SPREADING ACROSS THE INLAND NORTHWEST

Recreational Geology Field Trip

October 11, 2014

My interest in geology began, more than sixty years ago in southwestern Ohio. Our small farm was bisected by an escarpment of Early Silurian limestone. The tillable fields were above the break in slope. Below it pasture and wood lot sloped toward the floodplain of the Mad River. The pink limestone was only about six meters thick, on top of more than 400 meters of blue-gray Ordovician shale. Both lay as flat as they had been laid down. Melt water from the retreating Pleistocene ice sheet had carved the valley, leavin cobbles of gneiss from the Canadian Shield. Those outwash valleys turn the geologic map of Ohio from boring bands into a fractal geometry. For a small boy, the excitement came from the fossils that weathered out of the Richmond Shale: horn-shaped solitary corals, heavily ribbed brachiopods, and trilobites rolled in defensive posture. Mountain ranges and volcanoes were far away.

In Northeast Washington, we have a variety and complexity of geology and landscapes that are hard to match. The fossils are overwhelmingly those of single cell an microscopic organisms, but today we will see some of North America's best plant fossils. Unlike the flat-lying, thin strata of the Mid-west, our kilometers thick layers stand on end and lie overturned. We have the legacy of being on the edge of continents: successive mountain ranges and ripped apart land masses.

You have to search through fragmentary evidence to see: deep Precambrian mountains, a seaway over the continent, more great mountains, break up of Rhodinia, Devonian mountains built of exotic land masses, and the rise of a Tibetan scale plateau. The mountains and valleys familiar to us are little older than the Republic fossil leaves. An oceanic crust slab pushed and was pulled below the five kilometer high plateau. High topography could not stand, when the push stopped and the oceanic slab sank. Faults, where the great blocks had been pushed up, now reversed. Mountain range sized blocks of altered rock rose, from fifteen kilometers deep. Erosion stripped the uplifted rocks, filling the new valleys. Volcanoes erupted along the breaks in the crust. Lava and tephra added to the valley fill. The distance across our mountain belt doubled. Our mountains and valleys were literally spread across Northeast Washington. We will see how related rocks and structures were spread by fifty miles and more.

Our landscape is part of a belt, extending from central British Columbia to Sonora. The geological science of this Cordilleran belt and our mountains was the subject of an important conference, recorded in"Cordilleran Metamorphic Core Complexes", convened and edited by Max D. Crittenden. Max had been my USGS Southwest States Branch supervisor, in 1966. I learned about the build-up and older mountains, in part from the "Geologic Map of the Northport Quadrangle, Washington" and "Geology of the Deep Creek Area, Washington" (caution! the .pdf is over 450 pages). Both were by R. G. Yates – the Bob Yates in whose office we often ate lunch.

Road Log

Mileage	
0.0	Start west on 1st Avenue at Wynne Street, descending the face of terrace II formed during the post-glacial cold period.
0.3	First Avenue curves left.
0.4	The arterial curves right, becoming Oakshott Road.
0.5	Descending from terrace I, formed at the end of the Holocene Climatic Optimum (5Ka-4Ka BP).
1.2	Cross the Colville River – dredged and diked here. Former channels form meanders and ox-bows, over the 2,000 meter wide floodplain. Looking southwest, Corbett Creek and Gold Creek Loop Road follow a high-angle growth fault – Paleozoic carbonate rocks up to the south \ Tertiary volcanic rocks down to the north.
1.6	Turn right onto Valley Westside Road
1.7	The hillside quarry, on our left, exploits Tertiary basaltic andesite. Light colored veins in the roadside boulders are secondary, hydrothermal quartz, ankerite and K-feldspar (adularia) – volatile left-overs from the andesite magma. The ages of this and other similar rocks were analyzed and found to correlate closely, across Northeast Washington.
3.0	Crystal tuff in the road cut.
3.0	Tuffaceous sandstone in the cut-slope.
3.6	**Stop 1.** Park, as possible on the right shoulder. The cut-slope outcrop is tuffaceous sandstone and siltstone with very thin interbeds of carbonaceous shale.
4.0	Junction with Valley Westside Road
4.3	Recross the Colville River.
4.4	Turn left onto Highway 395. The line two-thirds up the hillside to the northwest is a shoreline of a glacial lake.
5.8	**Stop 2.** Park in the quarry access, on the right. The quarry exploits meta-conglomerate (rudite). The age is only constrained by early Devonian rocks below and Late Mississippian rocks above. Some of the clasts are similar to Belt Super-Group rocks and others to Windermere age rocks. A few of the clasts are themselves conglomerate. This is the southeastern limb of a tightly folded syncline, plunging to the south-southwest. The next ridge west is is the same rock in the opposite limb. Turn right to proceed northwest on 395.
6.8	Rock in the knob to the left and the quarry shotly on the right is Devonian greenstone (mafic meta-volcanic). Notice the slight up grade, a the end of the 4-lane section and most of the way to Kettle Falls.
7.6	To the left, you can see how a terrace face breaks from the elevation, sixty

