "Oq" of Chapman and others (1971). [Chapman and others, 1975a, 1971; Weber, 1989]

Pzm **Mafic and ultramafic rocks (Upper Paleozoic?)**--Diorite and gabbro sills; these rocks intrude unit **Pzq**. This unit is included as part of the "Globe unit" of Weber (1989). No datable minerals; age is based on correlation with the informally named "Keno Hill quartzite" of Tempelman-Kluit (1970). Unit **Pzm** occurs only south of the Beaver Creek fault in T3-7N, R2-10W. [Chapman and others, 1971; Weber, 1989]

WS: Wickersham terrane

ЄpЄg **Grit unit of Moore and Nokleberg (1988) (Lower Cambrian and (or) Precambrian)**--Thick bedded quartzose sandstone and granule to pebble conglomerate, locally interbedded with gray or green slate. According to Moore and Nokleberg (1988), the contact between unit **ЄpЄg** and **ЄpЄsl** is conformable and gradational in the vicinity of Cache Mountain (northeast of our map area); unit **ЄpЄg** structurally overlies unit **ЄpЄsl**, but there is much controversy as to which of the two units is stratigraphically higher. The contact between units **ЄpЄg** and **ЄpЄsl** was interpreted as a thrust fault by Chapman and others (1971) and by Weber (1989). Together, units **ЄpЄg** and **ЄpЄsl** may be as much as 7000 m thick. Unit **ЄpЄg** occurs in T3-7N, R2-10W. Rocks of unit **ЄpЄg** were mapped as unit "Єgq", which contains *Oldhamia* trace fossils identified as Cambrian in age, by Chapman and others (1971), and as the Late Proterozoic "basal grit subunit" of the "Wickersham unit" by Weber (1989). [Chapman and others, 1971; Moore and Nokleberg, 1988; Weber, 1989]

ЄpЄsl **Maroon and green slate unit of Moore and Nokleberg (1988) (Lower Cambrian and (or) Precambrian)**--Gray, maroon, and green slate; locally including quartzose sandstone and granule to pebble conglomerate, and minor dolomite and micritic limestone. Age is based on the occurrence of *Oldhamia*, a trace fossil, near the top of this unit. These rocks occur in T3-7N, R2-10W. Rocks of unit **ЄpЄsl** were mapped as the "maroon and green slate subunit" of the "Wickersham unit" by Weber (1989), and unit "Єal" by Chapman and others (1982, 1975b, 1971). [Chapman and others, 1982, 1975a, 1971; Moore and Nokleberg, 1988; Weber, 1989]

YTN: Yukon-Tanana terrane north of Tanana River

MDqs **Quartzite and schist (Mississippian to Devonian)**--Greenschist facies metasedimentary rocks, primarily quartzite and quartz-muscovite schist, and including felsic metavolcanic rocks. Age and origin are uncertain, but these rocks are considered by Nokleberg and others (1989) to be part of a metamorphosed Devonian to Mississippian igneous arc and associated metamorphosed wall rocks. U-Pb geochronology of primary zircons in metarhyolite yields Late Devonian ages, while detrital zircons indicate an Early Proterozoic provenance (2.1 to 2.3 Ga) (Aleinikoff and Nokleberg, 1989). Thickness is unknown, but estimated to be over 1000 m. Unit **MDqs** occurs in T6N-4S, R1E-7W. These rocks are part of the "Birch Creek Schist" of former usage. Unit **MDqs** is mapped as unit "gf" by Chapman and others (1971), unit "qq" by Foster and others (1987), unit "bc" by Péwé and others (1966), and the informally named "Fairbanks schist unit" by Weber (1989). [Aleinikoff and others, 1984; Aleinikoff and Nokleberg, 1989; Chapman and others, 1971; Foster and others, 1987; Nokleberg and others, 1989; Péwé and others, 1966; Weber, 1989]

Pzs **Schist, quartzite, marble, and eclogitic rocks (Lower Paleozoic?)**--Garnet-bearing biotite-muscovite schist, quartzite, and minor marble, mostly of epidote-amphibolite metamorphic facies, but including some eclogitic rocks. These rocks structurally overlie unit **MDqs** in fault contact. Age and origin are uncertain, but a Rb-Sr date of 509 Ma on muscovite and K-Ar ages up to 470 ± 35 Ma on amphiboles were interpreted as an Ordovician metamorphic event (Chapman and others, 1971). Weber (1989) mentions an Ordovician K-Ar age on amphibolite in the eclogitic rocks, and assigns the entire sequence a Paleozoic(?) age. Unit **Pzs** occurs in T3N, R1-2E. These rocks are part of the "Birch Creek Schist" of former usage. Unit **Pzs** is mapped as unit "eaf" by Chapman and others (1971), unit "ec" by Foster and others (1987), and the "Chatanika unit" by Weber (1989). [Chapman and others, 1971; Foster and others, 1987; Nokleberg and others, 1989; Weber, 1989]

