Geological Investigation of Bennet's Damsite

PL 767

GS 75/19

Plates (Transparencies) are ~~in Map Drawers~~
~~labelled 'DARWIN RIVER DAM'.~~

Now in Drafting Office with drawing numbers as shown on contents page. Glenn 28/5/81

NORTHERN TERRITORY GEOLOGICAL SURVEY REPORT G.S. 75/19

GEOLOGICAL INVESTIGATION OF BENNETT'S DAMSITE ON PL 767 IN THE BATCHELOR AREA

by

G.C. LAU

CONTENTS

SUMMARY

A geological investigation was made of a damsite about 70 km south south east of Darwin. The dam will be founded on interbedded quartzite, greywacke and carbonaceous phyllite. The interbeds strike 030° MN (NNE) and are almost vertical. At the site quartzite and greywacke crop out on the surface and are jointed; phyllite is completely weathered near the surface and is not exposed. The valley to be dammed contains 2 to 4 metres of loamy alluvium. Seismic traversing did not reveal any cross faulting through the valley. The foundation is thought suitable for the dam under consideration, but no reliable information on permeability through the foundation was obtained.

INTRODUCTION

Location

The damsite and proposed catchment lie on Pastoral Lease 767, about 70 km south south east of Darwin and 5 km east of the Stuart Highway. Access is via a well formed gravel road branching south from the Marrakai track. Plate 1 shows the location and access roads.

Purpose

Mr. George Bennett, owner of PL 767 approached Water Resources Branch with plans to build a storage dam which could be used for crop and pasture irrigation and for recreation. Water Resources Branch were engaged as engineering consultants to investigate the site, to design the dam and appurtenant works and to supervise construction. The proposed dam will be an earth fill structure 100 m long and 15 m high, with an outlet conduit placed in a shallow trench on the northern abutment. A spillway will be formed by a saddle on the southern abutment.

Water Resources Branch requested that Mines Branch

(a) provide a geological map of the damsite and spillway area
(b) assist with the location and interpretation of geophysical traversing
(c) assist with the location of auger and diamond drill holes and the interpretation of drilling results
(d) provide an engineering geological report on the damsite, spillway area and impoundment area, the report to include a cost breakdown of the work done.

Methods of investigation

Surface outcrops on each abutment were geologically mapped directly onto WRB drawing 3-5/16 at 1:500 scale. A plane table and alidade were used to place and locate reference pegs along the abutments; some WRB survey pegs were also used for reference. Tape and compass traverses were made across the abutments at the reference points.

../3

Mr. Bennett bulldozed several costeans in the creek bed to test the depth of overburden. A seismic refraction survey of the foundation area was made by C. Braybrook, WRB (1974). The location of the traverses and a discussion of the results is given below. To complete the site investigation, WRB drilled and pressure tested two continuously - cored diamond drill holes, the results of which are reported by I. Smith (1974) and discussed below.

The ridges rimming the storage area were examined on airphotographs and briefly inspected on foot.

Costing of Work
Approximately 45 man hours were spent mapping and assisting with the geophysical survey and drilling. Logging the drill core, writing, typing and editing the results involved an estimated 55 manhours of work.

GEOLOGY OF THE STORAGE AREA

The damsite and catchment area are in an area occupied by strike ridges of macroscopically folded quartzite. The quartzite is part of the Acacia Gap Tongue of the Lower Proterozoic Masson Formation. Plate 2 shows the geology as interpreted from air photographs and some field inspection.

There are some outcrops of grey-brown silicified shale in the area, but most outcrops are grey quartzite. The quartzite crops out in beds 1 to 3 m wide, with poorly defined bedding traces and some small scale cross bedding; where measured, the bedding is almost always steeply dipping (70° to 90°). Very close to moderately close open jointing is well developed in the quartzite. There is no outcrop in the spaces between quartzite beds.

No sites of potential major leakage from the catchment area were seen.