feet down to the level of the Colville River. The river has fallen only twenty-three feet. That wedge is a fan of sediment, deposited as melt water from the Columbia glacial lobe flowed into the Colville Valley glacial lake.

8.1 Look ahead beyond the hairpin of Vanasse Road, for the change in topography between low, rounded slopes of relatively soft middle Paleozoic shale and more resistant upper Paleozoic slates and limestone,. This is the trace of terrane bounding fault. Fossil fauna in the southeast (Kootenay?) terrane have North American mid-continent affinity. Northwest of the fault the faunas have Eurasian (Tethyan or McCloud) affinity Quesnel Terrane?).

9.1 The gray outcrop domes, north of Kettle Falls, reef-like accumulated shells of protists (foraminifera). The fauna is late Carboniferous, and includes bryozoans, crinoids and brachiopods. In 1988, I stood at the top watching Megan Miller (CIT Jet Propulsion Laboratory) and Thomas Dutro (USGS retired) go practically toe-to-toe over whether these fossils were Quesnellian, McCloud or some other.

10.1 Turn left onto Juniper Street.

11.3 **Stop 3.** Turn right, into the Meyers Falls interpretive site. This is a place to examine the Tertiary volcanic rocks, without No Trespassing signs or limited parking.

The sequence at Gold Hill still carries the name Palmer Volcanics, applied by C. E. Weaver in, 1920. He name similar rocks south of Hunters and southeast of Chewelah the Gerome Andesite. On the scale of all of Stevens County, the rock here was too limited to map. Mapping at 1:24,000 scale, the graduate students of Joseph Mills indicated only that it is intrusive dacite. Put these together with mapping in the Newport, Republic, Toroda and Tonasket areas and the age correlation; this represents the feeder system for all of those Middle Eocene volcanic rocks.

This erosion resistant dike rock determines the gradient of the Colville River, as far upstream as Twelvemile. At 0.0008 gradient (0.08%), if the land to the south had not rebounded after deglaciation the Colville Valley would hold a lake rather than a river.

The falls drop a total of 100 feet. Nearly all the tributaries to the Columbia and Kettle Rivers, from Wilmont Creek to the International Boundary have similar falls or cascades. The Pleistocene ice tongues scoured the valley mouths, to create hanging valleys, which were buried by outwash and Lake Missoula Flood sediment. Return to Highway 395 (Third Avenue).

12.9 Turn left onto Highway 395

13.2 Junction with Highway 25

13.4 The gentle hills are Pleistocene dunes of very fine sand.

16.0 Junction with Washington Highway 20. Continue on US 395.

16.6 **Stop 4.** Turn around and park in the junction with Kifer Road.
The Kifer family quarries a thinly fractured part of this mica quartzite (muscovite+plagioclase+biotite amphibolite facies) to produce the locally popular facing stone. This same rock forms the knick of the Kettle Falls. First peoples formed very thin fragments into ulu-shaped knives for butchering salmon.
Typical, complete metamorphic core complexes have five zones – structurally lowest to highest: 1 plastic deformation, 2 mylonite, 3 metamorphic carapace, 4 brittle detachment, 5 brittle superstructure. This is the middle zone. In spite of the high degree of metamorphic alteration, we can see cross-bedding and soft sediment deformation structures.
Across the lake, all of the rocks are part of the brittle superstructure. The Eocene and later faults are the brittle fractures. The detachment zone is rarely exposed, but you can see some of the chlorite rich sheard rock, in a small outcrop along Highway 25 just south of Pingston Creek. Return on 395.