YTS: Yukon-Tanana terrane south of Tanana River

MDt **Totatlanika Schist (Lower Mississippian to Middle Devonian)**--Metavolcanic and metavolcaniclastic rocks (schist and gneiss), both felsic and mafic, and subordinate amounts of intercalated metasedimentary rocks such as black (carbonaceous) pelitic schist and phyllite, and, at one locality, a thin interbed of fossiliferous marble. Interpreted to represent continental margin deposits by Csejtey and others (1986). Metamorphic mineral assemblages suggest recrystallization in the greenschist metamorphic facies. Maximum preserved cumulative thickness is over 5700 m, but in any one area the thickness of the rocks may be considerably less. Depositional age span inadequately known because fossils were found only at one locality within a thin marble interbed; however, these fossils indicate a Middle Devonian to Early Mississippian age. Unit **MDt** occurs in T8-16S, R1E-15W. These rocks were mapped as unit "Pzts" by Csejtey and others (1986) and as unit "DSt" by Péwé and others (1966). [Csejtey and others, 1986; Péwé and others, 1966]

Dms **Metasedimentary rocks (Upper or Middle Devonian)**--Schist, phyllite, quartzite, metachert, and marble; thin bedded with a well developed foliation that parallels bedding. Metamorphic grade is lower greenschist facies; metamorphism probably occurred during mid-Cretaceous time. Poorly preserved fossils in marble interbeds indicate a Middle or Late Devonian age. These rocks occur in discontinuous outcrops just north of the Hines Creek fault (T13S, R1E-1W and T14-15S, R11-13W). Unit **Dms** appears to be closely associated spatially with unit **MDt**; the contact between the two units may be a thrust fault. Along the Wood River (T13S, R1E-R1W) unit **Dms** is very similar to unit **Dy** (MK-PN) in lithology, metamorphic grade and level of recrystallization, deformation style, and apparent age and depositional environment. These rocks were mapped as unit "Pzms" by Csejtey and others (1986). [Csejtey and others, 1986]

Dmg **Metagabbro (Upper Devonian?)**--Dark greenish gray; fine to medium grained and foliated; greenschist facies metamorphism. These rocks occur only in two small intrusive bodies within unit **Pzp€s** (T12S, R1W and T13S, R5W). Age is uncertain; these rocks may be the intrusive equivalent of Late Devonian metabasalts and related metasedimentary rocks included in unit **MDt**; alternatively, these rocks may correlate with Jurassic to Early Cretaceous gabbroic intrusives north of the Hines Creek fault within units **Dy** and **Ŧcs** (MK-PN). These rocks were mapped as unit "Pzmg" by Csejtey and others (1986). [Csejtey and others, 1986; Wahrhaftig, 1970b, 1970c]

Pzkp **Keevy Peak Formation (Lower Paleozoic)**--Sequence of quartz-sericite or muscovite schist, black quartzite, black carbonaceous pelitic schist and phyllite, pebble conglomerate, gray or purple schist and slate, and a few thin marble interbeds. Rests unconformably on unit **Pzp€s**, and is overlain in fault contact by unit **MDt**. Thickness is unknown, but preserved section ranges between 700 and 1200 m. No fossils have been found; age is based on stratigraphic relations with the underlying unit **Pzp€s**, which is early Paleozoic in the upper part (Csejtey and others, in press). These rocks occur in T11-12S, R1E-5W. Mapped as unit "kp" by Csejtey and others (1986) and as part of unit "bc" by Péwé and others (1966). [Csejtey and others, 1986; Csejtey and others, in press; Péwé and others, 1966; Wahrhaftig, 1968]

Pzp€s **Pelitic and quartzose schist (Lower Paleozoic and (or) Precambrian)**--Pelitic schist, quartzite, phyllite, and a few marble interbeds; intensely deformed; lower greenschist facies metamorphism. Contact with the overlying Keevy Peak Formation (unit **Pzkp**) is thought to be a depositional unconformity. Base is not exposed, therefore, thickness is not known; however, thickness as measured perpendicular to the axial plane of cleavage is at least 3000 m. Fossils from a marble interbed indicate possibly an Ordovician or younger age (Csejtey and others, 1986, p. 82, no. 171); isotopic dates range from 1170 Ma to 120 Ma (Péwé and others, 1966), but are considered unreliable. Part of the "Birch Creek Schist" of former usage. Unit **Pzp€s** occurs in the Kantishna Hills (T12-16S, R15-19W) and in the Alaska Range (T11-14S, R1E-12W). These rocks were mapped as unit "pqs" by Csejtey and others (1986) and as unit "p€bc" by Reed (1961). [Csejtey and others, 1986; Reed, 1961]

REFERENCES CITED

Albanese, M.D., 1982, Two Holocene maars in the central Alaska Range: Alaska Division of Geological and Geophysical Surveys Geologic Report 73, p. 19-27.