GEOLOGY OF THE DAMSITE

Description of site
The creek to be dammed is a small tributary of the Adelaide River. At the damsite, the creek runs from west to east in a relatively flat bed about 60 m wide. The southern abutment is a strike ridge tending 030° MN. It has gentle slopes on the eastern side and small cliffs on the western side; the crest is quite low and undulating and is one limit on the height of the proposed dam. The northern abutment is much wider and rises steeply from the creek bed. Plate 3 shows the geology and topographic contours of the damsite.

Southern abutment

The only outcrop on this abutment is of quartzite and greywacke trending 030° MN and dipping steeply either east or west at 80° to 90°. The beds average about 3 m thickness and are discontinuous along strike, probably with lenticular form. They cover from 40% to 60% of the ground surface, with quartzite scree and some silicified shale scree between them. The 2 m thick, laterally continuous bed on the eastern edge appears to be silicified quartz sandstone; with close to very close open joints, it is the most jointed bed in the abutment, possibly because the clay-poor matrix makes it the most brittle. Other beds in the abutment have more detrital matrix and are silicified medium to coarse grained greywacke; they are jointed at moderately close to close spacing. The dominant joint set is near vertical and cuts directly across the general strike; the joints are open at the surface but may be tight or filled with clay in the subsurface.

In the saddle to be used as the spillway, shallow costeans exposed weathered, metamorphosed shale.

Northern abutment

Most outcrop on this abutment lies above the proposed storage level. It is geologically similar to the southern abutment. No misalignment or change of altitude possibly indicative of faulting was observed between the abutments.

Valley floor

Before excavation of the creek bed commenced, only red brown sandy clay and silt sediments with a few beds of quartzite boulder gravel could be seen. The costeans bulldozed by G. Bennett showed that alluvium is generally deeper than 1 m., but is shallower near the southern abutment where some moderately to highly weathered quartzite was uncovered.

The layout of seismic traverses shot by C. Braybrook (1974) is shown on Plate 3. A traverse along the proposed dam axis did not show any anomalies indicative of faulting or shearing through the gap. Both traverses across the axis showed that a low velocity anomaly trending along strike lies between 15 m and 25 m west of the axis. The anomaly is almost coincident with the projected westward edge of quartzite outcrops and may indicate some shearing along the shale/quartzite boundary. Depths to fresh rock were determined along the traverses, but it was not possible to distinguish alluvium from weathered rock. Fresh rock occurs at about 10 m to 15 m throughout the valley floor, and is deepest beneath the existing creek bed.

To determine the depth to weathered rock beneath alluvium, seven holes were drilled at five sites by J. Fisher, WRB using a Gemco 110A auger drill. Auger refusal were reached between 0.3 m and 2.1 m. depth; in each case the auger was grinding on hard rock. At the time of drilling, boulder gravels were thought responsible for the refusal, but from inspection of the costeans and later excavation of the outlet conduit trench it appears that some of the holes would have reached insitu weathered rock.

../5

Diamond Drilling

Two continuously-cored diamond drill holes were put down in the valley floor by WRB, using a Mindrill E1000 machine. Conventional N and B size barrels without a stationary inner tube were used, and the poor core recovery obtained is probably due in part to the use of this equipment. The location of the holes is shown on Plate 3, sections through the holes are shown on Plate 4, and the geological logs are included as Appendix 1.

Hole DD1 was proposed to test the subsurface geology and to allow water pressure testing in fresh rock, weathered rock and alluvium. The hole was drilled across strike at minimum depression of 45° to intersect the (supposed) near-vertical beds at the lowest possible angle. It was continuously cored from 2.9 m to total depth of 18.4 m. A 'pajari' survey at 18m showed 46.5° depression at 308.5° MN azimuth. Hole DD2 was planned by WRB engineers to intersect the dominant cross joint set in quartzite and to allow water pressure testing to measure leakage through these joints. The hole was sited on quartzite (extrapolated from Hole 1), inclined at 45° and drilled along strike. It was continuously cored from 3.2 m to total depth of 19.7 m. A 'pajari' survey at approx. 18.5 m showed 46.5° depression at 196° MN azimuth.

