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# PRELIMINARY GEOLOGY OF MCGRATH B-2 QUADRANGLE, ALASKA

By
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## ABSTRACT

Recent DGGS 1:40,000-scale geologic mapping of the McGrath B-2 Quadrangle has identified layered rocks ranging in age from Early Ordovician to Eocene, including well-dated Ordovician and Silurian sedimentary rock units. Relatively undeformed Middle to Upper Devonian shallow-water carbonates and overlying(?) pillow basalt and chert north of the Farewell fault contrast with polydeformed basin and slope deposits of early to mid-Paleozoic age south of the Denali suture. The latter sequence consists of Ordovician chert and shale and Silurian clastic sedimentary rocks overlain(?) by isoclinally folded clastic and deep-water carbonate deposits that are tentatively assigned a mid-Paleozoic age. Upper Silurian to Middle Devonian algal limestone and late Middle Devonian chert, argillite, sandstone, and ultramafic sills and volcanic rocks structurally or stratigraphically overlie the previously described lithologies.

Upper Cretaceous(?) to Eocene calc-alkaline igneous rocks intrude and overlie the Paleozoic section south of the Farewell fault. Quaternary glacial, colluvial, and alluvial deposits of several ages overlie all other lithologies in much of the quadrangle.

At least three periods of penetrative deformation have affected the layered rocks south of the Farewell fault, and crustal shortening of at least 10 km has occurred in the study area. Movement along the Farewell fault during Quaternary time has been predominantly vertical.

Mineralization in the study area consists of intrusive-related skarns, stockwork-style fracture fillings, epigenetic veins, and stratabound base metal occurrences in Paleozoic rocks.

## INTRODUCTION

As part of the 1982 state-funded CIP resource mapping program, DGGS completed a 1:40,000-scale map of the McGrath B-2 Quadrangle; previous project releases include geologic maps of the McGrath B-3 Quadrangle and Cheeneetnuk River areas (Gilbert and others, 1982; Gilbert, 1982). This report is a preliminary release of geologic and geochemical data collected during 63 man-days of field work in 1980 and 94 man-days of field work in 1981. Work on the petrology and chemistry of igneous rocks, on faunal and floral collections, and on mineral and Quaternary deposits continues.

The study area is a relatively low but rugged section of the northwest flank of the southern Alaska Range near Farewell. Elevation ranges from about 1,600 ft on the South Fork of the Kuskokwim River to 7,205 ft in the southwest part of the quadrangle (pl. 1). Layered sedimentary rocks compose moderately rolling hills; igneous complexes and associated altered rocks form steep and rugged massifs. Most of the area is above timberline, and bedrock and surficial geologic exposures are generally excellent.

## ACKNOWLEDGMENTS

Project geologists T.K. Bundtzen, J.T. Kline, and J.G. Clough were assisted by Larry Lueck and M.W. Henning in 1980 and by G.M. Laird in 1981. R.B. Blodgett (Oregon State University) examined fauna of Frasnian (early Late Devonian) age in the study area. W.A. Oliver, Jr. (U.S. Geological Survey, Washington, D.C.) worked on coral collections. We appreciate the efforts of Claire Carter (USGS) and C.J. Smiley (University of Idaho) for extensive graptolite and floral identifications, respectively. We especially thank B.L. Reed (USGS) for sharing his extensive knowledge of the mineral resources of the region. Rob Kell (Anaconda Minerals Company) and Michael Churkin, Jr. (ARCO) added to the geologic information base. D.N. Solie assisted in the cartographic preparations of plate 1. M.S. Robinson reviewed the manuscript.

## SUMMARY OF GEOLOGY

Part of the study area was briefly described by Brooks (1911) and Capps (1927), but the first modern examinations were conducted by Reed and Elliott (1968a,b) and May (1969). Lithologic units briefly described herein are described in detail on plate 1.

## PALEOZOIC SEDIMENTARY ROCKS

In the study area, sixteen mappable lithologies ranging in age from Early Ordovician to late Middle Devonian are exposed south of the Farewell fault. These rocks have been known for many years as the Post-Tonzona or Dillinger Group (Capps, 1927), after exposures in the Dillinger River area to the northeast. South of the fault, there appears to be a climb upsection from southeast to northwest. Frasnian (early Late Devonian) or younger carbonates, chert, and mafic igneous rocks compose the section north of the Denali suture.

Although Reed and Elliott (1968a,b) and Churkin and others (1973) believe that pre-Ordovician rocks exist in the general area, none have been recognized in the McGrath B-2 Quadrangle. Ten graptolite zones representing most of the Ordovician and Silurian Systems have been identified in the study area (table 1), and more graptolite zones may be delineated as additional fauna are identified. Graptolites collected are similar to those identified in the Terra Cotta Mountain type section 26 km southeast of the McGrath B-2 Quadrangle boundary (Churkin and others, 1973).

Structural repetition by thrust faulting and isoclinal folding complicates thickness estimates of the Ordovician and Silurian layered rocks (Osh, Sa, Sas, Scl units; pl. 1). We estimate that the Ordovician section on Sheep Creek is about 540 m thick and the Silurian clastic sequence is about 1,500 m thick; both figures are higher than estimates made by Churkin and others (1973) for probably the same section in the Terra Cotta Mountains. Within the Osh unit, shale and siltstone grade upward into darker gray shale, black chert, and thin volcaniclastic-sand intervals. The Ordovician section probably represents initial quiescent, deepwater deposition of fine-grained sediments either on an abyssal plain or in a restricted basin off the flanks of a continental margin. The presence of thin, tuffaceous sand and chert intervals near the top of the section suggests some volcanic activity and supports the existence of a continental land mass proximal to the basin. Similar lithologic features have been described for the Ordovician stratigraphy of the Selwyn Basin in central Yukon Territory (Blusson, 1976).

The Silurian clastic sequence consists of rhythmically layered, medium-to coarse-grained sandstone, siltstone, laminated limestone, and shale that grade upward into fine-grained siltstone and shale lithologies. Sandstones exhibit graded Bouma intervals, poor sorting, wedging, and scour-and-fill structures probably formed by turbidity currents on a submarine slope. Sandstone-shale ratios are quite variable but average 5:1 and 1:2 in the lowest and highest part of the section, respectively. The preponderance of channel deposits and a fining upward megacycle suggest channel infilling and overbank deposits in a submarine-fan environment. Seven paleocurrent measurements derived from striation casts, flow casts, and cross-beds suggest a current direction of N. 20-40° E. in the Sas unit on Sheep Creek (pl. 1); however, these data are insufficient to draw meaningful conclusions concerning direction of sediment transport. Most of the graptolites (table 1) are confined to thin sand or silt horizons in laminated limestone members of the Sl unit. A few faunal collections were obtained in overlying and underlying lithologic units.

