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INVESTIGATIONS OF SEA CAVES

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and
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INTRODUCTION

Over the past few years members of the Peninsula Speleological Group have been systematically documenting seacaves in the area of coast between Newcastle and Seven Mile Beach (South of Wollongong). Most of the work has been of a purely documentative nature, the principle aims being a cursory examination of the cave, the recording of a description and location of each cave and the assigning of a number. As a result, this work has also involved the development of a numbering system, techniques for locating and marking the caves and application of the A.S.F. cave record sheet to the storage of the data collected. Although the examination of each cave has not been particularly involved, it has been possible, in a general way, to relate structural control and lithologies to the form which the cave finally takes. Features covered in the paper include:

1. Joint control of caves in sandstone, conglomerate, and igneous rocks.
2. Dyke controlled development in sandstone and conglomerate.
3. The relation of cave debris to rock type, and the effect of debris on cave development.
4. Problems encountered in the locating, tagging and numbering of sea caves; technique used to overcome these problems.

STRUCTURAL CONTROLS

The majority of seacaves so far encountered in our investigations have some form of structural control. This control may be broadly divided into two categories. The first we have termed joint control. This encompasses firstly, simple joints caused presumably by the application or removal of stress where there has been no relative vertical movement, and secondly, faults, which result from similar stress situations but where there has been relative vertical movement. The distinction is made since there are often differences in the material adjacent to the joint planes, the faults often having breccia associated with them. The second form of structural control, which in many cases is consequential to the first, is dyke control. Dykes may have either intruded along pre-existing joint planes, or may have caused sufficient stress to cause the formation of joints and fractures. In many cases there is also evidence of post-intrusional stresses which cause joints thus providing joint rather than dyke control.

JOINT CONTROL

The most notable feature of a joint controlled cave is usually the linear style of development. As with limestone caves, the result is usually either long straight passage or frequent sharp bends. A further feature, which may in some circumstances be apparent is that of vertical walls. This seems to occur in regions where the vertical jointing is very pronounced, but in general the cross sectional shape of a cave which has formed along a joint due to mechanical erosion of sandstones is triangular e.g. The Ovens, Whale Beach, Sydney.

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Bedding is also a significant factor, since with suitable jointing, collapse is facilitated by parting along bedding planes. Bedding also enables the distinction between joint control in different sedimentary rocks to be made. Inter-bedded sandstones and shales found in the Sydney area contrast markedly with the conglomerates of the Newcastle area.

The typical example of a cave formed in conglomerate, with joint control is Fraser Park sea cave (2I6E40). The curved cross section of this cave is attributable to the nature of the rock, conglomerate which under continual mechanical erosion, readily breaks down to its constituents. The sea cave south of Flat Is., N.S.W. (2I6E19), shows a similar style of development on the ocean side. However, on the less exposed side, an earlier stage of development is apparent, the typical triangular cross section being noted.

The forms of jointing already mentioned may also occur in igneous rocks. Sea caves such as the Blow Hole at Kiama, N.S.W. may result. A joint type which is usually restricted to igneous rocks is columnar jointing. This form of jointing is a cooling phenomenon and results in the development of polygonal columns, within the rock, normal to the cooling surface. Joints are usually present parallel to the base of these columns, thus eroding waves may readily dislodge relatively large pieces of rock from sea cliff exposures to form caves. Admittedly the occurrence of such sea caves is very limited, the Little Blow Hole at south Kiama is the only example of which we know. In this example the blow hole itself has formed due to the collapse of a single column from the rock platform roof to leave a polygonal hole.

DYKE CONTROL

Igneous material, which had intruded normal to the bedding usually along planes of weakness, are termed dykes. In many places along the stretch of coast which we have investigated, the dykes seem to be the controlling factor in the formation or at least the initial development of the caves. The usual explanation given for this is, that although igneous rocks are frequently more resistant to mechanical erosion than are sedimentary rocks, the chemical stability of igneous rocks is in general far less than that of sedimentary rocks of non-chemical origin.

The chemical instability of igneous material, particularly the basic intrusives found along the N.S.W. coast, results from formation at high temperature and pressure. In ambient conditions the minerals are intrinsically unstable (particularly in an electrolyte atmosphere such as that provided by the sea). The breakdown of only a few of the minerals will facilitate increased mechanical erosion. Examples of caves whose development may be attributed to the presence of a dyke include Bilgola Sea Cave (2XSC3.UNS1), St. Michaels Cave (2XSCI.UNS3), Stanwell Park Sea Cave (2I6I.PSG1).