Albanese, M.D., and Turner, D.L., 1980, ^{40}K-^{40}Ar ages from rhyolite of Sugar Loaf Mountain, central Alaska range: implications for offset along the Hines Creek strand of the Denali fault system, *in* Short Notes on Alaskan Geology 1979-80, Alaska Division of Geological and Geophysical Surveys Geologic Report 63, p. 7-10.

Aleinikoff, J.N., and Nokleberg, W.J., 1989, Age of deposition and provenance of the Cleary sequence of the Fairbanks schist unit, Yukon-Tanana terrane, east-central Alaska, *in* Dover, J.H., and Galloway, J.P., eds., Geologic studies in Alaska by the U.S. Geological Survey, 1988: U.S. Geological Survey Bulletin 1903, p. 75-83.

Aleinikoff, J.N., Foster, H.L., Nokleberg, W.J., and Dusel-Bacon, Cynthia, 1984, Isotopic evidence from detrital zircons for Early Proterozoic crustal material, east-central Alaska, *in* Coonrad, W.L., and Elliott, R.L., eds., The United States Geological Survey in Alaska, accomplishments during 1981: U.S. Geological Survey Circular 868, p. 43-45.

Barnes, D.F., 1961, Gravity low at Minto Flats, Alaska: U.S. Geological Survey Professional Paper 424-D, p. D254-D257.

Blodgett, R.B., Wheeler, K.L., Rohr, D.M., Harris, A.G., and Weber, F.R., 1987, A Late Ordovician age reappraisal for the upper Fossil Creek volcanics, and possible significance for glacio-eustasy, *in* Hamilton, T.D., and Galloway, J.P., eds., Geologic studies in Alaska by the U.S. Geological Survey during 1986: U.S. Geological Survey Circular 998, p. 54-58.

Buffler, R.T., and Triplehorn, D.M., 1976, Depositional environments of the Tertiary coal-bearing group, central Alaska, *in* Miller, T.P., ed., Recent and Ancient Sedimentary Environments in Alaska, Proceedings of the Alaska Geological Society Symposium held April 2-4, 1975, at Anchorage, Alaska: Alaska Geological Society, Anchorage, Alaska, p. H1-H10.

Chapman, R.M., Weber, F.R., Churkin, Michael, Jr., and Carter, Claire, 1980, The Livengood Dome Chert, a new Ordovician formation in central Alaska, and its relevance to displacement on the Tintina fault: U.S. Geological Survey Professional Paper 1126-F, p. F1-F13.

Chapman, R.M., Churkin, M., Jr., Carter, C., and Trexler, J.H., Jr., 1981, Ordovician graptolites and early Paleozoic radiolarians in the Lake

Minchumina area date a regional shale and chert belt, *in* Albert, N.R.D., and Hudson, Travis, eds., The United States Geological Survey in Alaska, accomplishments during 1979: Geological Survey Circular 823-B, p. B32-B34.

Chapman, R.M., Weber, F.R., and Taber, Bond, 1971, Preliminary geologic map of the Livengood quadrangle, Alaska: U.S. Geological Survey Open File Map, scale 1:250,000, 2 sheets.

Chapman, R.M., and Yeend, W.E., 1981, Geologic reconnaissance of the east half of Kantishna River quadrangle and adjacent areas, *in* Albert, N.R.D., and Hudson, Travis, eds., The United States Geological Survey in Alaska, accomplishments during 1979: U.S. Geological Survey Circular 823-B, p. B30-B32.

Chapman, R.M., Yeend, W.E., Brosge, W.P., and Reiser, H.N., 1982, Reconnaissance geologic map of the Tanana quadrangle, Alaska: U.S. Geological Survey Open-File Report 82-734, 17 p., scale 1:250,000, 1 sheet.

Chapman, R.M., Yeend, W.E., Brosge, W.P., and Reiser, H.N., 1975a, Preliminary geologic map of the Tanana and northeast part of the Kantishna River quadrangles, Alaska: U.S. Geological Survey Open-File Map 75-337, scale 1:250,000, 1 sheet.

Chapman, R.M., Yeend, W.E., and Patton, W.W., Jr., 1975b, Preliminary reconnaissance geologic map of the western half of Kantishna River quadrangle, Alaska: U.S. Geological Survey Open File Map 75-351, scale 1:250,000, 1 sheet.