17.2 Turn right onto Washington 20.
We may park at the Tribal Trails, for fuel, resrooms etc.

18.8 **Stop 5.** Park in the Scneic Byway interpretive area. Dark rock in the cut slopes on this section are amphibolite with plagioclase pegmatite dikes. This is the lowest zone of the core complex. The amphibolite was altered from basalt, at depths greater than 15 Km. The feldspar veins and dikes intruded later. Those light colored show how the whole was deformed plastically, near but below the melting point. Where we can see a sense of rotation, the shear was top to the east. That may be either from when the rocks were thrust under a western continental mass, or from later when the crust extended to expose the Kettle River Range Gneiss Dome. Either way it was displacement of more than 20 Km horizontally and equally deep.

20.5 **Stop 6.** Park in the large turn-out on the left. Here is the mylonite – next to the lowest zone. Iron rich and alumina/silicate rock were ground and mixed, as cooled plastic and carapace blocks were sheared over each other. Metamorphic alteration welded the whole solid.
You can get a good view of the Sherman Creek gorge, but the falls are just out of sight. Continue on Highway 20.

20.7 **Alt stop 6.** Park in the paved turn-out on the left. Follow the foot-worn path to natural mylonite outcrop and the top of the lower falls of Sherman Creek.

21.3 Junction with Inchelium Highway.

23.6 Across Sherman Creek, the slope on the till deposit has failed nearly every year, since the highway was built. 1944 stereo air photos show a stable slope, the original road 200 meters north and the logging railway mostly clear. The raveling sand and gravel soils are part of the large delta built into the ice-dammed lake, by outwash through Hoodoo Canyon

24.0 Enter Colville National Forest.

24.8 The tan quartzite carries more feldspar than that at Kifer Road. It is also more highly altered – albite+staurolite facies.

26.4 2,360 feet elevation – level with the Spring Creek divide the head of the Cheney-Paloose scabland tract. This would be the limit, above which Lake Missoula Floods would not have reached.

27.9 Lower Lane Creek more or less follows the western edge of the Coyote Mountain/Hoodoo Canyon delta. West from here, the valley is more U-shaped. A valley glacier probably occupied that part of the valley, while the delta was being built.

Gong west from here, there is a terrace that starts at elevation 2,740 feet (180 feet above the highway. It rises slowly, going west. It is a valley train of outwash from a late Pleistocene valley glacier. Most of the terrace has been removed by greater slope moisture on the northerly aspect (south side of the valley).

This was the site of CCC Camp Growden and Sherman Lake and dam. The partial dam removal and channel reconstruction were completed in 2011.

30.8 Middle Falls of Sherman Creek. Removal of the Growden dam provided an additional 3.5 stream miles of fish passage, from the lower limit at the lower falls. Introduced rainow trout and eastern brook trout dominate Sherman Creek, but the tributaries and above the middle falls provide strongholds for the native pacific red band and west slope cutthroat trout.

33.9 The upper falls of Sherman Creek is an artifact of highway construction. Prior to 1945, Sherman Creek cascaded through an S-shaped canyon. Construction cut and filled across the S, forcing the stream course to the south of the road prism and over a ledge of gneiss. The bare slope is another chronic, human caused slope failure.

35.0 The 2-track road, taking off to the left, was the original wagon road, which crossed the Kettle River Range by a pass between Copper Butte and Midnight Mountain. That pass is 500 feet higher than Sherman, but the

grades are lower, had less outcrop to blast and accessed the Belcher Mining District.