Large slots are also common along the stretch of coast which we have examined. These are presumed to be formed by near total removal of dyke material.

The shape of caves which have formed due to dyke erosion often have fairly angular cross sections reflecting the shape of the original intrusion. On some occasions the style of erosion changes as the cave matures, for example Warriewood Sea Cave (2I6E.PSG2) which is eroded along a dyke, shows a change in cross section indicative of a combination of mechanical and chemical weathering at cross-section A (see map) where the elongate narrow cleft is due largely to chemical weathering and the wider chamber at the base is largely attributable to mechanical erosion. Further into the cave the effect of mechanical erosion is less than that of chemical weathering, which has (see cross-section B) removed a similar volume of dyke material to that removed at the entrance, cross-section A. By approximately forty metres from the entrance (see cross-section D), a different form of development is expressed, at that point bedding is such that planes of weakness exist and this in combination with the jointing associated with the dyke, results in fairly substantial collapse, the debris being buried in the sand floor. Towards the end of the cave there is a total absence of evidence of mechanical erosion, the cross section is uniform and the walls are parallel to each other (cross-sections E, F and G), rather than being convergent as at the entrance.

Another factor becomes apparent at the end of the passage. Ground water percolates through the rock surrounding the cave and this seems to be a suitable agent to aid the chemical decomposition, the floor of the cave beyond cross-section E is composed of clay, there are also limonite (or similar) formations present, which tends to substantiate the role attributed to percolating ground water in chemical weathering in this part of the cave.

CAVE DEVELOPMENT AND DEBRIS

The principal source of energy for the removal of rock and the formation of a cave is obviously the sea. The waves having once located a plane of weakness, are focused along it. The shape of the developing cave affects the approach of the waves and thus the shape of the cave may be a significant factor in the continuing development of the cave. It is possible that the presence of the sea within a sea cave may actually inhibit further development. In effect, standing waves may develop and act as a barrier to the more destructive waves coming straight in from the sea.

However, the observation that development is inhibited by the presence of the sea within a cave may be invalidated by a further observation that these standing or captive waves in general have a traction load, which although the wave action within the cave may be less than that at the cliff base, may make the captive waves more aggressively erosive. In some cases the material comprising the traction load is derived locally from the beach, thus giving the cave a sandy floor e.g. 2I6E23. In other cases the material in the cave is of pebble or cobble size and may have been derived from the decomposition of the rock surrounding the cave e.g. 2I6E40 (Fraser Park sea cave), or may have been transported. From current observations it appears that the caves undergoing most active development have pebble rather than sand floors. Continuous wave action tends to cause the pebble floor to move and thus mechanical erosion is intense.

It is apparent that since caves at sea level, which have pebble beaches are more prone to continued development than are other caves at sea level, the caves formed in conglomerate should be more active in their development. This in fact does appear to be the case as formation of the cave actually produces further abrasive material.

On the south coast of N.S.W. where the seas are frequently very rough, the majority of sea caves at sea level, have pebble beaches but the material is not locally derived since the caves in that region are formed in sandstones or fine conglomerates. Thus development is not self perpetuating as it appears to be in the Newcastle area.

The debris found in the sea caves of the Sydney area is markedly different to that of either the Wollongong or Newcastle areas. This is attributable princip-ally to the geology of the various areas being different. Also, differences in wave activity exist. The conglomerates of the Newcastle area give rise to sea caves, which have little massive debris since the rocks are readily degraded back into pebbles. In contrast the sea caves of the Sydney region, which are in general formed in sandstones and shales of the Newport Formation, contain large pieces of debris resulting from the combined effect of the vertical joint planes and the near horizontal bedding planes. The presence of these large blocks of debris tend to reduce the rate of development due to the formation of a rock barrier to wave action e.g. Platform Cave, Avalon, Bilgola Sea Cave, St. Michaels Cave.

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In the Wollongong Area, few caves appear to have much locally derived debris and most of the major caves are extensively wave washed. The smaller caves, as mentioned previously, have pebble beaches. This is attributed to the intensity of wave action rather than to the lithology.