The drill core contained interbedded quartzite, greywacke and phyllite. 'Quartzite' is used to describe sandstone that has a silicified matrix, so that fracture occurs through and not around the sand grains; the silicification is probably a result of metamorphic recrystallization. Greywacke is a type of sandstone with 15% - 50% detrital mud matrix; at the site most 'quartzite' is silicified greywacke. Phyllite is slightly metamorphosed shale or siltstone.

Quartzite in the core is brownish when weathered, and light to dark grey when fresh. It is typically silicified greywacke or quartz sandstone containing 80 - 90% quartz grains (poorly sorted, ≤ coarse sand size, subangular to rounded), 10-20% matrix (clay or mica, with some iron oxide and carbonaceous material) and 2% pyrite (locally up to 10%; removed by weathering above 9 m depth). Some quartzite is silicified black carbonaceous greywacke with 30-40% matrix. Quartzite was intersected in lengths up to 3 m, which represents beds about 2.5 m thick. From top to bottom of DD1, quartzite is fresh stained or slightly weathered, though some narrow zones are more intensely weathered. In DD2, quartzite near the ground surface is moderately weathered. Most quartzite is non-porous, but a few small beds around 18 m in DD1 are porous, probably due to removal of clay matrix. Fractures and joints occur throughout, but are not obviously open or highly permeable. Low angle fractures at 0° - 30° to core normal are common, but most have rough iron oxide coatings and are thought to be fairly tight (the surface of many of these fractures was destroyed by grinding in the core barrel).

../6

Some high angle fractures at 65^{o} to core normal occur; most are filled with white clay and are probably fairly tight. Thin iron oxide + crystalline quartz veins are generally tight, but a few are porous due to removal of iron oxide (e.g. DD 1, 8.6 m; the iron oxide may have been washed out during drilling).

Greywacke in the core is pink, brown, or grey to black. It contains 60-80% quartz grains (silt to medium sand size, poorly sorted), 20-40% matrix (clay or mica, generally carbonaceous), and less than 2% pyrite. It is interbedded with phyllite and contains some phyllite clasts. Phyllite in the core is dark grey, thinly bedded, carbonaceous metasiltstone with less than 2% pyrite. Some phyllite is markedly sandy and is transitional to greywacke. Greywacke and phyllite were first cored at about 4 m vertical depth. They are moderately weathered to 8-10 m, slightly weathered to 13-14 m, and fresh but stained below. Individual beds may be more deeply weathered e.g. the aquifer in DD1 mentioned below is possibly a deeply weathered phyllite bed. The depths and degrees of weathering suggest that 'fresh rock' as detected on the seismic refraction traverses is interbedded fresh stained or slightly weathered quartzite and fresh stained or slightly weathered greywacke/phyllite; interbedded slightly weathered quartzite and moderately or highly weathered phyllite make up the 'weathered basement rock' in the upper layer detected on the traverses. Both greywacke and phyllite are impermeable due to their fine grained matrix. They have fewer joints and fractures than quartzite, possibly because they are less brittle. Fracture faces are generally not well preserved due to core grinding and loss. The faces which are intact fit together fairly well but not exactly, so most of the joints and fractures are presumed to be slightly open.

Some sections of rock in DD 1 and more than half of DD2 were not recovered as core. During penetration of these sections the water return carried a lot of very fine black carbonaceous matter and the core losses are thought to represent soft, ? weathered greywacke and phyllite.

Water was struck at 17.4 m in DD 1 (12.3 m vertical depth). It had a pressure head estimated at 1.2 m above ground level and flowed undiminished at an estimated rate of 0.2 l/sec for a week. Brown ferric hydroxide was deposited around the drill collar. No core was recovered between 17.2 m and 17.6 m but the driller noted carbonaceous suspension in the water return. Brown, hard jasper-like silicified ironstone was cored at 17.2 m. It seems likely that the water is stored in a thin bed of deeply weathered phyllite, and that leaching and precipitation of iron oxide and silica has caused the jasper-like deposit.

To evalate the rock permeability beneath the proposed dam, WRB made water pressure tests on both holes. The results are reported on by I. Smith (1974), and are discussed below.

