1979/13. Seismic evaluation of proposed quarry site for H.Duggan and Sons, Cradoc.

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Abstract

A seismic survey of the proposed quarry site for H.Duggan and Sons, Cradoc, has confirmed the presence of a wide range of material and a substantial fault zone. The site is dominated by dolerite, which ranges from very weathered to very fresh rock. There is a substantial mix of rock grades and a large volume of weathered rock suitable for use as fill.

INTRODUCTION

A quarry site has been proposed on the concealed northern slope of a dolerite ridge above Cradoc [EN 027288]. The general layout of the site is shown in Figure 1. A portion of the area has been cleared and scraped, revealing less than one metre of soil with occasional dolerite boulders and a very weathered 'bedrock'. Some of this weathered rock has been ripped and heaped. Within the small excavation some extreme weathering effects may be noted and, together with the presence of travertine and increased fracturing, a fault has been implied. The regional geological map (Farmer, in press) of the area confirms that a fault passes through the saddle at the site (near A8, fig. 1), the evidence for this fault being stratigraphic and independent from the new exposures. The mapping, however, had implied that the fault occurred at the contact with the sandstone to the east (Leaman and Naqvi, 1968; Farmer, in press), but clearing at this site has proven otherwise.

The sandstone forms the basal unit of the Triassic succession and directly overlies Permian siltstone. The siltstone occurs as plentiful fragments at A9. The amount of sandstone on the hill is relatively small, but the exposure extends a considerable distance to the east. Both the sandstone and the siltstone have been hornfelsed (heat altered) by the intrusion of the dolerite and the contact appears normal. The faulting is displaced by about 10 m to the west and is more recent. Mapping of the dolerite/sandstone contact is difficult but the form appears to be normal and quite irregular.

Three factors affect the quality of a rock such as dolerite at this site. The most important is the effect of the faulting. Faulting normally shatters the material, allowing for ready passage of groundwater and consequent deep weathering. The physical effect of faulting thus results in a closely jointed rock mass which is usually rippable, while the chemical effects tend to destroy the strength and appearance of the material while coating all surfaces with breakdown products. The latter are usually clay, chlorite, zeolite or calcium deposits including travertine. The effects of the faulting may extend laterally for as much as 25-30 m from the axis of the fault.

The contact zone may introduce similar variations, as the rapid heating of one rock (sandstone) and the cooling of the other (dolerite) produces thermal fracturing and can lead to weathering problems. The lateral effect is not normally as pronounced, being 10-20 m in width.

Indirectly therefore, distance from any such disturbance usually means that good quality rock will be present, providing that the entire slope is of dolerite, that it is free of major joints and that the slope

QUARRY SITE: DUGGAN AND SONS, CRADOC.
SUMMARY OF SEISMIC EVALUATION

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Note: This map is not the result of precise survey

