Rock Structures and Associated Rock Alteration, Danjera Creek Dam, N.S.W.

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Alteration.
* Chemical instability
slides.

SUMMARY. - Danjera Creek damsite is an interesting case history of the association of rock structure and rock alteration. The most critical conditions are where fracture zones form permeability paths for hypogene and supergene circulations. Petrographic studies combined with structural analysis indicated sub-surface rock defects. At this damsite bedrock is comprised of steeply dipping intercalations of low-grade meta-sediments and basalt. Rock defects are caused by a combination of fracture and alteration associated with possible thrust faults. The "axial plane" of an anticline is parallel to the valley and dips 70°W. The resultant discontinuity pattern is asymmetric to the valley profile and rock cuts in the right abutment are less stable than those in the left abutment. Later deformation produced two fault/fracture sets at 50° and 90° to the valley axis. Secondary fracture porosity is greatest at the intersection of faults and is associated with alteration within basalt. Decomposition of basalt was initiated by hypogene circulations producing sulphide mineralization and weathering of basalt to clay is deepest in zones previously effected by hypogene alteration. Geological investigations during preliminary excavation work were utilised to redesign the concrete foundations.

INTRODUCTION

Danjera Creek is a right bank tributary of the Lower Shoalhaven River in the central coastal belt of New South Wales. The dam is located 15 miles west of Nowra and is being constructed to augment water storage for the Shoalhaven Shire Council.

Wallis (Ref.1) has described the preliminary investigations of 1965/66. 16 vertical diamond holes were drilled during 1965 in the dam foundations. The area was geologically mapped and bulldozer trenching utilized to gain further geological information. Electromagnetic survey of a quartzite breccia zone associated with a suspected fault in the eastern part of the valley floor was interpretated to indicate this fault zone had a steep easterly dip (Note that excavation showed this fault dipped 70°W). Six additional angle diamond holes were then drilled into this zone.

The geology of Danjera Creek damsite provides an interesting case history concerning the affect of rock structures and hypogene rock alteration on the engineering properties of rock foundations. The occurrence of rock decomposition resulting from hypogene processes, i.e. hydrothermal activity, mineralization, auto-metamorphism, etc., is of specific importance in foundation studies in view of its persistance at depth. Normal weathering by supergene water percolation is on the other hand a surface phenomenon. Hypogene rock alteration is most extensive in chemically unstable igneous rock. It is difficult to recognise hypogene rock alteration in the surface exfoliated zone where it is normally masked by weathering.

Basaltic rocks are particularly prone to alteration. Auto-metamorphism (decomposition by entrapped volatiles) in extrusive basalt complexes is widespread in Eastern Australia and recent investigations in northern N.S.W. indicate that rock structures partly control the extent of decomposition in basalt flows where contemporaneous movements have occurred. At Danjera Creek, basalt forms sill-like masses in which auto-metamorphic alteration is slight and extensive alteration is associated with sulphide mineralization in zones of fracture along faults.

GEOLOGY

The dam is founded on steeply dipping intercalations of Upper Devonian sediments and basalt, part of the western limb of an asymmetric anticline. The sediments consist of massive units of interbedded silty-mudstone and siltstone which contain thin beds of fine-grained quartzite and tuffaceous sandstone. These sediments have been affected by low-grade metamorphism and the rocks are indurated and cleaved, particularly parallel to a prominent "axial plane" cleavage trending 20°E of N and dipping 70°W. Bedding is indistinct, the few measurements possible indicate the bedding strikes 20°E of N and dips 60°W. The rock masses are isotropic, the asymmetric of the discontinuities resulting in the right bank foundations being less stable than the left bank in open cut.

The basalt varies in texture from sub-vitreous fine-grained to coarse-grained. Glassy material occurs near the sediment contact and it is assumed the basalt masses are sill intrusions. Decomposition of the basalt has selectively occurred along fault planes in association with pyrite/galena mineralization. Frequently the meta-sediment/basalt contacts are faulted.

Meta-sediments form the rock foundation in the abutments and basalt in the valley floor - see Fig. 1.