Overlying the Silurian clastic section is a thick undated sequence of laminated limestone, dolomitic limestone, calc-sandstone, shale, and minor chert and volcanogenic(?) sedimentary rocks (Pzsl, Pzl, Pzvp, Pzcv, Pzsh, Pzs units; pl. 1). These units have been structurally repeated by isoclinal folding and thrust faulting, and thickness estimates are not available. Gilbert and others (1982) estimate that correlative rocks in the McGrath B-3 Quadrangle are structurally thickened to 8,800 m. Channelized limestone conglomerate, rip-up clasts, flute marks, and graded bedding in the sandstone indicate a depositional environment similar to that of the Silurian clastic units. In fact, the Pzs unit is largely indistinguishable from the Sas unit and may be equivalent in some areas. The age of this undated section is problematical. In the McGrath B-2 Quadrangle, these undated lithologies either stratigraphically or structurally overlie the Silurian clastic units in all cases. Additionally, the undated units are structurally or stratigraphically overlain by late Middle Devonian units (mDsc, mDg units; pl. 1). Hence, the authors tentatively regard the Pzsl, Pzl, Pzvp, Pzcv, Pzsh, and Pzs units as post-latest Silurian in age. Churkin and others (1980) identify a similar sequence in the Terra Cotta Mountains as mid-Paleozoic in age.

The stratigraphically highest part of the Paleozoic section south of Farewell fault consists of Amphipora-bearing algal limestone (Dl unit), shale and chert (Dc, Dsh units), mafic to ultramafic flows, sills, and dikes (mDg unit), and a faunally dated late Middle Devonian clastic sequence mainly exposed in the western part of the quadrangle (mDsc unit). The algal limestone and shale-chert units (Dl, Dsh, Dc units; pl. 1) contain stromatolite-like structures, cross-beds, and dolomitic intervals that appear to represent a shallow water depositional environment that significantly contrasts with the underlying deep-water facies previously described. The algal limestone (Dl unit) is remarkably similar to a unit of approximately the same age in the White Mountain carbonate section north of the Farewell fault (Gilbert, 1982). The sedimentary environment of the overlying mDsc and mDg units is uncertain. The presence of chert and ultramafic to tholeiitic mafic igneous rocks stratabound within the sandstone and shale horizons suggests some type of ocean-floor or deep-water continental-margin assemblage. Some thin sandstone intervals in the mDsc unit contain graded bedding and shale or carbonate rip-up clasts suggestive of deposition by turbidity currents; however, these features are generally absent in much of the section. Abundant trace fossils such as Granolaria and Paleodictyon in the lower portion of the mDsc unit have been found worldwide in flysch sequences of Phanerozoic age (Reading, 1978). However, the mDsc unit appears to have been deposited above shallow-water carbonate and shale facies (Dl, Dsh units).

Layered rocks north of the Farewell fault are well-dated early Late Devonian (Frasnian) massive or locally laminated limestone (Dlm, Dll units) with minor sandstone intervals (Ds unit). These lithologies are structurally juxtaposed or stratigraphically overlain by mafic igneous rocks (MzPzb unit), chert (MzPzc unit), and fluvial(?) conglomerate (MzPzg unit). Lack of good exposures prevented determination of the nature of the contact between the dated Devonian carbonates and undated Mezozoic-Paleozoic units. The Frasnian carbonates are similar to shallow-water platform units of the same age near White Mountain (Gilbert, 1982). The mafic igneous rocks and chert are similar to the lower Upper Silurian Chilakadrotna Greenstone north of Lake Clark (Bundtzen and others, 1978), late Paleozoic to Triassic chert and mafic-igneous lithologies of the Gemuk Group exposed throughout southwestern Alaska (Cady and others, 1955), and parts of the Mississippian(?) Innoko terrane, described by Patton and others (1980) and Chapman and others (1982) in the Medfra and Ophir Quadrangles to the northeast. These lithologies also resemble the Upper Triassic Pingston Terrane (Jones and others, 1980) exposed along the north flank of the Alaska Range northeast of the study area. A Paleozoic-Mesozoic age bracket is possible for the MzPzb, MzPzc, and MzPzg units.

## IGNEOUS ROCKS

The stuy area includes 13 igneous rock units that range in age from latest Cretaceous(?) to Middle Tertiary. Intrusive lithologies include dike swarms, breccia pipes, and small plutons of dominantly intermediate composition (Tids, Tia, Tqm units; pl. 1), but mafic and felsic dikes also occur (Tim, Tif units; pl. 1). In some areas, subparallel swarms of dikes of variable composition are enveloped in complex wedges of hornfelsed Paleozoic sedimentary rocks (Tids unit; pl. 1); such concentrically shaped dike concentrations may constitute root zones of volcanic centers. The 'dumb-bell -shaped' intrusive on the 'Rat Fork' (Reed and Elliott, 1968a) is shown as this composite dike-swarm hornfels unit. Intrusions in the general area have been radiometrically dated as Paleocene in age (Reed and Lanphere, 1972; Shew and Wilson, 1981). DGGS radiometric dating of intrusive rocks is in progress.

Two major volcanic complexes occupy the map area units (Tvt, Tav, Tvd, Tvb, Tva, Tvat, Tvs; pl. 1). One caps a rugged north-south-trending ridgeline west of Veleska Lake, and the other overlies Middle Devonian units west and north of Sheep Creek. The latter forms the front range of hills immediately south of the Farewell fault. The Veleska Lake complex ranges from basalt to rhyolite in composition, but is predominantly composed of dacite. It is intruded by numerous Paleocene granodiorite or dacite dikes and sills that are difficult to distinguish from local flow rocks.

The Sheep Creek volcanic pile apparently postdates most of the Paleocene intrusive activity and is composed of basal basalt, andesite, and rhyolite-welded(?) tuff units overlain by well-graded airfall tuff of intermediate composition. Clasts up to 0.5-m diameter in the airfall units indicate proximity to a vent(s). Paleosols rich in floral remains (table 1) are interbedded in the air-fall sequence and locally in basalt flows. According to C.J. Smiley (written commun., 1982),

> The conifer Metasequoia appears to represent the species M. cuneata that was widespread in Late Cretaceous and early Tertiary times; the conifer Glyptostrobus europaeus was widespread in collections of early Tertiary age. Most of the dicotyledon leaves appear to represent early Tertiary rather than Late Cretaceous flora. On the basis of this preliminary analysis, I would say the flora collections are of Early Paleogene age.

