Fig. 12: Drilling being conducted at borehole No. BH-1 (the South Hill)

2.4 GEOPHYSICAL SURVEY

2.4.1 Introduction

Geophysical exploration techniques rely on the measurement of certain physical parameters, normally at the earth's surface, to determine the subsurface geological conditions at a site under investigation. The established geophysical techniques such as seismics, gravimetry, magnetics and geoelectric have been in use for over 100 years. One of the fundamental considerations that needs to be made in selecting a certain geophysical technique for an assigned task is the amount of contrast or change in the physical parameters between the "target" or the object of interest and the surrounding areas. This contrast must be sufficient to be detectable, for the given depth and size in order for the target to be determined.

For the study of the limestone reserve at the sites in Sungai Siput (U), Perak, the geoelectrical resistivity imaging technique was chosen. The purpose of this study was to detect the presence of cavities in the limestone and to estimate the volume (reserve) of underground limestone in the investigated area.

2.4.2 Theoretical Background

The geoelectrical resistivity is a fundamental electrical property of rock and the determination of the subsurface distribution of resistivity from measurements on the earth's surface can provide useful information on the subsurface structure and conditions. The long established geoelectrical resistivity imaging technique involves the introduction of electrical current into the earth using a pair of electrodes and measuring the potential associated with this current using a second pair of electrodes. From a series of such measurements with increasing electrode spacing, the apparent resistivity of the subsurface versus the electrode spacing can be plotted. Using appropriate techniques such as graphical curve matching with Master Curves or computer programmes, the specific geoelectrical resistivity of the subsurface layers can be determined.

The geoelectrical resistivity imaging technique represents a more recent advancement of the resistivity technique. In this case many electrodes are placed along a profile line and an automatic switching system introduces current into the ground using a selected pair of electrodes, with the measurement of potential at another pair. The actual number of electrodes used depends on the required depth of investigation, the nature of the target and the actual space available at the site for laying out the profile lines. The result obtained from an imaging survey is a "pseudo-section". From the field data, with the application of an interpretative geoelectrical software, a section of the subsurface, with the distribution of the geoelectrical resistivity values is produced.

2.4.3 Correlation with Borehole Data

It is useful to correlate the results of geophysical surveys with geological information on the subsurface conditions from other sources such as borehole data. In this manner, a certain degree of quantification and calibration of the geophysical survey results is obtained. This is particularly useful for techniques that are based on the potential field theory like the geoelectrical technique. In simple terms, a certain geoelectrical resistivity distribution pattern can be due to more than one set of geological conditions. Therefore the correlation with borehole data will not only aid in the interpretation of subsurface conditions but will also enable a determination of the subsurface conditions of adjacent areas with the geoelectrical technique, provided that there is no drastic change in the subsurface geology.

Fig. 13: The core samples from the drilling conducted at BH-1 (the South Hill).

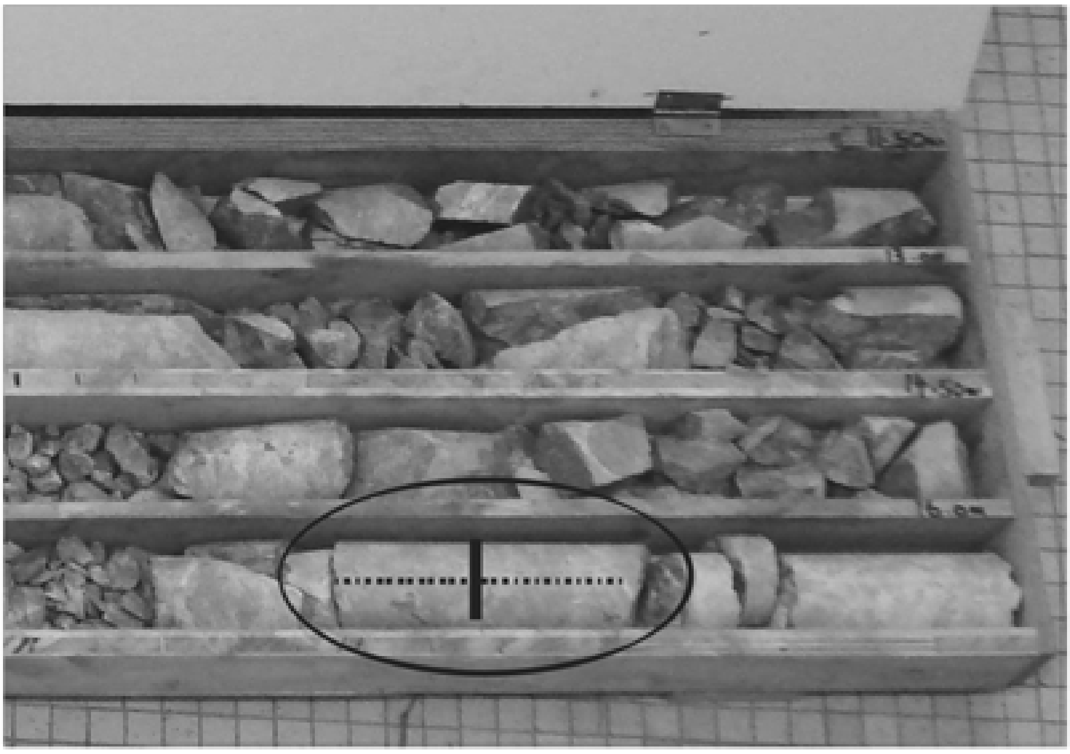

Fig. 14: The close-up of borehole samples with the marked area to be pulverized (BH-1; South Hill)

2.4.4 **Area Surveyed**

The geophysical survey involves 8 traverse lines, 100 m each. The traverse lines for the South Hill and the North Hill are shown in Fig. 15 and Fig. 16, respectively.

