



## 1. INTRODUCTION

The presented study is part of a broader basin evaluation which is being carried out by the Shell Company in connection with coal exploration work in areas adjacent to the Fingal Colliery in North Eastern Tasmania.

A Permo-Triassic sequence of up to 600 metres thickness covers about half of the area of Tasmania. FIGURE 1.

The Permian part consists of glacial, marine and fluvial deposits with locally some coal. The Triassic part contains extensive coal bearing alluvial and fluvial deposits which are locally grading into marine deposits.

In the north east, the Triassic coal measures have their optimum development with a thickness of more than 300 metres, and some 5-10 coal intervals. This area accounts for the bulk of Tasmania's total cumulative coal production of eleven million tonnes. One third of this has been produced at the Fingal or Duncan mine, which is currently the only operating colliery and produces about 200,000 tonnes annually.

Here, room and pillar workings in the Duncan seam extend over some three square kilometres. More than 50 kilometres of accessible roadways expose about half a million square metres of coal and roof rock surface. These continuous exposures of the seam and its immediate roof, as well as the numerous large roof falls offered an opportunity to study depositional features, especially larger ones which can not be observed in bore cores.

The invitation to visit the mine was obtained from Cornwall Coal Company on the basis of friendly relations and consultations between lease neighbours. Thanks are due especially to the mine manager, Mr. Robert Mellows for the permission to give this presentation and to Mr. Vic. Threader from the Mines Department, who kindly arranged access to bore cores and made core data available.

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SCOPE

During the last 10-20 years, the genesis of various sedimentary features such as types of bedding, marks on bedding planes and shapes of rock bodies have been studied by numerous authors, and were used as criteria for the recognition of depositional environments.

Models have been developed and refined for alluvial fans, alluvial plains, braided, straight and meandering rivers, lakes and coastal plains. Such models have been applied to coal bearing sequences especially in the Appalachian Basin by Wanless, Donaldson, Ferm and Horne and by many authors in European coal basins.

Sedimentological characteristics of the Tasmanian coal measures can now be compared in detail with those of similar deposits elsewhere which have been subject to numerous detailed investigations.

The overall assessment of the depositional environment of the studied sequence is largely based on bore core observations relating to lithology, type of bedding, vertical variations and correlations between boreholes.

A 180 metre thick interval representing about half of the total thickness of the coal measures in the studied area is shown on FIGURE 2.

The sequence consists basically of four rock types:

1. medium and coarse grained clastics which are according to PETTIJOHN'S terminology sub-greywacke.
2. fine grained sub-greywackes and siltstones.
3. mudstones with little or no carbonaceous material.
4. carbonaceous mudstone and coal

The basal 300 metres of a number of holes were found to comprise these rock types at the following percentages:

medium and coarse sub-greywacke	63%
fine grained sub-greywacke and siltstone	15%
mudstone (non-carbonaceous)	12%
carbonaceous shales	7%
coal	3%

As recognised already in 1968 by V. Threader, these rock types are usually arranged in upwards fining cycles, commencing above an erosional base with massive, apparently unbedded or faintly horizontally bedded medium and coarse grained units of 2-20 metres thickness. Mud pebble conglomerates, coal spars and clay bands occur often within these units. Commonly contorted bedding, slumping and grain flow is evident. Threader (1968) pointed out that these sandstones often cover as large areas as carbonaceous intervals.

Detailed bore core studies suggest that these sandstone intervals are composed of usually more than one sand body. The geometry of these individual bodies and the boundaries between them has been studied in the mine in some detail.

Horizontal and low angle cross bedding was found to be more pronounced in the finer grained intervals, while centimetre scale ripple cross bedding and millimetre scale flaser bedding was commonly observed in the fine grained, silty alternations at the top of these units. Bedding in some of the finer clastics was often blurred by bioturbation and small scale grain flow.

The sub-greywackes of this sequence are usually well sorted and contain often less than 30% quartz while rock fragments predominate. They are usually poorly cemented and friable. More mature, quartzose sandstones are missing here but are known to occur in lateral equivalents to the south-west and south-east.

Various types of mudstone and clay are observed. Some are massive and apparently unbedded, others are fine banded and show characteristics of deposition from suspension in bodies of more or less stagnant water.

Among the various types of clay and mudstone, the most conspicuous ones are the numerous cm-dm thin usually light brown beds, which have been used in the mine and in boreholes as correlation markers. Recent clay mineralogical studies by C. Bacon (1979) in this area have suggested a volcanic source of the material of some of them having high montmorillonite contents.

At the base of some of the observed coal seams there are 1-5 centimetre thin white or light brown clay beds which have some resemblance with underclays. Some of the carbonaceous shales at the base of coal seams

contain abundant plant remains, but roots have not been recognized in them. All coal seams in this section consist predominantly of dull coal. Most have fairly high inherent ash contents (more than 20-25%) and grade into carbonaceous shale or heavy dull massive inferior coal. Locally a few thin torbanitic shales have been observed.

The laterally most persistent rock units are the ones consisting of carbonaceous shale and coal. (FIGURES 3 and 4.) Borehole evidence suggests that some of them may extend over several hundred square kilometres. Coal is less persistent than shale, and may vary from less than one to more than 4 metres within a few hundred metres or less, as seen in the mine.

The lithology, frequency and succession of these rock types, their contacts and interval features such as bedding, and their lateral extent and lateral variations suggest the deposition in an alluvial plain environment.

Observations in the mine confirmed this interpretation and added some detailed evidence which is only obtainable from continuous exposures.

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In the Fingal mine, the Danden seam ranges in thickness between 1.5 and 4 metres. It consists predominantly of dull coal with fairly high inherent ash content. The predominance of dull coal is interpreted to indicate deposition in a comparatively well drained coal swamp with partial oxidation of the plant material. The high inherent ash contents, swept in by wind and water, may indicate rather slow coal deposition.

The base of the seam is rarely exposed. Below the seam there is usually a light grey or grey-brown mudstone, locally silty and firm but more often rather soft and not suitable as a working floor. The uppermost 1-3 centimetres of the mudstone are occasionally light brown and resemble an under-clay. A persistent stone band of 1-5 centimetres thickness occurs about 60 centimetres above the base of the seam. The working floor is usually kept at this band.

The seam includes a number of centimetre thin stone bands, which were found to extend throughout the mine workings and could be used as marker horizons. Of the stone bands higher up in the seam, two thin bands separated by some 6 centimetres of coal are usually easily recognizable and have been used as marker horizons throughout the mine. Other bands are more variable in thickness and lithology, consisting partly of splinter-hard stone and partly of soft plastic clay. Locally, some 20 centimetres of torbanitic shale occur within such a stone band.

The stone bands have usually a sharp, slightly erosional base, locally with some grains and mud pellets near the base. The top is often gradational. Upwards fining graded bedding is often clearly recognizable. Millimetre thin parallel and ripple lamination, some centimetre scale drag folds and local minor erosion and re-working indicate moderate current activity. Bands of similar type are known from many other coal basins. They are interpreted to be deposited from suspended mud during occasional floods when the entire coal swamp was inundated. After each of these floods, coal deposition obviously resumed rapidly.

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In the upper part of the seam, above the level chosen as key marker, detailed correlation is more complex, as illustrated on FIGURE 5.

In some areas, the deposition of coal continued, and as much as two metres of coal follow locally above the marker bed. This coal interval includes some clay beds of variable thickness. One of them ranges in thickness from a few centimetres to several metres and separates an upper coal ply of about one metre thickness from the main seam section.