The volcanic complexes are similar to both the Teklanika Formation (Gilbert and others, 1976) and Mount Galen Volcanics (Decker and Gilbert, 1978), which crop out in the central Alaska Range northeast of the study area. Detailed petrologic and stratigraphic examinations of all igneous rocks in the study area are in progress.

## QUATERNARY DEPOSITS

Ten Quaternary units, including Wisconsinan and pre-Wisconsinan drift, ice contact deposits and outwash of several ages, and Holocene colluvial and alluvial sequences overlay all older lithologic units.

### Drift

Fernald (1960) first described glacial deposits in the general area. At least two new stades of the Farewell glaciation were recognized during this study. In the vicinity of the mouth of Sheep Creek Canyon, evidence for a pre-Selatna (pre-Wisconsinon) glaciation includes:

a) Relict drift and erratics top an overlying limestone (carbonate) hill (2,100 ft elevation) just east of Sheep Creek, 3 km north of the mountain front.

b) Multistoried erosion levels of Sheep Creek show projected U-shaped profiles and suggest at least three major glacial erosion cycles in the valley.

Selatna- and Farewell-age drift deposits (Fernald, 1960) occur along the mountain front between the South Fork and Sheep Creek and west from Sheep Creek at least 0.5 km. Several smaller creeks draining the north flank of the Alaska Range between Sheep Creek and the Windy Fork were occupied by substantial valley glaciers during early and late Wisconsinan time. Moraines and till sheets from small piedmont lobes are mapped at the mouths of several small valleys along the present mountain front.

Aside from valley form, the lower 1.5 km of the west fork of Sheep Creek shows little evidence of glaciation. However, glaciers feeding this fork may have been extensive enough, at least during Selatna time, to fill this valley and join the trunk glacier on the main fork. Colluvial processes and vigorous stream erosion following rejuvenation may have eradicated most glacial deposits in this valley segment.

Terraces (Qdo unit; pl. 1), upper scour limits, and former valley floors indicate at least three cycles of glacial erosion. Whether these represent the Selatna, Farewell 1, and Farewell 2 glaciations of Fernald (1960) is problematical. The lack of good bluff exposures where Sheep Creek exits the mountain front makes stratigraphic observation of drift units difficult. The surface morphology of drift units at the mountain front is subdued, and test-pit identification of sediments is often necessary. Alluvial and colluvial modification of drift units adjacent to the mountain front has been accelerated by uplift along several strands of the Farewell fault; hence, assignment of ages according to morphological characteristics is extremely difficult.

## Gravel sources

Sand and gravel deposits are abundant on the piedmont north of the Farewell fault, and occur as outwash, alluvial terrace, and flood-plain deposits along the course of Sheep Creek (Qdo, Qat, Qal units; pl. 1), as abandoned glacial outwash planes and channels, and as ice-contact deposits between the South Fork of the Kuskokwim River and Sheep Creek (Qd, Qdo units; pl. 1). Regional climatic changes and periodic uplift of the Alaska Range have given rise to alluvial deposits ranging from coarse bouldery gravels to well-sorted sands and pebble gravels that are apparent in cutbanks along Sheep Creek.

Outwash materials are generally coarse (coarse sand to small boulders up to 255 mm diameter) and tend to contain more subangular clasts than does recent alluvium. Ice-contact materials in kames and escape channels between the South Fork and Sheep Creek are variable in composition, but are generally high in angular, polymictic coarse-sand content.

Alluvial sediment thickness (Qal unit; pl. 1) on the flood plain of Sheep Creek is not great, and bedrock is commonly exposed in wide braided stretches upstream from the canyon. In several places, bedrock crops out in the bottom of abandoned sloughs and braided channels. More often bedrock is exposed in main channels.

Bedrock cut terraces in the valley are generally thinly veneered by gravels, and in some cases till. Terraces on the first major right-limit tributary of Sheep Creek (hereafter referred to as the 'west fork') upstream from the Farewell fault are about 85 ft above the modern flood plain. Several narrow incised canyons and knickpoints that are separated by more shallow gradient stretches indicate episodic rejuvenation in this tributary, probably associated with uplift along the Farewell fault.

## Permafrost

Permafrost is present on northward-sloping piedmont in colluvial and mixed alluvial and colluvial deposits and in peat- and silt-covered outwash and drift deposits proximal to the mountain front. Depth to permafrost is variable and somewhat dependent on thickness of the organic mat.

Test pits excavated in early August 1980 in the upper outwash terrace west of Sheep Creek indicate frozen ground 0.3 to 0.7 m below the surface of the nearly saturated organic mat. Material in the pits was 70 to 90 percent organic (peat) with admixtures of a trace to some silt.

Farther north on the same outwash slope, the ground is thawed to a depth of at least 1.2 m in coarse cobble gravel. The surface organic mat is much thinner, and a fibrous peat and root mat of about 3 m is underlain by 10 cm of organic peat with trace to some silt. Below this is 30 cm of thawed loess. The water table occurs at 60 cm. Continuous permafrost is probably not present on the outwash plain 5 km beyond the mountain front. Younger alluvial terraces and flood plains near Sheep Creek are generally thawed.

Areas underlain by permafrost exhibit a characteristic vegetation assemblage consisting of *Sphagnum* sp., *Rubus chamaemorus*, *Ledum palustre*, *Vacunium uliginosum*, *Andromeda polifolia*, minor amounts of *Carex* sp. (sedges), *Cladonia* sp. and *Peltigera* sp. (lichens), and *Polytrichum* sp. (mosses). Near the contact with colluvial sediments from the mountain front, the outwash terrace is covered by a few shrubby plants (*Salix* sp., *Alnus crispa*). Where these do exist they are generally isolated in areas of bare gravel, which apparently exist in old channel scars with better drainage. Some of these scars are subject to local aufeis formation, which causes local bare-gravel exposures on the generally sloping surfaces. *Betula glundulosa*, *B. nana*, and a few species of *Salix* commonly occupy the margins of these disturbed areas.

## Colluvium

Presently active colluvial processes along the abrupt mountain front west of Sheep Creek show evidence of greater activity in the past. Slopes below the Farewell fault trace are commonly saturated diamictic colluvial and alluvial materials (Qca units; pl. 1) with a large silt- and clay-sized fraction. Streams cutting colluvial aprons are commonly diverted and even buried by saturated, fine-grained materials flowing in from the sides. Springs emanating from the fracture zone of the Farewell fault, bedrock weathering characteristics, solifluction, aufeising, and rapid uplift are responsible for instability of surficial materials in this area. At the range front, sediments form a gently to moderately sloping apron that extends 5-8 km to the north from a zone of rubbly colluvium (2,300 to 2,500 ft elevation) to alluvial fan and outwash deposits between 1,800 to 1,500 ft elevation.

