1983/39. Sinkholes at Railton railway station.

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Abstract

Sinkholes in cavernous limestone under recent sediments at Railton railway station are causing some concern. Seismic spreads and resistivity traverses were carried out over known sinkholes and it may be possible to determine the location of less obvious cavities in the limestone, and their extent, using these methods. Drilling would be required to prove the locations, but geophysical surveys may reduce the amount of drilling required. Drilling is recommended to determine whether the site of a proposed fuel depot is safe from the effects of a nearby sinkhole.

INTRODUCTION

Since a new station and yard was constructed at Railton [DQ516232] in 1974, to allow for the expansion of the Goliath Portland Cement Company Limited's limestone quarry, sinkholes have developed at locations near the track within the station yard. Part of the track has had to be raised because of settlement. It is planned to instal a fuel supply tank near the station building, and the proposed site for this is near one of the sinkholes that has recently developed. The Australian National Railways Commission requested a hammer seismic survey be undertaken in an attempt to determine the extent of any cavities that may extend under the track.

GEOLOGY

A geological map of the area (Jennings *et al.*, 1959) shows the area around the station to be underlain by Quaternary deposits. Where these can be seen in excavations, the sediments comprise clayey and silty gravel with coarse fragments consisting mainly of rounded quartz and quartzite. To the east of the station are areas of basal Permian beds, which at some locations are conglomeratic. Some of the material near the station could be *in situ* weathered basal Permian beds. Ordovician limestone has been quarried to the north-east of the station (at Blenkhorns quarry) and to the west (Goliath's quarry), and it is likely that limestone underlies the Quaternary (and possibly Permian) at depth beneath the station. This view is supported by the formation of the sinkholes. Some clay derived from *in situ* weathering of the limestone is also likely to be present.

FORMATION OF CAVITIES IN LIMESTONE

Cavities form in limestone because of the rocks relatively high solubility in water compared to most other rock types. Groundwater moving through fissures progressively dissolves material, resulting in enlargement of the open space through which the water passes. As a result, localised large cavities can form and if the roof of these cavities is not strong enough to support the overlying material, collapse can occur and a sinkhole is formed.

The limestone has been subject to surface or near-surface weathering conditions for long periods in the past (at least since the early Permian) and this has resulted in the formation of a very irregular surface to the top of the limestone, as indicated by exposures around Goliath's quarry. Steep-sided pinnacles of limestone extend up through the more recent