The mudstone and the upper coal are lateral facies equivalents of a medium to coarse sub-greywacke which usually forms the roof in the mine workings. The edge of this sub-greywacke is exposed along the periphery of the mine workings over a length of about 4 kilometres. All along this edge there are numerous large roof falls which clearly expose the transition zone. (FIGURE 6.) This sub-greywacke is composed of individual rock bodies, each of several decimetres to meters thickness, which laterally represent individual mudstone and coal beds.

The edge of the sand body is locally inclined at a low angle to the coal seam. Mostly the angle is in the order of 30 degrees but locally it is almost vertical (FIGURE 7 and 8).

Differential compaction along this zone has caused locally extensive squeezing of clay and coal, slickensides, fractures and faults which usually originate and terminate within the seam (FIGURE 9). It is evident that these displacements are caused by local compaction and not by regional tectonic stress. However, the fact that the most pronounced parts of the edge of the sand body follow fairly straight lines may suggest some slight syndepositional movements. (FIGURE 10).

The sand body was obviously deposited on the topographically lowest parts of the coal swamp while on the surrounding slightly higher ground coal and mudstone deposition continued. Compactional processes stabilized for some time the position of the edge of the sub-greywacke until eventually the sub-greywacke spread out over the entire area.

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COMPOSITION AND ORIGIN OF THE ROOF ROCK UNIT

The basal member of the roof sandstone of the mine workings is usually massive, either unstratified or with wide spaced faint horizontal lamination. This unit may locally exceed three metres in thickness. Where it is thick, the roof of the mine workings is stable and exposures of its full thickness in roof falls are rare. Where it is thin or missing, there is often some evidence for erosion. Where the massive basal sandstone is thick, its base is often undulating and shows channels and scours with pebble lag conglomerates.

This basal sand has all characteristics of a grain flow or sheet sand. Sand fans with similar characteristics have been described from different sub-aquatic environments where large amounts of sediment material were initially accumulated on relatively steep slopes, of perhaps 1-2 degrees, started to creep down-slope, became liquefied and eventually formed turbulent grain flows with high density and high velocity. In most reported cases such flows occurred entirely within extensive bodies of more or less stagnant water.

The basal member of the roof sandstone is followed by laminated and ripple cross bedded units which may indicate waning floods. Higher up follow low angle crossbedded sandstones with erosional base, which may represent stream channel deposits. Braided streams and straight channels appear to have been more common than meandering channels.

At many localities in the mine, large slumped masses are exposed in the immediate roof of the mine and can be studied in large roof falls. They have an erosional base and contain slumped and contorted material including blocks of several cubic metres. They may have been formed by undercutting of channel edges or simply by slope failure as a result of rapid deposition on a slightly inclined base.

The base of the sandstone which usually forms the mining roof displays a large variety of features with depositional significance (FIGURE 10).

In some parts of the mine, the roof is almost perfectly flat and shows no clear evidence of erosion. In other parts it is more or less undulating. Here some erosion is recognizable. The maximum amount of erosion observable under channels and scours rarely exceeds 10-20 cm. The amount of erosion was inferred from detailed mapping of the interval between the sandstone base and the main marker bed. Obviously the peat was not easily eroded by the basal sandstone, or by any scours cutting down from higher levels within the sandstone unit.

- Channels are perhaps the most conspicuous ones. They are usually roughly parallel and trend NNE SSW in the old workings. In the southern and eastern part of the mine they follow often the edge of the sandstone. Some protrude as much as one metre or more from the roof, have a width of 10-20 metres and a length of 100-200 metres. Their deepest parts are often filled with gravel lags. Differential compaction resulted in some squeezing of the coal underneath and in faults along the channel flanks.
- Smaller scours of 0.5-2 metres width, 3-10 metres length and 0.1-0.5 metres depth are locally common. Only few are assymetrical and indicate the direction of transport.
- Tree logs, branches and reed type plants, tool marks and various types of current lineations such as flute marks and furrows are common. They are usually parallel to the general transport direction although local deflections are evident.
- Areas with thicker and coarser sandstone have usually a more undulating roof while in areas where the basal sub-greywacke is thin the roof can be almost perfectly flat over as much as a hundred metres.
- Upright large trees and large roots are common in some parts of the mine.

There are locally minor compressional and tensional features in form of folds and what is elsewhere known as sandstone dykes. The sandstone dykes are roughly parallel to the edge of the basal sub-greywacke body, follow often straight lines of as much as 100 metres and have a width of 3-10 cm where they protrude from the roof. (FIGURE 11).

In the south eastern part of the mine the direction of transport was obviously from the SW to the NE. In the western part of the mine the transport was parallel to the many NNE trending channels.

#### 8. FAULTING (FIGURE 12)

Nearly all discontinuities observed in the mine are related to depositional and compaction phenomena and have little or nothing to do with real faulting. Some minor syndepositional block movements may, however, have influenced the topography on which the sand was deposited and thus predetermined the position of channel edges.

The most common discontinuities that look like faults occur along channel edges. They are not displacing the roof and floor of the seam but usually disappear in some horizontal bed that often shows slickensides. They are clearly the result of the different compaction rates of the coal and the channel fill.

The cleat pattern in the mine is poorly developed and not showing any persistent trends.

Horizontal or low angle slickensides occur often along the roof. Locally they surround lens or disc shaped bodies of roof rock material of several metres in diameter which have caused particularly dangerous sudden roof falls. They also are depositional and compactional features and have nothing to do with real faulting.

The thick dolerite which intruded about 150 metres above the mine workings has apparently not affected the interval exposed in the mine.

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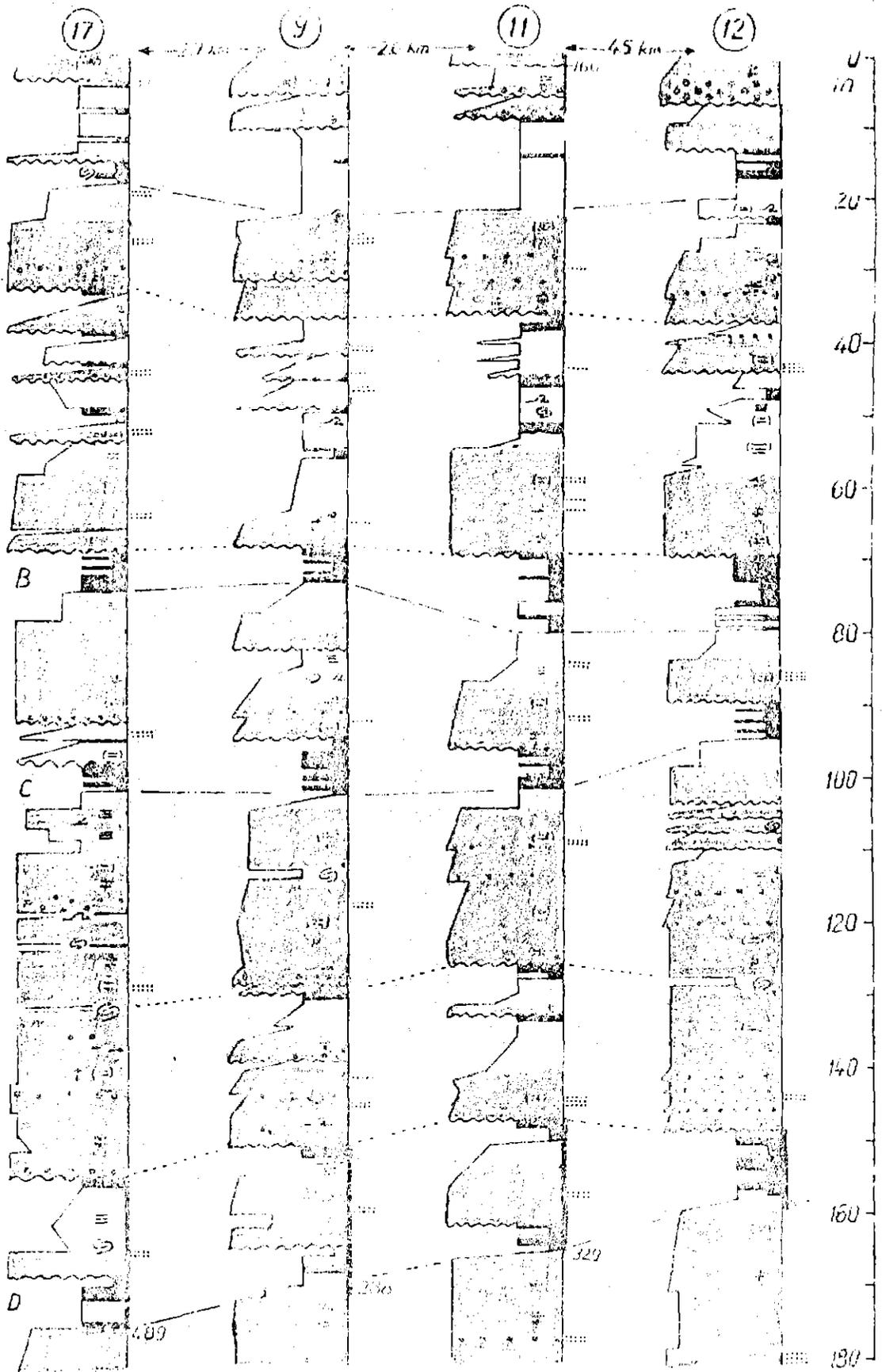
CONCLUSIONS (FIGURE 13)