Several large landslides are present within 1.5 km of the Farewell fault. One notable slide of middle Holocene(?) age occurred in Tertiary volcanic agglomerates and flows about 1 km south of the Farewell fault and 1 km west of Sheep Creek. The plane of failure is about 0.5 km long, dips between 70° and 80° to the south, and roughly parallels to the Farewell fault; it is oblique to the original volcanic bedding and may have occurred along a fault splay or pervasive joint system. To the east, approximately in line with the slide scarp, a wide shear zone runs subparallel to the presently active Farewell fault trace. This shear zone is probably an inactive strand of the Farewell fault.

## STRUCTURE

Paleozoic layered rocks in the study area south of the Farewell fault are deformed by subisoclinal folds with axes trending N. 10-40° E. locally overturned to the northwest. Secondary subisoclinal folds measured in outcrop show fold axes plunging N. 50° E. and S. 50° W.

Dike swarms, plutons, igneous breccia, and volcanic rocks of Cretaceous to Paleocene age cut the early-generation folds. The earlier subisoclinal folding events are overprinted by N. 50° E. to east-west-trending open folds. These structures have gently folded Paleocene volcanic rocks. The largest scale subisoclinal folds have amplitudes of up to 5 km. Three major overturned structures are responsible for at least 10 km of crustal shortening in the study area (cross sections; pl. 1). Layered rocks north of the Farewell fault are also deformed by northeast-trending subisoclinal and open folds, but their relation to the subisoclinal-fold deformation south of the fault system is unclear.

At least two ages of faults are known in the study area. North- to N. 30° E.-trending, high-angle faults and thrust faults parallel to and perhaps contemporaneous with pre-Cretaceous subisoclinal folding episodes acted as structural channels for dike swarms and plutonic bodies. Northeast- to east-west-trending high-angle faults cut all bedrock lithologies and offset earlier thrust faults.

The Farewell fault is a major right-lateral, strike-slip crustal feature that represents the westernmost extension of the Denali fault system in the Alaska Range. Reconstruction of offset plutons in Denali National Park indicates a right-lateral displacement of about 60 km (Reed and Lanphere, 1974). Regional offset solutions proposed by Gilbert (oral commun., 1982) correlate mafic igneous rocks (MzPzb unit) in the study area with those south of the Farewell fault on the Cheeneetnuk River and suggest a similar offset.

The Farewell fault exhibits evidence of vertical displacement with consistently upthrown scarps during Wisconsinan and Holocene time. This general pattern of upthrown south sides on successively older strands of the

Farewell and other high-angle faults may explain the down-section trend of Paleozoic stratigraphy to the southeast noted earlier. Apparent local stream-derangement features may result from other mechanisms. Lateral-offset features frequently indicate opposite directions of motion, namely, right lateral and left lateral. Preferential erosion of the sheared zones, coupled with aggradation and stream diversion caused by glacial deposition or ice position and resistant bedrock structures, are often responsible for right- and left-lateral drainage deflections.

Vertical offset varies along the most active strand of the Farewell fault. Along the active strand 3 km east of Sheep Creek, Selatna-age drift is vertically offset 15 m. To the east and west of this station, vertical offsets in drift vary from 5 to 20 m. Three Holocene fan terraces 3 km east of Sheep Creek are from oldest to youngest offset 5, 3, and 1 m, respectively. Other indicators of recent activity are numerous sag ponds, springs, and disrupted soil profiles on the fault trace.

Below the fault scarp, failures in 5-8° spring-saturated slopes are common. Solifluction, subterranean piping of fines, spring sapping, and gully erosion are the main erosional processes active along the piedmont below the fault trace.

## ECONOMIC GEOLOGY

Only cursory examinations of sulfide mineralization have been made to date. The reader is referred to Reed and Elliott (1968a,b) for additional discussions. Mineralization identified in the study area consists of:

a) Lead-zinc ± copper occurrences in Ordovician shale and chert.

b) Epigenetic lead-zinc-silver fracture fillings in Silurian to Devonian clastic sedimentary and Tertiary volcanic rocks.

c) Copper-lead-zinc-silver skarn replacement bodies in limestone adjacent to subvolcanic granodiorite intrusions.

d) Stockwork fracture fillings in brecciated zones and breccia pipes.

e) Anomalous nickel-chrome values in late Middle Devonian ultramafic sills.

Chip and grab samples were collected from mineralized zones, but representative channels were not collected. Thus, accurate estimates of the grade of mineral deposits in the study area cannot be made, and analytical results and descriptions in table 2 should be viewed only as indicators of mineralization. Only selected mineral occurrences are shown on plate 1.

Type b, c, and d deposits (above) are almost identical to those described by Reed and Elliott (1968a,b) in the Bowser Creek area within and south of the study area. We have not investigated the 'Rat Fork' occurrence west of Sheep Creek, and its location is only approximately shown on plate 1. Most skarn deposits (type c) occur as kidney or podiform masses intimately associated with hornblende granodiorite dikes intruding calcareous rocks. Chalcopyrite, sphalerite, galena, magnetite, garnet, and epidote-bearing skarns have developed in calcareous and igneous hosts. Cadmium and local cobalt anomalies are apparent in the analyses (table 2).

Composite grab samples of Ordovician shale, particularly on Sheep Creek, contain anomalous concentrations of lead, zinc, silver, vanadium, and molybdenum (table 2). Finely disseminated sphalerite was noted in thin stratigraphic intervals, and smithsonite-sulfur plumes are locally well developed along fracture and joint surfaces. Small, epigenetic galena-sphalerite veins (table 2) that intrude nearby Silurian clastics may be remobilized from the Ordovician section.

Sulfide mineralization is associated with brecciated border zones of several prominent plutonic masses that form high, rugged massifs in the study area. The highest such massif (7,205 ft) is a hypabyssal pluton of intermediate composition rimmed by up to 1.0 km of carbonate-shale breccia. Pipelike breccia masses also intrude through the central portions of the 'pipe.'

Reed and Elliott (1968a) report anomalous values of nickel and chromium in stream sediments in the northwestern part of the study area. These minerals are probably derived from the mafic and ultramafic flows, sills, and dikes of the mDg unit (pl. 1), as borne out in two selected analyses (table 2). Volcanogenic sedimentary rocks and lacustrine(?) members of the Tvs unit (pl. 1) contain thin bony coal seams and coalified wood. An analysis reported by Solie and Dickey (1982) indicates a subbituminous Btu ranking.