ROCK STRUCTURES

The fold axis trends 20°E of N and is parallel to the river course. An "axial plane" cleavage dips 70° W with two complementary sets dipping 35°/40°W and 50°E. Two near-vertical joint sets trend 40° and 80° W of N. Faults in the latter directions have displaced

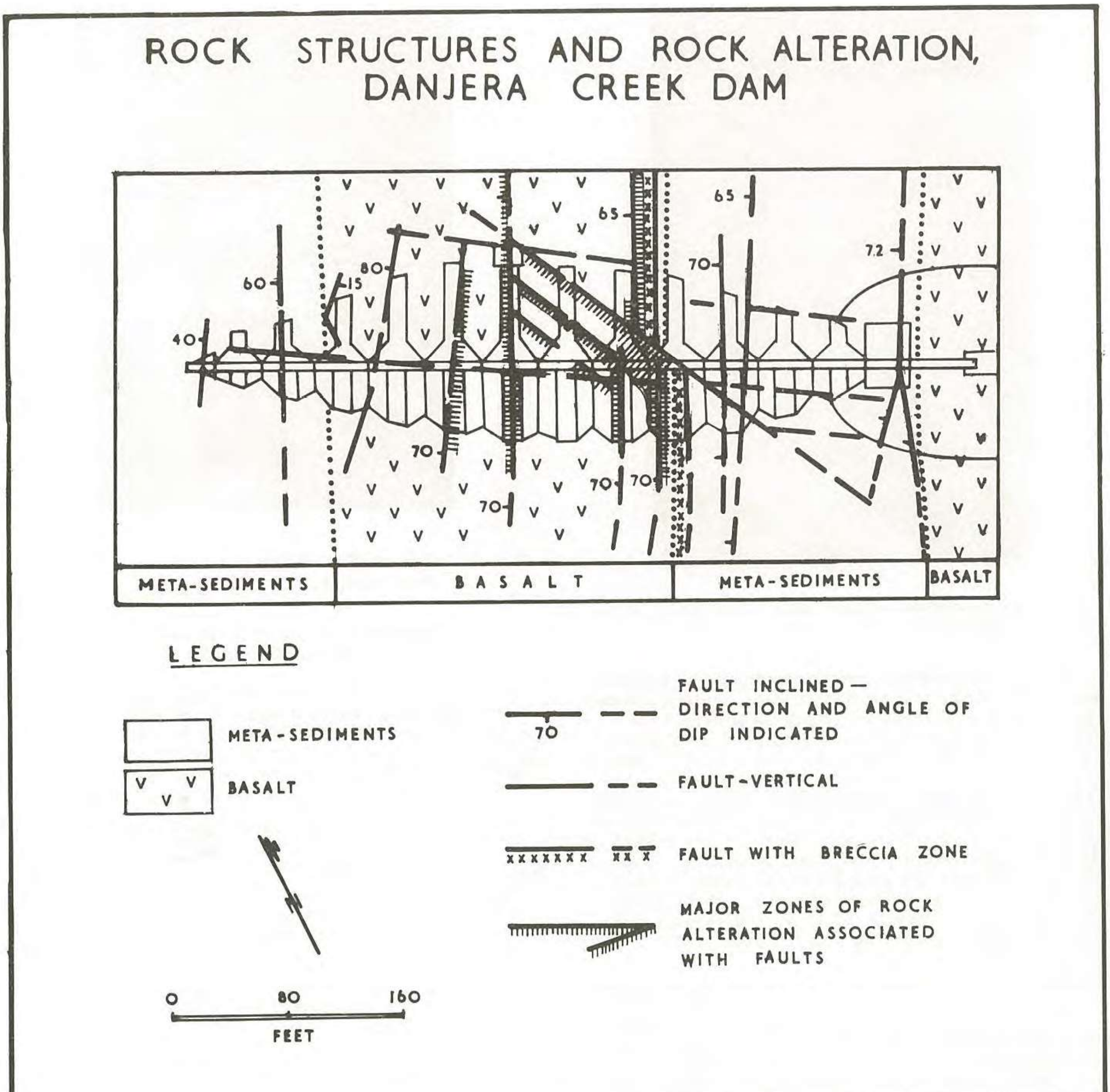

Fig.1

the "axial plane" faults. Many joints show displacement within the rock while major faults have sheared or brecciated the bedrock. The "axial plane" faults appear to be thrust planes and the sill-like basalt sheets may be repeated by faulting. The fault forming the eastern boundary of the valley floor basalt is associated with a mineralized quartzite breccia which appeared on the surface as a quartzitic gossan. Other faults were masked by the weathered mantle.