The investigated sequence was deposited in an alluvial plain environment and comprises extensive coal swamp deposits in alternation with lacustrine and stream deposits.

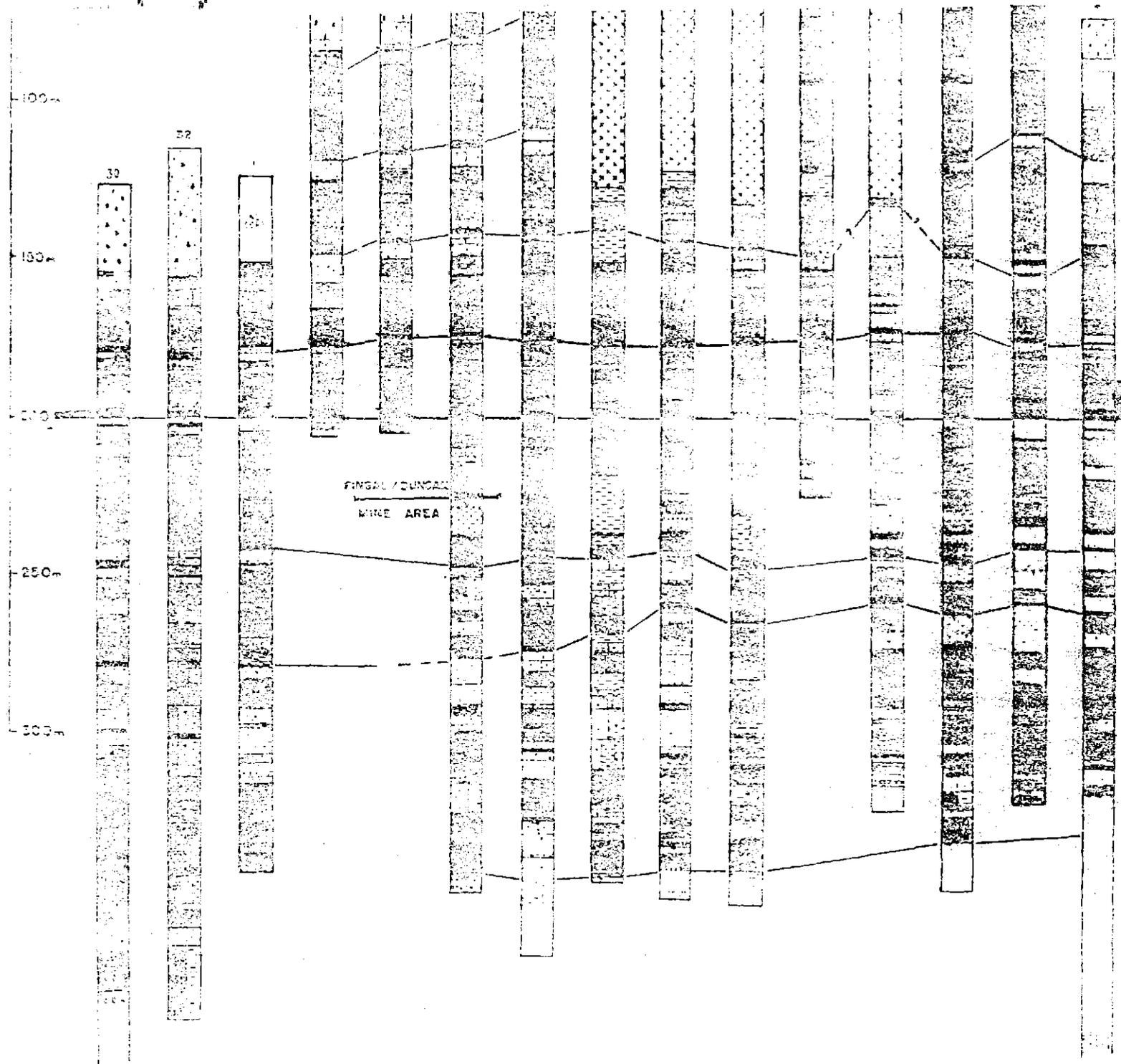
During periods of widespread flooding, large masses of sediment which had been accumulated at the edge of the basin, became unstable, were liquefied and moved as high density grain flows towards the central parts of the flooded areas, where they formed large fan shaped sheet sands. Laterally and above these grain flows, the suspended mud settled down. Such lakes were short lived, and some of their sediments were reworked while the floods were waning and in subsequent periods by stream channels. Slight variations in topographic gradients and fluctuations in the available sediment and water discharge caused the formation of a variety of stream channel types including braided, straight and meandering channels.

The alternation of widespread intervals of clastic sediments and of extensive coal swamp deposits could be fully explained with variations in water discharge. It is not necessary to postulate tectonic events, major changes in topographic relief and large variations in sediment availability.

Similar alluvial plain deposits are known from basins in Northern Spain, Central France and many other places to contain some locally very thick coal seams. The observations in the Fingal mine have shown that seam profiles vary significantly over very short distances, and that in such a depositional environment a relatively dense grid of boreholes and other observation points is required for outlining areas with optimum coal thickness and quality as well as favourable roof and floor conditions.