Outlet trench
Some months after the diamond drilling was finished, a trench for an outlet conduit was excavated by G. Bennett. The trench was excavated in the foot of the northern abutment (see Plate 3) and exposed rock along much of its length. No outcrop had been visible along the trench line, but weathered rock was found at shallow depth ($\leqslant$ 0.5 m). Plate 5 shows a geological sketch of the trench.

Quartzite, sandy phyllite and phyllite were exposed in interbeds which dipped about 80° westward.

Quartzite occurs in beds ranging from thin stringers up to about 4 m width, with most beds about 2 m wide. It is slightly to moderately weathered, hard, moderately strong to strong, and is close to moderately close jointed. Light blasting was required during the excavation.

Very close slatey parting in the phyllite obscures individual beds. Phyllite sequences range from thin stringers to a 7 m thick sequence near the centre of the trench; at the western end of the trench interbedded quartzite and phyllite pass into massive phyllite. Phyllite in the trench is slightly to completely weathered, moderately strong (where indurated by lateritization) to weak.

Engineering geological considerations
Strata at the damsite should provide a strong, stable foundation for the dam under consideration. There is no evidence of cross faulting with associated weathered, permeable zones through the gap, and no cross faulting was seen in outcrop on the abutments. Some beds on the western edge of the quartzite may be sheared and permeable along strike, but this should not have any effect on groundwater flow through the gap.

From observations at this site and at Darwin River damsite, some waterflow through vuggy, lateritized phyllite and through cross joints in adjacent quartzite beds is thought possible. DD2 was designed to test the permeability of cross joints in quartzite, but because the whole hole was tested as one interval and because much of the hole was drilled in phyllite, the results could not be related to quartzite jointing. Water lost during the test probably flowed parallel to bedding and not in the direction underflow from dam would take. The results suggest a permeability of about 6 lugeons (approx. 6×10^{-5} cm/sec.) but there is some scatter in the data and the testing is considered inconclusive. In DD1, the water loss decreased as effective test pressure increased, so the results have been disregarded.

../8

In summary, no reliable information on permeability through the foundation was obtained.

Metamorphosed shale in the spillway may be subject to some scour, but the amount of downcutting will be limited by the presence of quartzite at the western end of the spillway.

REFERENCES

Braybrook, C.J. 1974 Bennetts Damsite seismic refraction survey-May 1974. Water Resources Branch rep. (unpubl.)

Smith, I. 1974 Bennett Dam P.L. 767 Design report. Water Resources Branch rep. (unpubl.)

APPENDIX 1. Drill hole logs.

BENNETT'S DAMSITE   Drill hole log   Hole DD 1   Sheet 1/4

Lithology	Graphic log	Depth	Weathering	Strength	Fracture	Structure	Core size	Core lift and recovery
		metres						
Soil and QUARTZITE boulders, not cored		1.00						
		2.00						
		2.89						
QUARTZITE : grey to grey brown; 90% quartz sand grains (fine to very coarse, av. medium, poorly sorted, subrounded) 10% silicified matrix ≤ 2% pyrite holes		3.00				joints rough, iron oxide coating, joints tightly closed irregular hematite + quartz vein joints as above, at low angles, 10°-15° 2 longitudinal joints, 85°, 10mm thick clay + iron oxide + vein quartz coating, appears permeable		?100%
		4.00						4.26 ?100% 4.72
		5.00				thin irregular joints, 40°-60°		?100%

