

Northwest Geological Society



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Society Field Trips in Pacific Northwest Geology

Continental Margin Geology of Northeastern Washington

June 4-5 2005

Ted Doughty

Eastern Washington University

Andy Buddington

Spokane Community College

Bob Derkey

Washington State Department of Natural Resources

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Northeastern Washington State exposes the long-lived continental margin of North America (Kootenay Arc) that dates from the late Precambrian into the Mesozoic. Important geologic elements include: (1) the pre-rift Middle Proterozoic Belt Supergroup (and probably correlative Deer Trail Group) (Miller and Whipple, 1989), (2) the Late Proterozoic "rift" sequence of the Windermere Group (Miller, 1994), (3) early to middle Paleozoic platform sediments and shallow water to deep water passive margin sediments (Dutro and Gilmour, (1989), (4) Permian to Triassic marine sediments and mafic volcanics of the Quesnel terrane (Cheney et al., 1994), and (5) intense structural deformation related to terrane collision and suturing (Watkinson and Ellis, 1987). As well, the Deer Trail Group hosts interesting (if not significant) magnesite mineralization of questionable origin (Campbell and Loofbourow, 1962), and within the Windermere Group are two diamictites that possibly correlate with the global Sturtian (700 Ma) and Marinoan (635 Ma) Snowball Earth glaciations (Hoffman, 1998).

The field trip will begin in the southern portion of the Colville River Valley and travel via the town of Valley west to the Huckleberry Mountains. From there we will retrace our route back to the Colville Valley and then travel north to towns of Chewelah and Colville. The second part of the trip will travel from Colville northwestward to examine exposures in the Kettle Falls area along the Columbia River (Fig. 1).

Day 1: Valley-Stensgar Mountain-Colville areas

The first day will be a transect through the Precambrian to early Paleozoic stratigraphy of the platform and continental margin (Fig. 2). We will examine Middle Proterozoic rocks of the Belt Supergroup and Deer Trail Group (Fig. 3) along with a brief examination of Mississippian platform carbonates beneath the Jump Off Joe thrust fault. We will also examine rocks of the Windermere Group and a magnesite deposit in the

Magnesite Belt of Stevens County and finish with a look at Lower Paleozoic platform sequence rocks. The field trip (and mileages) will begin at the intersection of U.S. Highway 395 and the Deer Lake turnoff.

0.0 Set Odometer. From the Deer Lake road, turn right and drive north on U.S. Highway 395.

1.0 Hillside to left (west) is Middle Proterozoic Wallace Formation (Middle Belt Carbonate Group) of the Belt Supergroup.

1.2 Columbia River Group basalts on left. These are some of the most northerly exposed CRB's in NE Washington.

2.0 Ravines represent Pleistocene ice margin meltwater stream channels. 2.2 Addy Formation quartzites (Cambrian) on right (east).

2.9 Turn right on Roitz Road. Note to the east the prominent ridge/hogback of Addy Formation quartzite, which sits unconformably on Belt Supergroup rocks.

3.5 Turn right on Solokar Road.

3.7 Start climbing up glacial morainal deposits on top of Addy Fm.

4.0 Driving down and through an ice margin stream canyon.

4.4 STOP 1. A-Pease barite deposit.

Park on left. Cross road to quarry area. Sediments of Belt Supergroup (Fig. 3) are exposed in the pit walls and on outcrops adjacent to pit. A total production of 400 tons for drilling mud

is described (Moen, 1964). Note the quarry is elongated to bedding and follows a 3 foot wide zone of white to reddish black “bedded” barite (best exposures at south end and above). The host consists of thinly laminated, maroon argillite-siltite (some quartzite) with abundant mudcracks, salt casts, and ripples. Belt aficionados will undoubtedly make the call of the Formation within the Group.

Turn around and return to Highway 395.