PART OF TRIASSIC COAL MEASURES 10 km E. OF FINGAL MINE

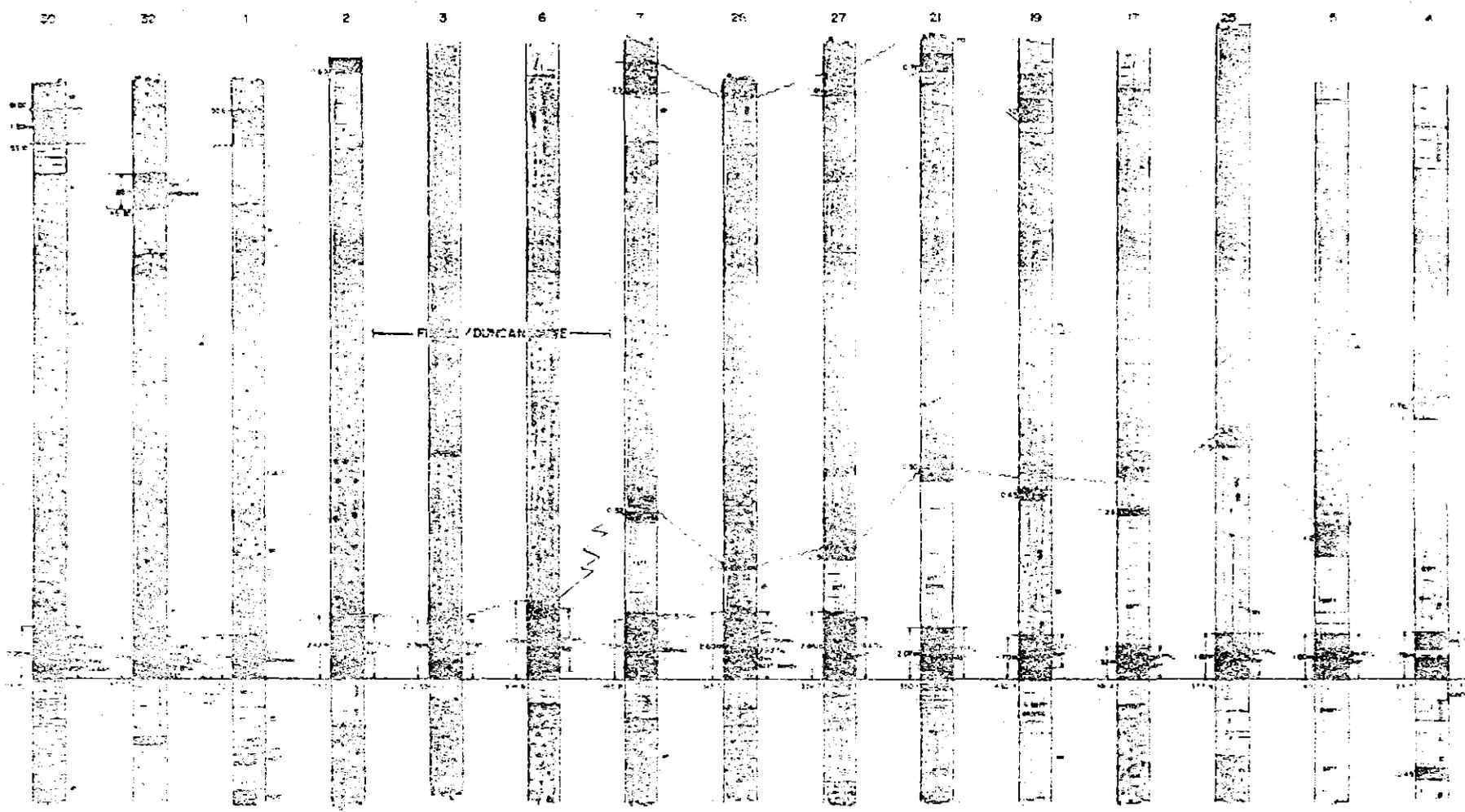


DUNCAN SEAM

RINGAL / DUNCAL  
MINE AREA

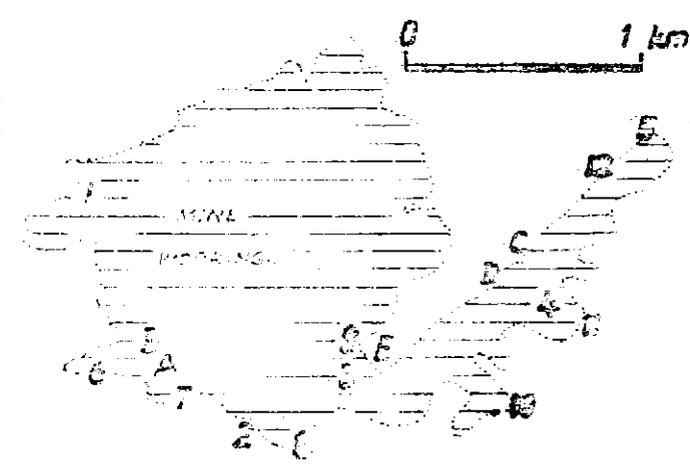
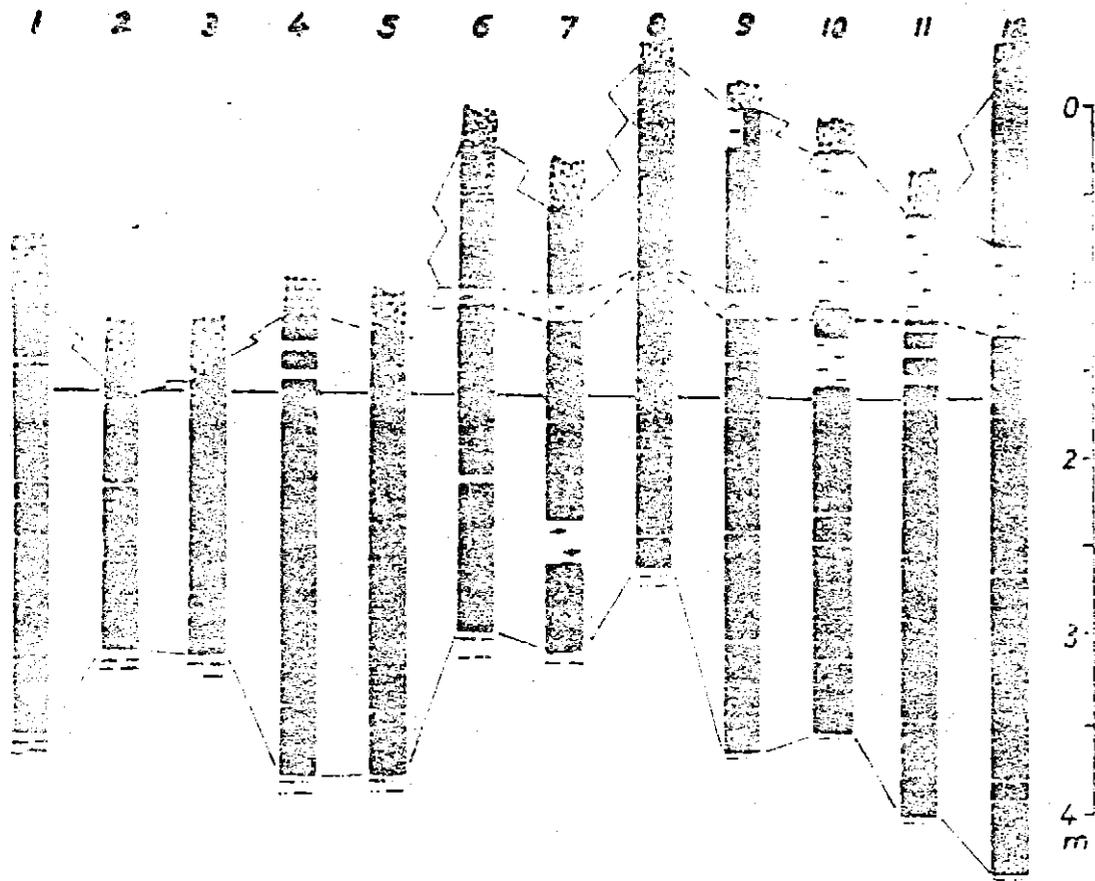
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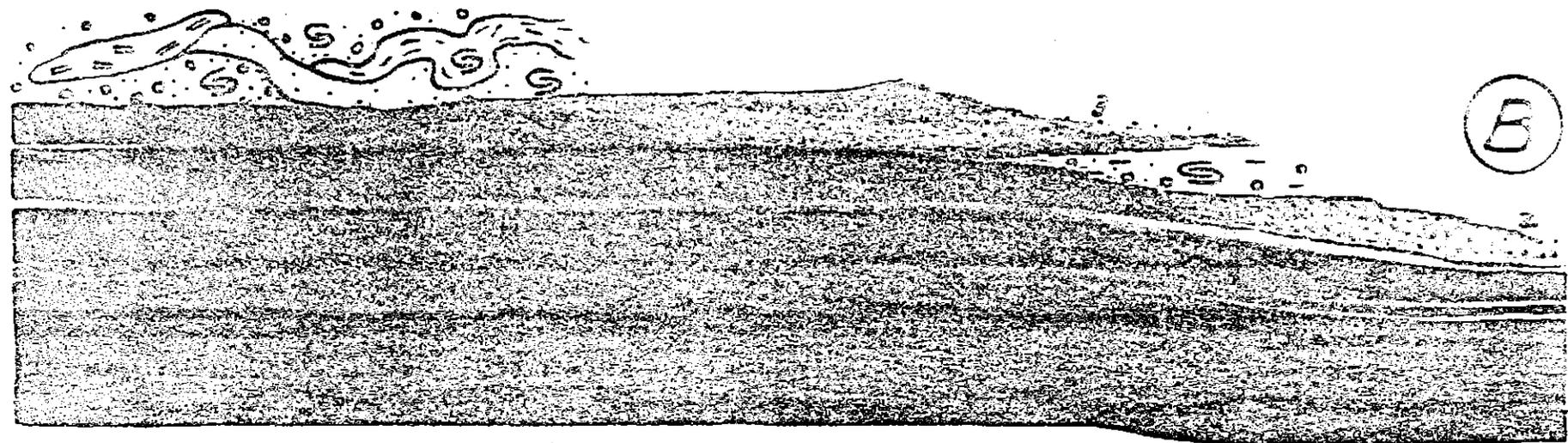
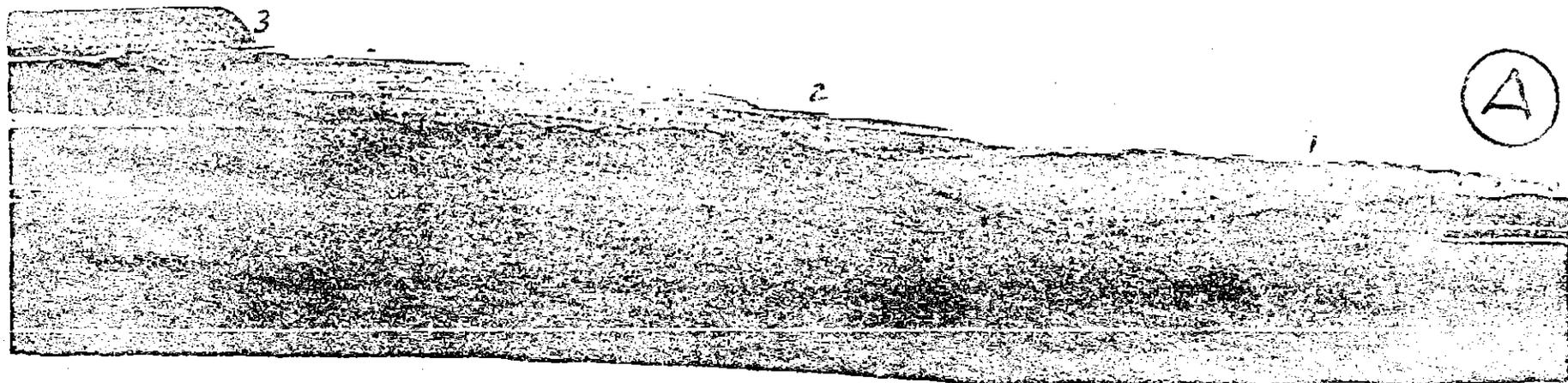
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DUNCAN SEAM  
 FINGAL MINE  
 TASMANIA