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Table 1. Preliminary fossil identifications, McGrath B-2 Quadrangle, Alaska

| Map locality | Field number | Description of sample site | Remarks |
|---|---|---|---|
| 1[1] | 80BT60 | 62°30" lat.; 153°52'00" long.; 2,000-ft elevation in roadcut on west side, St. John's Hill. | Occurrence of Cyrtospirifer and Atrypa brachiopods in Dml indicate early Late Devonian (Frasnian) age. Blodgett (written commun., 1982) believes fossils are similar to those in Frasnian lime mudstone south of Farewell fault, McGrath A-5 Quadrangle (Gilbert and others, 1982). Reed and Elliott (1968b) report several rugose coral identifications including Cylindrophyllum and Disphyllum of probable Middle Devonian age at or near this locality. |
| 2[1] | 80BT56 | 62°29'00" lat.' 153°48'00" long.; near summit of 2,115-ft isolated hill 1.2 km east of Sheep Creek. | Poorly preserved Favosites, Alveolites and Syringopora corals; Middle(?) Devonian age. |
| 3[1] | 80BT30; 80MW74 | 62°28'00" lat.' 153°49'30"; in stream bluff on west limit of Sheep Creek near mountain front. | Poorly preserved Atrypa brachiopods in silty limestone talus; probably Middle to Late Devonian age. |
| 4[2] | 80BT75 | 62°27'20" lat.; 153°47'00" long.; at 2,500-ft elevation on gentle ridge about 0.8 km SE of Lathram cabin. | Two recrystallized fragments of Ampiphora in algal limestone (Dl); indicate latest Silurian to to Middle Devonian age. |
| 5[1] | 81JC114 | 62°29'55" lat.; 153°42'00" long.; at 2,000-ft elevation at south rim of ridge connecting Farewell Mountain. | Cyrtospirifer sp.; large undetermined smooth brachiopod and pteroid clam. Cyrtospirifer has a range from early Late Devonian to Early Mississippian. However, these specimens resemble Frasnian Cyrtospirifer fauna from St. John's Hill (map locality 1). |

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| 6[2] | 80BT120 | 62°29'00" lat.; 153°92'30" long.; at 1,800-ft elevation 3.2 km east of locality 3. | Unidentified brachiopods, corals, and bryozoans; identification in progress. |
| 7[2] | 80BT119 | 62°28'45" lat.; 153°43'00" long.; about 0.8 km SW of locality 6. | Unidentified corals and brachiopods; identification in progress. |
| 8[2] | 81JC160 | 62°28'30" lat.; 153°32'00" long.; at 2,700 ft on south ridge of Egypt Mountain. | Calc siltstone (S1) contains Monograptus fragments. |
| 9[2] | 81J156 | 62°27'00" lat.; 153°37'00" long.; 1,600 ft on east bluff Tin Creek. | Monoserial graptolites in shale of Pzs; not well enough preserved for specific age assignment. |
| 10[3]-12 | 81BT437-39 | 62°25'30" lat.; 153°35'36" long.; at elevations 2,500 - 3,300 ft, northernmost ridge of Tunis Mountain. | Grapolites in coarse calc-sandstone interbedded in laminated limestone (S1). Monograptus n. sp. (c), M. cf. M. pseudodubius (Boucek, f). These collections are identical in fauna and lithology to some that we collected in the Terra Cotta section (Carter, written commun., 1982). Approximately G. nassa to N. nilssoni zones, Ludlovian stage, Silurian System. |
| 13[2] | 81BT440 | 62°25'45" lat.; 153°34'00" long.; 2.1 km west of Charlie Lake. | Abundant Ordovician graptolites in Osh shale; field identifications include Phyllograptus, Didymograptus, Isograptus and numerous biserial graptolites; probably late Early to Middle Ordovician age. |
| 14[2] | 81BT454 | 62°25'00" lat.; 153°34'00" long.; along tractor road 0.8 km north of Veleska Lake. | Coarse sandstone in Sas contains Monograptus fragments; Middle to Late Silurian. |

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| 15[2] | 81BT453, 442, 443 | 62°24'30" lat.; 153°56'00" long.2.8 km east of Veleska Lake at 3,000-ft elevation. | Poorly preserved biserial graptolites and Phyllograptus (Ordovician); more identifications in progress. |
| 16[2] | 81BT44 | About 200 m south of above locality. | Very well preserved, straight Monograptus sp. up to 20 cm long in sandy limestone bed (S1). |
| 17[3] | 81BT452 | 62°24'25" lat.; 153°35'00" long.; on creek valley 2.0 km east of Veleska Lake. | Calcareous sandstone bed within S1 contains Monograptus similar to localities 10-12. |
| 18[2] | 81BT445 | 62°24'00" lat.; 153°35'00" long.; at 3,500 ft knob 0.8 km east of Veleska Lake. | Fragmental curvilinear Monograptus in massive limestone (S1). |
| 19[2] | 81BT532 | 62°18'00" lat.; 153°39'00" long. | Numerous biserial graptolites in Osh shale; includes Didymograptus. More identifications in progress. |
| 19[4] | 81BT533 | 62°19'45" lat.; 153°32'00" long.; along Post River. | Climacograptus and Glyptograptus of Middle or Late Ordovician age. |
| 20[2] | 81JC257 | 62°19'00" lat.; 153°31'00" long. | Biserial graptolites of Ordovician age. |
| 21[2] | 81JC238 | 62°18'00" lat.; 153°30'95" long. | Biserial graptolites of Ordovician age. |
| 22[2] | 81JC243 | 62°17'30" lat.; 153°31'30" long. | Biserial graptolites of Ordovician age. Contains Phyllograptus. |
| 23[5] | 81BT541 | 62°18'00" lat.; 153° long. | Undetermined bark or bark chips, stems, and disseminated plant debris in Late Cretaceous to early Tertiary air-fall tuff. |

