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PRELIMINARY BEDROCK GEOLOGIC MAP OF THE TALKEETNA MOUNTAINS D-2 QUADRANGLE, ALASKA

by

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(map credits) Geologic mapping by T. E. Smith and T. K. Bundtzen, 1973-74; J. T. Kline, T. K. Bundtzen, and E. E. Harris, 1989; Petrography by T. K. Bundtzen, 1990

DESCRIPTION OF MAP UNITS

QUATERNARY DEPOSITS

Qs Undifferentiated Quaternary Deposits

MESOZOIC FLYSCHOID SEDIMENTARY ROCKS

KJs Conglomerate and Sandstone--Slightly calcareous interbedded polymictic conglomerate, lithic greywacke, siltstone and shale. This unit is confined to the northeasternmost corner of the map area and is bounded on the southeast by a segment of the Talkeetna Fault. Locally contains Bouma A-C intervals with upward-fining graded beds and fine crossbed sets. Conglomerates contain subrounded to well-rounded small boulder- to granule-sized clasts composed predominantly of basalt, andesite, diabase, greywacke, and siliceous argillite believed to be in part derived from the Amphitheater volcanics. Csejtey and others (1978) and Smith and others (1988) report the identification of fossils which were part of a late Jurassic faunal assemblage at a locality within this unit within less than a mile north of the map area. This unit is believed to be part of and/or correlative with the Kahiltna flysch basin (or terrane) as defined by Jones and others (1981), and the Gravina-Nutzotin flysch belt as described by Richter (1976).

TRIASSIC VOLCANIC, HYPABYSSAL AND SEDIMENTARY ROCKS OF THE AMPHITHEATER GROUP OF STOUT (1976).

Mafic metavolcanics and associated sediments and tuff are exposed in two prominent belts on both limbs of the Watana Creek Syncline in the study area. The name Amphitheater Basalt was originally applied to Triassic basalt on Paxson Mountain 100 km to the east of the study area by Rose and Saunders, (1965), and later expanded to Group rank by Stout (1976) and Smith (1981). The Group consists of four laterally and vertically defined rock units in the study area that appear to progress from pillowed marine flow deposits near its base to mainly subaerial flow and tephra deposits near its top. The total thickness of of the Upper Triassic section in the study area is estimated to be greater than 2,000 m.

TRl Limestone and shale--Remarkably undeformed light grey to dark grey, carbonaceous limestone lenses discontinuously exposed in reef-like lenses 1-2 km in strike length, and 10-30 m in thickness. One locality just north of the axis of the Watana Creek Syncline found by T.E. Smith in 1974 contains well preserved *Monotis* sp. of Late Triassic age.

Trmb Mafic basalt--Conspicuous unit of very dark green-grey to reddish-oxidized, medium- to coarse-grained, clinopyroxene-rich metabasalt. Locally cemented with iron oxide along fractures and prominent joints. Contains picritic sill complex (Mzms) near the axis of the Watana Creek Syncline and in the core of a fault-bounded block in the northeast portion of the study area near Coal Creek. The unit apparently constitutes the uppermost stratigraphic member of the Amphitheater Group.

TRab Partial marine and subareal amygdaloidal basalt flows, basaltic and andesitic tuffs, flows, dikes, sills and agglomerates--Generally altered. Color is dark to medium green in outcrop. Metamorphic minerals in amygdules include quartz, chlorite, epidote, prehnite, native copper and, locally, pumpellyite, indicating zeolite facies metamorphism. Unit similar to Tra but lacks pillows and displays hexagonal joint sets suggestive of columnar jointing.

TRa Pillow basalt and andesite--Dominantly a submarine eruptive sequence of dark green, fine- to coarse-grained, pyroxene-rich metabasalt and andesite. Original mineralogy inferred to have been clinopyroxene, calcic plagioclase, and olivine, later altered to prehnite, clinozoisite, chlorite and antigorite. Some outcrops display lava tubes and generally upright pillow structures (TRap) ranging upward to 2 m in long dimension. Local breccias observed. Unit apparently discontinuous along strike, but a thickness of several hundred meters occurs near the west central boundary of the study area on the south side of the Watana Creek syncline.