Beyond where this road crosses Sherman Creek, roads were built up Scalawag Ridge, to salvage timber not burned in the Dollar Mountain Fire and dozer thin the new stands. The area is now Inventoried Roadless Area.

35.4 Going around the hairpin turn, we first cross the North Fork of Sherman Creek. The gravel exposed in the cut slopes is outwash from the valley glacier, persisting in the Deadman drainage later than in Sherman. Next, the highway crosses Sherman Creek. Coming out of the turn, the highway heads away toward the drainage of Pass Creek.

37.0 The crumbly outcrops are the result high temperature and extreme pressure gneiss, being annealed by the high temperature, low pressure, and acid volatiles rising from Eocene intrusive rock.

38.3 From here and above the upper hairpin turn, we are going in and out of the contact between the Eocene monzonite (Herron Creek Suite).

39.0 Look up at about 10:00, to see the alcove of a cirque on the north face of Sherman Peak.

39.7 **Stop 7.** After a comfort stop and probably lunch, park near the interpretive sign. We will walk through the pass. Only the north side needed excavation for the highway. The south wall was the sheer side of a box canyon. As with many others, this canyon was carved along a joint in the intrusive rock, by glacial melt water. As the granitoid rocks and gneiss cooled, they lost their faculty to deform by stretching. The dome was still being buoyed by low density rock below. That stress created joints on a rectangular pattern – larger and more numerous trending north-south. The cirques on the north east and east of Sherman Peak and more V-shaped valleys to the west, indicate that glaciation lasted later on the east. Most of the melt water would have flowed east to west.

41.3 Controlling the 1988 White Mountain Fire was complicated by so many of the firefighting resources having already been committed to the Yellowstone fires. Much of what we see south of the highway resulted from burning out fuel, in front of the fire advancing over the ridge. North of the highway, most of the fire was in the slash of recent clear cuts.

41.5 At 1:00, the Mount Washington Gunsight cuts the ridge. It's another of the box canyons. A road cuts around to the north of the ridge, above the box canyon. The road was built to salvage a stand of large, fire killed trees. About 2,000 acres of timber was salvaged, in South Fork, O'Brien Creek and upper Ninemile Creek. To do that salvage, almost three miles of road were built, into Inventoried Roadless Area.

43.5 We are well within a large pluton of Herron Creek Suite granitoid rocks. The rocks are intermediate composition and bear some subtle gneissic foliation.

44.2 Junction of 2040 Karamip Road

46.1 **Stop 8.** Park in the turn-out on the right. The greenish rock, south of the road, is gouge mylonite in a strand of the Sherman Fault. The main fault zone is covered in the valley that we just curved across. Here, Herron Creek rocks are sliced together with Permian dolomitic limestone. Magnesium from the dolomite and amphibole with lime as a flux and plagioclase have been combined under shear force to produce talc, antigorite, periclase , serpentine and nephelene.

Till is exposed in the north side cut slope.

46.8 California Mine road

47.0 **Stop 9.** Park in the turn-out on the left, by the high wall of layered rock. We have been driving over a dome of rock that rose from great depth, as the superstructure dropped along extensional faults. The faults penetrated most of the thickness of the crust. Thinning of the crust lowered pressure, allowing deep, hot rock to melt. Volcanic eruptions accompanied the earthquakes the moved the faults. Each of the thick sandstone layers of the O'Brien Creek formation records one of the earthquake/eruption events. The thin siltstone and coal beds formed as upland and wetland soils, during the intervening quiet intervals. This is the lowest of the three formations of the Sanpoil Volcanic Group. A variety of granitoid rock suites are the frozen remnants of the magma chambers. The O'Brien Creek Formation is associated with the Devil's Elbow Suite – oldest and most mafic of three. Continue on Highway 20.