BENNETT'S DAMSITE Drill hole log

Hole DD 1 Sheet 2/4

Lithology	Depth	Structure	Core recovery
QUARTZITE: as above, av grain size medium; increasing grain size (downward)	5.00	joints 30°-40° rough, iron oxide coating	?100%
	6.00	low angle fractures, iron oxide coated; joints thin, discontinuous, slightly open	55%
	LOSS		
average grain size coarse			
QUARTZITE: brown; 80% quartz grains (av. fine grained) 20% clay or silt matrix; bedding 50°		thick quartz vein; low angle, rough, iron oxide coated fractures	90%
QUARTZITE: grey; medium grained			
~~QUARTZITE: light to dark grey,~~ patchy colour; medium grained, (?) turbidity slump	7.00	loss could be from this zone	
SILTSTONE: light to dark grey; bedding 30°		fractures 65°-90°, rough, clay + iron oxide coating, look permeable	
QUARTZITE: light to dark grey; 85-90% quartz grains (medium to coarse, subrounded). 10-15% silicified clay matrix 1-2% pyrite and pyrite holes			
	LOSS		
		numerous rough fractures; fractures 0°-20°, irregular, clay + iron oxide coating fairly tight	65%
	8.00	joint 15 mm wide, open, permeable, partly filled with vein quartz + iron oxide + clay	
QUARTZITE: as above		fractures 20°, iron oxide coating, fairly tight	
pyrite content 2-3%	9.00	quartz veins, scattered, very thin slightly permeable	
PHYLLITE: black, carbonaceous metashale		numerous rough fractures	
	LOSS		
	10.00		

BENNETT'S DAMSITE Drill hole log Hole DD 1 Sheet 3/4

Lithology	Graphic log	Depth	Weathering	Strength	Fracture	Structure	Core size	Core lift and recovery
		10·00						
		LOSS						65%
QUARTZITE: 3 fragments; black; 60-70% quartz grains 30-40% carbonaceous, silty, silicified matrix <2% pyrite		11·00				fractures rough to smooth, thin iron oxide + clay coating		
PHYLLITE: 1 fragment; black, laminated metashale								
		LOSS						10%
		12·00						
		LOSS						0%
QUARTZITE / GREYWACKE: black; 60-70% quartz grains (medium to coarse) 30-40% matrix (carbonaceous, iron oxide + silt + clay) may be less indurated greywacke, quartzite weathered after induration		13·00				numerous fractures, thin iron oxide coating		
						fractures smooth, along bedding lamination		
PHYLLITE and GREYWACKE: interbedded fine sandstone and siltstone, brown to grey, laminated, slightly pyritic; bedding 30°		LOSS						50%
PHYLLITE and GREYWACKE: interbedded sandstone (≤ medium grained) and siltstone (black, carbonaceous, thinly bedded, detrital mica flakes ≤ 0·5 mm); bedding 25°		14·00 LOSS	amount is diagrammatic					
		LOSS	amount of loss is diagrammatic			fractures mostly low angle, irregular probably fairly tight; some ground off during coring		55%
		LOSS	amount of loss is diagrammatic					
		15·00						

BENNETT'S DAMSITE   Drill hole log   Hole DD1   Sheet 4/4

Lithology	Graphic log	Depth	Weathering	Strength	Fracture	Structure	Core size	Core lift and recovery
PHYLLITE and GREYWACKE: as above (pyrite; pyrite)		15.00				fractures 0°–10°, many ground off during drilling		
		LOSS	the amount of loss is indeterminate					
		LOSS	amount indeterminate					
		LOSS	amount indeterminate					55%
		16.00						
transition to QUARTZITE: dark grey, silicified greywacke 70% quartz grains 30% silicified matrix (iron oxide + silt + clay)		LOSS	amount indeterminate					
		17.00				thin joints, partly open, slightly permeable		
?JASPER: brown, hard, quartz + silicified limonite						joints open, permeable		
		LOSS	driller indicated this zone was possibly phyllite					60%
QUARTZITE: light grey and brown; 90% quartz grains 10% silicified matrix; porous in bands (?) due to removal of clay; bedding 20°–25°		18.00				joints rough, thin iron oxide coating, probably fairly tight		
QUARTZITE: light to dark grey; 80–90% quartz grains (medium to coarse, subrounded) 10–20% silicified matrix; porous in patches but not as marked as above						a few fractures, thin iron oxide coating, probably tight; joint 85°–90°, quartz + clay coating, probably tight		100%