PERMIAN METASEDIMENTARY AND METAVOLCANIC ROCKS

The study area contains a 1500 m section of intermediate metavolcanic flows, tuff, pyroclastic detritus, and associated marine metasedimentary rocks repeated on both limbs of the Watana Creek syncline. The already complexly interfingering volcanic and sedimentary rocks have been further blurred and reconstituted by low grade regional metamorphism and by an array of intrusive sill and dike swarms injected along strike and bedding of preexisting rocks. The stratigraphic succession is partially tectonically dislocated, as can be seen in the interpretive cross sections accompanying the map. The section is tentatively correlated with lower portions of the Tangle subterrane as described by Nokleberg and others (1985), and Nokleberg and Fisher (1989), and which includes the Mankomen Group as defined by Richter and Dutro (1975), Richter (1976), and Richter and others (1977). The section is assigned an age of Early through early Late Permian based upon conodonts identified by Anita Harris (written communication, 1990) and collected from carbonates throughout the section.

Pac Light grey to medium grey meta-argillite, metachert, and cherty argillite intercalated with very fine-grained siliceous aquagene tuff--Locally banded (appears to be exhalative at some localities). Also included in this unit are distinctive siliceous conglomerates and breccias containing sparse to moderately common angular to subrounded black argillite and mafic igneous clasts suspended in a cherty matrix. Estimated thickness of about 20 m. May be laterally equivalent to ulPls.

Pvt Meta-andesite flows, tuff, and metasandstone--Distinctive uppermost unit of the Permian volcanics represented in this assemblage. Section consists of olive green, medium-grained, volcaniclastic crystal lithic aquagene tuff (30%) and pyroxene-hornblende meta-andesite flows (40%). The remainder of the section is occupied by mafic and intermediate flows. Meta-andesite contains albite, augite altered to antigorite, magnetite, abundant epidote, pumpellyite and pennine chloite.(flow units are locally amygdaloidal).

lPsmv Sheared mafic volcanic rocks--Mediun greenish-grey, conspicuously sheared meta-andesite and metadacite flow rocks on south limb of Watana Creek syncline. Contains minor sheared lapilli tuff with clasts of albitized plagioclase and clinopyroxene. Shearing is not well understood. Unit is estimated to be about 40 m thick.

ulPla Impure somewhat recrystallized silicious bioclastic limestone, chert and minor quartzite--Light gray fine- to medium-grained clastic limestone with quartz and argillitic angular lithic detritus. Locally crudely graded. Carbonate is frequently interbedded with pale green and light grey chert and cherty argillite. The unit grades laterally from carbonate-dominant to chert-dominant along strike. In one area a significant section of pure white orthoquartzite composed of fine- to medium-grained angular chert clasts is interbedded with carbonate. Unit contains both late Wolfcampian-to-Leonardian (middle to late Early Permian) and Leonardian-to-Guadolupian (late Early to early Late Permian) conodonts on each side of the Watana Creek syncline. Unit thickness ranges from 20-50 m.

Pmvs Metabasalt, meta-andesite, and metadacite--Generally undifferentiated unit containing volcanic flows, pyroclastics and tuff. Light to medium green, and fine- to coarse-grained for each volcanic rock type. Thin section examination of vesicular components shows the presence of abundant pumpellyite, chlorite, albitized plagioclase, and epidote.

Pat Aquagene tuff, argillite, and metasandstone--Dark grey to black, crystal-rich (albitized plagioclase) aquagene tuff, and interbedded dark green-grey fine-grained volcaniclastic sandstone and cherty argillite. May contain minor amounts of carbonate and thin, sheared metavolcanic flows. Unit generally overlies lPls limestone.

lPls Silicious bioclastic limestone and argillite--Light to medium grey, very fine-grained, laminated silicious limestone composed of fine-grained carbonate (45%), chert (40%), angular quartz (10%), and pelitic material (5%). Isolated grains of clinozoisite are probably the result of low grade metamorphism. Crinoid columnal-rich carbonate layers yield late Wolfcampian conodonts. Forms skarn (Tsk) adjacent to unit Tkif in north part of map.

HETEROGENEOUS METAMORPHIC ROCKS

Regionally metamorphosed rocks in the southern portion of the Talkeetna Mountains D-2 quadrangle are tentatively correlated with the metamorphic complex of the Gulkana River (Nokleberg and others 1989) and further east with the Strelna Metamorphics of Plafker and others (1989), which are defined as the metamorphosed portion of the Strelna Formation (now abandoned) of Moffit and Mertie (1923) and Moffit (1938). In the map area this heterogeneous metamorphic package appears to unconformably underlie Permian metasedimentary and metavolcanic rocks along the southeast limb of the Watana Creek syncline. The contact may represent a depositional unconformity which has later been faulted.

