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DEPARTMENT OF NATURAL RESOURCES

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GEOLOGIC MAP GM-31

GEOLOGIC MAP OF THE CLARKSTON 15 MINUTE QUADRANGLE, WASHINGTON AND IDAHO

By

P. R. HOOPER, G. D. WEBSTER, AND V. E. CAMP

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TO ACCOMPANY GEOLOGIC MAP GM-31

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DESCRIPTION OF MAP UNITS

SURFICIAL DEPOSITS

af ARTIFICIAL FILL — Includes rubbish disposal sites of variable depth and composition, generally covered with loess, and areas of major movement or leveling of loess and gravel deposits for human use

Qz MAZAMA ASH — Small deposits of clean ash 4 to 6 inches thick overlain by variable mixtures of ash and loess up to 5 ft thick; age 6,600 years b.p. Typically found along roadcuts or stream banks along valley floors. Especially well exposed in Steptoe Canyon

Qf ALLUVIAL FANS — Stream deposits. Composition variable, from nearly pure reworked loess to mixtures of angular to rounded clasts of basalt and loess, rarely containing reworked pebbles and cobbles of interbeds or gravel deposits. Present where tributaries enter major drainages in the Snake River, Steptoe and Stuart Canyons, and along Asotin and George Creeks

Qs DUNE SAND — Small pockets of wind-deposited sand and silt of mostly quartz and feldspar derived from sand bars along the Snake River

Qa ALLUVIUM — Stream sediments. Composition variable, commonly reworked loess or mixtures of loess and basalt, especially at higher elevations and in major tributary canyons to the Snake River. Along the Snake River canyon the sediments contain abundant pebbles and cobbles of granitoids, metamorphics, and volcaniclastics derived from exposures outside the map area and from reworking of older gravel deposits outside and within the map area

Qc COLLUVIUM — Mixtures of loess and angular to subrounded clasts of basalt, mostly without caliche cement. Occurs on canyon walls along the Snake River, Page Creek in the west-central part of the area, and Asotin Creek and the base of the canyon walls north of the Clearwater River in the east-central part of the area. Probably of Pleistocene and Recent age

Qt TALUS — Angular pebbles to cobbles of basalt accumulating at the base of basalt cliffs. Largest deposits are found along the lower elevations of the Snake River canyon and its tributaries. Probably of Pleistocene and Recent age

Ql PALOUSE FORMATION — Loess, predominantly of quartz and feldspar composition derived from the southwest throughout Pleistocene and Recent time. Thickness variable (Ringe, 1970) — thickest in the northern part of the map area and thinning to the south. Some deposits to the north of the Snake River canyon in the northeast corner of the map are up to 20 ft thick. Most deposits of the higher elevations in the southern part of the area are less than 3 ft thick

Qm MISSOULA FLOODS BACKWATER DEPOSITS — Rhythmite deposits of cross-bedded, dark-gray, basalt-rich gravels grading upwards into quartz- and feldspar-rich tan sands and silts; often with cut and fill structure and sandstone dikes. Found along some larger tributaries of the Snake River to elevations of approximately 1,200 ft but generally not extensive above 1,000 ft. They were first recognized in the Lewiston-Clarkston area by Bretz (1929). Equivalent to the Touchet Beds of the Walla Walla area (Waitt, 1980) and confined to ages of 14,000-15,000 to 13,000 years b.p.

Qb BONNEVILLE FLOOD DEPOSITS — Gravels and sandy gravels containing high percentages of basalt with lesser amounts of granitoids and greenschist facies volcaniclastics; may contain ash clasts of pebble and cobble size. Age of the Bonneville flood reported to be approximately 15,000 years b.p. (Scott and Shroba, 1980). The Bonneville flood deposits underlie Missoula floods backwater deposits in quarries along the Snake south of Lewiston, Idaho, and in the western part of Clarkston, Washington. They were recognized to be of Bonneville flood origin and reported in the Lewiston-Clarkston area by Stearns (1962), although Bretz (1929), unaware of the Bonneville flood, had mentioned some of the deposits

TQg_3 UNNAMED GRAVEL 3 — Subangular to well-rounded cobbles of basalt, granitoids, and metamorphics in a pebbly sand matrix. Sand, fine- to course-grained quartz, and feldspar with mica and hornblende. These gravels form a terrace on which North Lewiston is built. They are older alluvial gravels derived from the Clearwater drainage. Age is uncertain, but they may be equivalent to TQg_2

TQg_2 UNNAMED GRAVEL 2 — Well-rounded pebbles to cobbles of basalt (approximately 40 percent) and granitoids, metamorphics (dominantly quartzite), and red and green volcaniclastics. Basalts are angular in part and may be deeply weathered. Matrix gray-green, medium- to coarse-grained sand rich in basalt grains; matrix not always present. The deposits are overlain by the Missoula floods backwater deposits, alluvial fans, and dune sand. Common as lateral and point bars along the Snake River canyon; some of the lateral and point bars were incorrectly mapped as Scabland flood bar gravel by Hammatt and Blinman (1976). May be equivalent to the Clarkston gravel