All velocities in metres/second

Shaded area implies no seismic coverage

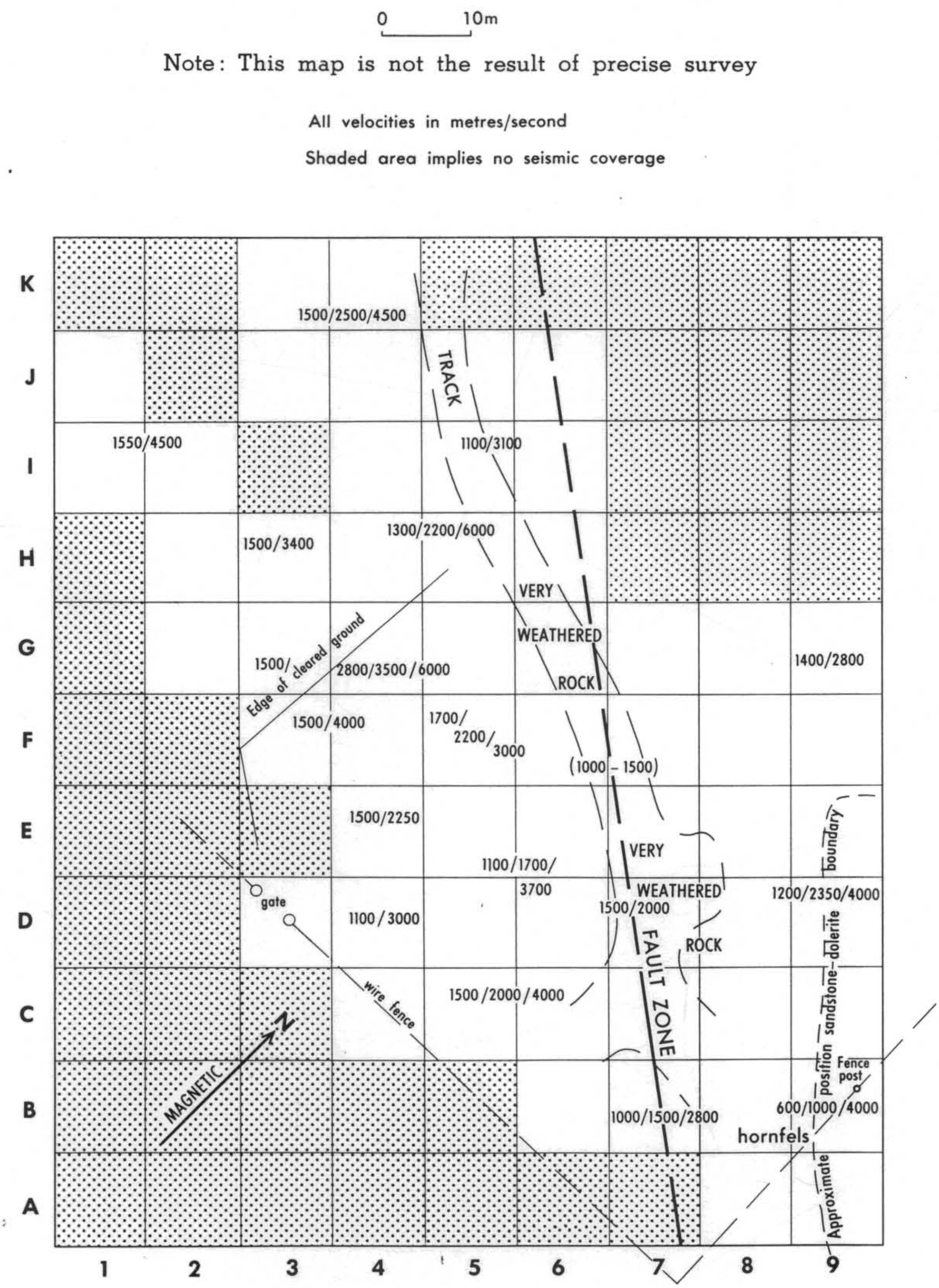

Figure 1.

5 cm

is steepening. This is certainly true north-west of the boundary fence with the gate (fig. 1).

SEISMIC SURVEY

The seismic survey sought to assess the quantities and general distribution of the various types of dolerite materials at the site. A number of 12 channel refraction spreads were fired across the site using small explosive charges and geophone separations ranging from 3 to 7.5 m. The extent of the coverage is indicated in Figure 1.

Method and application

The seismic refraction method provides a reliable method of sampling moderate volumes of rock. A series of detectors (geophones) are laid out on the surface and connected to a recorder by cable. A small shot is fired and the time of the shot is recorded and compared with the time taken for the shock wave to reach the geophones. Since the geometry of the entire layout is known, the velocity with which the wave was transmitted can be calculated. Alteration in the geometry allows different depths to be penetrated. The velocity calculated for different levels in the section provides a good guide to rock state and quality.

Inversion of the calculation procedure can transform the velocity - geometry observations into depth estimates, but these are not alway accurate for a first survey at a site without some independent control. At Cradoc the estimates are probably valid within 10-15%.

The characteristics of dolerite with various observed velocity values are given below. Note that there is some ambiguity in the middle ranges and that some independent confirmation may be necessary.

	Velocity (m/s)	*Comment*
1.	1000	Soil, detritus, clay with boulders.
2.	1000 - 1500	Very weathered rock, highly fractured with open fractures or fractures coated with porous friable material. Whole rock weathering with thick friable coatings on blocks.
3.	1500 - 2000	Very weathered rock but more coherent, few open or lightly sealed fractures but fracturing intense.
4.	2000 - 2800	Weathered rock with weathering largely restricted to fractures, surfaces or highly fractured reasonably fresh rock.
5.	2800 - 4000	Slightly weathered rock; weathering usually restricted to surface coatings only or moderately fractured rock.

	Velocity (m/s)	*Comment*
6.	4000 - 6000	Good rock. Increasing velocity reflects fewer joints or tighter joints. Weathering insignificant.

The rock is normally discoloured throughout in class 1-3 and at least partially so in class 4. Only in classes 5 and 6 is the dominant colour blue-grey. The usual limit of rippability with a large bulldozer is about 2800 m/s and thus classes 1-3 can be ripped easily, but parts of class 4 and 5 could require blasting. The reason for this uncertainty is readily explained.