Regional metamorphic grade ranges from prehnite-pumpellyite through lower greenschist to amphibolite metamorphic facies, and increases toward the south. Age assignment is based upon conodont collections from equivalent rocks east of the map area (Nokleberg and others, 1986b; Nokleberg and others, 1989; Plafker and others 1989).

uPzdt Dolomite and metatuff--Very distinctive white dolomitic marble and tan to green metatuff. The dolomitic marble appears to be very pure and entirely recrystallized. Samples collected from this unit for microfossil age determinations were barren. Intense folding and shearing causes local interdigitation of the dolomitic marble and enclosing metatuffaceous rocks. The unit is easily traced along strike for approximately ten miles on the southern limb of the Watana Creek syncline. The unit usually overlies or is enclosed by maroon and sparse green phyllitic tuff (uPzfv) and apparently lies beneath volcanigenic and impure bioclastic limestones and clastic sediments (lPls) having conodont ages ranging from Early to early Late Permian.

uPzfv Silicified felsic metatuffs and metarhyolite to metadacite flows--Intercalated with minor marble, calc-semischist and a very distinctive dolomitic marble associated with a maroon and green phyllite near its upper contact, which can be traced for several kilometers along strike. In places the dolomitic unit is intensely deformed and recumbently folded and rolled into moulin-like bodies together with the accompanying maroon phyllitic tuff. A very silicic and in part hydrothermally altered zone occurs in a 1-2 km wide belt flanking the southern limb of the Watana Creek syncline.

uPzsv Mafic metabasalts, metaandesites, agglomerates, minor impure carbonates and pelitic semischists--Petrographically this heterogenious unit is composed of: 1) Green, medium-grained, locally porphyroblastic, chlorite-rich semischist, with porphyroblasts and grains of albite and epidote up to 5 mm in a felt-like groundmass of clinochlore; 2) medium to light grey, fine-grained, subschistose, locally calcareous, sericite-albite-potassium feldspar metafelsite. Relict twinned albitized feldspar phenocrysts, quartz grains, and phenocrysts with prominent resorbtion textures are visible in thin-section. Groundmass composed mainly of quartz and clinochlore or pennine grains. Protolith believed to be intermediate pyroclastics and tuffs; 3) Coarse grained quartz-bearing semischist and banded marble. Chlorite semischist is the dominant lithology (60%), followed by metafelsite and tuff (25%), and impure marble (15%). The presence of the metamorphic minerals epidote, albite, and clinochlore in chlorite semischist suggests lower greenschist metamorphic facies. Grade of metamorphism not determinable in other lithologic members of this unit. Locally hornfelsed (uPzsvh) adjacent to unit Kgd. Age control is lacking in the map area; unit believed to be correlative to part of the mid- to upper Paleozoic Strelna Metamorphics of the Haley Creek metamorphic assemblage (Plafker and others 1989), and the metamorphic complex of the Gulkana River (Nokleberg and Fisher 1989).

uPzsl Metapelites, mainly dark slate and phyllite--Epidote, chlorite, and albite are indicative of greenschist facies metamorphism. Metamorphic grade appears to increase gradually toward the south. Unit forms distinct band about 1 km wide and traceable for about 10 km along strike. The unit is bounded on the top and bottom by uPzsv and uPzas respectively.

uPzas Pelitic and mafic metavolcanic(?) schist and amphibolite--Brown to grey, biotite-rich, quartz, feldspar schist with occasional almandine(?) garnet porphyroblasts and dark green, generally fine-grained, massive hornblende amphibolite. Presence of hornblende and plagioclase suggests a metamorphic grade of amphibolite facies. Protolith probably flyschoid sediments and mafic to intermediate volcanic and hypabyssal rocks associated with the Skolai arc as described by Plafker and others (1989). Regional metamorphic grade of upper Paleozoic pelitic and volcanic and older intrusive rocks appears to increase in a southerly direction.

PLUTONIC ROCKS

TKif Felsite and fine grained granite plugs--Poorly exposed, highly alterd and weathered small bodies occurring thoughout the map area. Most are highly altered to sericite and clay with pyrite.

Kqm Quartz monzonite--Medium-grained, equigranular biotite quartz monzonite (locally granite). Contains up to approximately 5% biotite in groundmass of somewhat altered oligoclase, fresh orthoclase and quartz. CI=10. Quartz content estimated at 18-20% in two samples whch are from the felsic core of a zoned stock in the upper Coal Creek drainage, that is successively rimmed by quartz diorite (Kqd) and gabbro (Kgab). Essentially unfoliated except for contact effects near intrusive margins. This unit is probably similar to other Late Cretaceous plutons in the region radiometrically dated by Turner and Smith (1974).