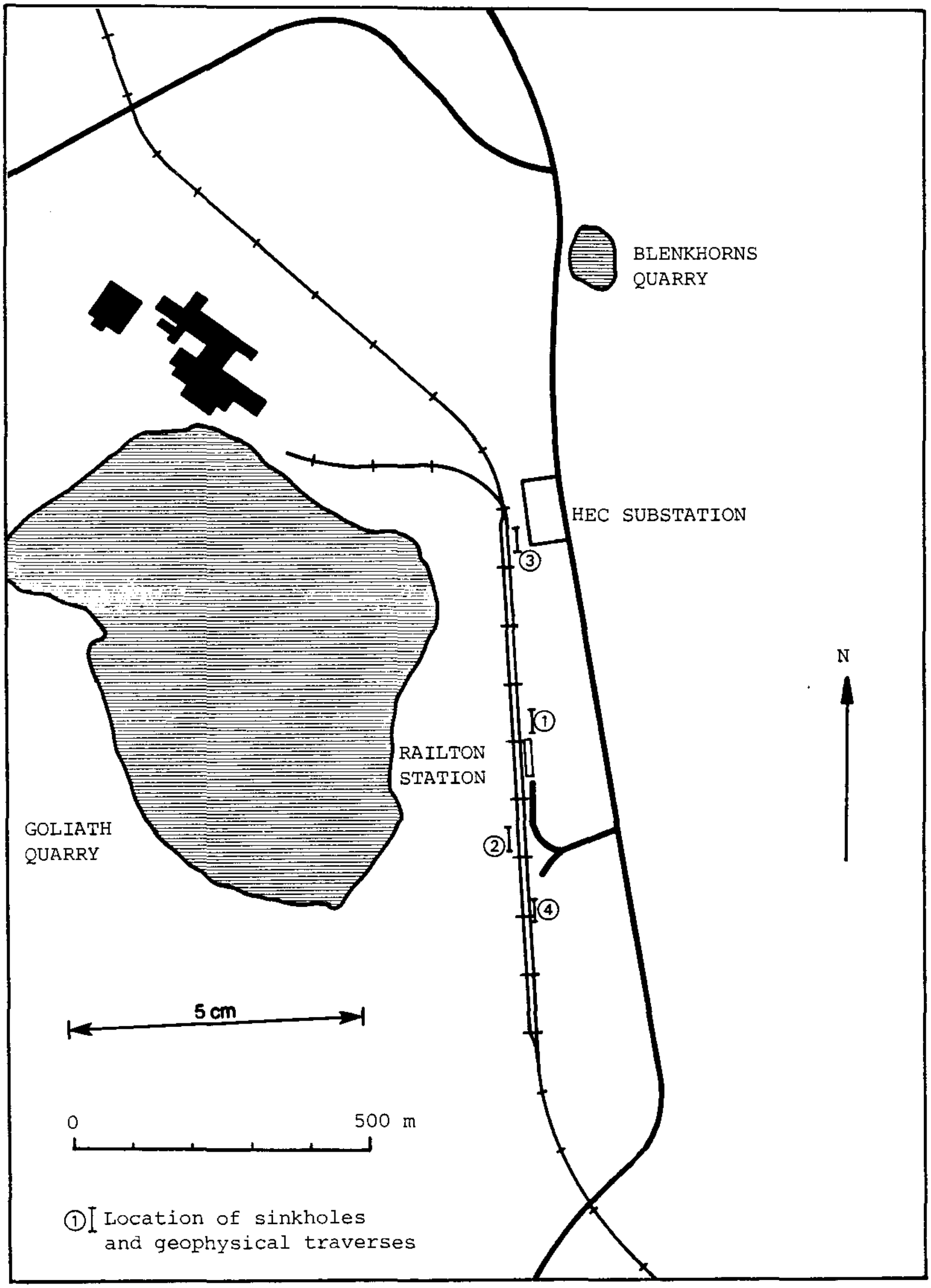

Figure 1. *Location map, Railton railway station.*

sediments. These pinnacles were recorded as being up to 30 m in height, with the spaces between the pinnacles being occupied by clay and gravelly clay (Jennings, 1961). The low zones between the pinnacles probably represent former collapsed caverns and sinkholes in the limestone. Partially filled caverns have occasionally been recorded around the Goliath quarry. This situation is likely to occur beneath the railway yard, *i.e.* a very jagged surface on the top of the limestone with sinkholes partially or completely filled with clay and gravelly clay, with the latter materials covering the whole local area.

GEOPHYSICAL SURVEY

Because of the irregular shape of the contact between the limestone and the overlying younger sediments, definite conclusions regarding the location and extent of unfilled caverns in the limestone are difficult. Because of this, work was concentrated around four known sinkholes (fig. 1).

Refraction seismic spreads and small resistivity traverses were undertaken over these four areas. Refraction seismic surveys will directly detect a particular refractor only if its velocity is faster than the velocities of the overlying layers. Therefore, if a cavity is covered by a layer of limestone or has a very narrow upward opening, the cavity would be invisible to such a survey. Irregular surfaces on the limestone make interpretation of depths of overburden difficult. Resistivity traverses may locate limestone covered caverns because of the difference in resistivity between limestone and clay (if clay filled), and limestone and air (if unfilled).