Csejtey, Béla, Jr., Mullen, M.W., Cox, D.P., Gilbert, W.G., Yeend, W.E., Smith, T.E., Wahrhaftig, Clyde, Craddock, C.C., Brewer, W.M., Sherwood, K.W., Hickman, R.G., Stricker, G.D., St. Aubin, D.R., and Goerz, D.J., III, 1986, Geology and geochronology of the Healy quadrangle, Alaska: U.S. Geological Survey Open-File Report 86-396, 92 p., scale 1:250,000, 4 sheets.

Csejtey, Béla, Jr., Mullen, M.W., Cox, D.P., and Stricker, G.D., in press, Geology and geochronology of the Healy quadrangle, south-central Alaska: U.S. Geological Survey Miscellaneous Investigations Series Map I-1961, scale 1:250,000, 2 sheets, pamphlet.

Decker, J.E., and Gilbert, W.G., 1978, The Mount Galen Volcanics--a new middle Tertiary volcanic formation in the central Alaska Range: Alaska Division of Geological and Geophysical Surveys, Geologic Report 59, 11 p.

Foster, H.L., Keith, T.E.C., and Menzie, W.D., 1987, Geology of east-central Alaska: U.S. Geological Survey Open-File Report 87-188, 59 p.

Gilbert, W.G., Ferrell, V.M., and Turner, D.L., 1976, The Teklanika formation--a new volcanic formation in the central Alaska Range: Alaska Division of Geological and Geophysical Surveys, Geologic Report 47, 16 p.

Grether, W.J., and Morgan, K.A., 1988, Exploration and hydrocarbon potential of interior basins, Alaska [abs.]: American Association of Petroleum Geologists Bulletin, v. 72, no. 2, p. 191-192.

Hite, D.M., and Nakayama, E.N., 1980, Present and potential petroleum basins of Alaska, *in* Landwehr, M.L., ed., Exploration and economics of the petroleum industry: New ideas, new methods, new developments: Dallas, Institute on Petroleum Exploration and Economics, p. 511-554.

Jones, D.L., Silberling, N.J., Chapman, R.M., and Coney, P.J., 1984, New ages of radiolarian chert from the Rampart district, east-central Alaska, *in* Coonrad, W.L., and Elliott, R.L., eds., The United States Geological Survey in Alaska, accomplishments during 1981: U.S. Geological Survey Circular 868, p. 39-43.

Jones, D.L., Silberling, N.J., Coney, P.J., and Plafker, George, 1987, Lithotectonic terrane map of Alaska (west of the 141st meridian): U.S. Geological Survey Miscellaneous Field Studies Map MF-1874-A, scale 1:2,500,000, 1 sheet.

Jones, D.L., Silberling, N.J., Gilbert, W.G., and Coney, P.J., 1983, Interpretive bedrock geologic map of the Mount McKinley region: U.S. Geological Survey Open-File Report 83-11, scale 1:250,000, 2 sheets.

Jones, D.L., Silberling, N.J., Gilbert, W., and Coney, P.J., 1982, Character, distribution, and tectonic significance of accretionary terranes in the central Alaska Range: Journal of Geophysical Research, 87(B5), May 10, 1982, p. 3709-3717.

Kirschner, C.E., 1988, Map showing sedimentary basins of onshore and continental shelf areas, Alaska: U.S. Geological Survey Miscellaneous Investigations Map I-1873, scale 1:5,000,000.

Loney, R.A., and Himmelberg, G.R., 1987, Ultramafic rocks of the Livengood terrane, *in* Galloway, J.P. and Hamilton, T.D., eds., Geologic studies in Alaska by the U.S. Geological Survey during 1987: U.S. Geological Survey Circular 1016, p. 68-70.

Moore, T.E. and Nokleberg, W.J., 1988, Stratigraphy, sedimentology, and structure of the Wickersham terrane in the Cache Mountain area, east-central Alaska, *in* Galloway, J.P. and Hamilton, T.D., eds., Geologic studies in Alaska by the U.S. Geological Survey during 1987: U.S. Geological Survey Circular 1016, p. 75-80.

Nokleberg, W.J., Dusel-Bacon, Cynthia, Foster, H.L., Lanphere, M.A., Plafker, George, and Aleinikoff, J.N., 1989, Structure and tectonics of the Yukon-Tanana, southern Wickersham, and Seventymile terranes along the Trans-Alaskan Crustal Transect (TACT), Alaska [abs.]: Eos, v. 70, no. 4, p. 1337.