51.3 Turn left onto Hall Creek Road, across from State Highway stock pile and garage.

51.8 **Stop 10.** Turn around and park near the closed road apron. May 24 through 27, 1998 over three inches of rain fell, at Republic. Wet snow fell and melted each day, at elevations over 4,000 feet. Many small landslides blocked streams. As the landslide dams overfilled, debris flows sluiced down the streams gaining remnant riparian snow, woody and earth debris. A 6' x 8' concrete box culvert carried, South Fork, O'Brien Creek under a 75' high fill, at the Refrigerator Canyon Road. The culvert rapidly plugged, making the fill into an unstable dam. You see the result of the break out of a 1,000 acre-foot lake of mud and woody debris.

Return to Highway 20 and turn left.

55.2 Look carefully to the right for larch high-stumps with spring board notches. Hand logging with crosscut saws ended rapidly, after the 1948 introduction of McCulloch power saws with all-position Tillotson carburettors.

56.9 These road cut outcrops are relatively part of a complex of Sanpoil Volcanic Formation lava domes. Their chemistry is relatively high silica and alkali feldspar. Calk-alkalic lavas are highly viscous, erupting as domes that grow from the inside squeezing out and cracking on the surface of the domes. The

term for the fresh lava is a'a'.

58.2 Turn right onto Washington Highway 21.

58.7 Rock in the bluff on the right is part of the feeder system, from the magma chambers to the volcanic vents. Scatter Creek Andesite has the same age and chemistry and age as the plutonic and volcanic rocks. It is medium (1-5mm) grain size – hornblende and plagioclase gains only slightly larger than the alkali feldspar grains.

59.1 The Kinross gold mill is 3.5 miles north of here. The mines near the mill are depleted. The mill processes ore from the Buckhorn Mountain Mine, 45 miles northwest by road. Each of the dump truck combinations that you will see carries about $18,000 worth of gold.

59.6 **Stop 11.** Turn left into entrance to the closed lumber mill, to turn around and park nearby. Cross the highway to the outcrop of basalt. The youngest unit of the Sanpoil Volcanic Group is the Klondike Mountain Formation. It is an highly varied suite of lava rocks, ranging from basalt to rhyolite, various tuffs, tuffaceous sandstone and pyroclastic flows. While this lava was settled on the surface, the volatile constituents exolved to form bubbles frozen in as vesicles. In this case the gas condensed as zeolite crystals.
Return to Highway 20.

60.8 Turn left, toward Republic.

61.0 The highway crosses North Fork, Sanpoil River by a steel pipe, which would be far too small for natural flow of the river. Flow of the River is buffered by the large, emergent wetland. The flow is seriously limited by two artifacts. The out flow of Sanpoil Lake is all by way of a 300 meter long pipe, under the abandoned sawmill area. In 1902, muck from excavating a railroad through-cut was dumped burying 230 meters of valley length. The river continues to seep through that rubble.

61.4 Confluence of North Fork, Sanpoil River and O'Brien Creek.

63.3 Turn right to go behind the Chevron convenience store.

63.4 **Stop 12.** Park along 13th Street W, by cut slope. The thin to medium bedded, light brown, tuffaceous sandstone is the Tom Thumb member of the Klondike Mountain Formation. The grains are high silica glass shards, orthoclase and plagioclase lithic fragments and weathered botite and hornblende crystals. It is tephra (volcanic ash), deposited in wetlands and lakes. Some of the layers record volcanic episodes. Other layers represent periods of intense storms and floods. There sequences of graded beds over mixed grain size layers, which are the remnants of underwater mud flows. You may find bits of fossil plants, mostly metasequoia twigs. All of the Stonerose fossil plant sites are in the Tom Thumb Tuff.

The thickest, darkest layer is basalt. Look closely to see that the rock grades from glassy at top and bottom to crystalline at the center. The mudstone beds, above and below weather differently from the rest. A lava flow would have a chilled basalt against baked sediment bottom.. The top would be vesicular basalt, with a weathered surface and normal sediment on the top. This sill was intruded, between the layers of mud, while they were still not fully cemented into rock.

Continue on 13th W, to turn right onto Clark Avenue.