TQg_1 UNNAMED GRAVEL 1 — Cobbles to 50 cm maximum diameter in a coarse-grained basalt-rich sand matrix. Cobbles are dominantly basalt (estimated 98 percent), with rare red and green volcaniclastics, quartzites, and volcanic porphyries. Basalt cobbles are all moderately weathered. Matrix with ferruginous cement in part. Degree of weathering and high basalt content suggests similarities with the North Lewiston gravel, but the red and green volcaniclastics imply a Salmon drainage provenance. Stratigraphic relationships do not permit a close age assessment, could be late Miocene to Pleistocene

TQs SLUMP BLOCKS OF TERTIARY COLUMBIA RIVER BASALT AND OVERLYING SEDIMENTS — These blocks are associated with one of the sedimentary interbeds in the basalts. Most common in the canyons in the southern half of the map area, south of Asotin

TQc CLARKSTON GRAVEL — Well-rounded cobbles to small boulders of 69 percent basalt, 9 percent greenstones of the Seven Devils Group (Vallier, 1977), 15 percent igneous rocks (mostly porphyries and granitoids), and 6 percent older metamorphics (mostly quartzites) in an uncemented bimodal pebbly and medium-grained sand. Waggoner (1981) restricted the term Clarkston gravel of Lupher (1945) to those gravels underlying the city of Clarkston, Washington, and interpreted them to be a point bar of late Pliocene or earliest Pleistocene age

Tcl CLEARWATER GRAVEL — A lower gravel, middle sand, and upper gravel. The gravels consist of well-rounded cobbles of approximately 50 to 55 percent basalt. The non-basalt content is granitoid and metamorphic lithologies lacking red and green volcaniclastics of the Seven Devils Group. Basalt and granitoid clasts are moderately to deeply weathered. The middle sand and matrix sand is fine- to coarse-grained, mostly medium-grained, and dominantly quartz and feldspar. Kuhns (1980) described the well-exposed section of the Clearwater gravel at the base of the new Lewiston grade, which is just east of the map area in secs. 20 and 31, T. 36 N., R. 5 W., Idaho. The Clearwater gravel is an entrenched terrace gravel found up to elevations of 1,150 ft along the lower Clearwater River. It is believed to be time-equivalent to the Clarkston Heights gravel. Age is uncertain, but confined between the Lower Monumental flow (6.0 m.y.b.p., McKee and others, 1977) and the Missoula flood deposits. Degree of weathering of the basalts and granitoids suggests an older age, probably Pliocene

Tch CLARKSTON HEIGHTS GRAVEL — Well-rounded cobbles of approximately 64 percent basalt, 13 percent red and green volcaniclastics derived from the Seven Devils Group, 13 percent granitoids and porphyries, and 10 percent metamorphics (mostly quartzites and gneisses) in a bimodal pebbly and medium-grained sand matrix. Sand lenses in the upper part of the unit and the matrix sand are dominantly quartz and feldspar. Alternating sand and pebble dominance in the matrix produces a weak rhythmic bedding to the unit. Ferruginous staining common and calcareous cement in irregular lenses in the matrix. Sedimentary structures include imbrication and foreset cross-bedding. Basalt and granitoid clasts are deeply weathered. The Clarkston Heights gravel was initially defined by Waggoner (1981) and discussed by Webster, Kuhns, and

Waggoner (1982). As discussed by Lupher (1940, 1945) and Lupher and Warren (1942), the unit filled, to an elevation of 1,250 ft, a northwestward-trending valley, which underlies the suburb of Clarkston Heights, and was formed after the Pomona flow (12.0 m.y.b.p., McKee and others, 1977). Overlain by Bonneville flood deposits and Missoula floods backwater deposits. Excellent exposures occur in quarries and roadcuts along Critchfield Road and Evans Road. Age of the unit is uncertain but believed to be coeval with the Clearwater gravel based on stratigraphic position and sedimentological and weathering similarities. A Pliocene age is postulated. Abundance of the Seven Devils Group lithologies in the clasts suggests a provenance of the Salmon River drainage

Tag ASOTIN CREEK GRAVEL — Well-rounded cobbles to small boulders of basalt in a medium- to coarse-grained sand matrix. Matrix dominantly quartz and feldspar, ferruginous-stained, and contains lenses of calcareous cement. Rare pebbles of red and green volcaniclastics from the Seven Devils Group, quartzite, and porphyries. Excellent imbrication of clasts, and all basalt clasts moderately to deeply weathered. The best exposures of this unit occur in roadcuts along the grade on Highway 129, south of Asotin. Asotin Creek gravel was deposited on a terrace on the Grande Ronde flow up to elevations of 1,365 ft in the canyon of Asotin Creek. Imbrication indicates current directions parallel to modern drainage. Nonbasalt clasts and much of the matrix sand were probably derived from the two sedimentary interbeds exposed in bluffs along and upstream of the Asotin Creek gravel deposits. Age of the gravels is uncertain but is probably Pliocene. Stratigraphic position and sedimentological and weathering characteristics suggest a possible time equivalence to the Clarkston Heights and Clearwater gravels

