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INFLUENCE OF BASIN RANGE FAULTING IN MINES AT BINGHAM, UTAH.

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INTRODUCTION.

THE Oquirrh Range, Utah, is the most easterly of those northerly trending fault-block mountain units that traverse the Great Basin, and are characterized by what Gilbert [1] has termed Basin-Range structure. This range is about 30 miles long and 5 to 15 miles wide, and its north end terminates against Great Salt Lake. The important mining camp of Bingham is situated in the north-central part of the range and the camps of Stockton, Ophir, Mercur and Sunshine are successively farther southward. And, in southerly continuation of the Oquirrh, the East Tintic Range contains the rich Tintic mining district. Basin-Range faulting along portions of the Oquirrh West Front was early recognized [2] and faults of this type have recently been described along much of the southern half of the range, where Gilluly [3] found that certain of them have been mineralized.

In the Bingham mining district the locally well-known Occidental fault is an important geologic factor in the Highland Boy mine (production $87,731,000) and in adjoining mines. Because this fault now appears to be a Basin-Range structure, its control of mineralization and its relation to the other geologic features at Bingham deserve special mention. Some of its characteristics may be expected in other of the many Basin-Range faults in the region.

[1] Gilbert, G. K.: Studies of Basin-Range Structure. U. S. Geol. Surv. Prof. Paper 153, p. 1, 1928.

[2] Gilbert, G. K.: Lake Bonneville. U. S. Geol. Surv. Mon. 1, p. 352, 1880.

[3] Gilluly, James: Basin Range Faulting along the Oquirrh Range, Utah. Bull. Geol. Soc. Amer., vol. 39, pp. 1103–1130, 1928.

OCCIDENTAL FAULT, A BASIN RANGE-STRUCTURE.

Underground Exposures.—The Occidental fault lies at the southwestern end of the Bingham mining district (Fig. 1), where underground workings in the Utah-Delaware mine (formerly Utah Consolidated, Highland Boy and Yampa mines) and in the Utah Metal and Tunnel mine have developed it intermittantly for 3500 feet along its strike and 2150 feet down the dip. Such abundant exposures of the fault zone permit a more intimate examination of its features than is possible in the usual

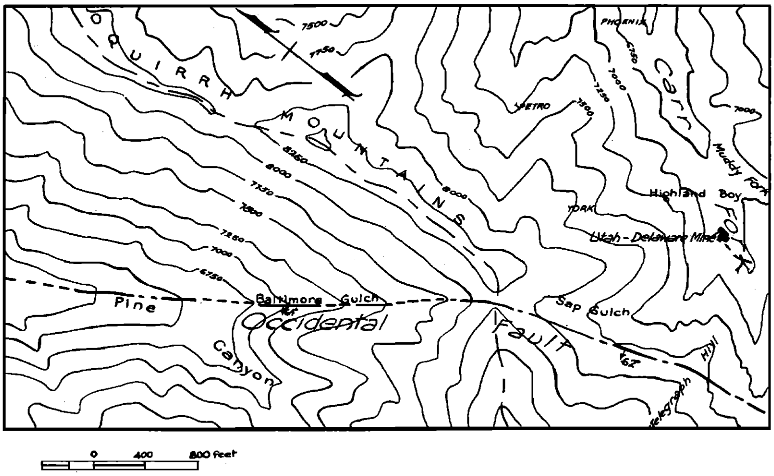

FIG. 1. Southwestern portion of Bingham district, Utah, showing outcrop of Occidental fault. (Topog. after U. S. Geol. Survey.)

Basin-Range fault occurrence, where surface expression alone may be seen.

Underground exposures of the fault zone commonly consist of 5 to 10 feet of intimately ground friction-breccia containing two or more slickensided walls. At exceptional points the rock has been crushed as far as 100 feet beyond the main fault walls, and the zone is a wet, sandy ground that is difficult to crosscut. Limestone breccia in the zone is mostly altered to a rubbery gouge, whereas the more abundant quartzite breccia varies from a sandy mass, kept granular by recent strains, to a hard rock of well cemented breccia at points undisturbed by recent movements.

The average strike of the fault plane is N. 25° W. and the dip 62° SW. Although there are local variations as large as 20° from the general attitude, the fault plane is exceptionally regular and its position may be projected from level to level of the mines with confidence.

Groovings which would indicate the direction of relative movement are lacking. The small striae on slickensided walls only indicate the direction of recent movements along the fault zone, with which the direction of the earlier major movement may not agree.

Displacement.—On each side of the Occidental fault, distinctive limestone members of the Bingham Quartzite dip northerly 30° to 60°, and from their displacement the fault movement can be estimated. Beds on the hanging-wall (west) side are relatively downthrown 1500 feet; or they have an apparent horizontal offset of 2500 feet southward. Because it has not been possible to match actual points in beds on opposite sides of the fault, such as displaced halves of a transected fold, the total displacement of the fault is not known. If the direction of movement were nearly parallel to the dip of the beds, the total displacement would be much larger than the above simple vertical or horizontal displacements. The fault is more probably a rotational one because its movement appears to increase to the north but probably splits up and dies out to the south.

Topographic Expression.—The surface trace of the fault is exposed in short prospect tunnels and trenches adjacent to the productive area of the mines. It extends northward through the saddle in Telegraph Hill,[4] across the eastern slope of Clipper Peak, and enters the sharp saddle in the main Oquirrh ridge at the head of Sap Gulch on the Bingham side, and at the head of Baltimore Gulch on the west side (Fig. 1). Northward, beyond the saddle, the fault trends down the sharp channel of Baltimore Gulch, along the east side of Pine Canyon and along the bases of the steep, triangular-faceted spurs of the Oquirrh West Front. Deep mine workings have developed the fault beneath Baltimore

[4] Hunt, R. N.: The Ores in the Limestone at Bingham, Utah. Trans. Amer. Inst. Min. Eng., 70, p. 861, fig. 3, 1924.