5.8 Turn right (north) onto Highway 395.

6.6 Pleistocene outwash gravels.

7.4 Turn left (west) on Bulldog Creek Road toward Valley/Waits Lake.

7.5 Kettle lake on left within lateral moraine of the Pleistocene Colville Lobe of the Cordilleran ice sheet.

7.8 Turn left (south) on West Jump Off Road. Stay straight on W. Jump Off.

8.5 Ridge on right is of Mississippian limestones.

9.2 Outcrops on right and up the hill of Mississippian carbonates.

10.2 STOP 2. Mississippian carbonates in the footwall of the Jump Off Joe fault.

Park in quarry area to right. This outcrop exposes Mississippian platform carbonates of North American affinity in the footwall of the Jump Off Joe thrust fault. The Jump Off Joe thrust fault is one of the major structures in the Kootenay Arc. It separates Belt Supergroup rocks overlain by a thin sequence of Paleozoic platformal sediments east of the fault from pre-rift Precambrian rocks of uncertain affinity (Deer Trail Group) overlain by a thick section of Windermere Group sediments and volcanics and a thick section of Paleozoic passive margin sediments.

This outcrop consists of gray, thinly to medium bedded limestones, locally fossiliferous with small crinoids stem fragments and fossil hash. Cherty interbeds (1-3 cm) show displacement by multiple high-angle (calcite-filled) fault structures. Also abundant throughout the outcrop with increasing intensity toward the top of the exposure (west) is brecciated carbonate with white sparry calcite matrix and calcite-filled vein arrays.

Climb to top for nice views of the Colville River Valley to the north. Miller (1969) mapped the Jump Off Joe fault directly to the west where these Mississippian limestones are overthrust by Middle Proterozoic Deer Trail Group and Late Proterozoic Windermere Group rocks.

Turn around and return to Bulldog Creek Road.

12.5 Turn left (west) on Bulldog Creek Road toward the

town of Valley.

12.9 Stratified sand & gravel in pit on right. Downslope movement of material has obscured exposure of stratification. The road drops down into the Colville River Valley, which was occupied by the Pleistocene Colville Lobe.

13.6 Turn right (north) on Highway 231 to Valley. Note large sand & gravel quarry on right in Pleistocene kame deposit.

14.3 Lane Mountain silica mill and plant on left. Mining of clean quartzites of Addy Formation supplies material for this silica production facility.

14.7 Entering the metropolis of Valley, Washington. Note prominent cliffs of Addy Formation to the north. 14.9 Turn left (west) on the Waits Lake Road at the main intersection in town.

15.0 Cross railroad tracks.

15.1 Cross Colville River. Note the small size of this stream relative to the broad valley. Also note that the Colville flows north toward the apparent highlands “up valley”. Both the Colville River and Pend Oreille River (to the east) have reversed drainage due to the lag time between glacial melting and isostatic rebound.

15.4 (Optional Stop) View to the south shows low-lying hills of the Springdale end moraine, the southernmost extent of the Colville Lobe. At this location, the estimated ice thickness would have been approximately 750 meters (Carrara, et al., 1996). To the west, the prominent cliff face is the northernmost exposures of Columbia River Group basalts in the Colville valley.

16.3 Begin climbing low hill, quarry in Stensgar dolomite (Deer Trail Group) to right (north).

The Deer Trail Group (Fig. 3, 4) consists of a >2 km thick sequence of argillite, siltite, quartzite, conglomerate, dolomite, and magnesite that was metamorphosed to lower greenschist grade and strongly deformed during the Mesozoic (Fig. 5) (Evans, 1987; Watkinson and Ellis, 1987). It is composed of two thinly bedded formations of dark grey to green slate with minor vitreous clean quartzite (Togo Formation and McHale Slate) that record relatively quiet water deposition. These formations are interbedded with two distinctive dolomite formations. The Edna Dolomite (now subdivided into the Wabash Detroit and Chamokane Creek Formations, see below) and Stensgar Dolomite, which occur in the lower third and near the top of the Deer Trail Group, and contain algal structures, oolites, salt casts, and layers of chert and are interbedded with minor amounts of argillite and conglomerate (Campbell and Loofbourow, 1957, 1962; Campbell and Raup, 1964; Evans, 1987; Miller and Whipple, 1989). The Stensgar Dolomite contains economic deposits of magnesite (one of only two districts in the U.S) that probably formed by seawater.

ter evaporation (Frank and Fielding, 2003). The Buffalo Hump Formation is the youngest unit in the Deer Trail Group and is composed principally of slate interbedded with lesser amounts of conglomerate and quartzite, some of which is festoon cross-bedded (Evans, 1987). It represents a major increase in the energy of deposition in the Deer Trail Group. The thickness of the Buffalo Hump and individual layers within it vary significantly along the strike of the magnesite belt (Campbell and Loofbourow, 1962; Evans, 1987).