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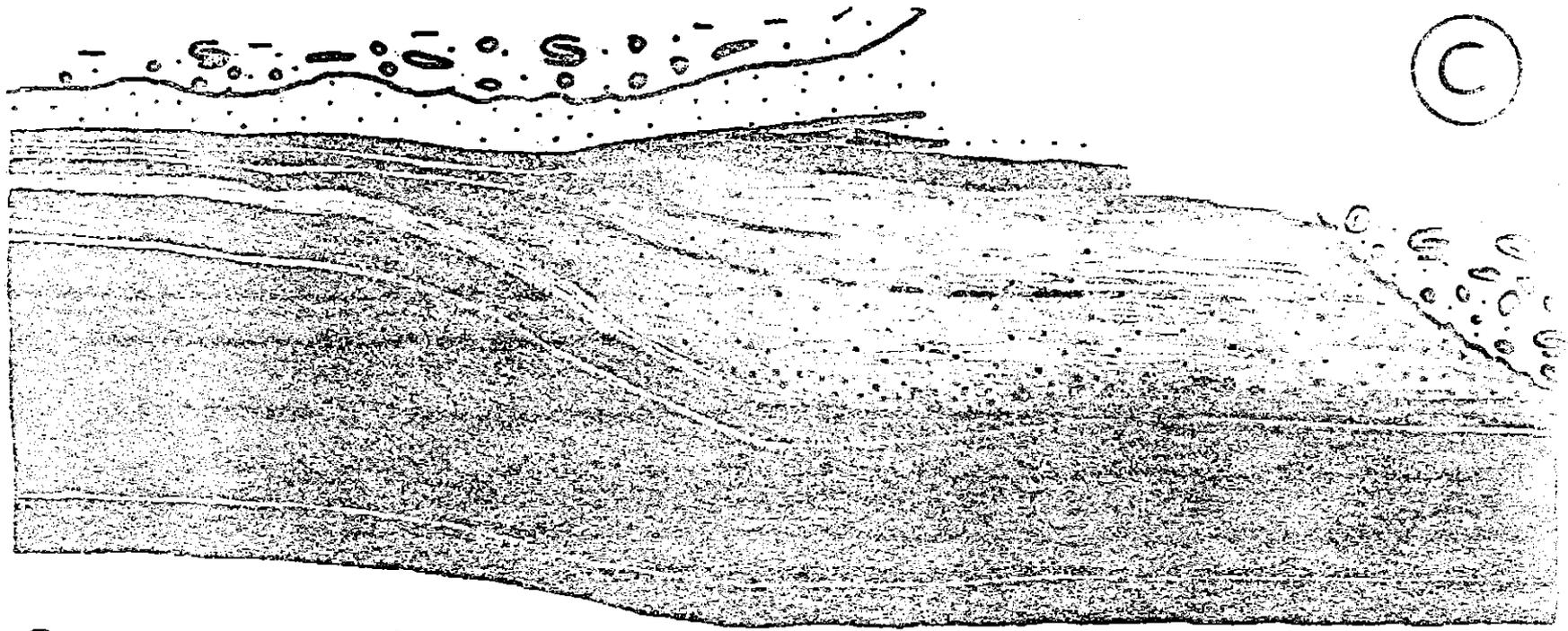
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0 3 m