Kqd Medium- to coarse-grained, generally equigranular, hypidiomorphic pyroxene-hornblende diorite--Partially rimming quartz monzonite on Coal Creek. In other localities occurs as small sill-like bodies in the metamorphic rocks south of the Susitna River and in metavolcanic and metasedimentary rocks to the north. Grades into both more felsic and mafic variants, and commonly contains xenoliths and pendants of enclosing metamorphic rocks. Locally forms a porphyry (Kqd-P) and locally foliated (Kqd-f).

Kgab Gabbro--Medium to dark grey, equigranular, pyroxene-hornblende rich gabbro, that may be the outermost mafic rim of the Coal Creek stock. Also occurrs as xenoliths in granodiorite stock on Jay Creek, suggesting that it constitutes the first phase of a multiphase stock complex in the southern portion of the map area.

Mzms Diorite, gabbro, picrite and pyroxenite sill and dike swarm complex--Locally profuse, highly differentiated intermediate to ultramafic dike swarms that intrude Permian volcanics and sediments and Triassic Amphitheater Volcanics roughly parallel to the strike. In places sills are difficult to differentiate from older flows. Two major compositional types comprise most of the unit: 1) gabbroic to picritic sills and 2) diorite to gabbroic sill and dike complexes. Other variants also occur, including hypabyssal stocks and laccoliths. The mafic-ultramafic sills as typified by those in the Watana and Jay creek drainages consist of cummulate, coarse-grained subophitic pyroxene-hornblende picrite that grade into gabbro and diorite normal to strike. Sill complexes are especially abundant on the northwest limb of the Watana Creek syncline. Garnet calc-silicate tactite skarns occur locally, close to sill and dike contacts with carbonates. Most sills typically are medium-grained, hypidiomorphic augite-rich gabbro with up to 25% clinopyroxene, and labradorite with ophitically intergrown reaction rims of hornblende.

The Mzms unit may have a wide range in age corresponding to multiple tectonic events. No isotopic ages are available for this unit within the map area, but unpublished hornblende ages of 97 and 92 ma were obtained by Bundtzen from similar rocks to the east on Miller Creek. Turner and Smith (1974) also suggest ages as young as Cretaceous for parts of the unit. Nokleberg and others (1985) suggest a comagmatic origin for some of the dikes and sills with the Nikolai Greenstone, which lies to the east of and is probably equivalent to the Amphitheater Volcanics, suggesting that some of the dikes and sills were feeders for portions of the Triassic volcanics.

KJgd Granodiorite--Light to medium gray, CI=25-30, medium-grained equigranular to gneissic biotite-hornblende granodiorite. Commonly foliated (KJgd-f). Isolated brown biotite grains average 5 mm long while pleochroic blue-green amphibole occurrs locally as aggregates and clots. Plagioclase averages andesine in composition. Modal quartz content estimated at 18-25% by volume. Age assignment based regional ages of similar foliated intrusives in the northern Talkeetna Mts (Turner and Smith, 1974).

REFERENCES

Bond, G. C., 1973, A late Paleozoic volcanic arc in the eastern Alaska Range, Alaska: Journal of Geology, v. 81, p.557-575.

Bond, G. C., 1976, Geology of the Rainbow Mountain-Gulkana Glacier area, eastern Alaska Range, with emphasis on upper Paleozoic strata: Alaska Division of Geological and Geophysical Surveys Geologic Report 45, 47 p.

Csejtey, Bela, Jr., Cox, D. P., Evarts, R. C., Stricker, G. D., and Foster, H. L., 1982, The Cenozoic Denali fault system and the Cretaceous accretionary development of southern Alaska: Journal of Geophysical Research, v. 87, p. 3741-3754.

Csejtey, Bela, Jr., Nelson, W. H., Jones, D. L., Silberling, N. J., Dean, R. M., Morris, M. S., Lanphere, M. A., Smith, J. G., and Silberman, M. L., 1978, Reconnaissance geologic map and geochronology, Talkeetna Mountains quadrangle, northern part of Anchorage quadrangle, and southwest corner of Healy quadrangle, Alaska: U.S. Geological Survey Open-File Report 78-598A, 60p., scale 1:250,000.

Forbes, R. B., Turner, D. L., Stout, J. H., and Smith, T. E., 1973, Cenozoic offset along the Denali fault, Alaska (abs): American Geophysical Union Transactions, V. 54, p. 495.