Oliver, W.A., Jr., Merriam, C.W., and Churkin, M., Jr., 1975, Ordovician, Silurian, and Devonian Corals of Alaska: U.S. Geological Survey Professional Paper 823-B, 44 p.

Paige, R.A., 1959, Tertiary geology of the Cheyenne Creek area, Alaska [M.S. thesis]: Seattle, University of Washington, 66 p.

Patton, W.W., Jr., Box, S.E., Moll-Stalcup, E.J., and Miller, T.P., 1989, Geology of west-central Alaska: U.S. Geological Survey Open-File Report OF 89-554, 41 p.

Péwé, T.L., Wahrhaftig, Clyde, and Weber, F.R., 1966, Geologic map of the Fairbanks quadrangle, Alaska: U.S. Geological Survey Miscellaneous Geological Investigations Map I-455, scale 1:250,000, 1 sheet.

Reed, J.C., Jr., 1961, Geology of the Mount McKinley quadrangle, Alaska: U.S. Geological Survey Bulletin 1108-A, 36 p., scale 1:250,000, 1 sheet.

Silberling, N.J., and Jones, D.L., eds., 1984, Lithotectonic terrane maps of the North American Cordillera: U.S. Geological Survey Open-File Report 84-523, 104 pp. and 4 sheets.

Stanley, R.G., 1987a, Effects of weathering on petroleum-source evaluation of coals from the Suntrana Formation near Healy, Alaska, *in* Hamilton, T.D., and Galloway, J.P., eds., Geologic studies in Alaska by the U.S. Geological Survey during 1986: U.S. Geological Survey Circular 998, p. 99-103.

Stanley, R.G., 1987b, Thermal maturity and petroleum-source potential of the Cantwell Formation (Paleocene), Alaska Range, *in* Hamilton, T.D., and Galloway, J.P., eds., Geologic studies in Alaska by the U.S. Geological Survey during 1986: U.S. Geological Survey Circular 998, p. 104-107.

Stanley, R.G., 1988, Hydrocarbon source potential and thermal maturity of the Sanctuary Formation (middle Miocene), northern foothills of the Alaska Range, *in* Galloway, J.P., and Hamilton, T.D., eds., Geologic studies in

Alaska by the U.S. Geological Survey during 1987: U.S. Geological Survey Circular 1016, p. 117-120.

Stanley, R.G., McLean, Hugh, and Pawlewicz, M.J., 1990, Petroleum source potential and thermal maturity of the Tertiary Usibelli Group of Suntrana, central Alaska, *in* Dover, J.H., and Galloway, J.P., eds., Geologic Studies in Alaska by the U.S. Geological Survey, 1989: U.S. Geological Survey Bulletin 1946, p. 65-76.

Templeman-Kluit, D.J., 1970, Stratigraphy and structure of the "Keno Hill Quartzite" in Tombstone River--upper Klondike River map areas, Yukon Territory: Canada Geological Survey, Bulletin 180, p. 1-102.

Valin, Z.C., Bader, J.W., Barnes, D.F., Fisher, M.A., and Stanley, R.G., 1991, Simple Bouguer gravity anomaly maps of the Nenana basin area, Alaska: U.S. Geological Survey Open-File Report 91-33, scale 1:250,000, 5 sheets.

Wahrhaftig, Clyde, 1968, Schists of the central Alaska Range: U.S. Geological Survey Bulletin 1254-E, 22 p.

Wahrhaftig, Clyde, 1970a, Geologic map of the Fairbanks A-3 quadrangle, Alaska: U.S. Geological Survey Geological Quadrangle Map GQ-809, scale 1:63,360, 1 sheet.

Wahrhaftig, Clyde, 1970b, Geologic map of the Healy D-2 quadrangle, Alaska: U.S. Geological Survey Geological Quadrangle Map GQ-804, scale 1:63,360, 1 sheet.

Wahrhaftig, Clyde, 1970c, Geologic map of the Healy D-3 quadrangle, Alaska: U.S. Geological Survey Geological Quadrangle Map GQ-805, scale 1:63,360, 1 sheet.

Wahrhaftig, Clyde, 1970d, Geologic map of the Healy D-4 quadrangle, Alaska: U.S. Geological Survey Geological Quadrangle Map GQ-806, scale 1:63,360, 1 sheet.

Wahrhaftig, Clyde, 1987, The Cenozoic section at Suntrana, Alaska, *in* Hill, M.L., ed., Geological Society of America, Cordilleran Section, Centennial Guide, v. 1, p. 445-450.

Wahrhaftig, Clyde, Wolfe, J.A., Leopold, E.B., and Lanphere, M.A., 1969, The coal-bearing group in the Nenana coal field, Alaska: U.S. Geological Survey Bulletin 1274-D, 30 p.