COLUMBIA RIVER BASALT GROUP

YAKIMA BASALT SUBGROUP

SADDLE MOUNTAINS BASALT

Tl LOWER MONUMENTAL MEMBER (Swanson and others, 1979) — Dense aphyric flow found as small isolated remnants at or near the base of present Snake River, Clearwater River, and Tammany Creek canyons. Probably the youngest flow of the Columbia River Basalt Group, dated at 6.0 m.y.b.p. (McKee and others, 1977), has normal magnetic polarity (Choiniere and Swanson, 1979), but has no known dike feeder. Microphenocrysts of plagioclase, clinopyroxene, and olivine are present in opaque glass

Tt TAMMANY CREEK flow — A previously unrecognized dense, plagioclase phyric flow that lies across the entrance of Tammany Creek canyon and on the southern side of the Snake River east from Silcott, filling valleys cut in the Elephant Mountain Member. Small plagioclase phenocrysts and glomeroporphyritic groups of plagioclase, zoned augite, and olivine lie in intergranular grains and opaque glass. Chemically similar to the Swamp Creek flow of Camp (1981), but Tt has higher SiO_2 and K_2O and lower Fe and CaO. It appears to be slightly older than Tl because it cuts across the mouth of Tammany Creek, which is partially filled by Tl. Magnetic polarity has not been properly established and no dike source is known

Tb BUFORD MEMBER (Walker, 1973; Swanson and others, 1979) — A pale, medium-grained aphyric flow that forms one small outcrop in the southern part of the Asotin quadrangle, where it forms a small patch on top of the Weissenfels Ridge Member. It is known to overlie the Elephant Mountain Member in northeast Oregon and has reversed magnetic polarity (Price, 1977; Ross, 1978; Swanson and others, 1979). Its age relative to Tl and Tt has not been well established (but see Swanson and others, 1979). No feeder dike has been established, probably because it is chemically almost indistinguishable from Grande Ronde Basalt

Tem ELEPHANT MOUNTAIN MEMBER (Waters, 1955; Swanson and others, 1979) — A fairly dense, dark-gray, aphyric to microphyric, multi-tiered flow that forms the top of the plateau from the middle of the western side of the Rockpile Creek quadrangle to the center of the Lewiston Basin, where it then fills deep canyons eroded across and adjacent to the canyon-filling Pomona flow (Camp, 1976; Swanson and others, 1979, 1980). Canyon fills may be over 400 ft thick, though on the plateau surface many thin vesicular horizons may be present. Laths of plagioclase and smaller grains of olivine and clinopyroxene are set in areas of dark-gray glass containing incipient pyroxene grains and ilmenite blades. The member is described as being both transitional and normal magnetic polarity (Choiniere and Swanson, 1979) and has been dated at 10.5 m.y.b.p. (McKee and others, 1977)

Tp POMONA MEMBER (Schminke, 1967; Swanson and others, 1979) — A medium-grained, medium-gray basalt, lacking obvious phenocrysts, which filled deep canyons to a depth of over 500 ft, almost as deep as the present Snake River canyon. It has not been found in other canyons such as those of Clearwater River or Tammany and Asotin Creeks. The thick sequences preserved are multi-tiered and include a thick unit of volcaniclastic material which may imply a local vent. No feeder dike is apparent in the Lewiston Basin, however. The correlation of the Weippe flow from the east in Idaho with the Pomona flow by Camp (1981) also provides a major feeder dike in the Clearwater embayment. Under the microscope, the flow has a variable grain size with grains of plagioclase, olivine, and clinopyroxene. It has reversed magnetic polarity (Choiniere and Swanson, 1979) and been dated at about 12 m.y.b.p. (McKee and others, 1977)

WEISSENFELS RIDGE MEMBER (Camp, 1976; Swanson and others, 1979) — Four similar holocrystalline flows, with variable olivine content, overlie a sedimentary interbed, Ts_2, which overlies the well-exposed Asotin cliff-forming member in a large part of the Lewiston Basin south of the Lewiston structure. The chemical differences of all four flows are shown on table 1. A feeder dike occurs in Asotin Creek near the western edge of the map. Two dikes on Weissenfels Ridge with identical chemical composition (table 1) could be feeders to either Tws or Twl or to neither. All flows of this member appear to have normal magnetic polarity

Tws Slippery Creek flow (Swanson and others, 1979) — Youngest of the four flows. Confined to the plateau surface south of Asotin Creek, with the exception of a single outcrop near the junction of the four quadrangles. While it does not have a higher MgO content than other flows of this member, the olivine grains tend to be larger and more conspicuous, often poikilitically enclosing plagioclase laths in clots. Well exposed near the top of Camp's (1976) Cloverland grade section

Twt Tenmile Creek flow — The flow with a Lololike chemical composition that Swanson and others (1979) describe as occurring around Anatone, immediately south of the present map. It is thinner and more glassy than the other three flows and occurs in a north-south band, from a dike in the middle of the Lewiston structure, across Asotin Creek to Anatone to the south. It is well exposed in a small road section at the top of the Asotin grade above the Asotin Member and beneath the Slippery Creek flow. Along the southern margin of the map, it overlies the Lewiston Orchards flow, the two typically separated by a thin sedimentary unit