Fig. 17 shows the instrumentations for geoelectrical resistivity imaging survey. Fig. 18 depicts the geophones on the geophysical traverse line at the vicinity of the North Hill.

2.5 ESTIMATION OF RESERVE

2.5.1 Above Ground Reserve

Estimation of reserve of a deposit involves a number of steps, i.e. estimation of volume of the deposit, estimation of its tonnage, grade, and then only the actual reserve.

2.5.1a ***Estimation of Limestone Volume***

Estimation of volume involves the following three steps:

a) Estimation of plan area

b) Estimation of average height above ground level

c) Estimation of cavity

Estimation of Plan Area

The plan area of the limestone outcrop was mapped using a GPS instrument, by taking GPS readings along the perimeter, at the foot of the limestone hill. The readings were transferred and plotted into a map on a graph paper. The plan area produced is also checked against the plan made by the surveyor. From the resulting map, the area was estimated by a combination of "give and take" and "counting squares".

Estimation of Average Height

Height of the hills was obtained by using a laser range finder. In areas where the foot of the cliff is not accessible due to thick vegetation or a body of water, an indirect reading was obtained by taking angle of inclination. From the various spot heights measured, an average height was obtained. Angles were measured using the Abney level of the Brunton Compass (see Fig. 19, Fig. 20 and Fig. 21).