Undated greenstone dikes, sills, and volcanics (?) are common throughout the Deer Trail Group and may be feeders for the lavas in the overlying Huckleberry Formation (see below) (Campbell and Loofbourow, 1957, 1962; Evans, 1987; Becraft and Weis, 1963). Some of the concordant igneous bodies, which occur at the upper contacts of both the Edna Dolomite and Stensgar Dolomite, may be volcanic in origin (Miller and Whipple, 1989), and a date on these could help determine the minimum age of the Deer Trail Group.

Prior to 1992, the entire Deer Trail Group was widely viewed as 1.5 Ga-1.4 Ga in age and correlative with the upper Belt-Purcell Supergroup (Wallace and Mt. Shields Formation) (Campbell and Loofbourow, 1962; Becraft and Weis, 1963; Evans, 1987; Miller and Whipple, 1989; Miller and Clark, 1975). This correlation was based solely on lithocorrelation between the two sedimentary rock units, but substantial differences in lithology (i. e., there is no appreciable magnesite in the Belt-Purcell Supergroup) led to considerable uncertainty in how to exactly correlate the two (Miller and Whipple, 1989). A Mesoproterozoic age for the entire Deer Trail Group and its correlation with the Belt-Purcell Supergroup have not been supported by the presence of 1070-1224 Ma detrital zircon in the lower part of the Buffalo Hump Formation (Ross et al., 1992). These detrital zircon ages demonstrate that the Buffalo Hump Formation, and therefore at least the upper part of the Deer Trail Group, cannot be older than 1.1 Ga and cannot correlate with the Mesoproterozoic Belt-Purcell Supergroup. As a result, Winston and Link (1993) split the Buffalo Hump Formation from the Deer Trail Group and correlated them separately. For the lower part of the Deer Trail Group (below the Buffalo Hump Formation), they retained the correlation of the Deer Trail Group with the Belt-Purcell Supergroup. For the upper part (Buffalo Hump Formation), there was too much uncertainty in its age to assign a possible correlation.

17.6 WaittsLake.

19.1 View to west of Lane Mountain quarry; ridge to south of Jurassic quartz monzodiorite of Lane Mountain (Miller, 1996). Approach to Huckleberry Mountains, Stevens County.

20.4 Outcrops on right of McHale slate; Middle Proterozoic, Deer Trail Group.

22.0 Quarry on right of stratified glacial outwash deposits.

22.3 On left, Lane Mountain silica quarry road. On right, abandoned adit (which we will visit on return).

22.4 Carrs Corner: go left on Red Marble Rd.

24.7 Cross creek; wetlands on both sides in the slate-rich Togo Formation (lower Deer Trail Group).

24.8 (Optional Stop). Chamokane Creek Formation (formerly Edna Dolomite), Deer Trail Group.

Miller (1996) defines as the carbonate-bearing siltite, quartzite, argillite unit formerly as the lower portion of the Edna Dolomite. Designated as top of highest thick, carbonate-bearing quartzite below the predominately dolomite section of the Wabash Detroit Formation (new name, Miller 1996). Above the Togo Formation. Note strong cleavage in phyllitic argillite with respect to the bedded dolomites and thick bedded quartzites. Is there more than one deformational event apparent in this outcrop?

24.9 Red soils, Wabash Detroit Formation (formerly upper portion of the Edna Dolomite), see Stop 4 below.

25.3 STOP 3. McHale Slate, Deer Trail Group.

Park on right. Small quarry in McHale slate; dark gray, well laminated argillite and slate. Note cleavage relative to bedding. Look closely for a second (or third?) deformation event recorded by crenulations of the cleavage.

The McHale Slate unit is named after exposures in McHale Canyon in the Addy quadrangle (Campbell and Loofbourow, 1962). In places argillite is interbedded with light-gray siltite with some exhibiting graded bedding. Some soft-sediment breccias are described by Miller and Clark (1975). Dolomitic interbeds (<2 cm) occur toward the top of the formation. Total thickness of the McHale Slate is estimated at approximately 370 meters (Miller, 1996).