Twl Lewiston Orchards flow — Confined to the eastern part of the map, and extends farther east into Idaho (Camp, 1976, 1981). It is the only flow of this member known to extend a significant distance outside the Lewiston Basin. Forms a shallow valley fill northwards from the top of the Lewiston grade through Colton and is found again north of Moscow (Hooper and Webster, 1982). It also has a similar chemical composition to the Sprague Lake flow (Swanson and others, 1979) much farther north, and to a small dike and vent near Riggins to the south (Hooper, 1982a). The three outcrops (Sprague Lake, Lewiston Basin, and Riggins) lie on a NNW-SSE line over 200 km long and were erupted in the same, rather broad, time interval so may represent another example of a major linear-vent system (Swanson and others, 1975)

Twl′ Second(?) "Lewiston Orchards" flow — The small outcrops exposed at the top of Lewiston grade appear to underlie a sedimentary unit beneath the Asotin flow (Ta). Originally regarded as an example of a flow plunging into older sediments (invasive), recently recognized small differences in the chemical composition (lower TiO_2) of this unit from normal Lewiston Orchards suggest it may be a different flow

Twc Cloverland flow — Confined to the southwest (Rockpile Creek) quadrangle. It underlies Tws from which it is separated by a thin sedimentary unit, but its age relative to Twt and Twl has not been observed. Its separation from Tws by thin sediment suggests it is older than Twt. It has the same typically holocrystalline microphyric texture as other flows in the member, but has more abundant olivine microphenocrysts than the others

Ta ASOTIN MEMBER (Camp, 1976; Swanson and others, 1979) — Dense aphyric flow in which olivine is usually recognizable in the field. North of the Lewiston structure Ta forms a thin veneer above the more obvious Wilbur Creek Member (Hooper and Webster, 1982). South of that structure, within the Lewiston Basin, the Asotin flow forms a well-exposed cliff, dominating the Wilbur Creek flow, and extending off the map to the southwest, south, and southeast. It has normal polarity (Swanson and others, 1979)

Tw WILBUR CREEK MEMBER (Swanson and others, 1979) — A dense, dark-gray aphyric flow, lacking obvious olivine in the hand sample. It forms a thick well-exposed unit at the top of Lewiston grade and along the north side of the Lewiston structure. South of the Lewiston structure, the flow is dominated by the cliffs of the overlying Asotin Member. It appears thinner than to the north, often buried beneath Asotin scree or removed by slumping. Most good sections through this part of the basalt succession include the Wilbur Creek flow, but on less well-exposed hillsides it is frequently not apparent. It is believed to be present over most of the Lewiston Basin with the exception of the southwest corner, where the Asotin Member lies directly on the Umatilla Member. A chemical variant is locally found at the top of the Wilbur Creek flow and the bottom of the Asotin Member. This has been named the Lapwai flow (Wilbur Creek Member) by Camp (1981) and Hooper and Webster (1982). Lapwai flow chemistry is intermediate between Ta and Tw and all three would be better regarded as a single member. It has normal magnetic polarity (Swanson and others, 1979)

UMATILLA MEMBER (Laval, 1956; Schmincke, 1964, 1967; Swanson and others, 1979; Hooper, 1981; Hooper and Webster, 1982) — Three flows placed within this member occur within the map area: Sillusi flow (Tus), the high Ti Sillusi flow (not shown on map), and the Umatilla flow (Tuu). All are unusually fine-grained aphyric flows relatively enriched in the incompatible elements, including Ti and P (table 1)

Tus Sillusi flow — Separates the Priest Rapids Member from the Wilbur Creek Member between the Steptoe and Snake River canyons in the northwest corner of the map.

Tuu Umatilla flow — By far the most widespread flow of the Umatilla Member in the Lewiston Basin, but it has not been found to the north or east of the Snake River. It forms the plateau surface west of the Snake River, north of Alpowa Creek, and is poorly exposed within the thick Ts_1 unit over most of the Lewiston Basin. Sometimes occurs above this sediment and sometimes below it. In many cases, it occurs as lenses within Ts_1 and is probably at least partly invasive to Ts_1. This relationship, the flow's tendency to poor rounded exposures, and severe slumping of the Ts_1 unit results in the apparent absence of the flow in less well-exposed areas. Like the Wilbur Creek Member, it is usually found if the exposure is adequate, as on the various highway grades.

A well-exposed vent forms Puffer Butte above the Grande Ronde River immediately south of the map area with a dike system which extends as far SSE as Hells Canyon Dam on the Oregon-Idaho border. A probable vent for Tuu occurs in the Troy Basin (Hooper, unpublished data). The member has normal magnetic polarity (Swanson and others, 1979)

WANAPUM BASALT

PRIEST RAPIDS MEMBER

Tprl Lolo flow (Bingham and Grolier, 1966; Swanson and others, 1979) — This easily recognized coarse flow with obvious plagioclase and olivine microphenocrysts is present over the whole map area (Camp, 1976; Swanson and others, 1980). Northward from the Lewiston structure, it has a relatively uniform thickness, resting on the saprolite horizon developed on the top of the Grande Ronde Basalt. South of the Lewiston structure, however, in the Lewiston Basin, it is very thick at the center of that basin just south of Swallow Rock on the Snake River, where it is pillowed. Sediments and the extent of the pillows at the base of the flow from the base of the Lewiston grade to Tammany Creek, Asotin grade, and the Cloverland grade define the earliest evidence of the Lewiston Basin. Major feeder dikes occur to the east in Idaho (Camp, 1981) and the flow has reversed magnetic polarity (Swanson and others, 1979)