The velocity values observed are derived from bulk sampling and are to some extent averages. This procedure is reliable if the material is reasonably homogeneous. However, dolerite weathers irregularly and at this site has been disrupted by a contact and a fault which has also led to irregular decomposition. Production of a series of harder kernels of material within the mass is the result. In addition, the weathering is not regularly stratified or layered and the depth to a given class of material varies erratically. All these characteristics have been observed at this site. The great variation in properties can mean that two areas could yield velocity averages of 2800 m/s and be very different when treated. Each may be slightly weathered and fractured, but the spacing of the fracturing in one instance may preclude ripping while making it possible in the other case. Hence some of classes 4 and 5 may or may not be rippable. However the overall quality of the material will be validly estimated.

Site assessment

A summary of the results is shown in Figure 1. It will be noted that velocities of 1100-1900 m/s are typical of the central part of the site and the fault zone has been traced across it. Velocities of 900-1150 m/s are related to the intensely broken rock near the fault. This material will occur to considerable depths in a narrow band. Some similar velocities were recorded near the sandstone contact.

Across the remainder of the site a profile of 1500/3500/4500 m/s is typical. Rock as exposed on the western side of the existing small pit has a velocity of 1500-1900 m/s which confirms that it is rippable and contains numerous open fractures and weathered fills of the type clearly visible in the exposed face. At relatively shallow depth this converts into more massive non-rippable rock, but with a most irregular interface. Some very high velocities have been recorded in parts of the site and some good fresh rock can be anticipated after removal of the weathered material. No simple depth estimate can be applied to the velocity values since the seismic records clearly show some extreme vertical and horizontal variations.

The following notes refer to the 10 m squares shown in Figure 1 and provide more detailed information on the site. The variability of the rock mass will be apparent.

A8. Slight depression. Fault zone (V=1000 m/s). Thick cover of soil debris (800 m/s) to 2-3 m. General rock 1900 m/s to 4-6m. Some blocks of 4000 m/s noted at 4 m depth. Compare B7.

A9. Up to 3 m soil overlying rippable contact rocks (1450-1900 m/s).

B6. Weathered rippable rock (1600-1900 m/s) to at least 8 m. Some kernels of more massive material (2100-3700 m/s) indicated at shallower depth. These appear to be less than 5-7 m across and would require some blasting.

B7. Fault zone (1000 m/s). Very weathered material. Some pockets of harder rock noted at about 4 m (2800 m/s).

B8. Compare A8. Cover of material (1450-1900 m/s) with kernels to 2800 m/s.

B9. Very deeply weathered rock including contact zone (600-1000 m/s) 2-4 m thick overlying massive rock (4000 m/s).

C4. Weathered rock to about 10 m (1500-1900 m/s) with some kernels of less weathered rock (2100-2800 m/s).

C5. Possibly 20 m of weathered rock (1500-1950 m/s) with good rock (4000-4500 m/s) at depth. Depth estimate very uncertain.

C6. Up to 3 m of shattered, weathered rock (1000-1100; 1500-1900 m/s) overlying most irregular rock of 2100-2800, 3700 m/s. Some blasting to be expected at relatively shallow depths unless the material is very mixed.

C7. Up to 2 m rubble and fill (700 m/s), then weathered rock (1500 m/s) to about 5 m. Fault zone deposits and travertine observed. Dolerite at 5 m still rippable (2000 m/s).

C8. Compare B8.

C9. Compare B9. Massive beneath the contact zone (?) at 3-4 m (4000 m/s).

D3. Thin soil, less than 1.5 m of very weathered rock (1100 m/s) overlying moderate quality rock (3000 m/s).

D4. Scraped area. Surface rock (1500-1600 m/s). Similar material to 7 m but with harder kernels of 3000 m/s.

D5. Weathered rock (1100-1700; 1450-1550 m/s) overlying rippable but slightly less weathered rock (2000-2250 m/s).

D6. 2-5 m of weathered rock (1100-1500 m/s) overlying good material 3750-4000 m/s). Abrupt interface but very irregular.

D7. Very weathered jointed rippable dolerite to at least 5 m. No massive rock indicated. Compare C7.

D8. Compare E8.

D9. Variable rock interfaces. Patchy cover of material at 1200 m/s (7 m average) on rock of 2350-3000-4000 m/s. Unpredictable treatment.

E4. See D5. Cover of 1450-1550 m/s over rock of 2250 m/s. All rippable.

E5. See D5. Cover of 1100-1700 m/s over rock of 2200 m/s. Some traces of kernels to 3000 m/s at 4-7 m depth.

E6. See D6.

E7. See D7.