25.5 Dark gray to black McHale slate.

25.7 STOP 4. Wabash Detroit Formation (formerly the upper section of the Edna Dolomite).

Park wherever there's room. Fold nose in dolomites of Miller's (1996) new Wabash Detroit Fm. (approx. 240 meters thick), defined as the interval between the base of the lowest dark-gray argillite of the McHale Slate and top of highest thick carbonate-bearing quartzite of the Chamokane Creek Fm. The Wabash Detroit contains abundant stromatolitic beds that have been affected by cleavage development. Greenstone flows or sills occur "persistently" within the Wabash Detroit unit up to the base of the McHale Slate (Miller, 1996).

27.1 (Optional Stop). Upper McHale Slate.

Gray to dark gray phyllitic argillite and slate. Well developed crenulation cleavage cuts "ghost" bedding with carbonate interbeds. Tension fractures are filled with calcite. Again try and see if there is more than one deformation exposed in

this outcrop.

27.5 Orange-red soils; Stensgar Dolomite.

28.2 Red Marble Quarry; lower benches.

28.7 STOP 5. Red Marble Quarry, Stensgar Dolomite, Deer Trail Group.

Park on left. Walk 50 meters, on left, exposures of steeply dipping McHale slate. Continue 250 meters along upper bench road to Red Marble Quarry. This quarry exposes the Stensgar Dolomite (Fig. 3, 4), which is a well laminated dolomite, that has been extensively mineralized with magnesite (MgCO₃). Small-scale crossbedding in the Stensgar dolomite suggests deposition in shallow water. At this locality, the Stensgar is intruded by a diabase dike. Dikes and sills of this composition are common in the Deer Trail Group. The age of these sills is uncertain. Miller (1996) suggested that some of the sills could be lava flows, but conclusive evidence is lacking. More likely, the mafic igneous rocks were feeders for the extensive mafic volcanics in the overlying Huckleberry Volcanics (Windermere Supergroup).

The Red Marble Mine is one of numerous magnesite deposits of the Magnesite Belt (Campbell and Loofbourow, 1962). All deposits occur exclusively within the Stensgar Dolomite and appear to be within the same time horizon (middle Stensgar). The Stensgar Dolomite is up to 500 meters thick at the Keystone mine (Evans, 1987) and thins to the southwest. The Stensgar consists of white to light-gray laminated to thin-bedded dolomite, with minor silty to argillaceous interbeds.

The Red Marble mine, in production from 1949 to the early 1980's, contains refractory-grade magnesite and is thought to have contained over 5 million tons of ore. The Red Marble magnesite occurs in a variety of colors from gray to blackish-gray to the unique red magnesite. Textural varieties include massive, coarse sparry magnesite, to fine, bedding parallel magnesite, to "spotted" and "zebra-like". Spectacular solution breccias can also be observed in the southeastern bench faces at mid-level. The magnesite occurs as a lens shaped mass up to 150 meters thick with a 1000 meter strike length that is overall stratabound (within the Stensgar). But in places the magnesite clearly crosscuts bedding within the dolomite.

Origin of the deposits is uncertain. Purity of the Stensgar may be a controlling factor with the host horizon of the Stensgar having the purest (least amount of pelitic or silicic impurities) dolomite within the Deer Trail Group. Early workers suggested a hydrothermal replacement origin possibly associated with regional igneous activity. Arguments against igneous-related hydrothermal replacement include the fact that no magnesite mineralization occurs within any other dolomitic units within the Deer Trail. An alternative interpretation for mineralization is the remobilization of syndepositional magnesite (Middle Proterozoic) as the result of an elevated geothermal gradient during tectonism.

29.1 Stensgar Dolomite.

29.2 Contact with Buffalo Hump Formation. Stratigraphically above the Stensgar (Fig. 3, 4), the Buffalo Hump is composed mainly of slates (poorly exposed) and quartzites at least 750 meters thick (Campbell and Loofbourow, 1962). Black to brownish gray slates dominate the unit with interbedded white to pale gray, light-brown, fine to coarse-grained quartzites. Quartz pebble conglomerate interbeds occur within the unit with clasts flattened parallel to cleavage. In the Stensgar Mountain area, Evans (1987) describes 4:1 stretching ratios for clasts that plunge to the NNE. The Buffalo Hump is named after the characteristic assemblage exposed in the prominent knob (the Buffalo Hump) south of Huckleberry Creek over which passed the aerial tram from the Finch mine to the Keystone and Red Marble mines. The tram was built by Northwest Magnesite Co to transport magnesite ore to the milling facility near Chewelah.