Tr ROZA MEMBER (Mackin, 1961; Bingham and Grolier, 1966; Swanson and others, 1979) — This flow with its large independent plagioclase phenocrysts has been mapped over a large part of the Columbia Plateau together with its linear vent system, which lies just west of the western margin of this map (Swanson and others, 1975, 1980; Hooper, 1982b). Despite the proximity of its linear vent system, the Roza Member is only present in the western part of the map area, decreasing in thickness rapidly and dying out from west to east in Page Creek, and dying out above Asotin in Asotin Creek. The most easterly part of this flow in Asotin Creek is uncharacteristically glassy and has only very rare plagioclase phenocrysts. The member has transitional to reversed polarity (Choiniere and Swanson, 1979)

ECKLER MOUNTAIN MEMBER

Tes Shumaker Creek flow (Swanson and others, 1979) — Camp (1976) recognized an aphyric flow of Grande Ronde Basalt appearance but Umatilla-like chemistry lying above Grande Ronde Basalt and below the Lolo flow in his Cloverland grade and Meyer Ridge sections. Swanson and others (1979) correlated this flow with their Shumaker Creek flow in the Blue Mountains to the south. On the present map, the flow extends up Rockpile, George, and Pintler Creeks to the southwestern edge of the map. Isolated outcrops in the Snake River canyon just south of Swallow Rock and in the poorly exposed ground east of Silcott imply a considerable extension to the north side

GRANDE RONDE BASALT (Camp and others, 1978; Swanson and others, 1979) — The Grande Ronde Basalt is a thick sequence of aphyric flows that occurs over most of the Columbia Plateau. It is divided into four unequal stratigraphic units Tgr_1, (bottom), Tgn_1, Tgr_2, Tgn_2 (top) dated at between 14.0 and 16.5 m.y.b.p. (Watkins and Baksi, 1974). All four units are present in the map area

Tgn_2 Upper flows of normal magnetic polarity — A few flows of normal magnetic polarity lying above Tgr_2 are present in Page Creek and Asotin Creek on the western edge of the map (Swanson and others, 1980)

Tgr_2 Upper flows of reversed magnetic polarity — Forms the top of the Grande Ronde Basalt over most of the map except along the western margin where it is overlain by a few flows of Tgn_2. Northwest of the Vista fault, 6 flows total 500 ft. On Weissenfels Ridge, Camp (1976) recorded 8 to 10 flows totaling nearly 900 ft in thickness

Tgn_1 Lower flows of normal magnetic polarity — Fully exposed between Tgr_1 and Tgr_2 north of the Vista fault on the sides of the Snake River canyon in the northwest corner of the map. Approximately 10 normally magnetized flows have a total thickness of about 800 ft. The upper part of the unit is again exposed in the Snake River canyon in the southeast corner of the map

Tgr_1 Lower flows of reversed magnetic polarity — Lowest magnetic stratigraphic unit with reversed magnetic polarity is fully exposed at Moses Siding, north of Silcott, where 10 flows with a total thickness of 600 ft lie on Imnaha Basalt on the southeastern side of the Vista fault (Camp, 1976) and are overlain by Tgn_1

Ti IMNAHA BASALT (Hooper, 1974; Swanson and others, 1979) — Approximately 5 coarsely porphyritic flows of Imnaha Basalt, totaling between 300 and 400 ft in thickness, dip at 10° southeast from the Vista fault, and the upper flow is exposed again in the Gaging station anticline, the core of the Lewiston structure. The Imnaha Basalt is dated at between 17.0 and 16.5 m.y.b.p. (McKee and others, 1981)

SEDIMENTARY INTERBEDS

Ts_3 SEDIMENTARY INTERBED 3 — Well-rounded alluvial cobbles, approximately 95 percent basalt, and 5 percent metamorphic and acidic igneous rocks, in a pebbly silt to sand matrix with orange oxide staining, matrix sand rich in basalt grains. Kuhns (1980) referred to these gravels as the North Lewiston Gravels. They are known from a few exposures along the north side of the lower part of the Clearwater River valley and are overlain by the Lower Monumental flow

Ts_2 SEDIMENTARY INTERBED 2 — As exposed in roadcuts along the upper part of the Cloverland grade, this unit is 42.65 m (136.4 ft) thick and consists of silty clay and clay overlain by sand which grades upward into clay. The clays are gray to yellow and are slope formers. The sand is white to cream color, very fine- to medium-grained quartz and feldspar with mica and hornblende, trough cross-bedded, finer-grained, and clayey in upper part. At the top of the grade at Weissenfels Ridge (NW¼ sec. 24, T. 9 N., R. 46 E.) this interbed includes a gravel containing abundant well-rounded cobbles of red and green volcaniclastics and basalt. Exposures of this somewhat extensive slope former are generally poor and very incomplete. The Asotin Member underlying this unit generally forms a prominent cliff, and the overlying basalts form a cliff. Lateral variation in thickness and lithology of this unit requires additional study