BENNETT'S DAMSITE   Drill hole log   Hole DD2   Sheet 1/4

Lithology	Graphic log	Depth (metres)	Weathering	Strength	Fracture	Structure	Core size	Core lift and recovery
		1.00						
		2.00						
		3.00						
QUARTZITE: silicified greywacke; grey to brown; 80% quartz grains (medium to coarse, subrounded to rounded) 20% silicified clay matrix <2% pyrite holes, solution cavities porous due to solution of matrix; scattered clasts of quartzite and phyllite ; (?)bedding 70°		4.00				quartz veins 25°, slightly porous fracture 60°, white clay coating, (?) tight	N	100%
		5.00				low angle fractures, slightly ground ends, (?) fairly tight fracture 60° white clay coating, (?) tight	B	65%

BENNETT'S DAMSITE Drill hole log Hole DD2 Sheet 2/4

Lithology	Graphic log	Depth	Weathering	Strength	Fracture	Structure	Core size	Core lift and recovery
QUARTZITE: as above		5.00						
GREYWACKE: brown to grey; 60-70% quartz (poorly sorted, silt to medium sand size, subangular to rounded) 30-40% mica or clay matrix <2% pyrite holes						fractures irregular, ~60°, poorly tight?		65%
		6.00						
		LOSS						25%
GREYWACKE: brown; 60-70% quartz (very fine to medium, subangular to rounded) 30-40% mica + clay matrix <2% pyrite holes		7.00				fractures low angle, with ground ends and fractures 65°-80° along bedding	B	
(?) BRECCIA, or broken core?								
interbedded GREYWACKE and PHYLLITE; dark grey, carbonaceous, thinly bedded 65°-80°								
		LOSS						0%
		8.00						
GREYWACKE: pink to grey; 70% quartz (silt to medium sand) 30% clay or mica matrix <2% pyrite holes; scattered dark grey PHYLLITE clasts						fractures low angle, with ground ends and fractures 60°, along bedding		85%
PHYLLITE: grey, bedding 60°								
pebbles of greywacke and phyllite		9.00						
GREYWACKE: brown to grey; 80% quartz (silt to coarse sand size, subangular to rounded) 20% carbonaceous, clay or mica matrix <2% pyrite holes								15%
		LOSS						
		10.00						

BENNETT'S DAMSITE   Drill hole log   Hole DD2 Sheet 3/4

Lithology	Graphic log	Depth	Weathering	Strength	Fracture	Structure	Core size	Core lift and recovery
		10.00						
								15%
interbedded GREYWACKE and PHYLLITE; dark grey, carbonaceous, fine greywacke and metamorphosed silty shale, thinly bedded at about 85°; <2% pyrite overall, ≤10% pyrite in patches		11.00				fractures along 85° bedding		
		12.00						
								5%
		13.00						
PHYLLITE: dark grey; pyritic, carbonaceous metasiltstone, some sandy sections; <2% pyrite generally, some ≤10% patches; (?) bedding 85°–90°		14.00				fractures along 85°–90°(?) bedding		
								10%
		15.00						

BENNETT'S DAMSITE — Drill hole log — Hole DD 2 — Sheet 4/4

Lithology	Graphic log	Depth	Weathering	Strength	Fracture	Structure	Core size	Core lift and recovery
		15.00						10%
		16.00						
		LOSS						
		17.00					B	
								0%
		18.00						
interbedded GREYWACKE and PHYLLITE: black, pyritic, carbonaceous; bedding 60°						fractures along 60° bedding		
SANDSTONE: light grey; very fine grained; pyritic		19.00						
QUARTZITE: grey; 80-90% quartz (fine to coarse size) 10-20% silicified matrix <2% pyrite						fractures with thin iron oxide coating open		90%
SANDSTONE in GREYWACKE and PHYLLITE as above						fractures along 40° bedding; Sandstone is porous		
QUARTZITE as above						irregular fractures, some with thin iron oxide coating		

COMMONWEALTH OF AUSTRALIA

MINES BRANCH

NORTHERN TERRITORY ADMINISTRATION

DEPARTMENT OF THE INTERIOR

NORTHERN TERRITORY GEOLOGICAL SURVEY RECORDS