The Buffalo Hump formation was originally included in the Deer Trail Group, but recent dating of detrital zircons (Ross et al., 1992) show that the Buffalo Hump Formation can be no older than 1070 Ma. It may be part of the Windermere Supergroup, or perhaps part of a sedimentary sequence between the age of the Deer Trail Group and the Windermere Group.

29.3 (Optional Stop) Quartzite of the Buffalo Hump Formation. Thick bedded coarse-grained, clean white quartzite.

29.8 Trace of Stensgar thrust of Evans (1987) and Miller and Yates (1976). This "thrust" places the younger Huckleberry Formation over the older Buffalo Hump Formation—a relationship that is more compatible with an unconformity.

30.0 Outcrops of Huckleberry Formation (Windermere Group) diamictite.

30.2 STOP 6. Stensgar Mountain saddle and Huckleberry Formation, Windermere Group.

Park at saddle. Beautiful views to the west of the Huckleberry Mountains in foreground with Lake Roosevelt (Columbia River) and the southern Kettle Core Complex (to northwest) and Lincoln Dome to the southwest. Walk back down road approximately 200 meters. Cross contact (not exposed) from upper Greenstone member back down into the lower Conglomerate member of the Huckleberry Formation (Fig. 6).

The Conglomerate member of the Huckleberry Formation is up to 480 meters and contains diamictite, conglomerate, siltite, argillite and lithic quartzite (Miller, 1996). The diamictite and conglomerate are pale green to gray matrix-supported and dominate the unit. Clasts are of Deer Trail lithologies and consist of dolomite, argillite, siltite, and quartzite. Clasts are flattened and have developed schistosity in plane of flattening. The Huckleberry diamictite is the lower of two diamictite units within the Windermere (Miller, 1996). The Huckleberry

diamictite and conglomerate correlates with the Shedroof Conglomerate in the Salmo-Priest area to the northeast and with Toby Formation of southern British Columbia. Hoffman (per. comm.) concludes that the diamictites of the Huckleberry (and Toby) are generally correlated with the globally recognized Sturtian glacial diamictites associated with Snowball Earth glaciation during the Late Proterozoic. Sturtian diamictites have been recently dated around 710 Ma in southern Idaho. Evidence for Sturtian glaciation being a “Snowball” event includes the paleomagnetic data (Frankline mafic suite) indicating the northern Cordillera lay close to the Proterozoic (727 Ma) equator.

The Deer Trail Group is overlain by the Huckleberry Formation, which consists of a basal conglomerate member and an upper mafic volcanic rocks member (Campbell and Loofbourow, 1962; Evans, 1987, Miller, 1994). The Huckleberry Formation is correlative with the Shedroof Conglomerate and Leola volcanic rocks to the northeast (Campbell and Loofbourow, 1962) and the Toby Formation and Irene Formation in British Columbia (Brown et al., 1995; Miller, 1994).

The Huckleberry conglomerate member is composed of polymictic conglomerates and glaciogenic diamictites whose drastic changes in thickness along the strike of the Magnesite Belt records deposition in fault-bounded, rift basins (Kubli and Simony, 1992; Lickerish and Simony, 1995; Evans, 1987; Warren, 1997; Miller, 1994; Lis and Price, 1975; Aalto, 1971). The upper volcanic member is composed of greenstones deposited as basalt flows, pillow lavas, and mafic tuffs (Campbell and Loofbourow, 1962; Evans, 1987, Miller, 1994). The age of the Huckleberry Formation volcanic rocks are not well known. Miller et al. (1973) reported K-Ar dates that ranged in age from 918-233 Ma and Devlin et al. (1988) reported a Sm-Nd isochron age of 762 +/- 44 Ma. Given the high uncertainty in these ages, the Huckleberry Formation volcanic rocks could range widely in age from ca. 780 Ma (Gunbarrel event, Harlan et al., 2003) to potentially as young as ca. 700 Ma (Lund et al., 2003). It is unlikely, although possible, that they could be as young as 570 Ma (rifting in southeastern British Columbia, Colpron et al., 2002). The Huckleberry Formation is unconformably overlain by the Cambrian Addy quartzite in the Magnesite Belt (Campbell and Loofbourow, 1962), but overlain by the Monk Formation, a slate and diamictite unit, to the northeast (Miller, 1994).