Ts_1 SEDIMENTARY INTERBED 1 — This unit includes all sediment between Ta and Tprl. The flows of the Umatilla and Wilbur Creek Members often lie within the unit, frequently as poorly exposed units. The flows are possibly invasive. As exposed in the Cloverland grade roadcuts, this sedimentary interbed is 25.65 m (84.1 ft) thick and consists of silty clay and clay overlain by a sand with gravel beds followed by clay and capped by a thin coal bed. The clays and silty clays are light-yellow to cream color. The sand is light-yellow to off-white, very fine- to medium-grained quartz and feldspar with accessory mica and hornblende. Thin gravel stringers of well-rounded quartzite pebbles occur near the base of the sand. A thin bituminous coal caps the sequence. The interbed is a slope former on top of the Priest Rapids Member. It is best exposed in roadcuts along grades leading out of the Asotin Creek canyon and its tributaries. Lateral variation in lithology and thickness of this unit needs further study

Table 1. *Average chemical analyses of Columbia River Basalt lava flows and dikes in the Lewiston Basin*[1]

Geologic Unit	Number of analyses	SiO_2	Al_2O_3	Fe_2O_3[2]	FeO	MgO	CaO	Na_2O	K_2O	TiO_2	P_2O_5	MnO
Lower Monumental Member (Tl)	12	49.98	14.65	2.00	12.01	4.79	8.61	2.62	1.51	3.03	0.59	0.22
s.d.[3]		(0.44)	(0.33)		(0.43)	(0.21)	(0.15)	(0.17)	(0.05)	(0.04)	(0.02)	(<0.01)
Tammany Creek flow (Tt)	5	53.04	14.78	2.00	10.80	3.96	7.63	2.72	1.73	2.79	0.36	0.19
Buford Member (Tb)	2	54.23	15.54	2.00	8.48	4.71	8.49	2.48	1.35	2.23	0.32	0.17
Elephant Mountain Member (Tem)	42	50.97	14.21	2.00	12.31	4.05	8.42	2.51	1.23	3.58	0.51	0.21
s.d.		(0.59)	(0.30)		(0.66)	(0.28)	(0.39)	(0.22)	(0.11)	(0.09)	(0.02)	(0.01)
Pomona Member (Tp)	16	51.93	15.71	2.00	8.29	6.48	10.72	2.16	0.58	1.71	0.24	0.18
s.d.		(0.28)	(0.26)		(0.45)	(0.36)	(0.64)	(0.17)	(0.11)	(0.03)	(<0.01)	(<0.01)
Slippery Creek flow (Tws)	9	51.63	15.32	2.00	9.94	5.20	9.41	2.39	0.94	2.54	0.41	0.20
Tenmile Creek flow (Twt)	5	50.04	14.43	2.00	11.40	5.12	9.55	2.62	0.94	3.09	0.60	0.22
Tenmile Creek dike (Twt)	1	49.81	14.36	2.00	11.49	5.26	9.76	2.38	0.92	3.18	0.62	0.22
Lewiston Orchards flow (Twl)	16	49.30	15.23	2.00	9.74	6.69	11.06	2.34	0.41	2.52	0.52	0.20
s.d.		(0.64)	(0.36)		(0.41)	(0.67)	(0.20)	(0.22)	(0.08)	(0.20)	(0.04)	(0.02)
Lewiston Orchards dikes (Twl)	2	51.44	15.42	2.00	10.07	5.03	9.14	2.41	0.99	2.77	0.54	0.19
Cloverland flow (Twc)	6	50.07	16.07	2.00	8.29	7.52	11.05	2.25	0.29	1.86	0.39	0.20
Cloverland dike (Twc)	1	50.49	16.50	2.00	7.92	7.36	10.80	2.02	0.44	1.90	0.39	0.16
Asotin Member (Ta)	36	51.04	16.71	2.00	7.49	7.50	10.85	2.05	0.50	1.50	0.21	0.16
s.d.		(0.50)	(0.31)		(0.47)	(0.44)	(0.42)	(0.21)	(0.12)	(0.05)	(0.02)	(0.01)
Wilbur Creek Member (Tw)	12	53.89	15.91	2.00	8.54	4.41	8.48	2.34	1.82	1.97	0.46	0.19
s.d.		(0.42)	(0.53)		(1.07)	(0.20)	(0.45)	(0.25)	(0.09)	(0.04)	(0.01)	(0.04)
Sillusi flow (Tus)	4	54.42	15.32	2.00	9.71	2.77	6.30	2.98	2.68	2.74	0.87	0.21
Umatilla flow (Tuu)	22	53.29	15.05	2.00	10.54	3.18	6.65	2.79	2.45	3.14	0.71	0.21
s.d.		(0.48)	(0.29)		(0.63)	(0.20)	(0.16)	(0.20)	(0.12)	(0.07)	(0.03)	(0.01)

Table 1. *Average chemical analyses of Columbia River Basalt lava flows and dikes in the Lewiston Basin*[1] — Continued