Refraction seismic surveys

Interpreted profiles across the known sinkholes are shown on Figure 2. Each spread shows a thicker layer of lower velocity material in the area of the sinkhole (except Spread 3 where a refractor was not obvious when firing from one direction). At some sites there is some offsetting of the position of the thicker surface layer with respect to the position of the surface expression of the sinkhole. This could indicate a sloping side to the sinkhole. The position of the refractor has been calculated assuming a 4000 m/sec velocity for the limestone. This is regarded as a probable minimum velocity, and with the use of greater velocities in the calculations greater depths of sediments overlying the limestone would be indicated. However the low in the refractor surface would still be indicated, no matter what velocity was used.

On two of the spreads there are signs of a lower velocity refractor (in the range of 2-3000 m/sec) which could indicate the presence of Permian rocks, a fractured zone in the limestone, or the uneven surface on the top of the limestone.

In general, the thickness of the lower velocity material overlying the limestone is probably in the range of 15-25 m. It is probably not less than about ten metres (except where sharp pinnacles occur) but may be up to 30 m or more at some points.

Resistivity traverses

Five resistivity traverses were undertaken over the four sinkholes (fig. 3). Wenner electrode configurations were used over Sites 3 and 4 and asymmetrical Schlumberger arrangements (with fixed current electrodes) were used over Sites 1, 2, and 4. A probe was also undertaken at Site 4.

Most of the traverses show a change of resistivity in the vicinity of the sinkholes, usually a rise, and this is probably due to the presence of voids and perhaps a lower water content than the surrounding unconsolidated material. Of the traverses undertaken, the Schlumberger traverses appear the more promising as an exploration method. The use of different electrode spacings and increasing the number of readings may increase the definition of particular zones when using the Wenner method.

Strong lateral variations in apparent resistivity (as found by the Site 4 Wenner and Schlumberger traverses) preclude interpretation of the Schlumberger probe in the usual quantitative manner (which requires a horizontally stratified earth).

The usual rise in apparent resistivity in the vicinity of a sinkhole suggests that the traverses are sensitive primarily to lateral variations of resistivity of the alluvium and that the varying depth of the alluvium/ limestone interface is a second order effect for the configurations employed. This interpretation is supported by the depths to limestone indicated by the seismic traverses.

CONCLUSIONS

The survey has shown that known sinkholes are indicated, at least to some extent, using refraction seismic spreads and resistivity traverses, and it may be possible to extend the use of these methods to locate uncollapsed caverns or zones that have only settled a small amount. Experimentation with different geophone separations and shot distances for seismic spreads, together with changes in electrode spacings and configurations in resistivity traverses, may increase the probability of locating unfilled caverns and indicate their extent. The two geophysical methods would need to be used together, as both have limitations when used on their own, *e.g.* resistivity values for near-surface limestone and cavities are likely to be high, but seismic refraction should allow the separation of these two possibilities. However the very uneven surface on the top of the limestone is likely to confuse geophysical interpretations.

Drilling would be required to definitely prove the presence of cavities, but there is a good chance that geophysical work would reduce the amount of drilling that may be required.

The work undertaken near the fuel storage tank site to date has not defined the extent of the nearby cavity, and as the installation of the tank is rather urgent, drilling is suggested at two points on opposite sides of the foundation area. The depth of material overlying the limestone is likely to be in the order of 15-25 m thick and may be more. An auger drill could probably drill this material and, if limestone could be cored for 3-4 m in each hole without encountering cavities, the chances of the tank being affected by a collapse into a sinkhole should be small.

REFERENCES

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[16 August 1983]