Gulch, making certain its identity with the Basin-Range fault on the surface. A good outcrop of the fault occurs at a waterfall in the lower end of Baltimore Gulch, where it consists of a central zone of cemented fault breccia and rock flour, bounded by parallel slickensided walls four feet apart, with irregularly shattered and brecciated rock extending 20 to 75 feet on either side.

On the surface, above the point in the mine where the fault has a 1500-foot throw, the topographic relief produced by the fault is noticeable but not large. North of Pine Canyon, however, the topographic relief due to the fault increases to 2500 feet, and presumably the stratigraphic displacement is even greater. In its non-persistence the Occidental fault resembles a Basin-Range fault [5] twelve miles southward, which dies out completely two miles south from a point where the stratigraphic displacement is 3000 feet.

RELATION OF OCCIDENTAL FAULT TO MINERALIZATION AND TO OTHER GEOLOGIC FEATURES.

The ores at Bingham [6] are of three types: (*a*) bodies of various combinations of copper, lead, zinc, silver and gold minerals replacing siliceous limestone members of the Carboniferous Bingham Quartzite formation, (*b*) disseminated "porphyry copper" ore, and (*c*) fissure ores in monzonite intrusive rock. The sequence of geologic events climaxed by mineralization is: (1) early normal faulting of the sedimentary rocks; (2) folding, which produced some large bedding faults; (3) Basin-Range faulting and northeast faulting; (4) intrusion of monzonite and accompanying metamorphism of the sedimentary rocks; (5) additional northeast faulting, following by hydrothermal alteration and by mineralization; and (6) additional small movements on all faults, resulting from renewed movement on Basin-Range faults.

[5] Gilluly, James: Geology and Ore Deposits of the Stockton and Fairfield Quadrangles, Utah. U. S. Geol. Surv. Prof. Paper 173, pp. 83–85, 1932.

[6] Boutwell, J. M.: Economic Geology of the Bingham Mining District, Utah. U. S. Geol. Surv. Prof. Paper 38, p. 123 et seq., 1905.

To support the above stated sequence: (1) early normal faulting is represented in Utah-Delaware and Utah Metal mines by South and Top faults (Fig. 2) which offset the limestone beds as much as 900 feet. Subsequent folding, faulting, intrusion, alteration, and mineralization have greatly obscured these ancient faults. (2) Yampa Foot Wall fault is an example of a strong bedding slip produced along a sharp stratigraphic contact by folding strain. It displaces South fault 450 to 550 feet and cuts the quartzite beds which South fault left aligned with the

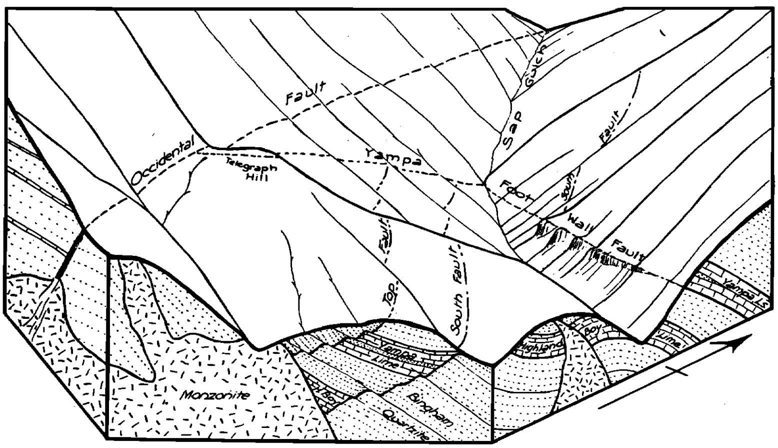

FIG. 2. Diagram of surface and underground geology near Utah-Delaware mine, Bingham, Utah.

base of the Yampa limestone (Fig. 2). (3) Both Basin-Range faulting (Occidental) and northeast faulting (*e.g.* Ball fault) truncate folds and cut bedding slips; therefore they are younger than folding. Also, lack of drag along the Occidental fault argues against its origin as a rupture during folding strain. (4) Intrusion of the monzonite followed Basin-Range faulting—perhaps closely—because it sent dikes along the Occidental and Ball faults. Moreover, the Last Chance monzonite stock stoped out the Occidental fault zone, although later minor fractures have extended into the monzonite in rough prolongation of the fault zone. The intrusive is likewise younger than folding, as has been suggested by Hunt,[7] because dikes and sills cut cleanly through folded limestone beds without disturbing the symmetry of the separated limbs of the folds (Fig. 2). (5) Postmineral movements on northeast faults have produced slickensides in ore and have offset sills of monzonite a few tens of feet. Recent Basin-Range movement on the Occidental fault probably is not much greater than 100 feet at the southern end but may be considerably greater northward along the fault. A common origin for all recent movements on the various faults seems likely.

Ore deposition in the limestone has been controlled at different points by a variety of structures, both tangible and obscure. Prominent among them are plunging intersections of beds or bedding slips against northeast faults, and roof structures, such as the intersection of Yampa Foot Wall fault against the South fault, together with a northeast fault to close the structure. Although the Occidental fault zone has been sparingly mineralized at points, it has played a much more important part as a roof structure, presenting a relatively non-replaceable overhanging wall of quartzite to mineralizing solutions that raked up toward it through the limestone. For this reason a number of ore bodies increase in size as they approach the fault and either mushroom out against it or are deflected along it. A Basin-Range fault has thus formed a definite, favorable boundary for several important ore bodies at Bingham.

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[7] Hunt, R. N.: *Op. cit.*, pp. 863–866.