Geologic Unit	Number of analyses	SiO_2	Al_2O_3	Fe_2O_3[2]	FeO	MgO	CaO	Na_2O	K_2O	TiO_2	P_2O_5	MnO
Lolo flow (Tprl)	22	49.52	14.42	2.00	11.83	5.16	9.20	2.55	1.11	3.29	0.70	0.23
s.d.		(0.39)	(0.28)		(0.42)	(0.31)	(0.21)	(0.22)	(0.10)	(0.08)	(0.02)	(0.01)
Roza Member (Tr)	10	50.42	14.80	2.00	11.31	4.86	8.77	2.57	1.26	3.15	0.64	0.22
s.d.		(0.72)	(0.37)		(0.74)	(0.47)	(0.30)	(0.21)	(0.16)	(0.13)	(0.05)	(0.01)
Shumaker Creek flow (Tes)	10	53.53	15.06	2.00	11.20	3.11	6.65	2.98	1.85	2.55	0.80	0.26
s.d.		(0.43)	(0.27)		(0.75)	(0.17)	(0.21)	(0.18)	(0.13)	(0.03)	(0.02)	(0.02)
Grande Ronde flows (Tg)[4]	7	53.24	15.57	2.00	9.50	5.06	8.95	2.43	1.01	1.78	0.27	0.20
Imnaha Basalt (Ti)[4]	2	51.69	15.45	2.00	10.86	4.85	8.84	2.83	0.71	2.27	0.31	0.20

1 Analyses normalized on a volatile-free basis.

2 Iron is reported as 2.00 percent Fe_2O_3, and the rest as FeO.

3 One standard deviation in percent oxide, given for flows with ten or more analyses.

4 The Grande Ronde (Tg) and Imnaha (Ti) average analyses include many different flows.

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STATE OF WASHINGTON
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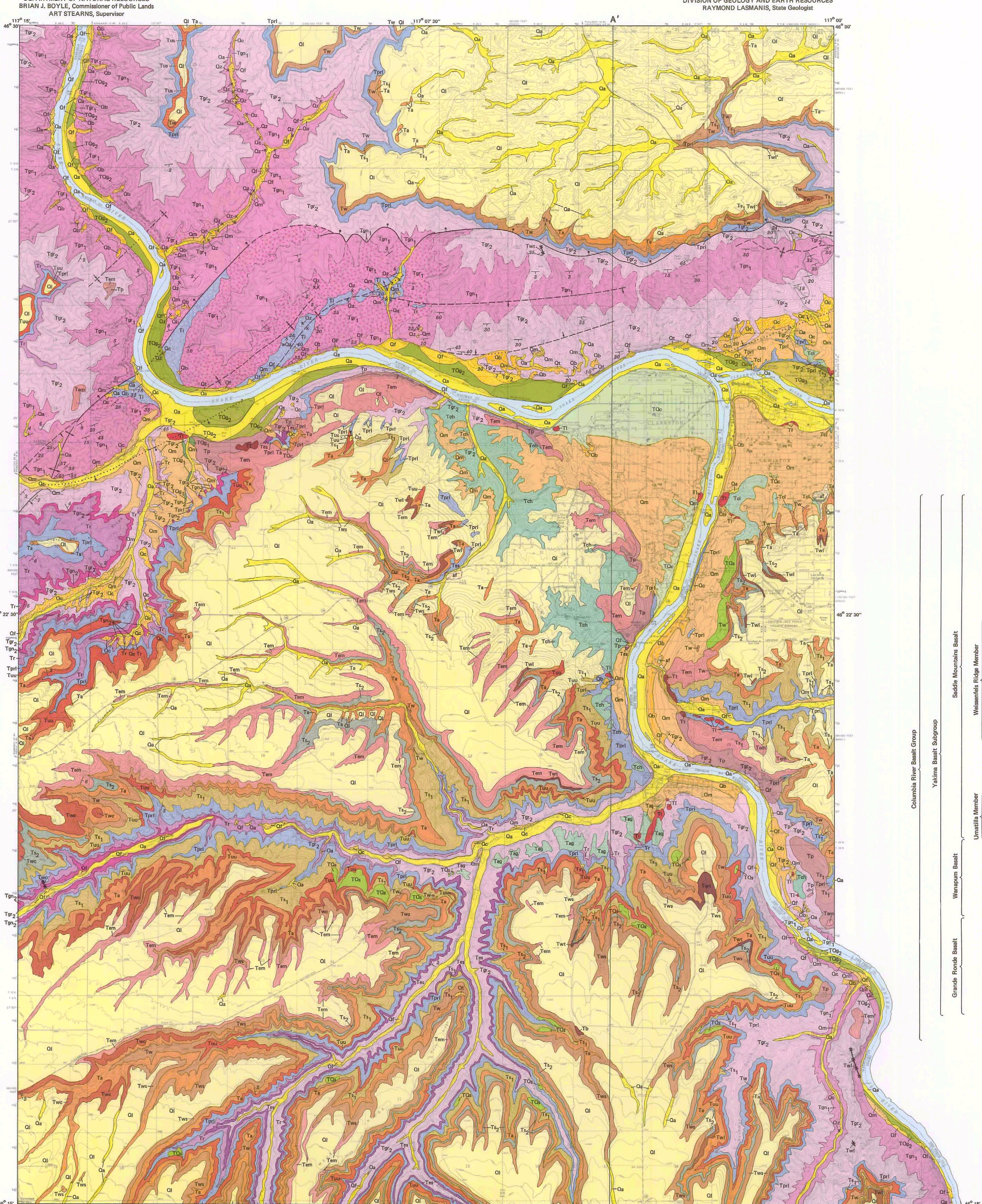
GEOLOGIC MAP
GM-31