PROBLEMS OF TAGGING

Rock Type

The standard method of fixing tags for cave numbers has for some time been to drill a hole, plug the hole with wood or lead and affix an aluminium tag by hammering a copper nail through a hole in the tag into the prepared hole. In many of the rocks encountered along the N.S.W. coast this practive is not practical. The soft rocks are easy to drill but the presence of a hole increases the rate of weathering to such an extent that the tag may drop out. To remedy this, an absurdly deep hole is needed. In the harder rocks the drilling of a hole takes an excessively long time and in conglomerates the pebbles are especially hard.

After much consideration of possible alternatives to the standard method a Ramset gun was used. Durability of the nails will be discussed later. The Ramset method solves the penetration problem and tagging is very swift. However a relatively flat surface is requred for efficient functioning of the Ramset gun, and trouble is also encountered in driving nails into quartz. 1½" nails have been found to be satisfactory and the charge is selected according to the estimated hardness of the rock. Green or yellow is usually sufficient for sandstone and hard shales, red being necessary for harder sandstone and conglomerates, purple charges are required for basalts and the more solid conglomerates.

Tag Durability

Due to the extremely corrosive nature of the sea water, tag materials need to be carefully selected. Aluminium is very easily corroded and steel rusts very readily. The only materials sufficiently durable so far found are Polycarbonate plastic and Phosphor Bronze. In order to stop the Ramset nail passing right through the tag the plastic needs to be about 5mm thick. Phosphor Bronze is expensive. So even these materials present problems. We are at present conducting tests but current observations show that the Ramset nail is corrosion resistant to a sufficiently high degree to be used for tagging sea caves. (It is high tensile steel.)

Tag Site

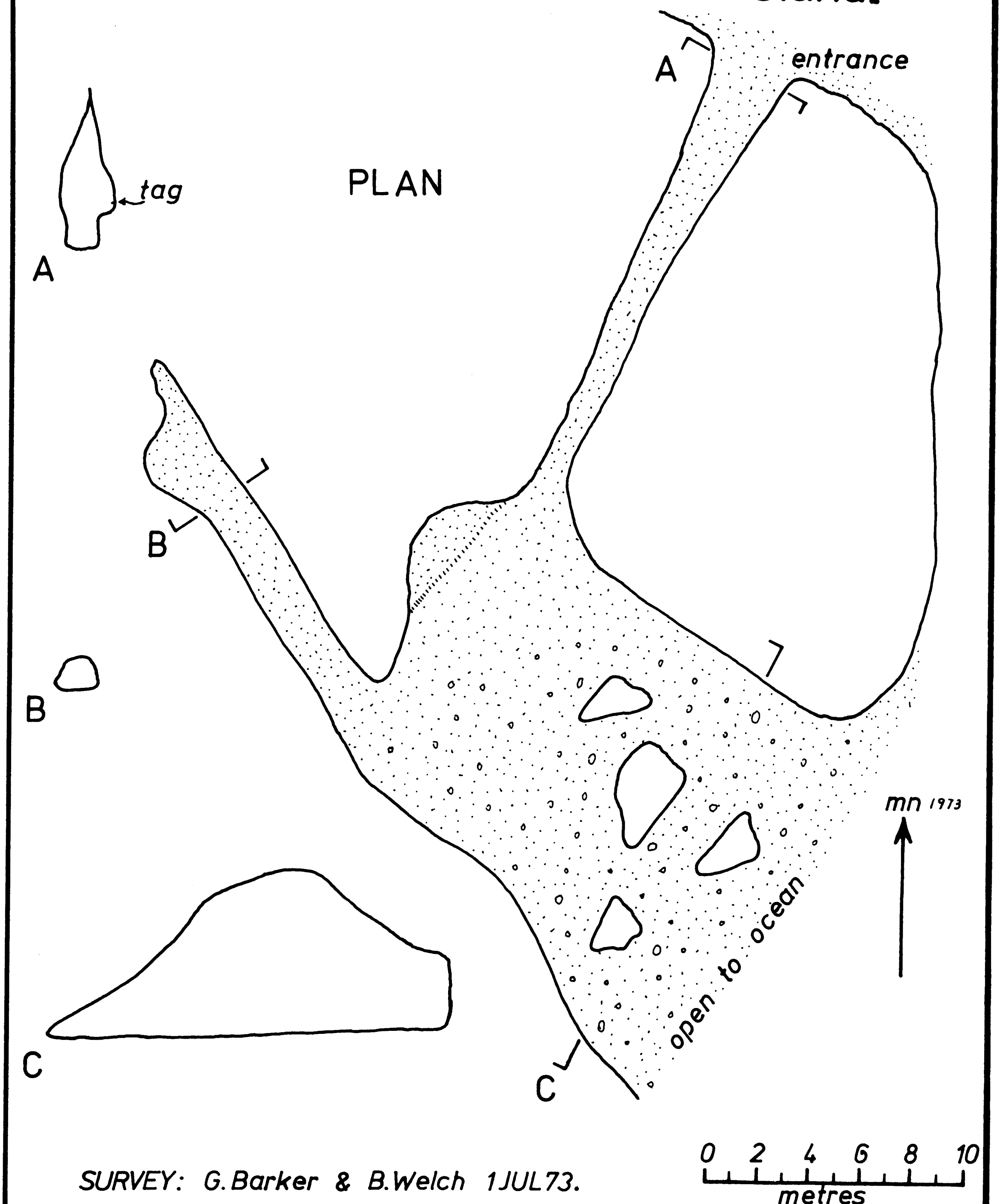
Several problems are encountered when attempting to tag a cave. On occasions it is impossible to reach the entrance so placing a tag there may not be possible, and the tag may have to be placed above the cave entrance.