5 cm

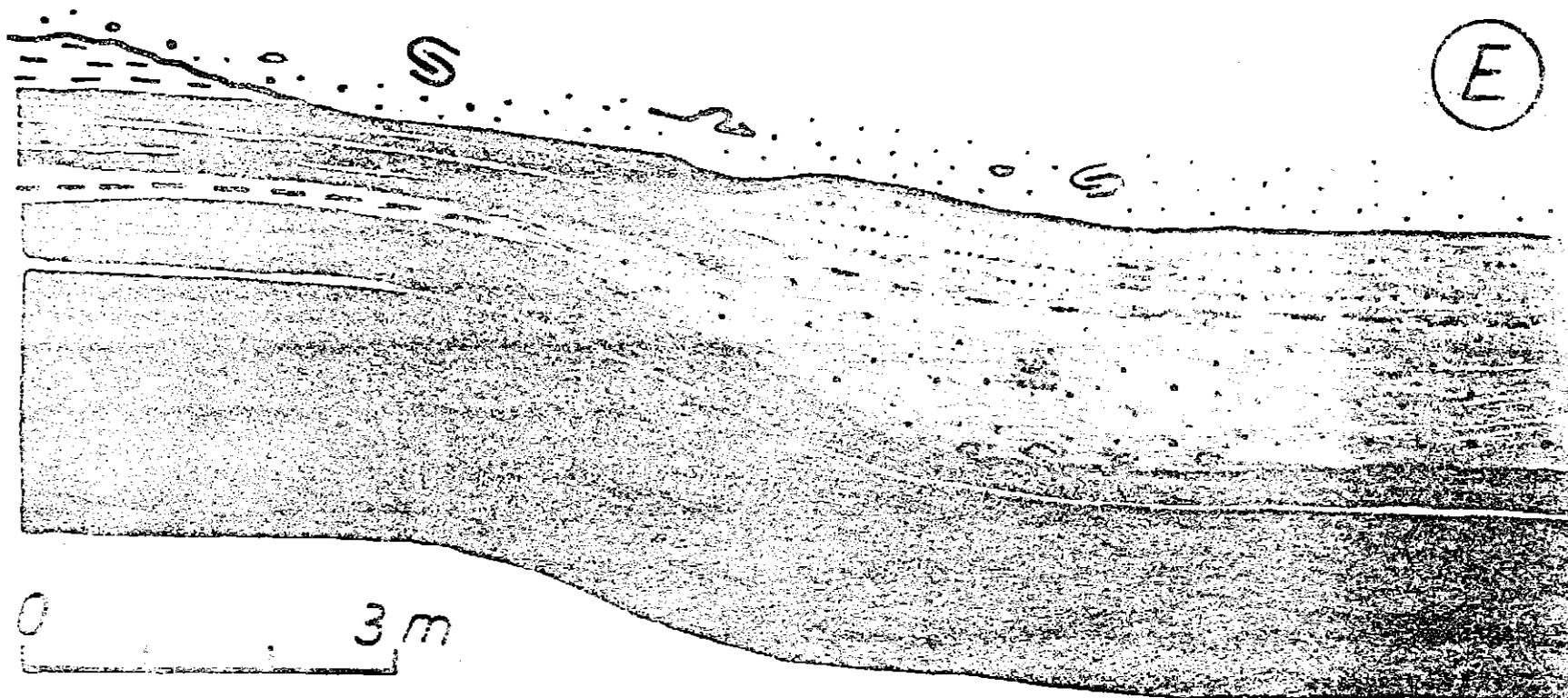
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0 3 m

5 cm

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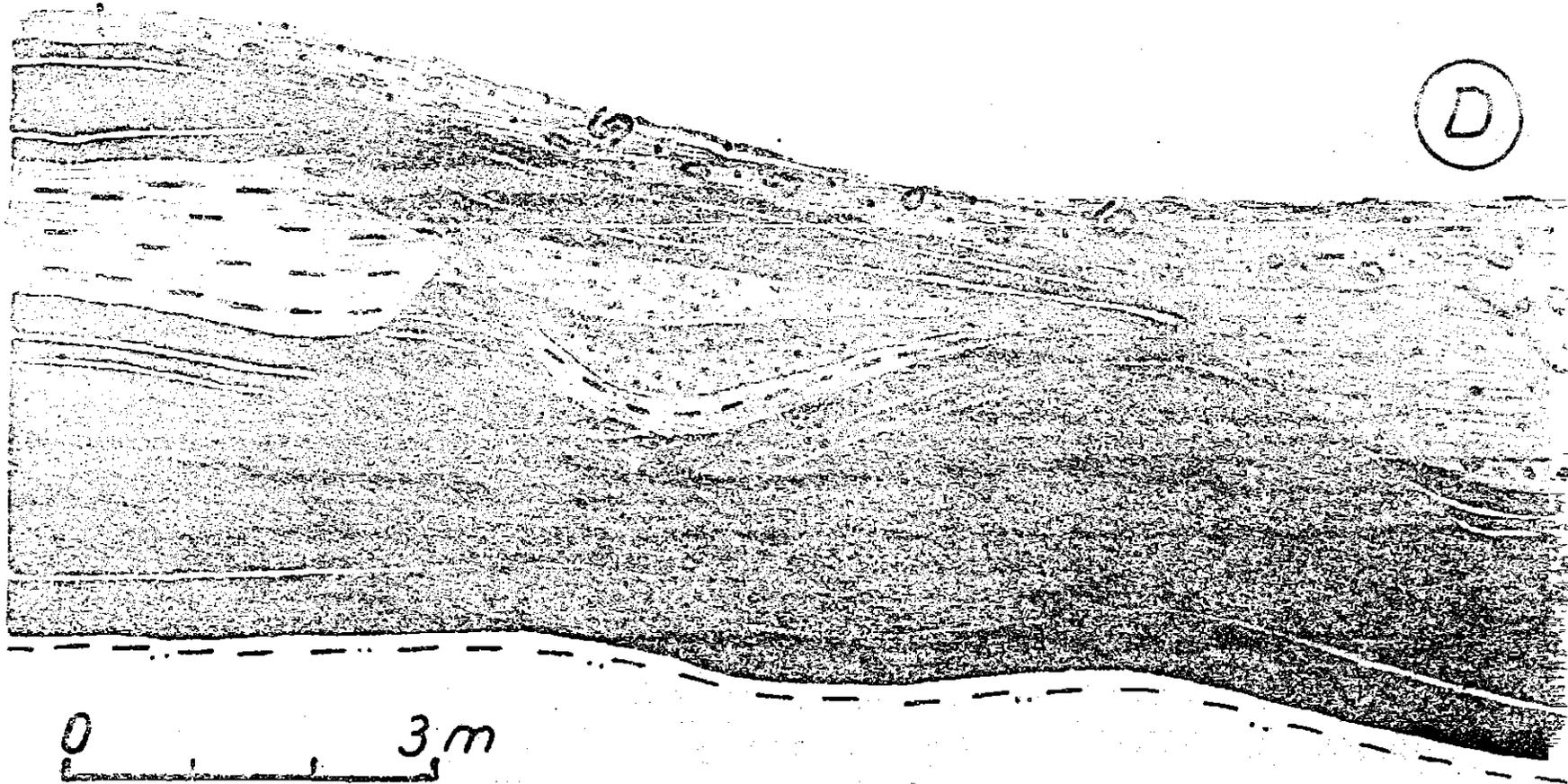