Jones, D.L., Silberling, N.j, Berg, H.C. and Plafker, George, 1981, Tectonostratigraphic Terrane Map of Alaska: U.S. Geological Survey Open-File Report 81-792, 2 sheets.

Jones, D. L., and Silberling, N. J., 1979, Mesozoic stratigraphy--The key to tectonic analysis of southern and central Alaska: U. S. Geological Survey Open-File Report 79-1200, 37 p.

Hillhouse, J. W., 1977, Paleomagnetism of the Triassic Nikolai Greenstone, McCarthy Quadrangle, Alaska: Canadian Journal of Earth Sciences, v. 14, p. 2578-2592.

MacKevett, E. M., Jr., 1978, Geologic map of the McCarthy quadrangle, Alaska: U. S. Geological Survey Miscellaneous Investigations Series Map I-1032, Scale 1:250,000.

Mendenhall, W. C., 1905, Geology of the central Copper River region, Alaska: U. S. Geological Survey Professional Paper 41, 133 p.

Moffit, F. H., 1912, Headwater regions of Gulkana and Susitna Rivers, Alaska, with accounts of the Valdez Creek and Chistochina placer districts: U. S. Geological Survey Bulletin 498, 82 p.

Moffit, F. H., 1938, Geology of the Chitna Valley and adjacent area, Alaska: U. S. Geological Survey Bulletin 894, 137 p.

Moffit, F. H., 1954, Geology of the eastern part of the Alaska Range and adjacent area: U. S. Geological Survey Bulletin 989-D, P. 65-218.

Moffit, F. H. and Mertie, J. B., Jr., 1923, The Kotsina-Kuskulana district, Alaska: U. S. Geological Survey Bulletin 745, 149 p.

Nokleberg, W. J., Albert, N. R. D., Bond, G. C., Herzon, P. L., Miyaoka, R.T., Nelson, W. H., Richter, D. H., Smith, T. E., Stout, J. H., Yeend, Warren, and Zehner, R. E., 1982, Geologic map of the southern part of the Mount Hayes quadrangle,Alaska: U.S. Geological Survey Open-File Report 82-52, 1 sheet, scale 1:250,000. 26 p.

Nokleberg, W. J., Foster, H. L., and Aleinikoff, J. N., 1989a, Geology of the northern Copper River Basin, eastern Alaska Range, and southern Yukon-Tanana Basin, southern and east-central Alaska, in Nokleberg, W. J., and Fisher, M. A., eds., Alaskan Geological and Geophysical transect 1989 International Geological Congress Guidebook T104.

Nokleberg, W. J., Plafker, George, Lull, J. S., Wallace, W. K., and Winkler, G. W., 1989b, Structural analysis of the southern Peninsular, southern Wrangellia, and northern Chugach terranes along the Trans-Alaskan Crustal Transect (TACT), northern Chugach Mountains, Alaska: Journal of Geophysical Research, in press.

Nokleberg, W. J., Wade, W. M., Lang, I. M., and Plafker, George, 1986b, Summary of geology of the Peninsular terrane, metamorphic complex of Gulkana river, and Wrangellia terrane, north-central and northwestern Gulkana quadrangle, in Bartsch-Winkler, Susan, and Reek, K. M., eds., Geologic studies in Alaska by the U.S. Geological Survey during 1985: U.S. Geological Survey Circular 978, p. 69-74.

Plafker, George, Nokleberg, W. J., and Lull, J. S., 1989b, Bedrock geology and tectonic evolution of the Wrangellia, Peninsular, and Chugach terranes along the Trans-Alaskan Crustal Transect in the northern Chugach Mountains and southern Copper River basin, Alaska: Journal of Geophysical Research, V. 94, no. 84.

Richter, D. H., 1976, Geologic map opf the Nabesna quadrangle, Alaska: U. S. Geological Survey Miscellaneous Geological Investigations Series Map I-932, scale 1:250,000.

Richter, D. H., and Dutro, J. T., Jr., 1975, Revision ofthe type Mankommen Formation (Pennsylvanian and Permian), Eagle Creek area, eastern Alaska Range, Alaska: U.S. Geological Survey Bulletin 1395-B, p. B1-B25.

Rose, A. W., 1966a, Geological and geochemical investigations in the Eureka Creek and Rainy Creek areas, Mount Hayes quadrangle, Alaska: Alaska Division of Mines and Minerals Geologic Report 20, 36 p.