Consideration must also be given to re-location of the tag. In some situations heavy seas have removed several metres of sand, or deposited similar quantities thus placing the tag metres above eye level or under a beach. Here the method of sequential numbering aids in determining the number of the cave (See Toomer & Welch elsewhere this volume).

It is felt that a cave should be numbered as soon as publication is contemplated and that whenever possible a cave should be tagged as soon as documentation commences, to prevent confusion and duplication.

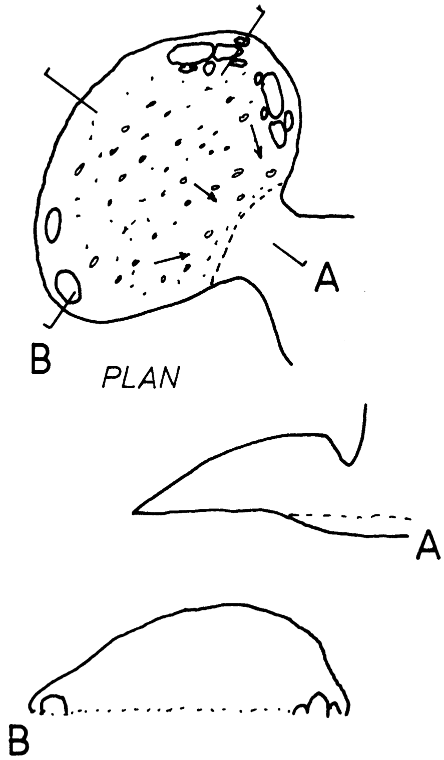
The authors hope that the foregoing has given some insight into the current investigation of sea caves, the deductions made or sought from the data collected, and the problems encountered in the documentation.

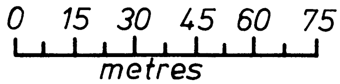
SEA CAVE, south of Flat Island.



SURVEY: G. Barker & B. Welch 1JUL73.
DRAWN: B. Welch 12APR74.
INSTRUMENTS: SUUNTO KB 14, tape, clinometer. 1:200 *2I6E19. PSG 1*