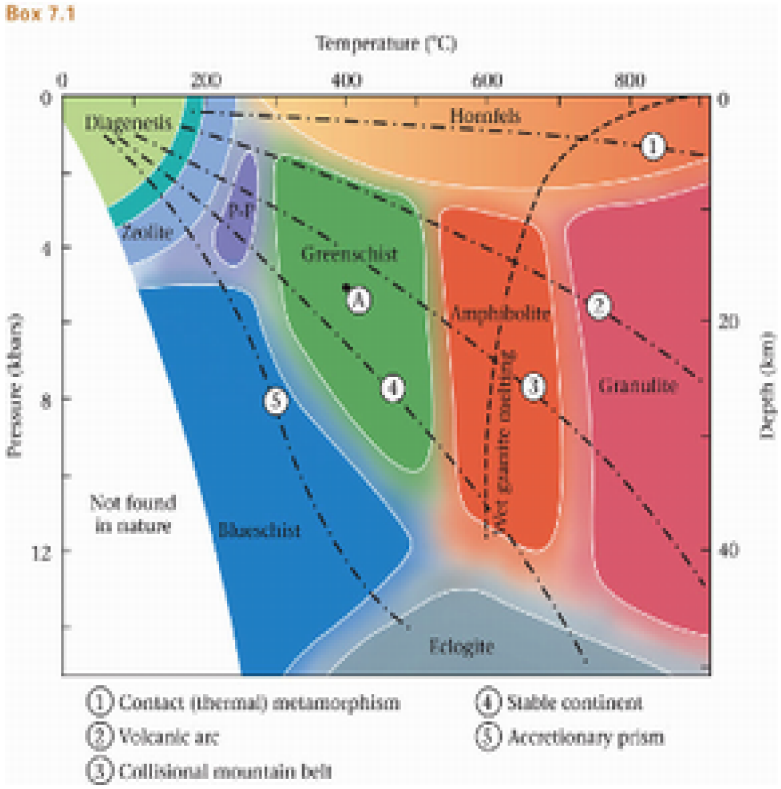
63.6 On the right, what looks like an incomplete basement excavation is the original stone rose fossil site. Researchers have made new discoveries here. It is closed to the public.

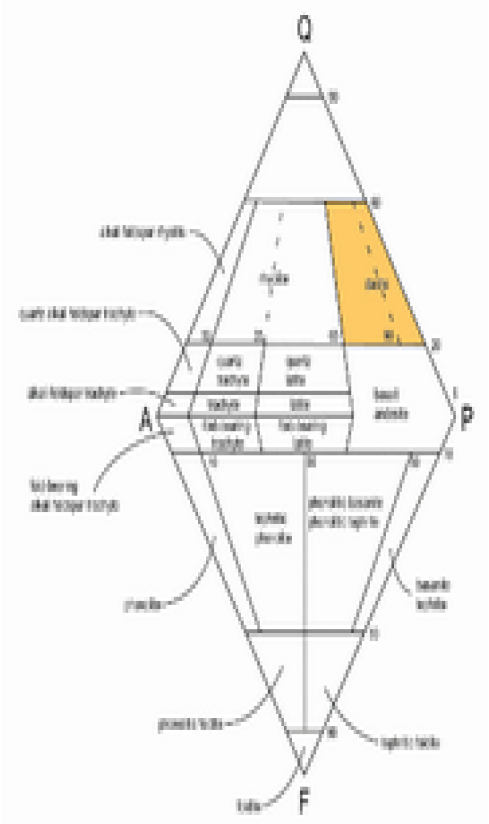
63.9 Turn left onto West 6th Street to remain on Highway 20. Take the first right, and park beside the city park and across from the Stonerose Interpretive Center.

We end the trip with experiencing the Center and searching for fossils at the Boot Hill site. Thank you for coming. I could not do with out your curiosity.