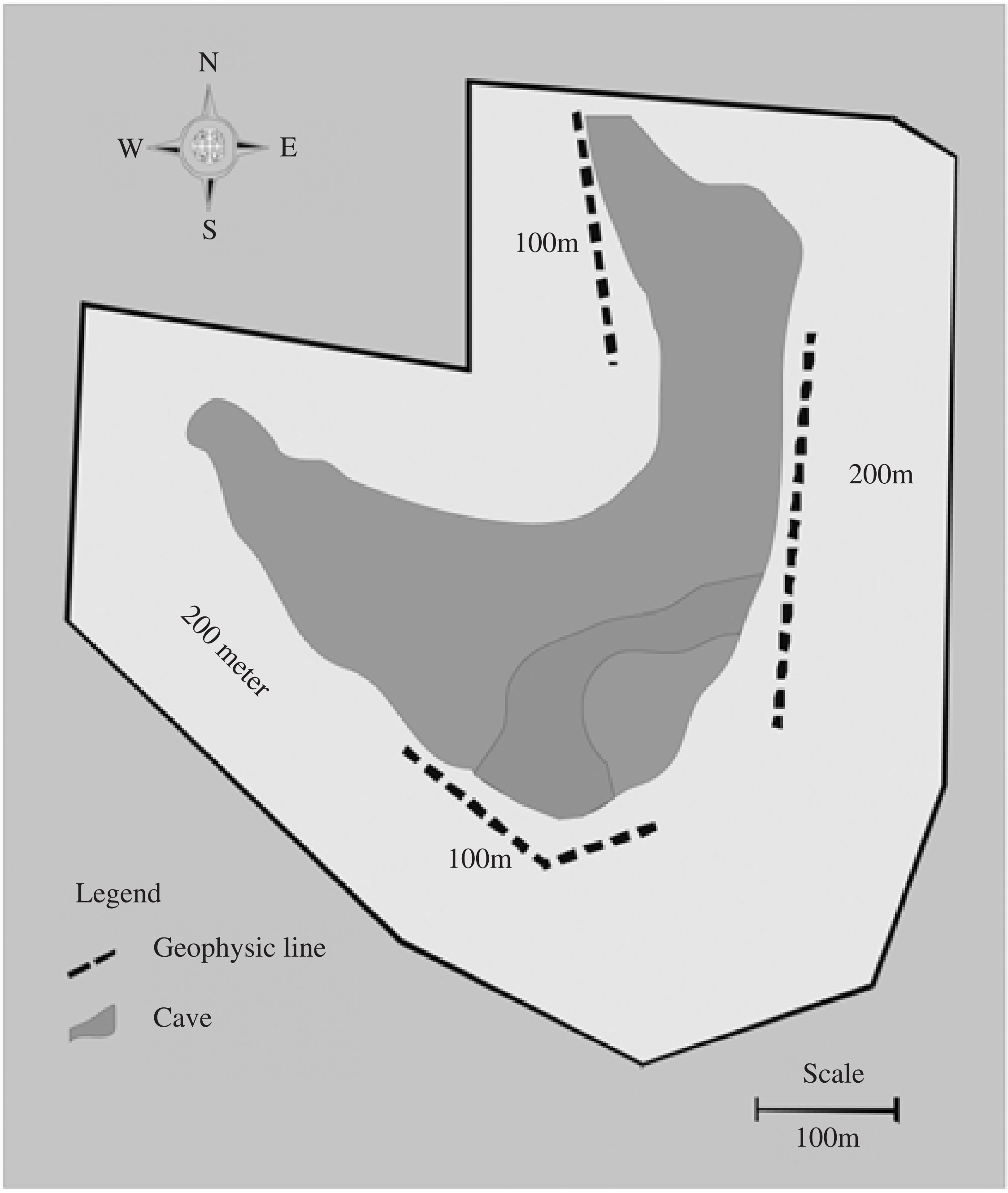

Fig. 15: The geophysical traverse lines for the South Hill.

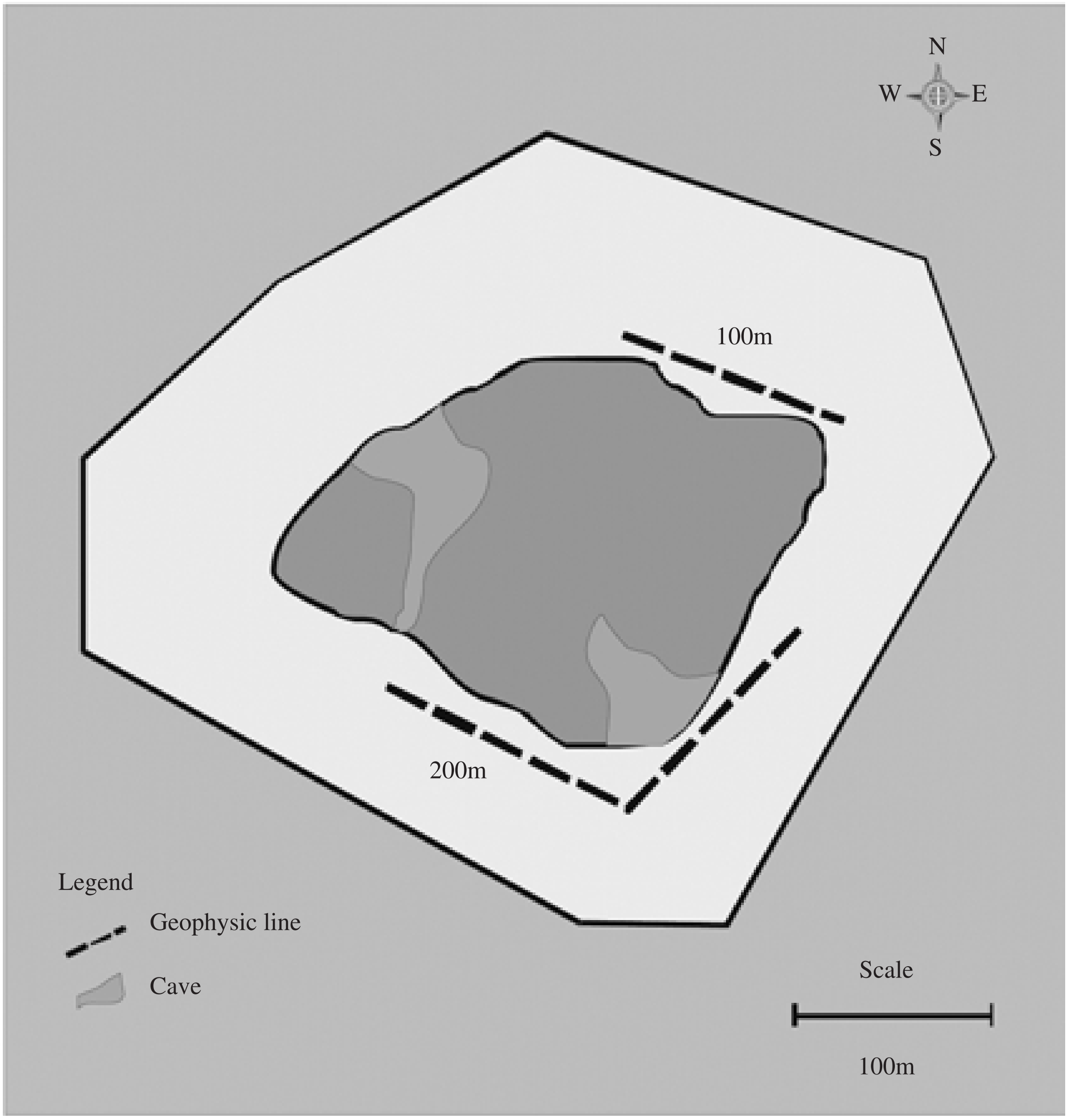

Fig. 16: The geophysical traverse lines for the North Hill.

Fig. 17: The instrumentations for geoelectrical resistivity imaging survey.

Fig. 18: The geophones on the geophysical traverse line at the vicinity of the North Hill.