Base map from U.S. Geological Survey Clarkston, Silcott, Rockpile Creek, Asotin and Lewiston Orchards South 7½ minute quadrangles, Washington and Idaho

Cartography by Donald W. Hiller

Prepared under U.S. Department of Energy Contract Number DE-AC06-81-RL10297

QUADRANGLE LOCATION

Scale 1:48,000

0 ½ 1 2 3 Miles

0 2000 4000 6000 Feet

0 ½ 1 2 Kilometers

CONTOUR INTERVAL 40 FEET

N MN 20°

EXPLANATION

SURFICIAL DEPOSITS

QUATERNARY

Holocene
- af — Artificial Fill
- Qz — Mazama ash
- Qf — Alluvial fans

Pleistocene and Holocene
- Qs — Dune sand
- Qa — Alluvium
- Qc — Colluvium
- Qt — Talus
- Ql — Palouse Formation

Pleistocene
- Qm — Missoula Floods backwater deposits
- Qb — Bonneville Flood deposits
- TQg3 — Unnamed gravel 3
- TQg2 — Unnamed gravel 2
- TQg1 — Unnamed gravel 1
- TQs — Slump blocks of Tertiary basalt and overlying sediments

TERTIARY

Pliocene
- TQc — Clarkston gravel
- Tcl — Clearwater gravel
- Tch — Clarkston Heights gravel
- Tag — Asotin Creek gravel

IGNEOUS ROCKS

Columbia River Basalt Group — Yakima Basalt Subgroup

Late Miocene

Saddle Mountains Basalt
- Tl — Lower Monumental Member
- Tt — Tammany Creek flow
- Tb — Buford Member
- Tem — Elephant Mountain Member
- Tp — Pomona Member

Weissenfels Ridge Member
- Tws — Slippery Creek flow
- Twt — Tenmile Creek flow
- Twl — Lewiston Orchards flow
- Twl' — Second "Lewiston Orchards" flow
- Twc — Cloverland flow

Middle Miocene
- Ta — Asotin Member
- Tw — Wilbur Creek Member

Umatilla Member
- Tus — Sillusi flow
- Tuu — Umatilla flow

Wanapum Basalt
- Tprl — Lolo flow, Priest Rapids Member
- Tr — Roza Member
- Tes — Shumaker Creek flow, Eckler Mountain Member

Grande Ronde Basalt
- Tgn2 — Upper flows of normal magnetic polarity
- Tgr2 — Upper flows of reversed magnetic polarity
- Tgn1 — Lower flows of normal magnetic polarity
- Tgr1 — Lower flows of reversed magnetic polarity

Early Miocene
- Ti — Imnaha Basalt

SEDIMENTARY INTERBEDS
- Ts3 — Sedimentary interbed 3
- Ts2 — Sedimentary interbed 2
- Ts1 — Sedimentary interbed 1

Contact, dashed where approximately located

Syncline, dashed where approximately located, dotted where concealed

Anticline, dashed where approximately located, dotted where concealed

Monocline, dashed where approximately located, dotted where concealed
Arrow on steeper limb

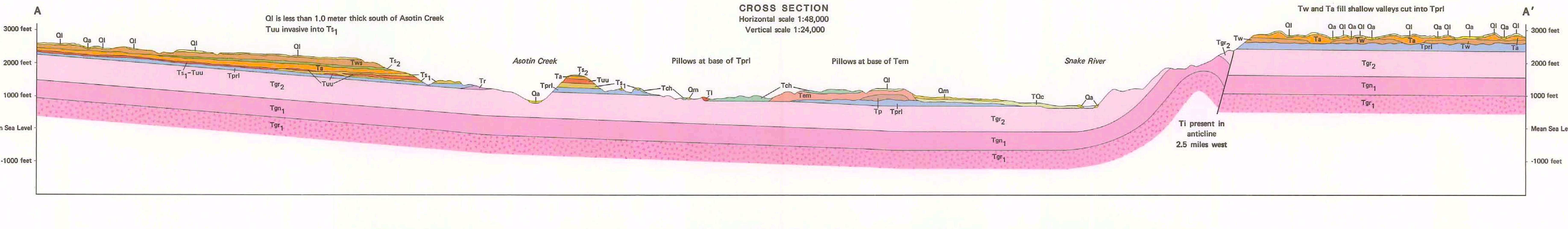
Fault, dashed where approximately located, dotted where concealed
Bar and ball on downthrown side

× Outcrop

13 Strike and dip of beds

Dikes of Weissenfels Ridge Member, Tenmile Creek flow (Twt), Lewiston Orchards flow (Twl), or Cloverland flow (Twc)

CROSS SECTION
Horizontal scale 1:48,000
Vertical scale 1:24,000



GEOLOGIC MAP OF THE CLARKSTON 15 MINUTE QUADRANGLE, WASHINGTON AND IDAHO

BY

P. R. HOOPER, G. D. WEBSTER, and V. E. CAMP

1985