WEATHERING (SUPERGENE) AND ALTERATION (HYPOGENE)

An open jointed exfoliation zone extends 20' - 30' below the surface in the valley slopes. Basalt is completely to highly weathered in this zone and the meta-sediments less weathered with clay filled joints. Below the exfoliation zone the meta-sediments are slightly weathered with limited development of clay in joints. Seams of altered fractured basalt along faults are completely weathered to clay immediately below the exfoliation zone.

Fig. 2 - Slip surface on low-angle cleavage in meta-sediments.

Sulphide mineralization is prominent in faulted basalt with a quartz, calcite, pyrite, galena assemblage. Wallrock alteration occurs in mineralized zones with the rock substance grading from plastic clay to clay-basalt of moderate strength. The zone of alteration is a few feet wide along fault lines increasing in thickness within highly fractured basalt at fault intersections. The strength of fractured decomposed basalt increases with depth as the effect of supergene groundwater percolation decreases. The most critical zone of alteration was found in the eastern part of the valley floor where three fault sets intersected. A mass of clay, clay-basalt and fractured basalt extending over an area of 30' x 60' was excavated to 30' depth.

TREATMENT OF THE FOUNDATION ZONE DURING CONSTRUCTION

The dam is an articulated diamond head buttress design approximately 120 feet in height (see Fig.4) which has relatively low foundation loading, but needs uniform foundation conditions and stable abutment slopes. At the initial excavation stage (1969) it became apparent that the bedrock was highly fractured in fault zones and that rock alteration associated with mineralization would occur within the basalt. Three problems were to be expected:-

i) Instability in the right abutment where three discontinuities trending parallel to the slope form potential slip planes viz. bedding planes with dip 60^{o}W; "axial plane" faults and cleavage with dip 70^{o}W; cleavage with dip $35^{o}/40^{o}$W.

ii) The presence of zones of alteration in fault zones within the valley floor basalt - see Fig. 3.

iii) The irregular depth to sound bedrock due to fracture in the meta-sediments and chemical alteration in the basalt.

Fig. 3 - Clay seams and altered fractured basalt in fault trench.

The initial excavations were carefully mapped and three additional angle diamond holes were drilled which located additional faults. As these investigations proceeded the results were utilised to modify the footings to suit the rock conditions. It was found necessary to carry out additional work viz:

a) Lowering the buttress foundation level in the abutments to alleviate slip on the low angle (35^{o}) cleavage planes.

b) Excavation of highly fractured fault zones then backfilling with mass-concrete to a height which would effectively buttress less stable slopes - see Fig. 5.

c) Where a bed of quartzite formed a natural face this was maintained and rock-bolts used to stabilize the cut.

d) Buttress footings were extended to bridge fault zones.

e) Examination of the basalt was initiated, weak rock excavated and backfilled with mass concrete. Longitudinal faults (i.e. normal to the dam wall) were trenched and sealed with concrete to increase the permeability path of water circulation below the structure and prevent scouring.

f) Cross-faults in the valley floor basalt were excavated and the excavations utilized to pour concrete ribs between buttress footings. This method of strutting between buttresses will resist any earth pressures which might develop tending to rotate the buttresses in the valley floor.

Fig. 4 - Right abutment.

Fig. 5 - Left abutment - note buttress foundation supporting base of cut.

CONCLUSION

This case history illustrates the need to gather all available geological information in order to present the engineer with a true picture of the foundation conditions (Ref.3).

Alteration of bedrock is frequently associated with rock structures and may be more important than fracturation in chemically unstable rock. As supergene weathering masks alteration effects in the surface soil zone, careful examination of drill cores is essential. The association of alteration with orientated rock structures emphasizes the value of structural analysis in engineering geology. Directed angle-drill holes are the best method of locating thin sheets of altered rock which may not be obvious in geophysical traverses.

Borehole-log sheets using a degree of weathering classification should be replaced by those differentiating weathering and alteration, such as the type proposed by Dixon (Ref. 2).

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