THE OLYMPIC-WALLOWA LINEAMENT.

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ABSTRACT. In connection with this paper, the author presents his "Landform Map of the Northwestern States" 1:1,400,000 which is one of the most detailed maps of its kind. The map shows several new geomorphologic features, the most important of which is the Olympic-Wallowa lineament. This is a straight four-hundred-mile-long structural line extending from Cape Flattery to the Wallowa Mts., very apparent on the map. The line is described in detail as it appears on each topographic sheet, but it was left undecided whether this line is a transcurrent fault-zone, or an accidental alignment of different features.

Among the other features shown on the map, the multitude of small fault scarpes in the Fort Rock area are discussed. They are likened to a nature-made relief model of the Basin Ranges. The map also extends the boundaries of the Blue Mts. province to the southwest, and shows the Blue Mts. as a part of the Northern Rocky Mts.

THE attached Landform Map of the Northwestern States is the result of a season's field work sponsored by the Northwest Regional Council in 1940. More than 15,000 miles of travel by auto and plane was followed by a study of all available source material, such as topographic sheets, Forest Service maps, irrigation maps, soil maps, and a great number of airplane photographs. Where no other material was found the original General Land Office plots were consulted in Washington. The state authorities were also very helpful in rendering maps and information. The Landform Map represents about a year's work.[1]

When the map was completely finished in ink, it happened that the author, looking sideways on the map, noticed a peculiar line stretching from Cape Flattery at the entrance of Juan de Fuca Strait to the Wallowa Mts. This line must be obvious to anyone looking at the map from the northwestern corner toward the center. Apparently we may have here one of the major structural lines or lineaments. Similar features

[1] The map was published by the author in 1941 and appeared first as an inset in the "Pacific Northwest" by Otis Freeman and others. John Wiley and Sons. 1942.

have been described by several authors.[2] The obvious method of procedure would have been to return to the location and study this feature in the field, but wartime duties and travel restrictions prevented this. The next best method was the study of the available topographic and geologic maps which strongly suggest the presence of a continuous lineament of great magnitude. A sheet-by-sheet description of the line is presented as follows:

Cape Flattery, Wash. quadrangle, Corps of Engineers, 1: 62,500. The Oligocene marine strata show strong parallelism around Classet and all along the north shore. No such trend elsewhere on the map.

Callam. C. of E. 1: 62,500. Parallel ridges along north shore somewhat obscured locally by a 400-foot bench, probably of marine planation. No such northwest trend appears elsewhere on the map.

Pysht. U.S.G.S. 1:62,500. Strong scarp from Slip Pt. to Pillar Pt. Parallel trend appears four miles to the south. Farther east along the cost the trend is locally obliterated by the 400-foot bench.

Lake Crescent quad. U.S.G.S. 1: 62,500. The line leaves the shore and continues along Sadie Creek offsetting the front of the Olympic Range and forming the north shore of Lake Crescent.

Port Crescent quad. U.S.G.S. 1: 62,500 Several parallel lines show the trend of the lineament. The strongest line is from Lake Crescent to Lake Sutherland, Indian Creek, and Little River. Parallel lineaments are observable two miles north and two miles south.

Port Angeles. C. of E. 1: 62,500. The line follows Little River trail and Morse Creek trail, offsetting the north rim of the Olympic Mts. and passing from the coastal Oligocene strata into the Mezozoic of the Olympic Mts.

Mt. Constance. U.S.G.S. 1: 125,000. The line enters the map in the north center and continues along Gold Creek with several small splinters clearly shown. Parallel line south of Jimmycomelately Creek.

Quilcene. C. of E. 1: 62,500. The line continues along Deadfall Creek, and Little Quilcene River, until it reaches the Puget

[2] Umpleby, J. B.: 1924. The Osburn Fault, Idaho, Journal of Geol., Vol. 32. pp. 601-614.

Hancock, E. T.: 1918. Geology and Oil and Gas Prospects of the Lake Basin Field, Montana, U. S. Geol. Survey Bull. 691-D.

Letter from Edward Sampson: 1942. Princeton University.

Betz, F., Jr., and Hess, H. H.: 1942. The Floor of the North Pacific Ocean, Geog. Rev., Vol. 32. pp. 99-116.

Kennedy, W. Q.: 1938-39. The Great Glen Fault, Geol. Soc. of London Abstracts of Proc. Sess. No. 1354, pp. 42-43.

Sound. Under the young sediments of Puget Sound the lineament can be traced only faintly. The little sinkhole two miles north of Quilcene is possibly in the line, and the peculiar bend in the shoreline at Camp Discovery is suggestive.