30.7 Outcrops of Huckleberry volcanics; greenstone flows, tuffs, and volcanic breccias.

30.8 STOP 7. Huckleberry Formation, Greenstone member.

Park up above the outcrop near switchback in road (at 30.9) and walk back down. Huckleberry greenstones (Fig. 6) with chlorite-filled vesicles. Flow units (etc.) difficult to recognize. Greenstone composition is tholeiitic basalt and may contain pyroxene and plagioclase crystals, and is locally porphyritic (Miller and Clark, 1975). Up to 975 meters thick; upper contact

is an unconformity and the lower contact is a fault (Miller, 1996). Miller et al. (1973) reported K-Ar dates that ranged in age from 918-233 Ma and Devlin et al. (1988) reported a Sm-Nd isochron age of 762 +/- 44 Ma.

31.2 Contact between Huckleberry greenstones and overlying Addy Formation.

31.3 STOP 8. Addy Formation.

Park at switchback; if caravan of numerous vehicles, pull well into side road to north; this will be the turn around point. Another option is to continue to the summit of Stensgar Mtn. for scenic view and to examine Huckleberry greenstones on north side of summit. A cell tower at summit makes for good reception for those that need their hourly cellular phone fix. Walk up the road to prominent outcrops of Addy Formation.

Outcrops of Addy quartzite. The Addy (Fig. 7) (latest Proterozoic to lower Cambrian) unconformably overlies the Windermere and is composed of a white, gray, tan to purplish quartzite with lesser amounts of siltite and argillite. It has been divided into four members: upper member, coarse-grained member, purple member, and lower member. Here bedding is easily discerned and some crossbedding is present. Total thickness of Addy is at least 1160 meters in the Stensgar-Addy map areas. Miller designates this section of Addy as “undivided” (1996), but presence of crossbeds and white, vitreous quartzite suggests this to be the Lower member.

The unconformity between the Addy Formation and underlying Precambrian rocks is commonly referred to as a breakup unconformity, which records subsidence and sea level rise as the passive margin becomes fully developed and moves away from the rift.

A major conundrum of Kootenay Arc tectonics is the timing of rifting recorded in the Huckleberry Formation and the development of the passive margin. Devlin et al. (1988), used subsidence curves of Paleozoic rocks along the western edge of North America to show that rifting, subsidence, and development of the passive margin did not occur until about 560 Ma. The age of the Huckleberry Formation (~ 762 Ma), which presumably relates to rifting, predates the formation of the passive margin by ~ 200 Ma. This discrepancy implies two rifting events, one in the late Proterozoic and another in the early Cambrian. If so, where is the evidence for the younger rifting event?

Return to Carrs Corner.

40.7 Turn right at Carrs Corner back towards Waitts Lake

40.8 STOP 9. Monk Formation conglomerate and Lane Mountain fault.

Park on left across from Lane Mtn. silica quarry road. Proceed to outcrops (north) adjacent to abandoned adit. Here the Togo Formation (Deer Trail Group) is thrust over (Lane Mountain thrust) the Monk Formation (upper Windermere Group) conglomerate. At the adit, Togo dolomite (white to gray) occurs to the northwest with Monk Formation stretched pebble conglomerate to the southeast. Miller informally subdivides the Monk into 3 members; Argillite member, Greenstone member, and Conglomerate member. In the latter he describes a conglomerate with a khaki siltite/argillite matrix (west side of Lane Mountain). He also describes a matrix-supported diamictite in the conglomerate above the Greenstone member. The diamictite has a tan carbonate-bearing to dark green siltite/argillite matrix with a volcanoclastic component. He does not describe clast components. Near Waitts Lake he describes the Conglomerate member to consist of a megabreccia with angular dolomite blocks.

This Monk diamictite (Fig. 6) probably correlates to Marinoan-aged Snowball Earth glaciation (635 Ma). One interesting question regarding the Snowball Earth diamictites in NE Washington is the absence of a carbonate cap that typically follows the Snowball deep freeze event. Carbonate caps for Sturtian-aged Snowballs are “less well developed than the Marinoan ones” and that may be because the Sturtian oceans were “less oversaturated with CaCO₃ at the time of Sturtian glacial termination” (Hoffman, per. comm.). An alternative is that the Huckleberry (and Monk) diamictites represent either very deep basinal environment (reverse solubility of CaCO₃) or subaerial deposition. Which of these Snowball scenarios do you prefer?