Weber, F.R., 1989, Geology between Fairbanks and the Yukon River, *in* Alaskan Geological and Geophysical Transect, Field Trip Guidebook T104, 28th International Geological Congress: American Geophysical Union, Washington, D.C., p. 84-95.

Wheeler, K.L., Forbes, R.B., Weber, F.R., and Rinehart, C.D., 1987, Lithostratigraphy, petrology, and geochemistry of the Ordovician Fossil Creek volcanics, White Mountains, east-central Alaska, *in* Hamilton, T.D., and Galloway, J.P., eds., Geologic studies in Alaska by the U.S. Geological Survey during 1986: U.S. Geological Survey Circular 998, p. 70-73.

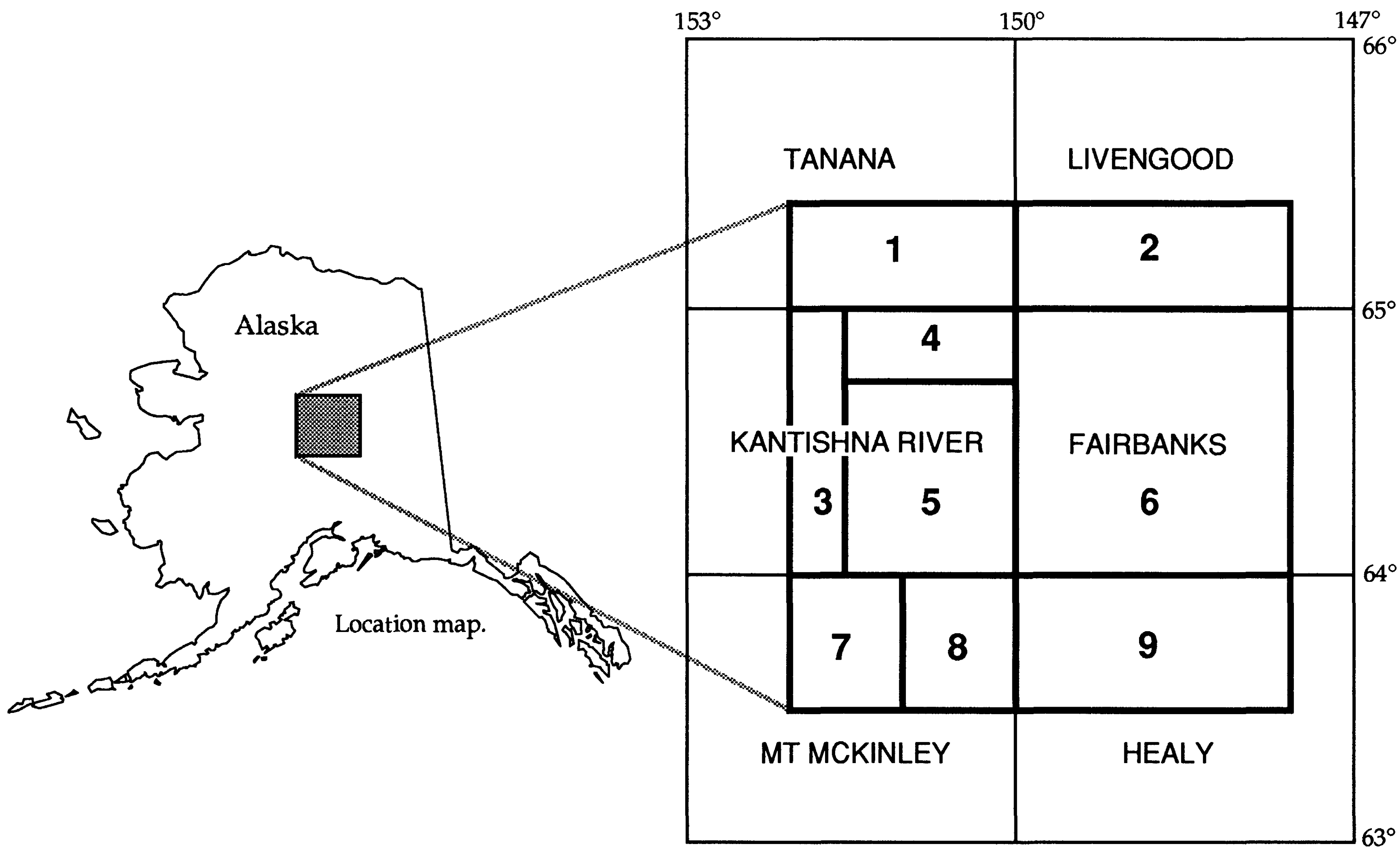
Wolfe, J.A. and Wahrhaftig, Clyde, 1970, The Cantwell Formation of the central Alaska Range: U.S. Geological Survey Bulletin 1294-A, p. A41-A55.