Port Orchard. C. of E. 1:62,500. Here the major north-south trend of topography is chopped off by the shore of Liberty Bay which runs in the line of our lineament. Two miles south is a parallel oblique line running from Brownsville in the center of the map to Eagledale in the east center.

Snohomish, Wash. U.S.G.S. 1:125,000. The oblique line continues in Elliott Bay. Seattle is right on the line and its northwest-southeast street system may be a direct result of the lineament. The location of Seattle on a line of weakness in the earth's crust makes it especially liable to earthquakes even though the lineament does not seem to show the major dislocations since the Ice Age. From Seattle the lines form the north shore of Mercer Island and on to the bold cliff of Squak Mt. There is a parallel line four miles to the north at Green Lake. This connects with Kingston and can be traced to Jimmycomelately Creek.

Cedar Lake, Wash. U.S.G.S. 1:125,000. The line enters in the northwest corner and follows headwaters, Issaquah Creek, Fish Creek, Cedar Lake, and Cedar River. Parallel line four miles north.

Snoqualmie, Wash., folio 139. U.S.G.S. 1:125,000. Here the line crosses the crest of the Cascade Range. Its course is somewhat obscured by heavy glaciation. It passes at the headwaters of Meadow Creek, a 3700-foot low gap, and at Stampede Tunnel. The general north-south trend of the Cascade divide is offset here six miles towards the northwest on the northern side. The line continues along the sharply southeast trending hills south of Easton. Parallel alignments may be noted north and south of this line. The geologic map shows a series of Tertiary igneous rocks of extreme complexity. The western part of the line is in the Miocene andesitic flows where the line may easily be obscured. In the southeast, several faults are shown parallel to the lineament, but none on the lineament itself. The "drawing out" of the Kachess rhyolite at Easton (Eocene) and the same of the Easton schist (Carboniferous), however, suggests that a fault line might be there. The echelon arrangement of the lenses of the Easton schist is also suggestive.

Mt. Stuart, folio 106. U.S.G.S. 1:125,000. The line forms the southern rim of the Kittitas basin. Most of the line is in the Upper Miocene Yakima basalt, which does not seem to show displacement along the line. The section shows a monocline in the Eocene formation at the line; otherwise the map is not conclusive.

Ellensburg, folio 86. U.S.G.S. 1:125,000. The line forms the southern rim of Kittitas Valley along Manastash ridge. A short fault line in proper place and direction is shown in the geological map which, according to the section, passes over into a monoclinal flexure in the Yakima basalt.

From here on the topographic trend is but slightly oblique to the lineament and probably branches off into many small lines in the great mass of Yakima basalt, and several lines can be considered. The choice of the line described below as the major one is tentative.

Badger Pocket. U.S.G.S. 1:48,000. The line continues along Manastash Ridge.

Priest Rapids. U.S.G.S. 1:62,500. On this sheet the lineament is obscure. It could have been eroded by the strong bend of the Columbia River, or covered by the Yakima basalt, or offset into Yakima Ridge.

Prosser. U.S.G.S. 1:125,000. The line enters in the north center and forms the scarp of the eastern end of Rattlesnake Hills. Again the northern half is downdropped, forming the broad basin of Cold Creek Valley.

Pasco. U.S.G.S. 1:125,000. The most unmistakable expression of the line is along the straight line of ridges from the east corner to the Butte in the southeast.

Wallula. U.S.G.S. 1:125,000. The line enters south of Hover, and it forms Wallula gap. Its well-marked scarp of Miocene volcanics leaves the map in its south center.

Topographic Map, State of Oregon, 8 miles to 1 inch. 1939 Lewis A. McArthur. Oregon State Planning Board. The line continues east from Wallula gap and is well marked by the elongated ridges north of Pendleton on the southern rim of the Walla Walla basin.

Umatilla National Forest. U. S. Forest Service. 1:250,000. From Milton on, the line follows the South Fork of the Walla Walla River up to the dam at 1957—from here to Target Meadows. It crosses the main crest of the Blue Mts. at this point and descends into the Grande Ronde Valley at Cricket Flats. The divide of the Blue Mts. is here offset seven miles to the northwest on the northern side. From here it forms the northern rim of Wallowa Mts., chopping off obliquely the north-south ridges and valleys of the mountain.

General Characteristics. The Olympic-Wallowa lineament is responsible for many major features of northwestern topography. Generally it has mountains on its southern side and a series of depressions and basins on the north. The first such

depression is submerged under the waters of Juan de Fuca Strait; farther to the east are the Kittitas Valley, the Cold Creek Valley-Pasco-Wallula depression, the Walla Walla Basin, and the Wallowa Flats. On the south side we find the Olympic Mts.; the line chops off obliquely the Manastash, Umtanum, Yakima, Rattlesnake, and Horseheaven Mts. and forms the N. E. rim of the Wallowa Mts. It offsets the main crest of the Cascade Mts. about six miles to the northwest on its northern side, and the crest of the Blue Mts. with roughly the same amount in the same direction. It may also be responsible for the fact that Vancouver Island is offset to the northwest in relation to the Coast Ranges. In almost its entire length it is oblique to the major trend of topography. In most places the lineament is rather a zone than a line, with many parallel ridges and splinters.