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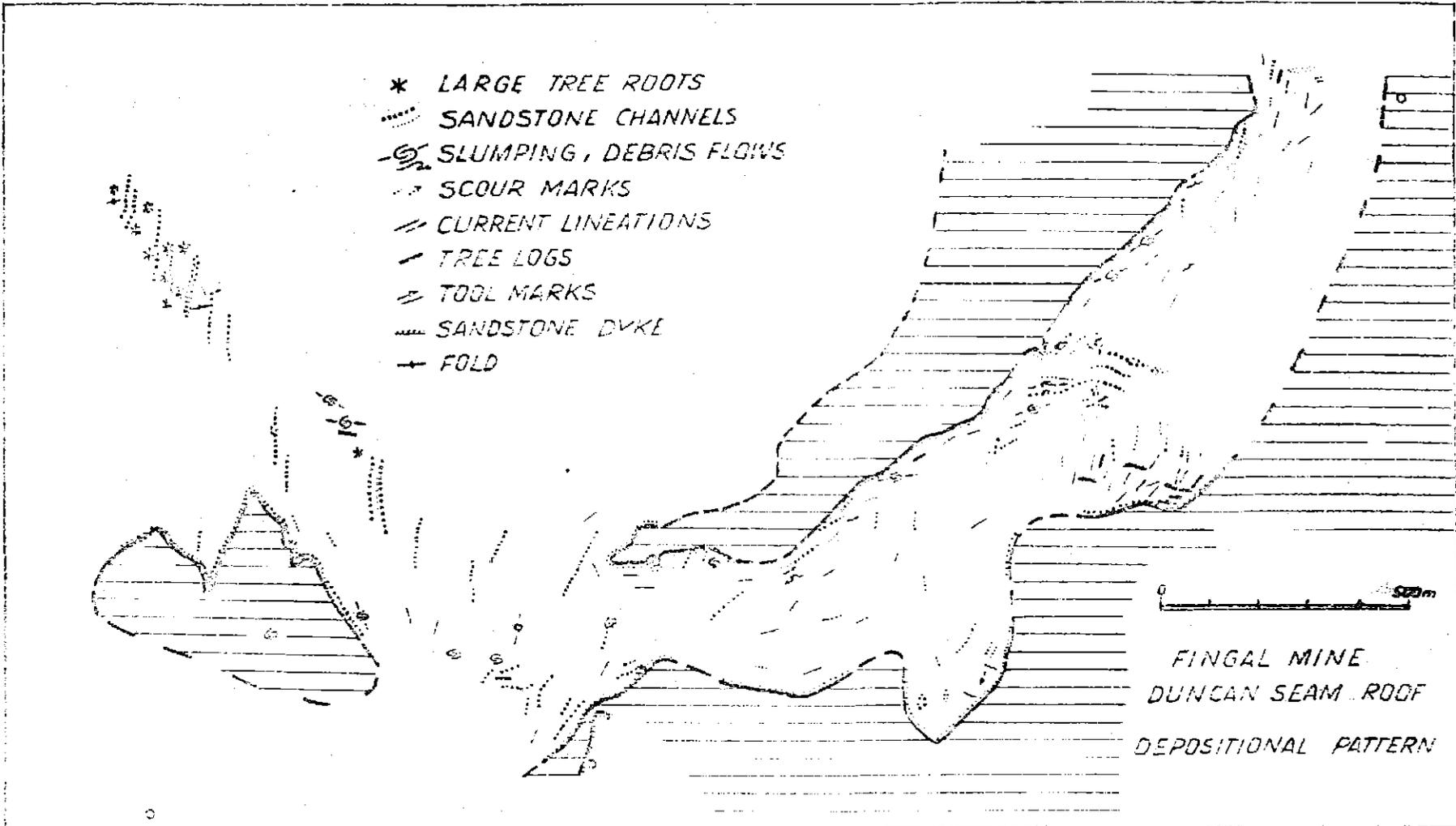
(S)



(D)

0 3 m

5 cm



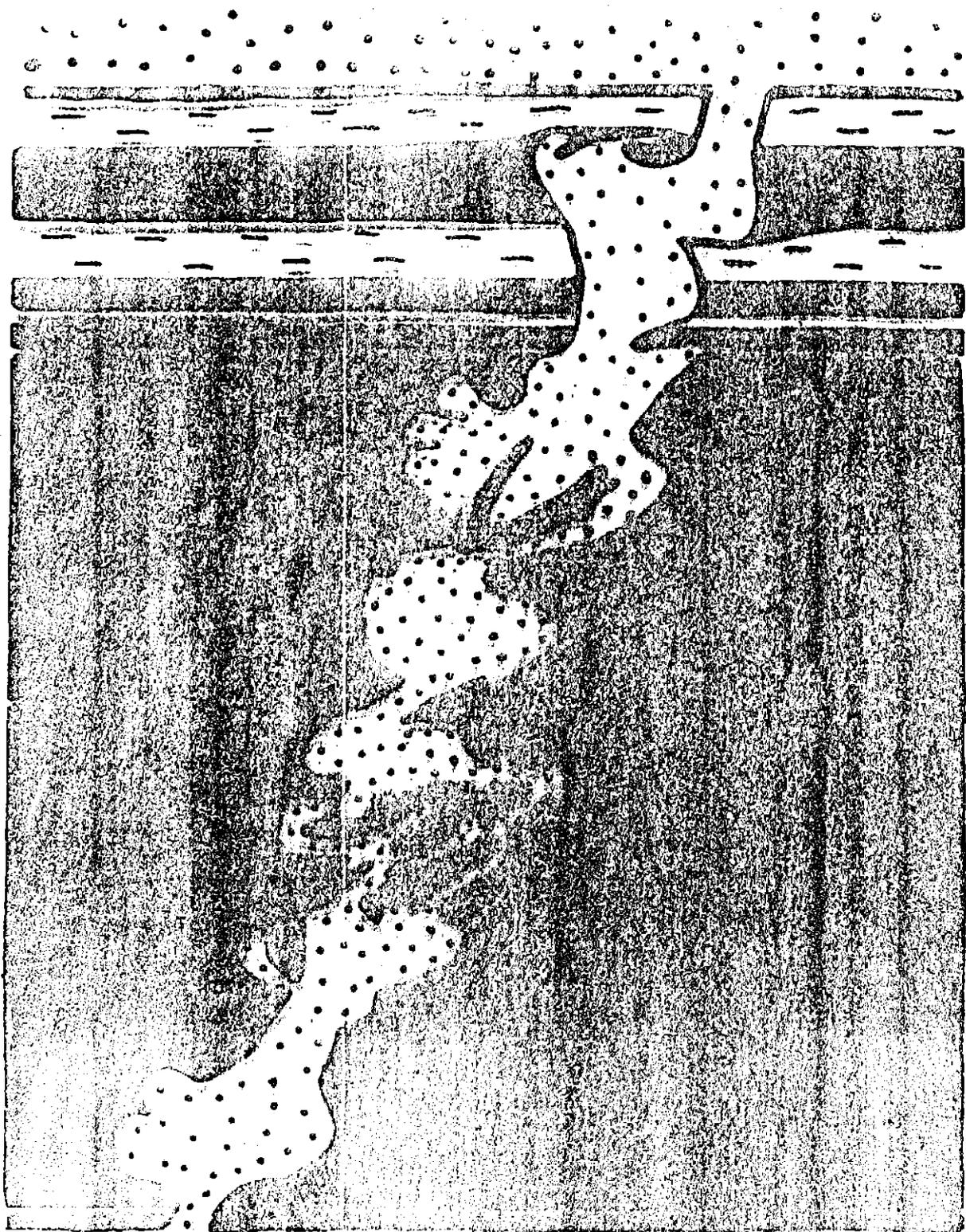
5 cm

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(10)

