

On June 12th and 13th, last, in company with Dr. S. Warren Carey, Government Geologist, and Mr. H. H. Thomas, Engineer of the Hydro Electric Commission, I visited the Butlers Gorge damsite for the purpose of continuing the detailed geological mapping of the damsite excavations. The general geology of the area already has been described in previous reports, so that I need refer only to the specific problem of the fracture pattern and related features in so far as they have a bearing on the safety and effectiveness of the proposed dam.

The foundation of the Butlers Gorge dam consists of massive, compact and sound rock (dolerite) interrupted at irregular intervals by fractures, which are partly open, partly filled with clay or calcite and zeolitic material, and for a part of their length with the walls in close contact. Although the foundation rock is essentially a dense, non-porous one, it has some permeability due to the agency of the extensive system of fractures. It is the number of kinds and spacing of the openings in the generally interconnecting systems of fractures that is the subject of this study.

The study of the fracture systems of the dolerite within the area of the dam excavations is too restricted to give a complete interpretation of the structure of the igneous mass, and the absence of observable flow structures in the rock prevents a correct orientation of the three primary systems of fractures recognised, because their true position is determined by angular relations to flow lines. For the purpose of this report, the three systems recognised are referred to the following types:-

- (1) diagonal joints
- (2) longitudinal joints
- (3) flat lying joints

The diagonal joints are planes that form angles of approximately 45 degrees with the probable trend of the flow line. Of the two conjugate systems, the one with a meridional trend and an easterly dip appears likely to be locally suppressed, while the other with a general strike of north 30° east and a north-westerly dip appears to be strongly developed.

It is possible that the latter may be more rightly termed inward-dipping marginal joints and, although some of them show evidence of displacement, suggest that the upward lengthening of the rock mass during intrusion was not great and that the marginal joints sufficed for the necessary adjustments.

The longitudinal joints are steep planes that strike parallel to the trend of the flow lines and probably are represented here by three sets of nearly vertical joints striking north 10° east, north 15° west and north 46° west respectively.

The system of flat-lying joints is most probably one of tension joints, but some may be due to exfoliation at the surface.

The fault which traverses the dam-site near the left bank abutment strikes north 52° east and dips north west at 85°; the rock between adjacent fracture planes exhibits localised disintegration, being chloritised and impregnated with iron oxides. It flakes easily parallel to the joints, resembling a decomposed schistose rock.

There are two subsidiary sets of joints developed contemporaneously with the faulting.

- (1) the platy structures due to secondary shearing parallel to the fault.
- (2) and at least, one of the two sets of conjugate feather joints usually developed along faults in igneous rocks.

In considering the general stability or load-bearing ability of the foundation rock, it is necessary to know its general crushing strength. The International Critical Tables, New York, Vol. 2, 1927, indicates that the average compressive strength of dolerite, under a lateral pressure of one atmosphere is 1800-2700 kilograms per square centimetre. Under high all sided pressure, the same material would have a much greater compressive strength. It is apparent then that any failure of the rock will be due to certain structural features such as fissuring and faulting rather than to deficient crushing strength of the foundation rock.

The study of the fracture pattern has shown that there are no clay seams of sufficient magnitude to affect seriously the stability of the dam foundations. As the three directions of maximum weakness in the major jointing systems are south 87° west at an elevation of 45° , south 20° west at an elevation of 19° , and south 8° west at an elevation of 22° , it is apparent that the direction of the major thrusts of the dam are most advantageously placed.

Some special treatment may be necessary in the case of a few of the clay seams and I would suggest that some attempt be made to remove the clay from the larger seams by jetting before grouting.

Regarding the advisability of covering any portion of the foundation rock with a blanket of concrete immediately after excavation to prevent erosion or decomposition of rock or clay seams, I am of the opinion that, with the exception of the faulted zone in Block A which requires special treatment, and the area in the old river bed, near the inlet pipes, which requires probably another ten feet of excavating to reach unweathered rock there is no need to blanket with concrete, as the rate of weathering of the dolerite is extremely slow and no observable change in the rock could be noted in the interval between final excavation and commencement of actual construction of the dam.

All rocks are somewhat permeable and loss of water is inevitable from any reservoir which abuts on rock masses lying above the pre-existing water table. But as pointed out above, the only possibility of leakage of water under the dam and/or through the abutments is through localised porosity by means of the interconnecting systems of fractures. The majority of the fractures have a general meridional trend and consequently cross right under the dam into the reservoir basin, but the cover of glacial material on the upstream side will effectively seal the greater proportion of those that reach the surface. However, as the main effect of the joints will be piping, this could be entirely removed by an effective curtain of grout under the heel of the structure.

The problem of shear, in particular, depends upon the relationship of the moment of thrust on one hand to the frictional resistance of the possible shear surface on the other. This resistance being determined by the

nature of these surfaces and their attitude or inclination with reference to direction of shear force. The study of the fracture pattern has shown that there are no fractures so situated as to promote shearing movement by sliding. The very nature of the fractures also militates against any such possible movement in that they vary considerably along individual fractures, sometimes being partly open, partly filled with clay or calcite and zeolitic material and for a part with the walls in close contact.

Regarding the fault, which crosses under Block A of the left abutment, the evidence of striae and slickensides indicates that the general movement has been horizontal in the direction of the fault. Although the fault has been long inactive, there is no evidence of its stability and the possibility of renewed movement along the fault cannot be overlooked entirely. This is one of the hidden factors, the full effect of which cannot be predicted, even after careful geologic study.

The chance of renewed movement upon this fault is extremely remote, but as the possibility of earth movement has to be considered, due allowance must be made in the design.

In the matter of local treatment of the excavation on the fault zone, all that is necessary is to pick out only the weathered rock, in the shattered zone, for a few feet and back fill with concrete. The downstream side of the excavation will not require any further excavation.

Concerning the weathered zone in the river bed, in the vicinity of the intake pipes, it is recommended that the excavation be deepened to at least ten feet in this area in order to get below the weathered rock in the old river bed. At the time of my inspection, the deepest excavation was no greater than three feet below the old river bed. I am of the opinion that, with the deepening of the excavation in this area, sound unweathered rock will be obtained.

In a memorandum dated 22nd June, 1945, from the Chief Civil Engineer of the Hydro Electric Commission, per Mr. H. H. Thomas attention was drawn to a possible leakage of water from the reservoir basin below the outlet of Lake Rufus. It was suggested that the leakage may be due to absorption into or passage under the button grass plains, but I do not think that any appreciable quantity of water could be diverted from the river in this manner. It was suggested further that there was a possible leakage underground either to the Derwent or to the River Gordon. In order to ascertain if limestone beds do occur in this area it will be necessary to examine the reservoir basin before expressing an opinion as to the possible source of leakage. I think it desirable that the question of possible leakage from the reservoir basin should be investigated.

FIELD GEOLOGIST

Department of Mines,
17th December, 1945