FIGURE CAPTIONS

Figure 1. Location and index map. Area of map and index of primary sources. Key to index of primary sources: 1--Chapman and others (1982, 1975a); 2--Chapman and others (1971); 3--Chapman and Yeend (1981) and Chapman and others (1975b); 4--Chapman and others (1975a); 5--Chapman and Yeend (1981); 6--Péwé and others, (1966); 7--Reed (1961); 8--Jones and others (1983); 9--Csejtey and others (1986).

Figure 2. Terrane map. Lithotectonic terranes of the Nenana basin area of central Alaska. Abbreviations: C_z, Cenozoic deposits; BRY-RB, Baldry and Ruby terranes, undivided; DL, Dillinger terrane; LG, Livengood terrane; MAN, Manley terrane; MK-PN, McKinley and Pingston terranes, undivided; MNK, Minook terrane; NN, Nenana terrane; NX-MN, Nixon Fork and Minchumina terranes, undivided; SV, Seventymile terrane; TZ, Tozitna terrane; WHM, White Mountains terrane; WS, Wickersham terrane; YTN, Yukon-Tanana terrane north of Tanana River; YTS, Yukon-Tanana terrane south of Tanana River. Adapted from Jones and others (1987) and Silberling and Jones (1984).

Figure 3. Explanation of map symbols.



Index map showing 1:250,000-scale quadrangles.

Figure 1. Location and index map.