Origin. Two hypotheses of the possible origin of the lineament are here presented: (1) Accidental alignment of independent features; (2) Transcurrent fault.

(1) In favor of the first hypothesis it should be mentioned that:

(a) The Olympic section of the lineament line coincides partly with the boundary of the Oligocene and the Mezozoic series and the linear character can be explained as a result of warping in the Tertiary rocks.

(b) On Toandas Peninsula in the Puget Sound region, the line is not well expressed in topography.

(c) It does not show clearly in the Snoqualmie and Mt. Stuart geologic folios obscured by Tertiary igneous rocks.

(d) On the Priest Rapids sheet the line is obscure.

No detailed topographic maps are available in the Oregon part of the line.

(2) Transcurrent faults, as described by Betz and Hess[3] should have the following characteristics: "They are extremely long and have relatively straight courses; the dip of the fault plane is in all cases nearly vertical; huge horizontal displacements are possible; in some cases the vertical component is so small that there is little topographic expression; in other cases the vertical component is large and measurable in thousands of feet, though this is small when compared with the horizontal component, which may be on the order of miles or scores of

[3] Op. Cit. p.

miles; if we are considering only the vertical displacement, the fault can be normal for part of its course and then assume a reverse character; basaltic volcanism may be associated with such faults in places, suggesting the presence of uninterrupted fractures extending to great depths; intermittent movements may occur on such fault zones over geologically long periods of time. It seems likely that, once developed in the crust, they will persist indefinitely as zones of weakness."

As for the Olympic-Wallowa lineament no data are available about the angle of the fault plane and the exact amount of horizontal displacement, but all the other characteristics seem to be present. It appears, however, to be a more complex structural line than a simple fault. It may have started as a transcurrent fault but the line of weakness thus created probably suffered further dislocations.

The author does not confess to be competent to arrive at any conclusions. The facts are presented here for what they are worth and await appraisal by structural geologists. It should be mentioned that the Osburn fault stretching from Missoula to Coeur d'Alene, one hundred and fifty miles away, and the Hope fault on the Pend Oreille district, one hundred and ninety miles away, both well recognized by mining geologists, are parallel to the Olympic-Wallowa lineament. There are, somewhat obscure, indications that the line may extend way into Idaho. It shows up well on the northern part of the Meadows quadrangle and forms the southern rim of Stanley Basin. The Great Fissure Fault of the Craters of the Moon is in the direct line of the lineament.

Other features of the map "Landforms of the Northwestern States." Minute Scarps in the Oregon Desert. The author had access to airplane photographs of the region between Summer Lake and Juniper Mts. in the Oregon desert. These photographs have the most striking appearance, showing hundreds of small parallel scarps in the lava. These scarps are only 50 to 200 feet high and rarely longer than a few miles. They are apparently minor fault scarps somewhat like a small-scale model of the Basin Ranges. They cut off obliquely the major north-south lines represented by the Winter Rim, Abert Rim, and Poker Jim Ridge. Their trend is similar to the Olympic-Wallowa lineament and deserves a tectonic study.

Extension of the Blue Mts. Province. The map shows the area of the Blue Mts. larger than on previous maps, and

apparently there is no distinct topographic break between the Northern Rocky Mts. and the Blue Mts. The Snake River canyon can certainly not be regarded as a regional boundary. The Blue Mts. seem to have a double crest. The northern is represented by the Umatilla Mts., the Umatilla Plateau, and extends toward Lewiston. This is flat topped and seems rather the upper end of a monoclinal swell than a mountain. The southern crest is sharp and is represented by the Ochoco Mts., Wolf Ridge, the Aldrich Strawberry Mts., extends toward the Owyhee Mts., and is cut across by the Malheur Canyon. This ridge seems to be the northern edge of a south-facing warp. In between the two crests are the blocks of the Greenhorn, Elkhorn, and Wallowa Mts., giving a great complexity to the Blue Mts. Region.

The chief value of the preparation of detailed landform maps like the one here presented lies in the fact that it discloses the true complexity of landforms, where they were often represented as features requiring but simple explanation. This is especially true of the Northwestern States which have perhaps the most complex morphology of the entire country. It is hoped that in more normal times the preparation of detailed landform maps for the whole country can be resumed.

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