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| 24[3] | 81BT407 | 62°15'10" lat.; 153°48'10" long.; near quadrangle boundary. | Osh shale contains *Climacograptus riddellensis* Harris (f), *Pseudoclimacograptus* cf. *P. scharenbergi* (Lapworth) (r), *Diplograptus decoratus* cf. subsp. *decoratus* (Harris & Thomas) (f), *Cryptograptus schaferi* (r), *Didymograptus* sp. (r). zone of *D. decoratus*, Llanvirnian stage, Middle Ordovician. |
| 25[3] | 81BT412 | 62°15'33 5" lat.; 153°48'30" long. | Stratigraphic top of Osh; very scrappy *Climacogratus*? sp. (wide) (f), *C* sp. (narrow) (f), *Orthograptus*? (r). Zone indeterminate, probably Middle or Late Ordovician(?). |
| 26[3] | 81BT413, 414 | 62°15'40" lat.; 153°49'00" long.; in Creek Canyon. | *Pristiograptus* aff. *P. dubius* (Suess). Approximately *M. ludensis* zone; abundant fauna in coarse sandstone beds within S1 limestone. |
| 27[3] | 81BT411 | 62°15'40" lat.; 153°48'00" long.; in northern tributary stream. | Folded Osh shale contains *Dicellograptus gravis* Keble & Harris (r), *D* cf. *D. angulatus* Elles & Wood (same as Trail Creek, Idaho) (r), *Climacograptus tubuliferus* Lapworth (f). Zone of *C. tubliferus*, Caradocian stage, Ordovician. |
| 28[3] | 81BT410 | 62°17'00" lat.; 153°48'00" long.; on ridgetop above locality 27. | Fragmentary material; Osh shale contains *Climacograptus*, *Glyptograptus*, *Diplograptus decoratus* cf. Probably zone of *D. decoratus*, Llanvirnian Stage, Ordovician. |
| 29[2] | 81JC175a, 175b | 62°17'00" lat.; 153°49'00" long. | Apparently both monoserial and biserial forms preserved in Osh; possibly Early Silurian. |
| 30[3] | 81JC176, 177 | Nearly the same as locality 29; 150 m west. | Sandstone beds in S1 contain *Pristiograptus* off *P. dubius* approximately *M. ludensis* zone, Wenlockian Stage, late Middle Silurian. |

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| 31[2] | 81BT480 | 62°16'30" lat.; 153°59'00" long. | Stemlike fragments in mDsc; also trace fossil remains (burrowing organisms) that include Fucusopsis(?), Granularia and irregular variety of Palaeodictyon. |
| 32[2] | 81BT545 | 62°18'30" lat.; 153°47'00" long.; at 3,500 ft elevation in steep headward canyon of Sheep Creek. | Osh contains badly deformed biserial graptolites and Phyllograptus. |
| 33[3] | 81BT340 | 62°19'50" lat.; 153°48'00" long.; west fork Sheep Creek in canyon cut. | Sulfur-stained Osh shale near top of section contains Dicellograptus g. gurleyi (c), Cryptograptus schaferi (r), Corynoides? sp. (r), Glyptograptus sp. (f), Climacograptus sp. (c). Approximately C. bicornis zone, Caradocian Stage, Ordovician. |
| 34[3] | 81BT339 | 62°20'00" lat.; 153°48'00" long.; west fork Sheep Creek, up steep fork about 1/4 mi. | Sandstone bed in Sl limestone contains (very poorly preserved, faint) Monograptus ex gr. M. ludensis (r), Monograptus? sp. (f). Approximately late Wenlockian-early Ludlovian Stage, Silurian System. |
| 35[7] | - - - | 62°20'30" lat.; 153°49'45" long. | According to May (1969), locality contains poorly preserved pelecypods of Early Devonian (?) age. However, we tentatively regard upper Sl member as Silurian. |
| 36[2] | 81BT359 | 62°20'30" lat.; 153°47'30" long. | Sa argillite bed yields undetermined mollusc shell casting. |
| 37[2] | 81BT336<br>177 | 62°22'00" lat.; 153°49'00" long.; on ridgeline south of western tributary. | Sl limestone contains Monograptus ludensis and other Monograptus(?) fragments; probably Wenlockian - early Ludlovian Stage, Silurian System. |

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| 38[3] | 81BT335 | 62°21'15" lat.; 153°48'00" long.; west fork, Sheep Creek. | (Only two pieces in collection have identifiable graptolites) Climacograptus cf. C. caudatus Lapworth (r), Orthograptus cf. O. quadrimucronatus (Hall) (r). Zone of C. tubuliferus (early Late Ordovician) believed to be stratigraphic top of Sheep Creek Osh unit. |
| 38[3] | 81BT334 | Found up hill about 100 m from locality 38a. | Silt layer in Scl contains (poorly preserved and fragmentary) Monograptus? sp. (r). Silurian (?); (May (1969) reports graptolites of "Early Silurian" age at this locality). |
| 39[3] | 81BT330 | 62°21'15" lat.; 153°46'15" long.; near intersection of Smith and Sheep Creeks. | Osh shales yield (very large collection) Climacograptus bicornis (Hall) (common), Orthograptus calcaratus acutus Elles and Wood (r), Orthograptus sp. (f), Glyptograptus sp. (c), Amplexograptus? sp. (r), Dicellograptus gurleyi, subsp. gurleyi Lapworth (c), D. sextans, subsp., sextans (Hall) (r) D.? aff. D. caduceus Lapworth (r), Dicranograptus nicholsoni, subsp. nicholsoni, Hopkinson (r), Cryptograptus tricornis (r), Cryptograptus sp. (wide) (r), Reteograptus geinitzianus Hall (r), Didymograptus? sp. (f). Zone of C. bicornis, Caradocian Stage, Ordovician. |
| 40[2] | 81BT305 | 62°17'30" lat.; 153°43'00" long.; 1.6 km south of south end, Smith Lake. | Pzl limestone contains recrystalized coral(?) debris and algal-like structure; appears less laminated than other Pzl but not enough like Dl to consider reclassification. |
| 41[3] | 81BT329 | 62°21'00" lat.; 153°46'00" long.; about 0.4 km south of locality 42. | (Very poorly preserved, tectonically distorted) Phyllograptus cf. P. augustifolius, subsp. augustifolius Hall (f), P. cf. P. anna Hall (r), Climacograptus? sp. (r), Glossograptus? sp. (r). Phyllograptids indicate zones of Tetragraptus fruticosus to Isograptus victoriae lunatus but Climacograptus and Glossograptus occur much later Diplograptus decoratus zone). Apparent mixing of sample localities evident. |