FRASER PARK SEA CAVE





redrawn from ;
SPAR 21 (29)
by P. Toomer

SURVEY : R.Allum, R.Connor &
C.Fisher 22 OCT 72
DRAWN : R.Connor 25 OCT 72
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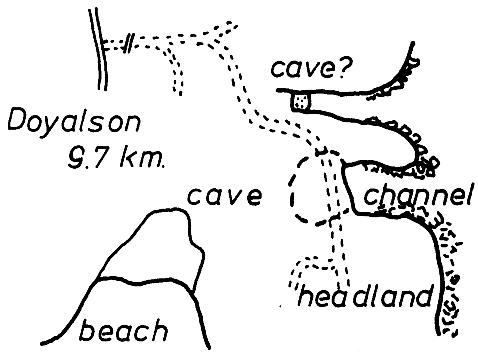
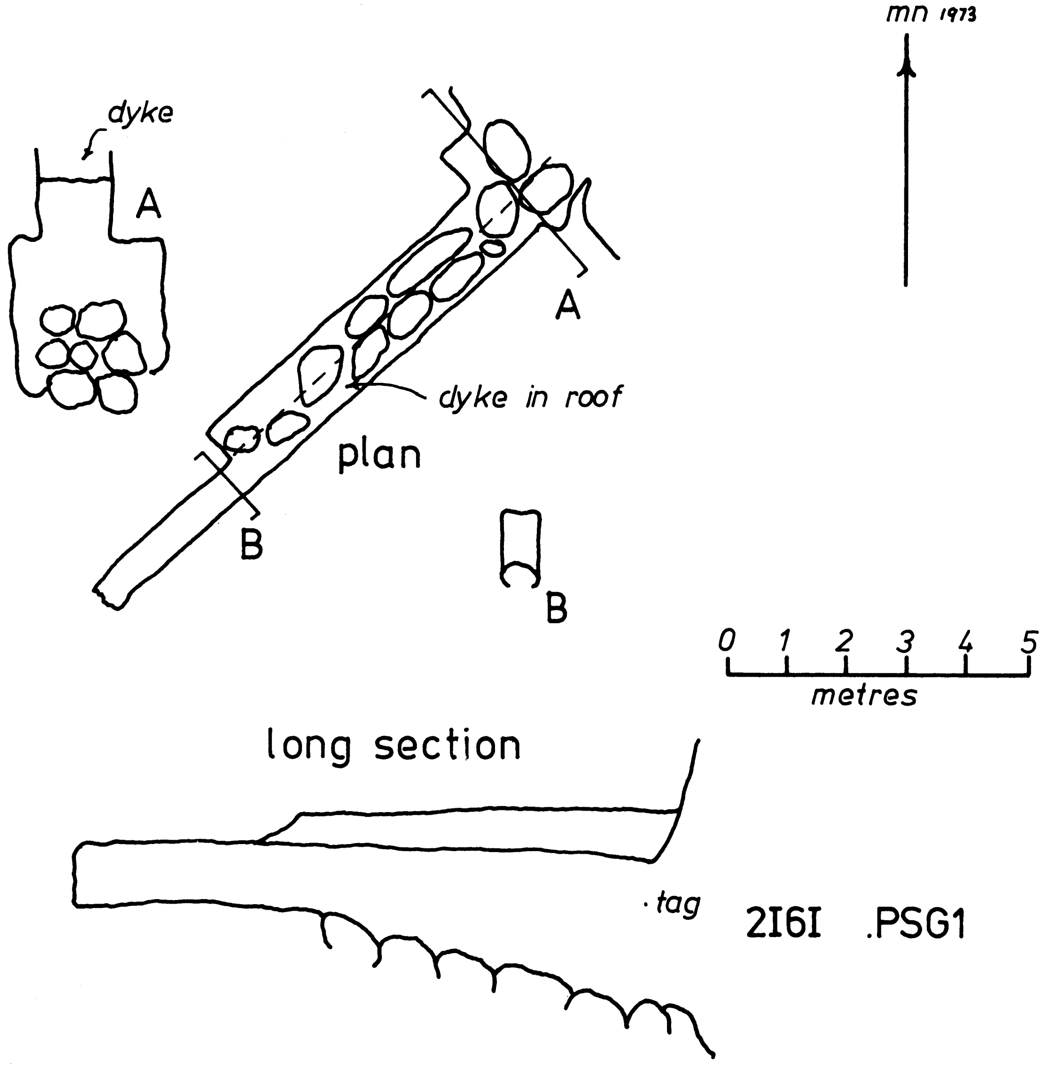


STANWELL PARK SEA CAVE (south of beach)