Return Valley via Waitts Lake Road.

0.0 At intersection with Highway 231, reset odometer and turn left (north) toward Chewelah.

2.6 Outcrops of argillite-siltite on right. Mapped by Miller (1969) as Precambrian rocks of uncertain age above the Jump Off Joe fault. Directly behind and up the ridge, Huckleberry Formation is overlain by the Addy Formation. The presence of the Huckleberry Volcanics suggest that these argillites and siltites are part of the Deer Trail Group.

3.3 Junction with Highway 395. Turn left (north) toward Chewelah.

6.2 Old magnesium plant on left.

7.3 Entering Chewelah.

9.6 Glacial terraces to north; glacial lake sediments.

11.0 Addy quartzites on right.

11.5 Cross Jump Off Joe fault (or Lane Mountain Fault?).

12.5 Quarry on right in Stensgar Dolomite.

13.5 We are following the course of the Colville River to the

north; note how the valley narrows “downstream” toward highlands.

13.7 STOP 10. Huckleberry Formation volcanics.

Drive past prominent roadside outcrop and park on right. Near vertical greenstone flows of the Huckleberry Formation. Look closely for pillows and chlorite filled vesicles. Pillows are most abundant in the lower portion of the Greenstone member of the Huckleberry. A fault zone occurs on the north end of outcrop with well formed fault breccia.

14.8 Huckleberry greenstones on right.

14.9 Addy quartzite makes rounded and polished (with striations) on right. Note glacially sculpted knob of Addy to west.

16.1 Thriving metropolis of Addy, Washington.

16.2 Addy Formation in hillside and cliffs to right (east). Good fossiliferous Addy on back side of small hill. The fossiliferous section at Addy marks this as the Upper member (Cambrian).

18.1 Addy quartzites on right.

19.4 Glacial lake deposits and hummocky outwash terrain, underlain by Cretaceous intrusives.

21.8 Cretaceous granitics (Kaniksu) with ridge of Metaline Formation (Cambrian-Ordovician carbonates) to north.

25.3 Old Arden Highway on right with ridge of Metaline-Ledbetter Formations.

26.4 High ridge to right consists of limey argillite of the Ledbetter (Ordovician).

27.2 Metaline Formation carbonates.

27.6 (Optional Stop) Metaline Formation limestones (Fig. 7) with carbonaceous interbeds on right.

28.1 Metaline limestones.

28.6 Entering Colville; end of Day 1. Camping available at Stevens County Fairgrounds (turn left at Columbia Street). The Comfort Inn motel located on the north side of Colville on Highway 395 (behind the Arby's and next to the SuperOne Foods store).

Day 2: Colville - Kettle Falls areas.

0.0 Intersection of U.S. Highway 395 and Williams Lake Road (northwest of town). Turn right on Williams Lake Road. Here the Colville Valley is underlain by Eocene-aged volcanics and sediments that were deposited in a microbasin

that formed above the Kettle Dome detachment.

0.8 To the left across the Spanish Prairie valley (north-west), quarry in Covada Group sediments; on ridge on right is composed of Metaline carbonates. A major structure within the valley separates distal North American sediments of the Covada Group to platform sediments of the Cambro-Ordovician Metaline.

4.1 Glacial outwash terrace.

6.3 STOP 1. Argillites of the Covada Group (?).

This package of rocks (Fig. 8) is dominated by argillites with interbedded cherts, tuffs, and pillow basalts (Mills, 1983). It contains late Early Ordovician conodonts, trilobites, and brachiopods (Snook and others, 1981). Directly east of this local, the package is dominated by argillite and greywacke with minor interbedded chert. Smith and Gehrels (1991) report 1.76-2.7 Ga detrital zircons from Covada Group rocks consistent with derivation from the North American shield. There is no evidence of offshore arc volcanics and the Covada Group is viewed as a distal eugeosynclinal sequence deposited adjacent to North America.

8.8 Greywacke and black argillites of the Covada.

9.3 Black argillites with gray limestones (Metaline/Ledbetter Fm.). Crossed large fault that separates the Covada Group from Metaline-Ledbetter Formation (distal N.Am. vs. N.Am. platform sequence).