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| 42[3] | 81BT314 | 62°21'10" lat.; 153°46'00" long.; near Smith-Sheep Creek intersection. | Very poorly preserved Climacograptus? sp. (frequent), Glyptograptus cf. G. euglyphus (Lapworth) (f), Glossograptus? sp. (rare), Cryptograptus cf. C. schaferi Lapworth (r), Leptograptus? or Didymograptus? (r). Zone indeterminate; somewhere between zones of D. decoratus and C. bicornis. |
| 43 | 81BT366 | 62°23'30" lat.; 153°47'15" long.; in canyon bottom 1.6 km west of Sheep Creek. | Abundant remains of biserial graptolites in Osh talus near south side of canyon cliffs; samples lost during field shipment. |
| 44[5] | 81BT362 | 62°22'30" lat.; 153°50'30" long.; along east-west ridgeline 3.2 km west of Sheep Creek at about 5,100 ft. | Collected in 1.2 m paleosols in air-fall tuff sequence; Equisetum sp. Metasequoia cuneata cf. Flabellaria alaskana. Several unidentifiable dicot leaf fragments. |
| 45[5] | 81BT363 | 62°22'30" lat.; 153°51'00" long.; about 0.5 km west of locality 44. | Collected from paleosol in air-fall tuff about 30 m stratigraphically higher than map locality 44; Metasequoia cuneata, Glyptostrobus europaeus cf. Podocarpus sp.? Conifer stem (cf. Lariz)? Conifer needles (? Pinus) cf. Persea spatiosa (vide Hollick) cf. Alnus corylina (vide Hollick) Juglans nigella (vide Hollick)? Vitis sp.; undetermined insect wing. Petrified branches and tree stumps nearby. Reed and Elliott (1968b) report Metasequoia cf. occidentalis, and Cocculus cf. flabella at or near this locality (USGS Paleobotany locality 11126). |
| 46[5] | 81BT364 | 62°22'50" lat.; 153°51'15" long.; near top of peak 5160. | May be derived from lacustrine silt above air-fall units; Metasequoia (cone). Large fragments of wood chips in coarse matrix. |

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| 47[5] | 81BT386 | 62°23'00" lat.; 153°52'00" long.; western ridgeline at 4,300-ft elevation probably same horizon as locality 45. | 4-m thick paleosol (?) yields: Metasequoia cuneata, Glyptostrobus europaeus? Conifer stem (cf. Larix)?, conifer needles (? Pinus), conifer seed (Pinaceae), Taxodiaceae (? Sequoia, or ? Cunninghamia) cf. Hicoria (= Carva) magnifica (vide Hollick), dicot leaf fragment (? Fagaceae) cf. Quercus greenlandica (vide Hollick), Betula sp. (3-lobed bracts), dicot leaf fragments of Betulaceae (Corylos or Betula). Disseminated, fine plant debris. Populus sp. Betulacea (? Alnus). |
| 48[5] | 81JC125; 80BT150 | 62°24'00" lat.; 153°51'00" long.; about 0.4 km northwest of 4980 peak. | In Tvs overlying tuff sequence; contain Betulaceae (? Alnus). Several stacked leaves of one species; abundant charcoal branches. |
| 49[2] | 81BT471 | 62°24'30" lat.; 153°50'00" long.; at 3,500-ft elevation. | Bryozoan and brachipod fauna indicate possible late Paleozoic age. Remains of burrowing organisms as at map locality 31. |
| 50[5] | 80BT153 | 62°24'40" lat.; 153°50'10" long.; at about 3,900-ft elevation. | Coalified wood, plant stems, and unidentifiable dicotyleon leaves. |
| 51[2] | 80BT102 | 62°25'00" lat.; 153°50'00" long.; 1.2 km north-northwest of locality 50. | mDsc sandstone bed about 9 m thick contains abundant remains of burrowing organisms similar to Paleodictyon, and Granolaria. |
| 52[6] | 81BT548 | 62°23'30" lat.; 153°58'00" long.; about 1.4 km southwest of peak 5550 along ridgeline. | Thin, 1-m-thick lens of limestone in shale and sandstone (Dsc) contains Dendrostella sp. cf. D. trigemme. Species is indicative of late Eifelian and Givetian ages; genus is known only from Middle Devonian strata in North America and most other areas, although it ranges lower on some continents. Corals are probably not in growth position. |

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| 53[6] | 81BT554 | 62°24'00" lat.; 153°59'30" long.; about 0.5 km north-northwest from peak 5240. | Massive recrystallized limestone in Dl contains <u>Amphipora</u> <u>sp.</u>; phaceloid corals are recrystallized and not identifiable. Massive, laminated specimen seems to be of inorganic origin. <u>Amphipora</u> is probably Devonian (pre-Famennian) but may be Late Silurian. Because Dl is stratigraphically below mDsc, upper limit would tentatively be late Middle Devonian. |

[1]Identification by R.B. Blodgett, Oregon State University, Corvallis, Oregon.
[2]Field identifications by T.K. Bundtzen and J.G. Clough after Nelson (1979), Churkin and Carter (1972), and Bulman and others (1970).
[3]Identification by Claire Carter, USGS, Menlo Park, California; zones after Cooper (1979), and Rickards (1976).
[4]Reed and Elliott (1968b).
[5]Identification by C.J. Smiley, University of Idaho.
[6]Identification by W.A. Oliver Jr., USGS, Washington, D.C.
[7]May (1969).

Table 2. *Summary of selected mineral occurrences, McGrath B-2 Quadrangle, Alaska.*