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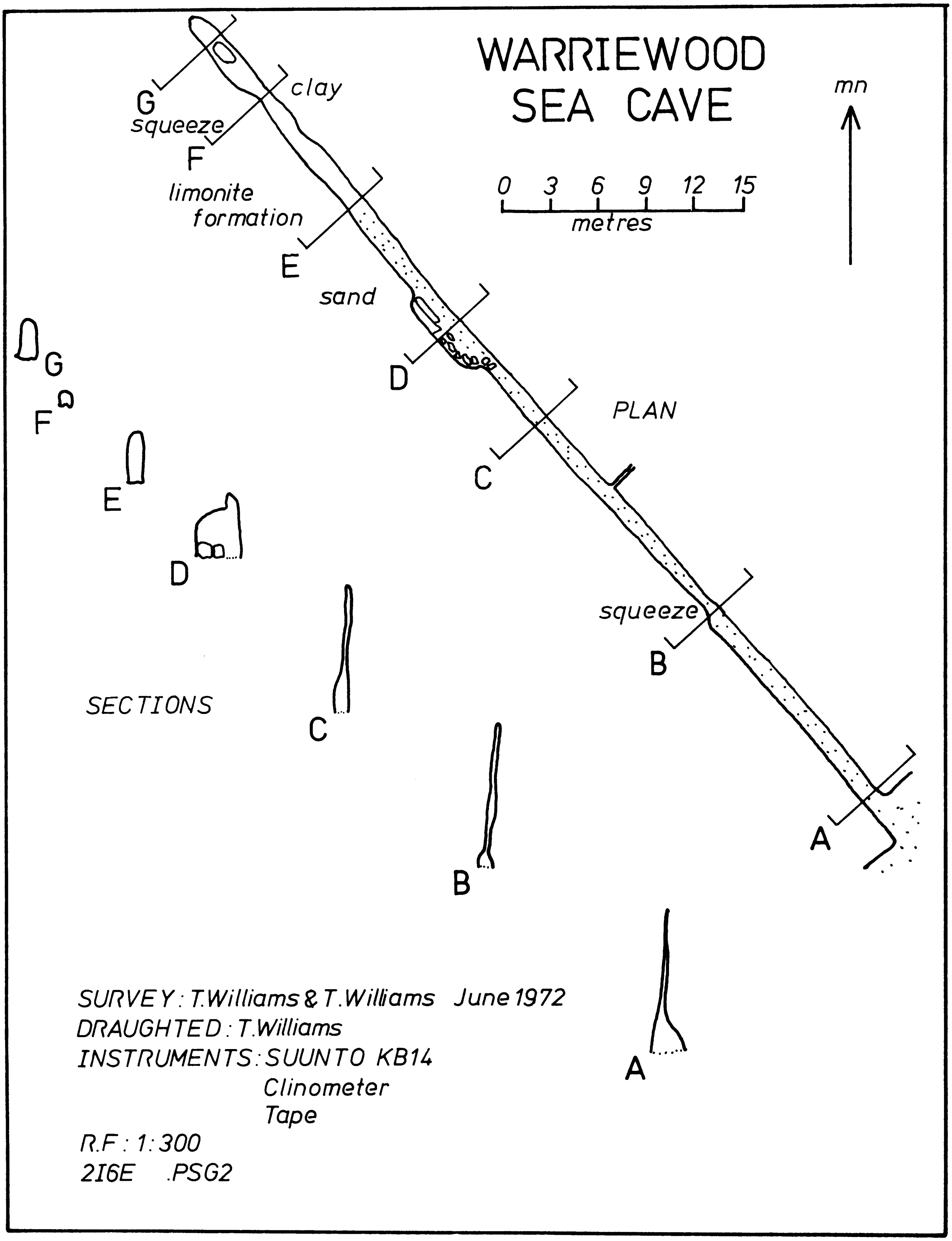
SURVEY: P.Toomer & B.Welch 20APR 73