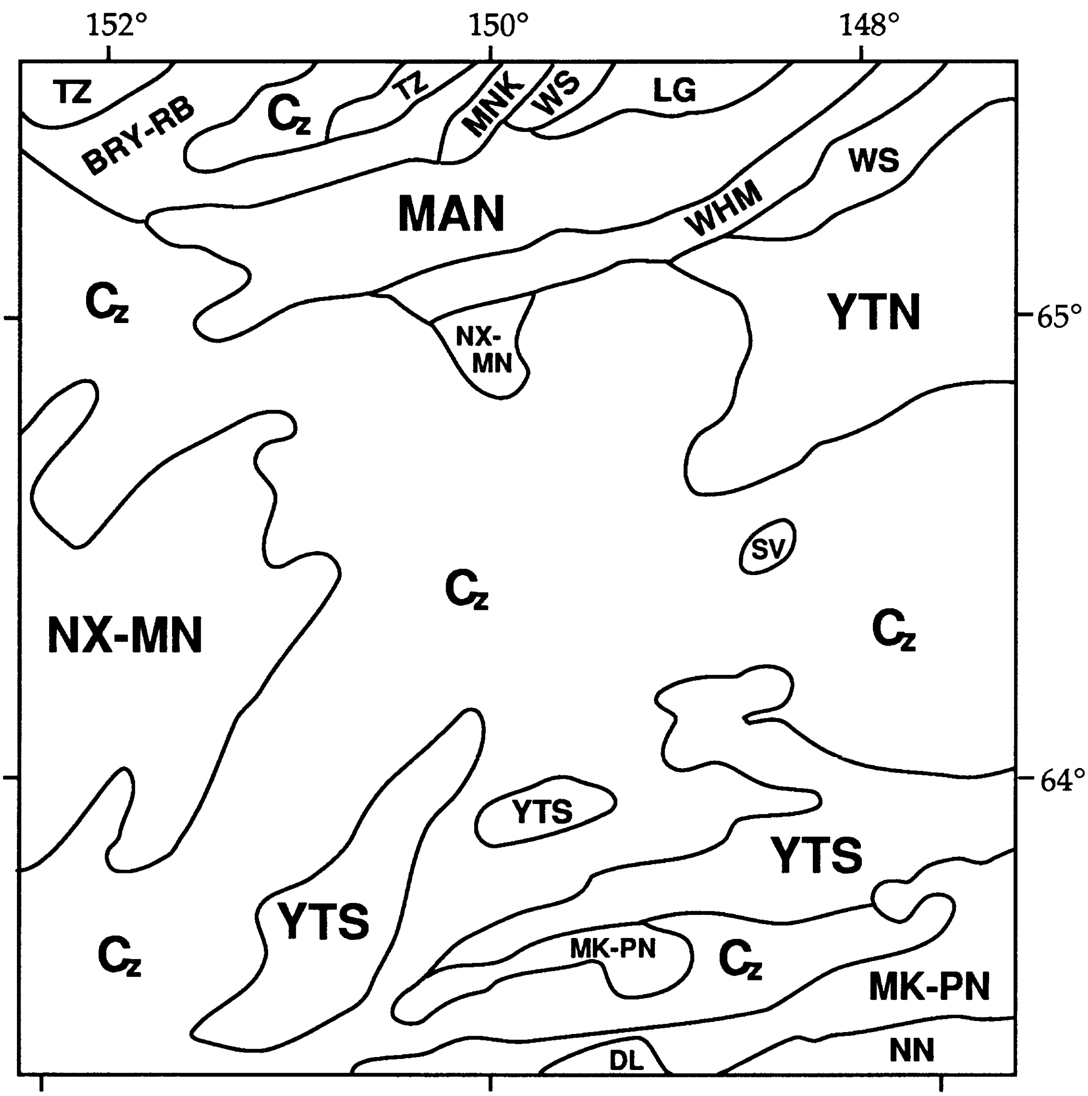
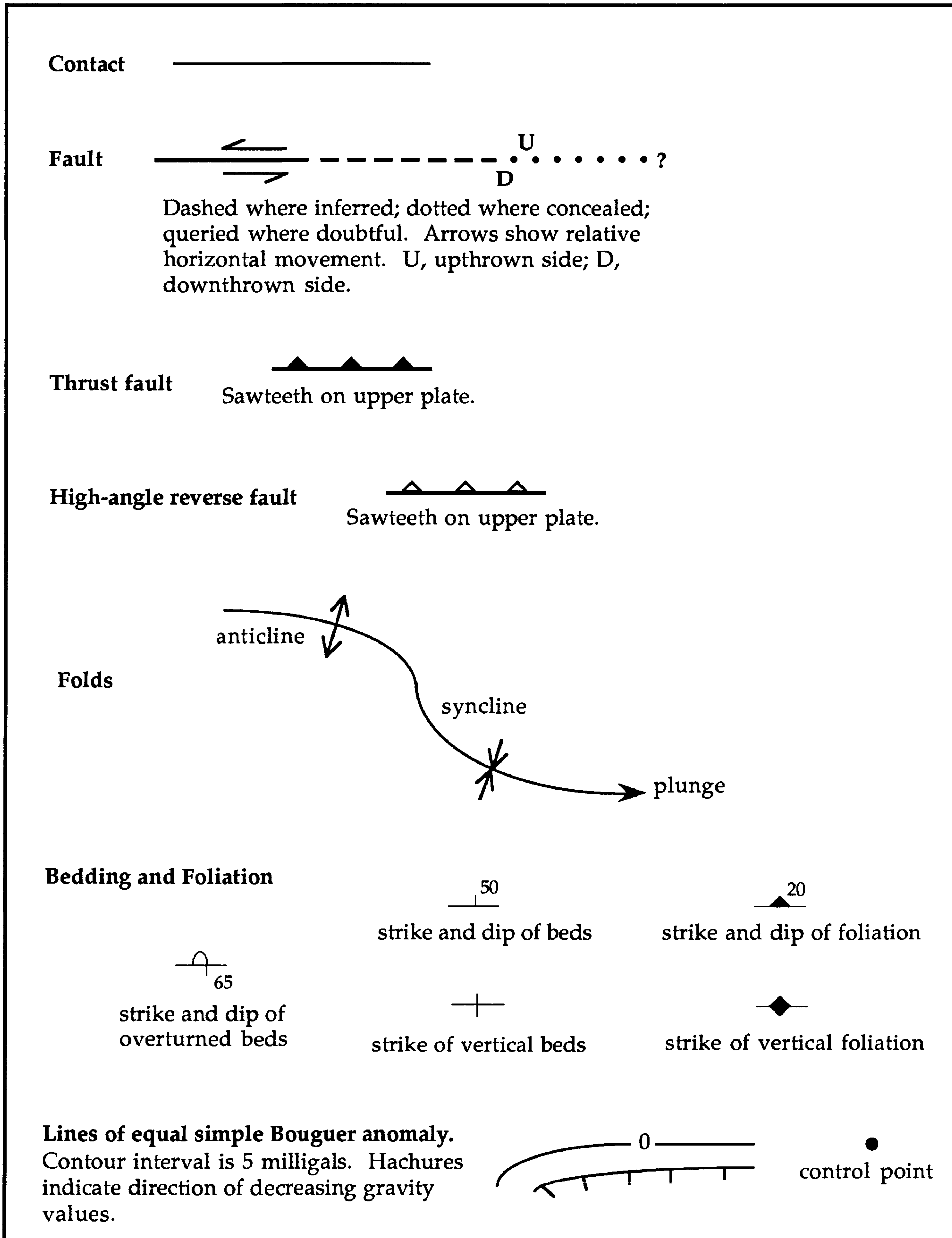


Figure 2. Terrane map.



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