Rose, A. W., 1966b, Geology of part of the Amphitheater Mountains, Mount Hayes quadrangle, Alaska: Alaska Division of Mines and Minerals Geologic Report 19, 14 p.

Rose, A. W., and Saunders, R. H., 1965, Geology and geochemical investigations near Paxson, northern Copper River Basin, Alaska: Alaska Division of Mines and Minerals Geologic Report 13, 35 p.

Silberling, N. J., Richter, D. H., Jones, D. L., and Coney, P. C., 1981, Geologic map of the bedrock part of the Healy A-1 quadrangle south of the Talkeetna-Broxson Gulch fault system, Clearwater Mountains, Alaska: U. S. Geological Survey Open-File Report 81-1288, scale 1:63,360.

Smith, T. E., 1981, Geology of the Clearwatewr Mountains, souith-central Alaska: Alaska Division of Geological and Geophysical Surveys Geologic Report 60, 72 p., 1 sheet, scale 1:63,360.

Smith, T.E., Albanese, M.A., and Kline, G.L., 1988 Geologic Map of the Healy A-2 Quadrangle, Alaska: Division of Geological and Geophysical Surveys Professional Report 95, 1 sheet, scale 1:63,360; .

Smith, T. E., Forbes, R. B., and Turner, D. L., 1974, A solution to the Denali fault offset problem: Alaska Division of Geological and Geophysical Surveys, Annual Report, 1973, p. 25-27.

Smith, T. E., and Turner, D. L., 1973, Geochronology of the Maclaren metamorphic belt, south-central Alaska; A progress report: Isochron/West, no. 7, p. 21-25.

Stout, J. H., 1976, Geology of the Eureka Creek area, east-central Alaska Range: Alaska Division of Geological and Geophysical Surveys Geologic Report 46, 32 p.

Turner, D. L., and Smith, T. E., 1974, Geochronology and generalized geology of the central Alaska Range, Clearwater Mountains and northern Talkeetna Mountains: Alaska Division of Geological and Geophysical Surveys Open-File Report AOF-72, 10 p.

TABLE 1

INVERTEBRATE FOSSIL IDENTIFICATIONS FROM THE TALKEETNA MOUNTAINS D-2 QUADRANGLE, SOUTHCENTRAL ALASKA

Map No. (Field No.)	Location	Description	Age
1 (89BT178B)	from lowest carbonate unit (lPls) on Northwest limb of Watana Creek syncline.	3 Pa element fragments of Neogondolella bisselli; 4 indetermentant bar, blade, and platform fragments; CAI=5.5 indicating host rock reached 350 C.	middle to late Wolfcampian (early, but not earliest Early Permian).
2 (89BT179)	in uppermost siliceous carbonate unit (ulPla) on Northwest limb of Watana Creek syncline; about 100m stratigraphically above fossil locality #1.	3 Pa element fragments of Neogondolella bisselli; (Clark and Behnken) and Neogondolella, Idahoensis plexus (Youngquist, Hawley and Miller). CAI=5.5 to 6.0	late Wolfcampian to Leonardian (middle to late Early Permian).
3 (73AST63)	from Trl carbonate lenses in Watana Creek Valley.	several Monotis sp and unidentified coral remains.	Upper Triassic (probably Norian stage).
4 (89HA44)	from fossiliferous limestone (ulPla) overlain by interbedded banded chert; on Southeast limb of Watana Creek syncline.	2 Pa elements of Neogondolella gracilis; 18 Pa element fragments of Neogondolella sp; CAI=5.5 to 6.0 indicating host rock reached 350 C.	late Leonardian (latest Early Permian).
5 (89HA53)	from recrystalized crinoidal limestone (lPls) in Watana Creek drainage, on the Southeast limb of Watana Creek syncline.	2 Pa element fragments of Neogondolella sp and 1 Pa element of Xaniognathus sp; CAI=7.0 indicating host rock reached 450 C.	Permian.
6 (89BT161)	from siliceous carbonate unit (ulPla) on Southeast limb of Watana Creek syncline.	1 Sa and 1 Sc element of Hiddeodus excavatus; 1 M element of Xaniognathus sp; 4 Pa elements of Neogondolella biteeri; 16 indeterminate bar, blade and platform fragments.	Probably early to middle Guadalupian (late Early to early late Permian).

Conodant identifications by J.E.Repetski, U.S.Geological Survey;
Mollusc identification from locality #3 by N.L.Silberling, U.S.Geological Survey.