DRAWN: P.Toomer *1:100*

INSTRUMENTS: SUUNTO KB14, tape, clinometer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SURVEY: T.Williams & T.Williams June 1972
DRAUGHTED: T.Williams
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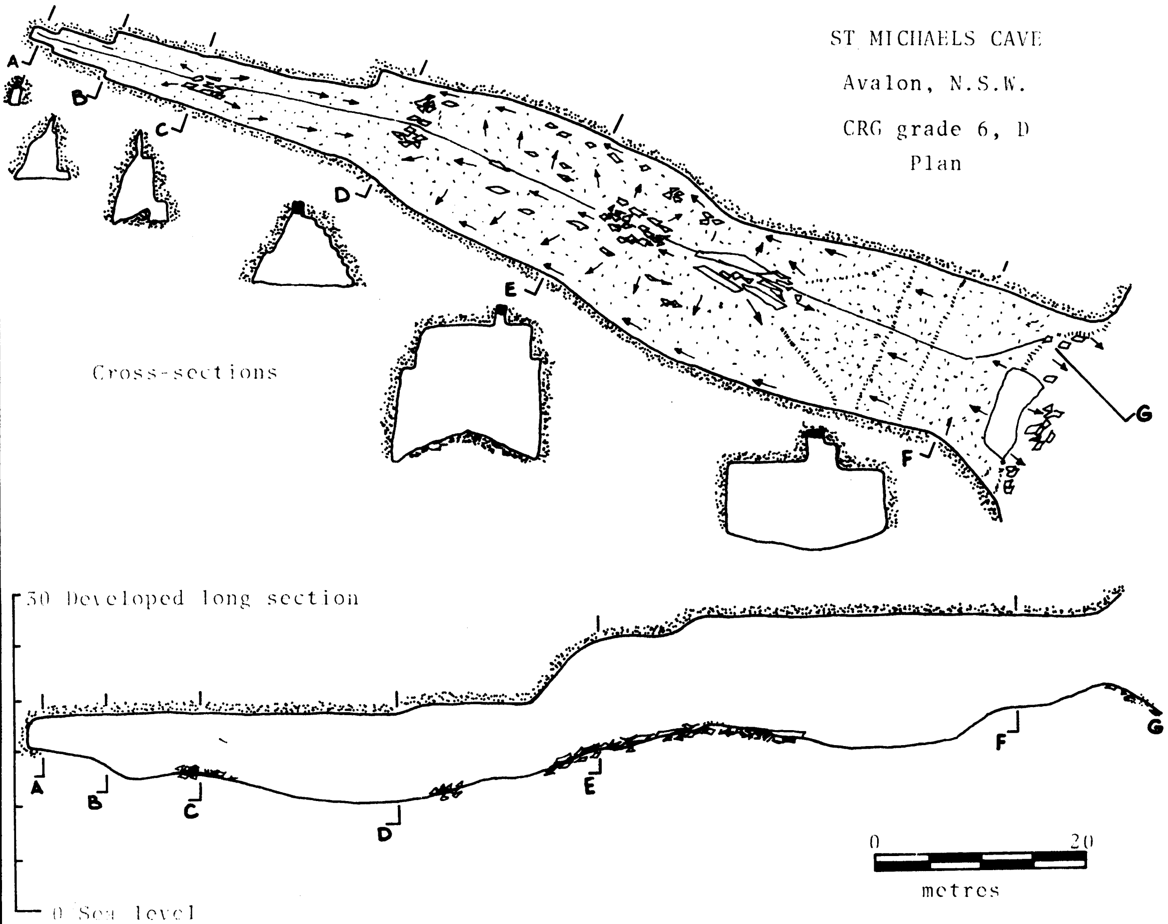
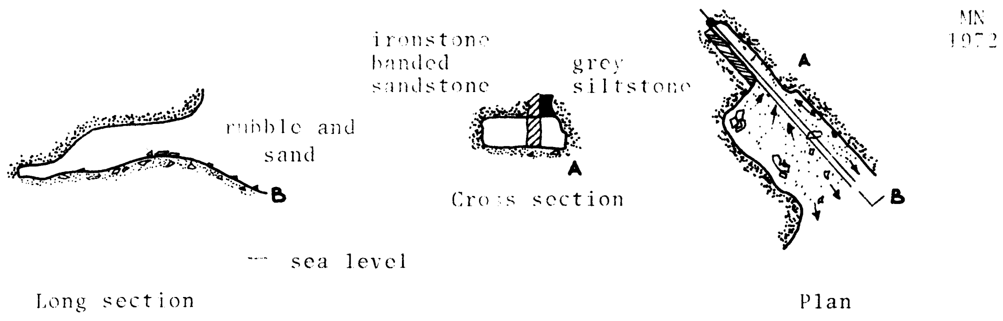
Clinometer
Tape
R.F: 1:300
2I6E .PSG2





BILGOLA BEACH SEA CAVE

North End of Bilgola Beach, Sydney.

CRG grade 6, D

(both maps from SPAR, 16, pp 16-17, June 1972).