

CROSBY REPORT SHOWS VARIETY OF FORMATIONS

(Continued from Page 1.)

exception, we might, then, assume for the reservoir a continuous sub-floor of the older and, probably, more impervious basalt.

Whether the flood of basalt from either side ever submerged the transverse rhyolite ridge, is very doubtful. On the west side of the river, north of Benham Falls rhyolite tuff is seen to be capped with basalt. But the rhyolite of the Benham Falls ridge, with its vertical flow structure, must be regarded as a true volcanic neck. The basalt falls far short of covering it now; and since the sharp ridge of rhyolite must have lost elevation by erosion much more rapidly than the broad plain of basalt, we can only conclude that the floods of basalt burst around the rhyolite relief but did not overtop it.

Lava Tunnels

No feature of the basalt is of greater scientific interest or practical importance than the lava tunnel. This exists where after the main part of a flow has cooled and solidified, cracking of the crust allows the still molten residuum to escape, and the tunnel, or a vacant space of some form, naturally results. Whether or not water or some other constituent of the basalt tending to promote its liquidity, determines the location or formation of a tunnel is an unsolved problem; but to the writer it appears more probable that the principal factors are differential cooling, gradient and velocity.

The incandescent lava is cooled and stiffened by contact with the cool earth below and the cool air above. Between the two crusts thus determined it flows most rapidly in the lines of highest gradient (most rapid descent). Where the gradient is low and the movement sluggish, as on upland areas, the lava first solidifies through the entire thickness of the flow; and the more fluid, rapidly moving portions are confined more and more to the valleys or topographic lines of steepest descent. The hottest, most fluid and most rapidly flowing lava will be that freshest from the crater or fissure and the subterranean sources, and when the latter finally fail, the lava within the tunnel drains away and leaves the tunnel empty.

Lava Tunnel Important

The normal topographic relations of the lava tunnel are of special practical importance in connection with this study because of its tendency to follow the axis of the valley as it existed at the time of the eruption and the outpouring of the lava, and also because there exists in the Deschutes valley above Benham Falls, and there in the proposed reservoir area, a magnificent example of the lava tunnel.

The entrance to this tunnel is on the east side of the valley, about one and one-half miles southeast of the main road at a point one mile south of Lava Butte; and probably in Section 35 of Tp. 19 S., R. 11 E. For the discovery of the tunnel and for access to its interior we are indebted to a local fall of the roof, due, perhaps, to the passage of earthquake vibrations.

The general course of the tunnel is northwest-southeast; but it is far from straight, winding much as a surface stream of water might in traversing the same territory. It

is said to have been traversed for a mile southeasterly from the entrance; and in company with Assistant Engineer Irving B. Crosby I traversed it to a point nearly one and a fourth miles northwesterly from the entrance.

Erosion Slight

The transverse dimensions of the tunnel are fairly uniform—say 20 to 30 feet wide and 15 to 25 feet high, disregarding extremes; and the roof ranges from 20 to 40 feet in thickness. The walls are surprisingly smooth, except for the minor drip forms of lava; and the characteristic columnar jointing or basaltic structure is conspicuous by its absence. The floor is sensibly level, save where encumbered by sand washed in through cracks in the roof or by rare falls of rock. The tunnel, however, is not level; but it has a surprisingly uniform northwesterly gradient, agreeing, approximately, with the general slope of the ground above it. Toward the inner or northwestern end of the tunnel, the said derived in part, at least, from the roof, becomes more and more abundant, and finally reaches the roof and closes the tunnel, without, however, appreciable contraction of its bore. As the sand gains in depth it appears to gain, also, in moisture, the appearance being, at the last, that the tunnel is nearing the water-table. Either this supposition is true or the damp sand conserves with great tenacity the drip water of the tunnel.