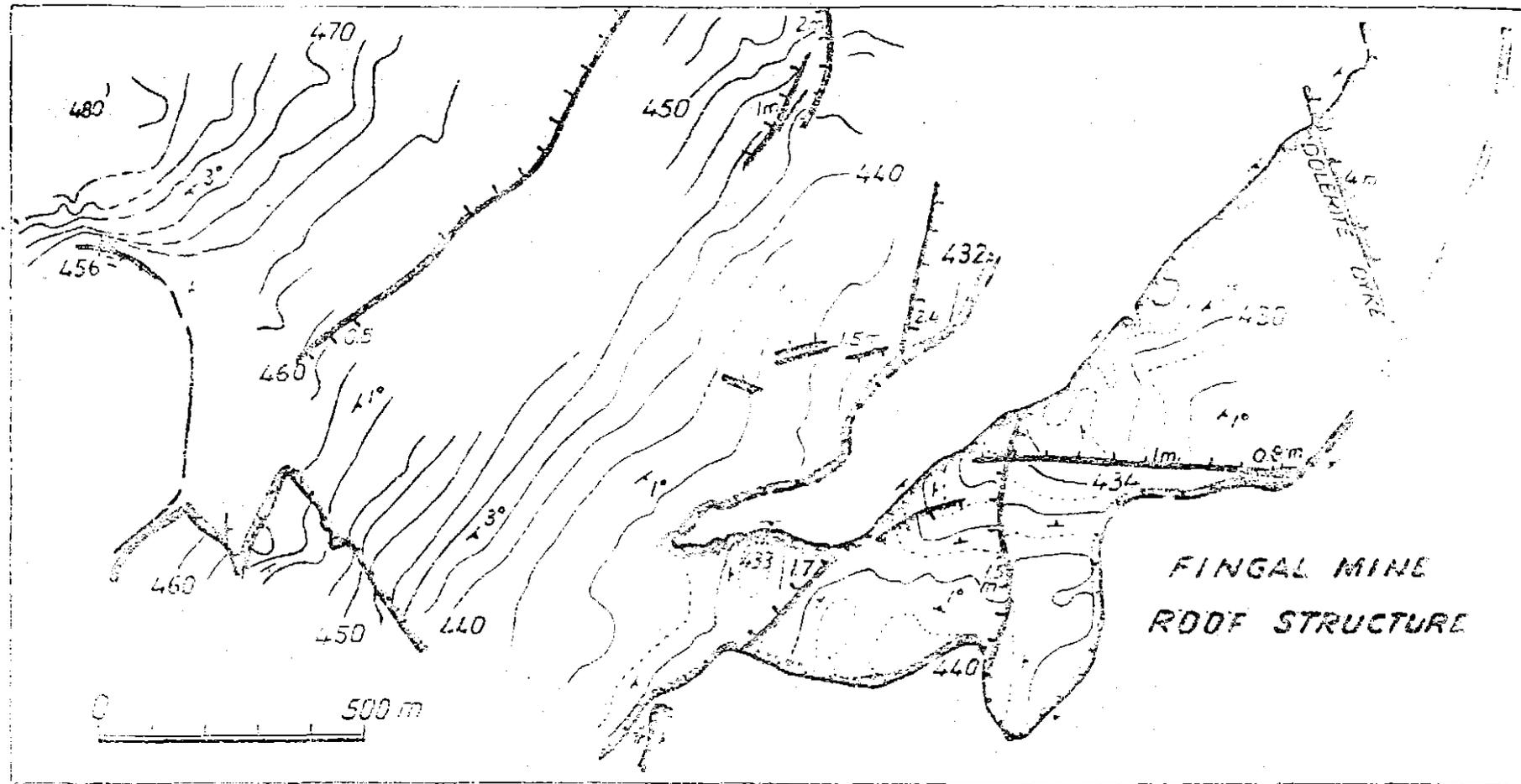


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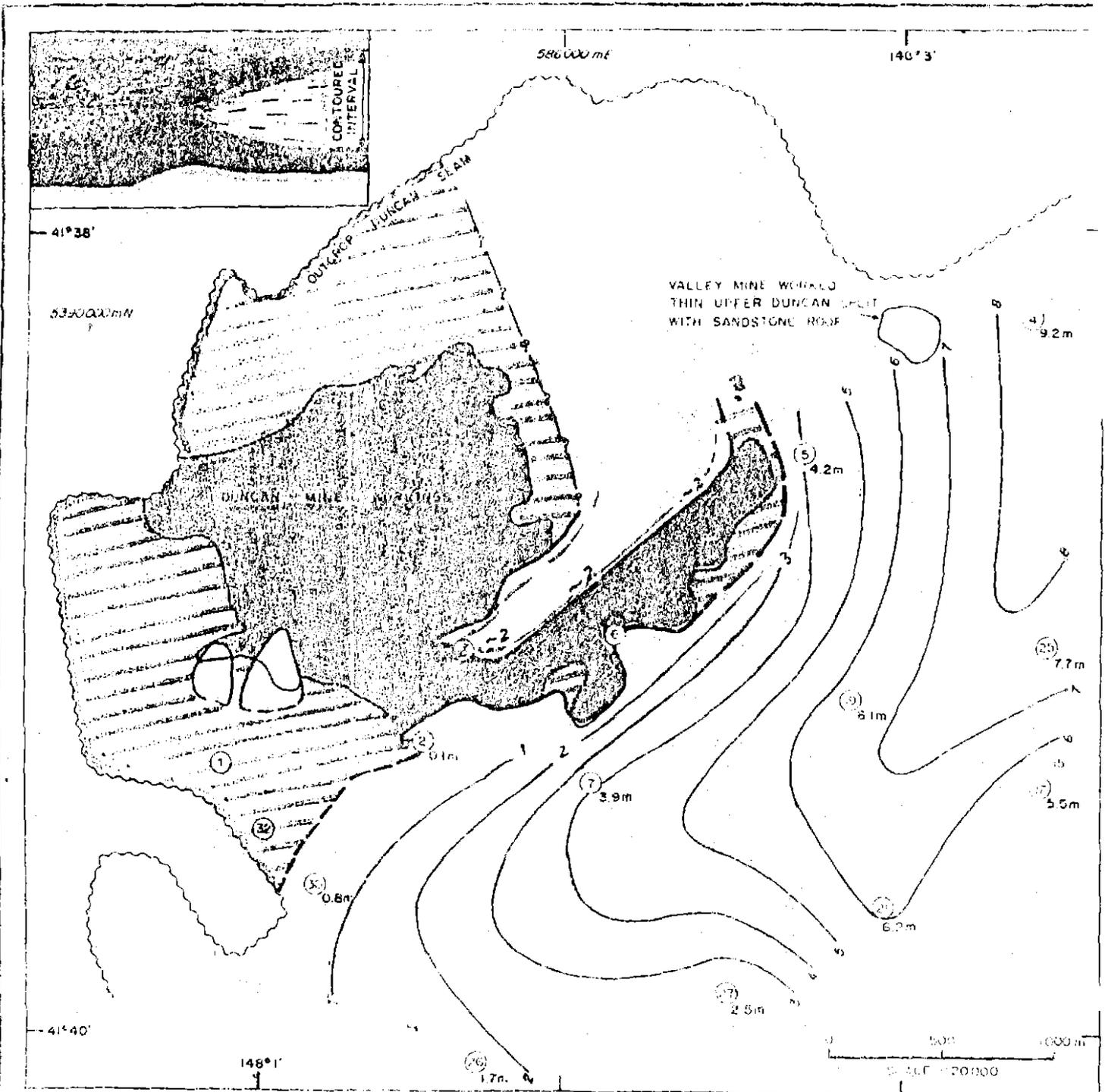
"SAND DYKE" IN THE DUNCAN SEAM  
FINGAL MINE, TASMANIA

 BELL & HOWELL



5 cm

170023



DUNCAN SEAM - DISTRIBUTION AND THICKNESS (m) OF ROOF ROCK TYPES

Sandstone roof with erosional boss (3) Borehole with hole number

5 cm