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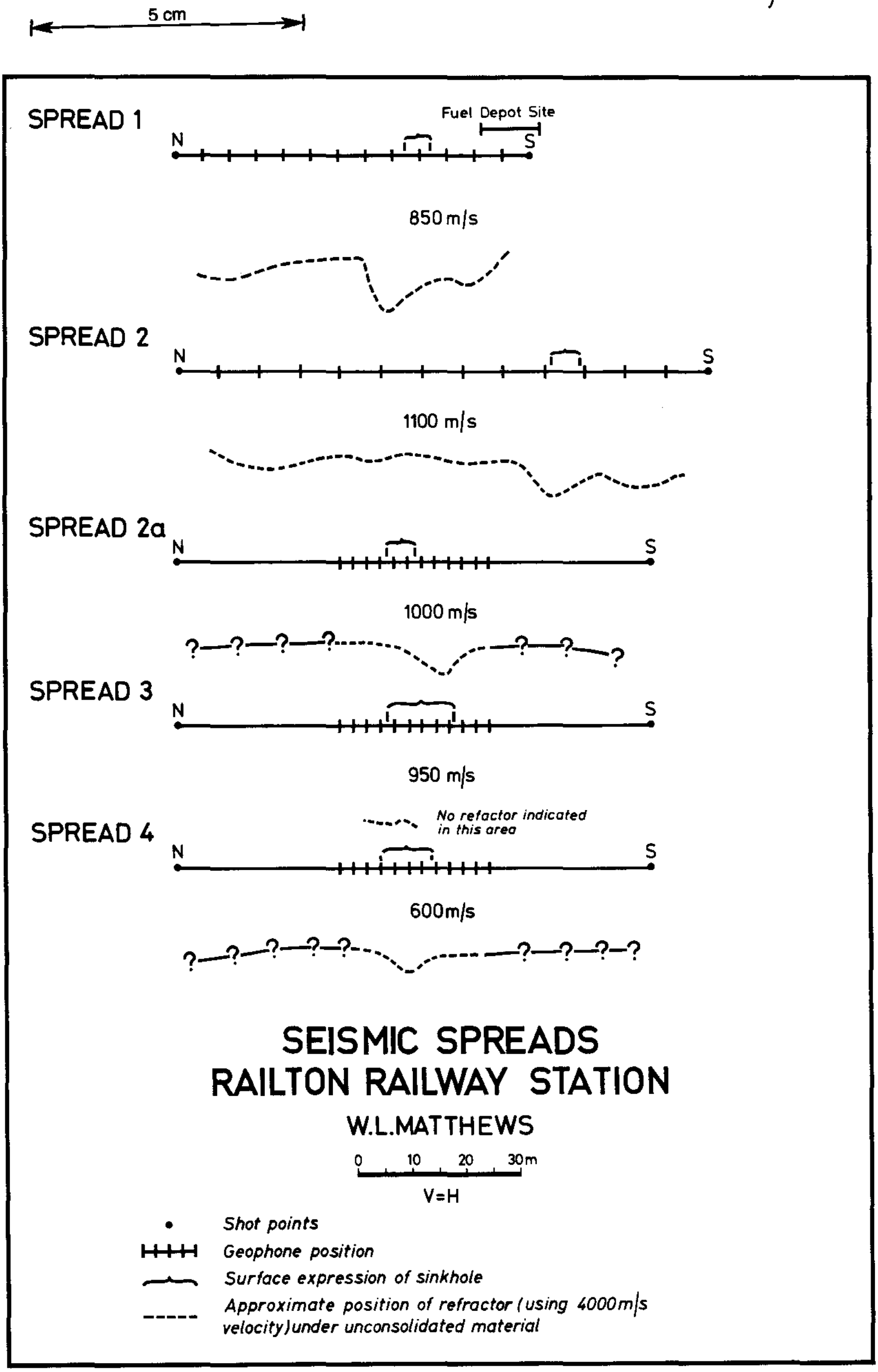
5 cm
SPREAD 1
Fuel Depot Site
N
S
850 m/s
SPREAD 2
N
S
1100 m/s
SPREAD 2a
N
S
1000 m/s
SPREAD 3
N
S
950 m/s
No refactor indicated in this area
SPREAD 4
N
S
600m/s
SEISMIC SPREADS
RAILTON RAILWAY STATION
W.L.MATTHEWS
0 10 20 30m
V=H
Shot points
Geophone position
Surface expression of sinkhole
Approximate position of refractor (using 4000m/s velocity) under unconsolidated material

Figure 2.