EON	ERA	PERIOD	MILLIONS OF YEARS AGO
Phanerozoic	Cenozoic	Quaternary	1.6
		Tertiary	66
	Mesozoic	Cretaceous	138
		Jurassic	205
		Triassic	240
	Paleozoic	Permian	290
		Pennsylvanian	330
		Mississippian	360
		Devonian	410
		Silurian	435
		Ordovician	500
		Cambrian	570
Proterozoic	Late Proterozoic Middle Proterozoic Early Proterozoic		2500
Archean	Late Archean Middle Archean Early Archean		3800?
Pre-Archean			

Box 7.1


Temperature (°C)
0
200
400
600
800
Pressure (kbars)
0
4
8
12
Depth (km)
0
20
40
Diagenesis
Hornfels
Zeolite
P-T
Greenschist
A
Amphibolite
Granulite
Wet granite melting
Not found in nature
Blueschist
Eclogite
1
2
3
4
5
1 Contact (thermal) metamorphism
2 Volcanic arc
3 Collisional mountain belt
4 Stable continent
5 Accretionary prism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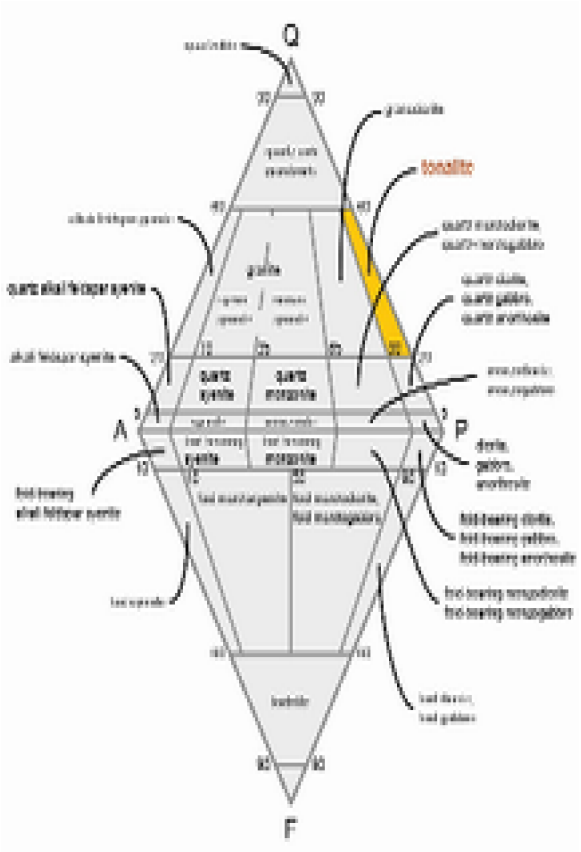
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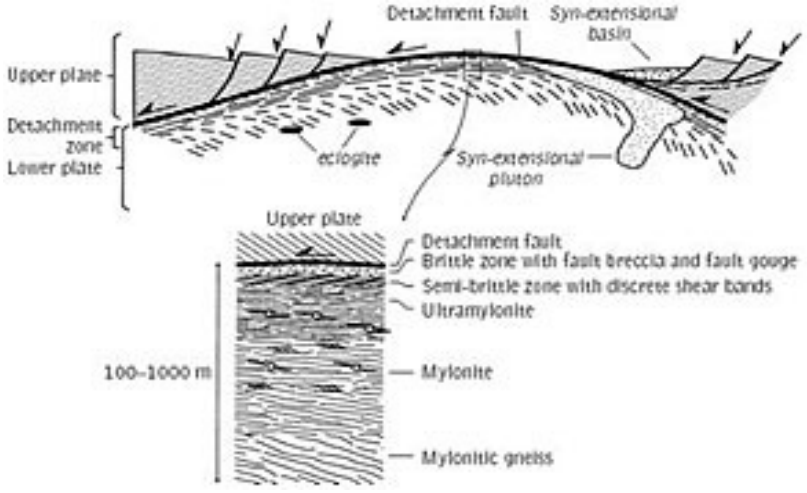
Detachment fault
Syn-extensional basin
Upper plate
Detachment zone
Lower plate
eclogite
Syn-extensional pluton
Upper plate
Detachment fault
Brittle zone with fault breccia and fault gouge
Semi-brittle zone with discrete shear bands
Ultramylonite
100–1000 m
Mylonite
Mylonitic gneiss