| Map | Field | Cu (%) | Pb (%) | Zn (%) | Ag (oz/ton) | Au (oz/ton) | Sb (ppm) | Sn (ppm) | W (ppm) | Cd (ppm) | Co (ppm) | Ni (ppm) | Bi (ppm) | Mo (ppm) | Hg (ppb) | Cr (ppm) | V (ppm) | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 81BT428b | 2.3 | 0.20 | 3.1 | 0.98 | Tr | ND | ND | 3 | 200 | 100 | 10 | 100 | 4 | 70 | ND | 100 | Magnetite-diopside-garnet-sulfide skarn pods developed in laminated limestone (Pzl). Near contact of hornblende granodiorite dike. |
| | 81BT429a | 0.01 | 0.01 | 0.12 | 0.80 | Tr | ND | -- | 2 | 600 | 30 | 20 | 60 | ND | 70 | 150 | 600 | |
| | 81BT428a | 1.1 | 0.30 | 6.2 | 2.25 | 0.1 | ND | -- | -- | 100 | 100 | 20 | 30 | 10 | -- | 20 | 100 | |
| | 81BT428c | 1.0 | -- | 0.09 | 3.22 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | |
| 2 | 81BT427 | 0.36 | 0.17 | 0.94 | 0.39 | ND | ND | -- | 3 | 100 | 60 | 20 | 20 | 16 | 95 | 20 | 500 | 20 ppm gallium. Fracture fillings containing sulfides in chert near granodiorite dike. |
| | 81BT427a | 0.02 | 0.01 | 0.01 | Tr | ND | ND | -- | 2 | 500 | 30 | 20 | 50 | 10 | 90 | 150 | 500 | |
| | 81BT427b | 0.01 | 0.01 | 0.01 | Tr | Tr | ND | -- | -- | 600 | 30 | 7 | 20 | 4 | -- | 20 | 300 | |
| 3 | 80BT141 | 0.02 | 0.01 | 0.01 | 0.02 | ND | -- | ND | -- | -- | 20 | 150 | ND | 3 | -- | 20 | 500 | Disseminated chalcopyrite in mafic volcanic. |
| 4 | 80BT128 | 0.03 | 0.05 | 0.02 | 0.16 | Tr | -- | 60 | -- | -- | 70 | 70 | 20 | 3 | -- | 20 | 300 | Massive pyrrhotite in metasediments. |
| 5 | 81BT434a | 0.70 | 0.86 | 1.16 | 1.22 | ND | ND | -- | 3 | 200 | 30 | 10 | 30 | 9 | 120 | 20 | 200 | Diopside-garnet skarn zone (20 ft wide) containing base metals. |
| | 81BT432 | 0.17 | 0.01 | 0.02 | 0.17 | Tr | ND | -- | 2 | 150 | 20 | 2 | 60 | 13 | 65 | ND | 300 | |
| 6 | 81BT484 | 0.04 | 1.3 | 14.7 | 1.70 | ND | ND | -- | 2 | ND | 300 | 10 | 1000 | 4 | 115 | ND | ND | High-grade massive-sulfide skarn in carbonate xenolith within granodiorite dike. |
| 7 | 81BT459 | 0.05 | 0.47 | 0.56 | 0.21 | Tr | ND | -- | 2 | 160 | 50 | 2 | 70 | 10 | 60 | ND | 200 | Pyrrhotite-rich gossan in fracture filling, Tvb unit. |
| 8 | 81BT300 | 0.01 | 1.74 | 3.76 | 0.65 | Tr | 7 | -- | 3 | ND | 100 | 10 | 100 | 3 | 115 | ND | ND | Pyrrhotite-rich vertical shear zone in Silurian sandstone (Sss unit); contains disseminated galena and sphalerite. |
| | 81BT300a | 0.01 | 0.10 | 1.07 | 0.04 | ND | ND | -- | 2 | 200 | ND | 10 | ND | 5 | 100 | ND | 300 | |
| | 81BT300b | 0.09 | 0.84 | 3.24 | 0.80 | ND | 5 | -- | 2 | ND | 100 | 10 | 60 | 5 | 60 | ND | ND | |
| | 81BT301 | 0.06 | 0.60 | 2.2 | 0.33 | ND | ND | -- | 2 | 100 | 20 | 10 | 60 | 4 | 75 | ND | 100 | |
| 9a | 81BT331 | 0.02 | ND | 0.01 | Tr | ND | ND | -- | 2 | 100 | 20 | 20 | 20 | 7 | 75 | ND | 200 | Random grab samples of limonitic graphite-rich shale and chert, Osh unit, along 1/2 mi of Sheep Creek. |
| | 81BT332 | 0.01 | 0.01 | 0.02 | 0.02 | ND | ND | -- | 3 | 20 | 50 | 20 | 20 | 26 | 50 | 100 | 1000 | |
| | 81BT333 | 0.01 | 0.01 | 0.03 | 0.02 | ND | ND | -- | 3 | 20 | ND | 20 | 20 | 65 | 75 | 50 | 1000 | |
| | 81BT345 | 0.02 | 0.01 | 0.17 | 0.08 | ND | ND | -- | 3 | 200 | 50 | 20 | 20 | 75 | 60 | 50 | ND | |
| | 81BT322 | 0.02 | 0.06 | 0.14 | 0.08 | ND | 3 | -- | 3 | ND | 50 | 10 | 20 | 5 | 25 | ND | 300 | |
| 9b | 81JC102 | 0.50 | 0.11 | 13.0 | 0.77 | ND | ND | -- | 2 | ND | 300 | 10 | 20 | 3 | 160 | ND | ND | Skarn near granodiorite to rhyolite sill(?). |
| 10 | 81BT480 | 0.01 | 0.01 | 0.30 | 0.09 | 0.01 | 14 | -- | 2 | 150 | 50 | 100 | 30 | 6 | 70 | 1000 | 300 | Mafic sill, mDg unit with disseminated sulfide. |
| 11 | 81BT334 | 2.0 | 0.01 | 0.10 | 0.01 | ND | ND | -- | 2 | 150 | 20 | 10 | 50 | 7 | 90 | 20 | 200 | Silicified breccia pipe zone; in Silurian clastic. |
| 12 | 81BT339a | 0.85 | 0.98 | 0.68 | 2.51 | 0.02 | 10 | -- | 2 | ND | ND | 5 | 20 | 6 | 90 | 20 | 50 | Silicified breccia containing disseminated galena. |
| | 81BT339b | 0.10 | 1.01 | 0.30 | 2.10 | -- | -- | -- | -- | 30 | -- | -- | -- | -- | -- | -- | -- | |
| 13 | 81BT481 | 0.02 | 0.09 | 0.12 | 0.11 | ND | ND | -- | 2 | 300 | 20 | 5 | 50 | 6 | 80 | 100 | 200 | Disseminated chalcopyrite in extensive pyrite-rich halo; around Tqm breccia pipe. |
| 14 | 81BT488 | 0.02 | 0.01 | 0.01 | 0.02 | ND | ND | -- | 3 | 500 | 70 | 20 | 100 | 4 | 320 | 20 | 500 | Serpentenized zone near ultramafic sills, mDg unit. |
| | 81BT549 | 0.01 | -- | 0.01 | -- | -- | -- | -- | -- | -- | -- | 600 | -- | -- | -- | -- | -- | |
| 15 | 80BT150 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | Bituminous coal locality; Solie and Dickey (1982). |
| 16 | 81BT491 | 0.10 | 0.01 | 0.01 | 0.01 | ND | ND | -- | 4 | 500 | 50 | 30 | 50 | 2 | 180 | 100 | 700 | Sulfide gossan near granodiorite dike. |

Analyses by DGGS Minerals Laboratory, 1982. Cu, Pb, Zn, Ag, Au, Sb, and Mo by atomic absorption spectrographotometry; Cd, Co, Ni, Bi, Cr, and V by emission spectrography; Hg, W, and Sn by X-ray fluorescence; Be, Zr, Y, and Nb below detection limits.