E8. Less than 5 m cover of very weathered rock on fair rock (2500 m/s). Probably rippable to at least 10 m

E9. Between 5 and 8 m of weathered rock cover (1200-1400 m/s) on moderate quality rock (2350-3000 m/s).

F3. Estimated 5 m cover of weathered rock (1600 m/s) on good rock (>4000 m/s).

F4. Complete profile noted. 1450-1500/2750/6000 m/s. Weathered rock/ fair rock/first grade rock. Depth to good rock 15-17 m. Fair rock from 1 m. It may be noted here that few descriptive notes reveal similar sections. This is a function of rock quality distribution, site topography and geophone geometry. Rock in excess of 4500 m/s is to be expected everywhere under the site at some depth. This depth cannot always be stated but 20 m does appear to be the likely maximum. Other entries note that rock in excess of 4000 m/s occurs at less than 4 m in some eastern and far western parts of the site.

F5. Some pockets of surface fill overly up to 10 m of weathered rock (1700-2200 m/s) although some kernels of better rock (3000 m/s) occur as shallow as 4-5 m.

F6. Some shallow kernels of good rock (3750 m/s) occur in 5 m of weathered rock (1500 m/s) which thickens locally toward the fault zone.

F7. Soil and rubble 2 m thick overlies a substantial thickness of weathered rock (see D7, C7). More than 20 m is implied.

F8,F9. Weathered rock (1400 m/s) 5 m thick overlies barely rippable rock (2500 m/s).

G3,G4. Less than one metre of very weathered rock (1250-1500 m/s) overlies about 2 m of moderate rock (2800 m/s). Fair rock is common at 4 m (3400 m/s) and a suggestion of first grade rock at 12-15 m has been noted (6000 m/s).

G5. Some pockets of rubble (700 m/s)overlie weathered rock (1500-2200 m/s) and good rock (5500 m/s).

G6. See F6. Much weathered rock implied (1100 m/s).

G7. See F7.

G8,G9. 3-5 m of weathered work (1400 m/s) overlies fair to moderate rock (2200-2800 m/s).

H2,H3. Weathered rock (1550 m/s) over fair rock 2800-3400 m/s).

H4. Less than 4-5 m of very weathered rock (1350-1500 m/s) overly fair material (2200 m/s). Excellent rock is suggested at 10-15 m (6000 m/s).

H5. Less than one metre of very weathered rock (1050 m/s) over weathered rock (2250 m/s).

H6. Irregular interface between poor and fairly good rock (1100;3750 m/s) Depth ranges up to 7 m.

I1,I2. Thin cover of weathered rock (1550 m/s) or moderate material (2800 m/s) at 4 m. Depth to good rock (4500 m/s) uncertain.

I4,I5. Profile 1350-2400-5000 m/s.

I6. See H6. 1100 m/s material thicker

J1. See I2.

J3,J4. Very weathered rock (1350-1500 m/s) at less than one metre, fair rock at 2-4 m (2500 m/s) and good rock (4500 m/s) at about 10 m.

J5. Limited detail but fair material implied (2500 m/s).

J6. Up to 6 m soil, fill, debris overlying fair material (2200-3100 m/s).

K3,K4. Uncertain thickness of very weathered rock (1500 m/s) on good rock (>4500 m/s).

SANDSTONE

A preliminary inspection has shown that there is less than 10 m of sandstone adjacent to the fence line but that the thickness increases eastward. The base of the sandstone is exposed near the large fence post in B9. The sandstone has been altered and weathered and near the dolerite is of relatively poor quality.

However, the material on a rock knoll some 15-35 m east of the fence post is of better quality and up to 15 m in thickness. Little current bedding is apparent and the normal bedding dips very shallowly into the hill. Further east the rocky exposures are rare and boulder fragments are deeply weathered.

Jointing and cross bedding features are not significant and the sandstone is, in general, quite massive. No fresh faces were observed and the better rock appears free of extreme discolouration. The sandstone contains some feldspar, but the amount probably does not exceed 15%. The feldspar content affects the weathering characteristics of the rock. Clay pellets appear to be absent.

If an appropriate test face established rock of sufficient strength, appearance and composition a small stone quarry could be established. The site is well disguised and could be easily worked.

CONCLUSIONS

Working of the site southward into the hill spur will ultimately yield a good dolerite quarry. In the early stages selective working around the fault zone will produce a useful mix of aggregate materials. Only patchy blasting can be foreseen in the early to intermediate stages of working the site. The ultimate quarry should be in rock which is massive and hard and only very slightly weathered. This weathering should only be displayed as insignificant coloration on fractures.

REFERENCES

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