One difficulty in deriving the main part or any large part, of the tunnel, sand through the roof is the general tightness of the tunnel, the floor and lateral walls being almost absolutely tight, and the roof ditto, so far as could be seen by candle light. The sand is of very uniform character, entirely free from clay clearly of volcanic origin, and identical in character with large volumes of sand which the drill has shown to underlie the Benham Falls reservoir area. To account for its abundant presence in the lower part of the tunnel we need only assume a local collapse of the tunnel roof. The tunnel is much newer than the basalt of the western slope and contemporaneous with that of the eastern slope, but older than the gorge which the river has cut in the newer and older basalts, and older still than the volcanic and organic sediments deposited in this gorge and over the general floor of the Benham Falls basin and the prospective reservoir.

Tunnel's Course Sought

We are, naturally, specially concerned to discover, if possible, the probable course of the lava tunnel beneath the reservoir area and its relation to the buried gorge of the Deschutes river. The safest assumption is that, as previously indicated, the tunnel follows the steepest and deepest line of flow of the east side basalt. This would bring it to and into the ancient gorge of the Deschutes river at or above the point where the Deschutes or that time cut through the rhyolite ridge.

That the static pressure and the high liquidity of the column of lava would maintain the discharge to the point of exhaustion, and finally leave the tunnel empty, is most probable; for the loss of heat sustained by the lava in its passage through the tunnel would be inconsiderable; and lava sufficiently fluid to enter the tunnel would be likely to complete the passage. This is the conservative view and certainly accords with the present state of the tunnel, especially with its regular form and smooth walls. It is a perfect con-

duit, of ample bore and well fortified against loss of heat; but becoming, as it slowly cools, an ideal channel of a subterranean river. It does not appear, however, to have been occupied, even temporarily, by a stream of water, at least not in the part now accessible, for we detected not the slightest trace or indication of stream erosion, or deposition; even the sand with which the tunnel is finally clogged having more the appearance of having been deposited by drip water than by running water.

The tunnel is not only an important contemporaneous structural feature of the great east side flow of basalt; but it is probably throughout, and not alone where the roof has fallen, a comparatively shallow feature; for this sheet of basalt has not been covered, along the probable line of the tunnel, by any later formation, save, perhaps, the flood-plain deposits (silt, etc.) of the river channel and the reservoir area. It is plain, therefore, that, in view of the probable leakage of the tunnel roof, and its possible local collapse, a heavy responsibility rests upon this carpet of silt.

Also in view of the fact that the discovery of the tunnel is due to a mere accident, a chance fall of the roof, it is a natural thought that there may be others, far beyond the limits of the collapsed portion we look in vain for any surface indication of the tunnel. Almost our only clue is afforded by the thought that the tunnels tend to follow the depressions or valleys of the original or pre-lava surface; and here we encounter the difficulty that the pre-lava depressions are likely to be effaced by the flow. In fact this appears to be the case with the tunnel under discussion. It is not now conspicuously marked by a surface depression. It does appear reasonable, however, that the lava tunnels will not be closely spaced, in other words, that the occurrence of a tunnel immunizes a considerable breadth of lava on either side.

Besides the unnamed tunnel already described, I have knowledge, derived from the Deschutes National Forest map, of only two tunnels on the eastern slope of the Deschutes valley. These are the Arnold Ice Cave, a dozen miles southeast of Bend and trending in that direction, and Horse Cave, about three miles east of Bend, but sharing, also the northwesterly trend. Horse Cave is irregularly branching; and there are indications that the Arnold Ice Cave may also be branched. But whether the branches are tributaries or distributaries (converging or diverging) is not very clear. The Arnold Ice Cave also belongs, as the name implies, to the class in which the drifted snow of winter exceeds the summer melting. Such examples might be called natural ice houses. Although we can not suppose that the ice extends far from the opening it may accumulate to such an extent as to make exploration difficult or impossible. The Edison Ice Cave, some 17 miles in a direct line southwest of Bend, and eight miles west of the reservoir, is a case in point. It is at an elevation of about 5,000 feet.

(To Be Continued.)

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