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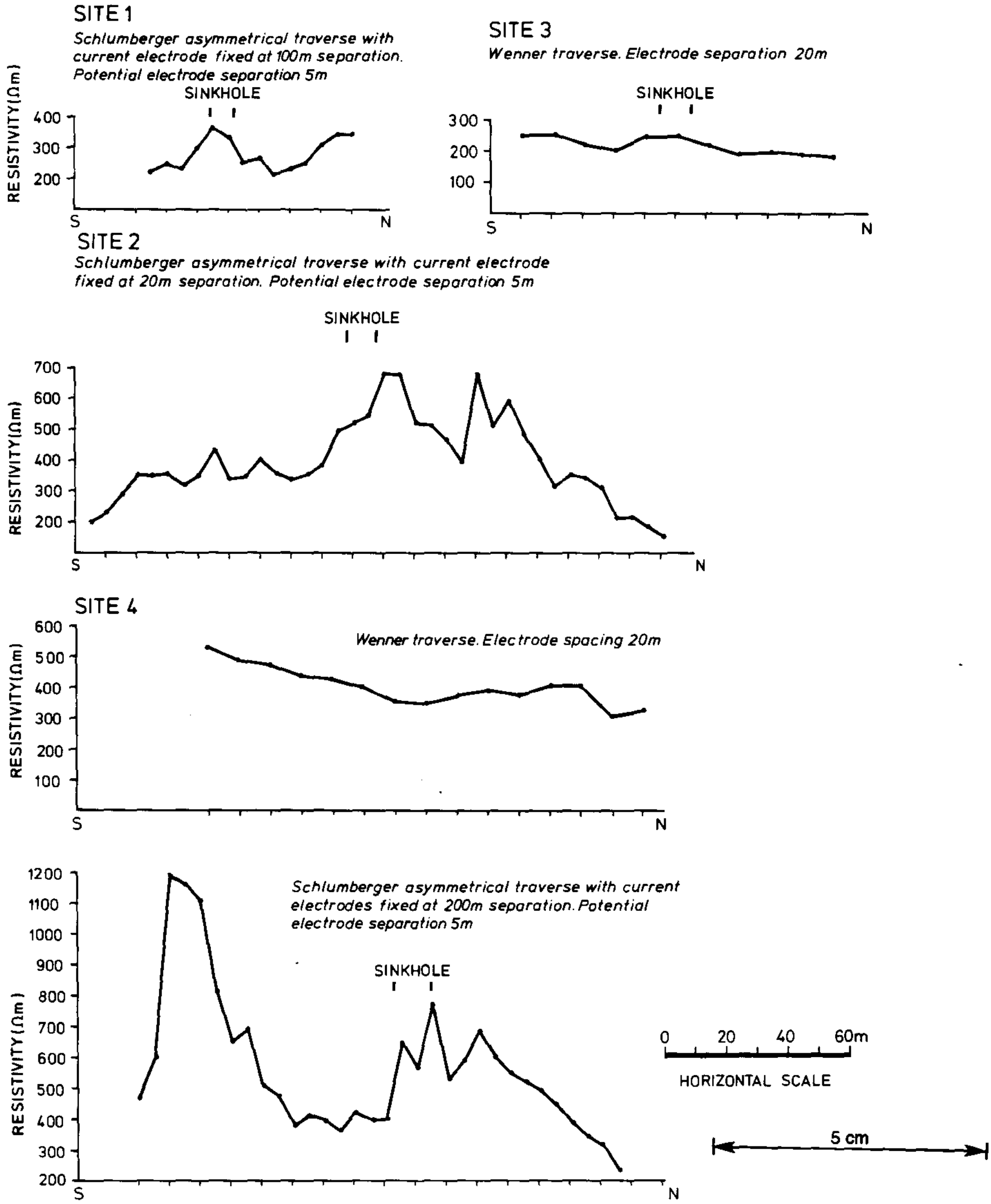

RESISTIVITY TRAVERSES - RAILTON RAILWAY STATION

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Figure 3.