10.7 (Optional Stop) Deformed Ledbetter Slate. Described by Dutro and Gilmour 1989 as tectonized and highly contorted.

12.6 STOP 2. Metaline Limestone and Ledbetter Slate.

Park on right or left. Large outcrop in bend of road. North end is composed of the upper part of Metaline Limestone Formation (Fig. 7). Dutro and Gilmour (1989) report Early to Middle Ordovician conodonts from the upper 100 ft. of the Metaline here. The Metaline is moderately recrystallized. On the south end of the outcrop in fault contact with underlying Metaline is graptolite-bearing Ledbetter Slate.

Turn around and return to intersection of Clugston Creek Road and Williams Lake road. Reset odometer at intersection.

0.0 Intersection of Williams Lake (Echo Valley Rd.) with Clugston Creek Road; turn right (north).

0.3 Mountain ahead on right of limestone and argillites with pillow lavas (Butcher Mountain Formation of the Covada Group?, Fig. 8). Flat lying top of the mountain is composed of limestone.

6.6 High cliffs to right are Tertiary volcanics and sediments

deposited in a fault-bounded microbasin above the Kettle fault.

7.4 Argillites and greywacke in poorly exposed outcrops on right.

11.8 Junction with Highway 25. Turn left (south). Glacial sediments on left.

Major terrane bounding fault hidden in glacial sediments. Separates distal NAM rocks (Covada Group) from Quesnellia.

12.8 (Optional Stop) Outcrops on left of Permian (Quesnellian, Fig. 9a, 9b) limestone and black argillite.

Unnamed metasedimentary package with Permian marine brachiopods, crinoid stems, pelecypods, gastropods and plant fragments (Mills, 1985). Correlates late Early Permian metasediments near Barstow. Rocks show S*A M/0 strong deformation with chaotic folding. Parking and North Gorge campground entrance on right.

13.7 Bedded limestones (Permian).

14.7 STOP 3. Permian Limestones of Quesnellia.

Park on right. Well bedded gray limestone with recumbent isoclinal folding and disharmonic folds. The limestone has bioclastic interbeds and apparent crossbedding. What would the depositional environment of this carbonate be? Marine fossils reported by Mills and Davis (1962) are Early to Late Permian, including fusulinids, tetracorals, bryozoans, crinoids, and foraminifers. These carbonates have been correlated to the Quesnellian Attwood Group assemblage (Fig. 9a, 9b)(Cheney et al., 1994).

18.7 Permian limestone (Attwood Group) as discontinuous pods in argillite (Mills, 1985). The limestones represent reefs that were probably deposited in an active tectonic environment where limestones formed in close proximity to an active volcanic arc?

20.7 Permian (Attwood Group) argillites.

22.3 Triassic siltstones and greywacke with minor chert pebble conglomerate (Mills, 1985). Cheney et al. (1994) designates as Quesnellia Mesozoic rocks (undivided).

23.3 Town of Marcus.

24.3 Massive Triassic greenstone (Mills, 1985) with strong deformation with interbedded quartzitic argillite and minor carbonate.

24.8 STOP 4. Triassic greenstones of Quesnellia.

Park on right. Triassic greenstone of Mills (1985). The rocks

are well foliated (in places) with talc-bearing greenschist and quartz-rich pods (interbedded metacherts or metatuffs?) Cheney (1994) described as Mesozoic rocks (undivided) of Quesnellia (Fig. 9a, 9b).

25.8 Triassic greywacke and siltstone.

26.0 View of Kettle Dome (Eocene core complex) to the west across the river.

26.7 STOPS. Triassic greywackes and siltstones of Quesnellia.

Park on right in turnoff. Interbedded rusty medium-grained chert-bearing greywacke with siltstone and black argillite. The beds are cut by strongly altered (and deformed), sulfide-bearing leucocratic dikes. Abundant brittle fractures in the dike rocks. Greywacke beds have been folded into a broad synclinal structure.

27.9 Pleistocene, varved (?), lakebed sediments on left.

28.8 Junction with Highway 395 and Highway 25. Turn left to return to Spokane via Kettle Falls.

Optional Stop; turn left to examine exquisite mylonites in the Kettle Dome detachment fault at Barney's Junction directly across Columbia River.

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