

EVIDENCE OF A NEGATIVE MOVEMENT OF THE
STRAND LINE OF 400 FEET IN
NEW SOUTH WALES.

By T. HODGE SMITH AND TOM IREDALE.

(Contribution from the Australian Museum.)

(With Plate VII. and two Text-figures.)

(Read before the Royal Society of N.S. Wales, Sept. 3, 1924.)

The nature of the evidence of a negative movement of the strand line of four hundred feet in New South Wales is both geological and biological. So much evidence has been collected that it is thought advisable to place it on record.

Part 1.—Geological Evidence by T. Hodge Smith.

This is based on the lithological character of sandstone slabs dredged from the seventy fathom line, the nature of this line and sections of the drowned river valleys of Port Jackson and Georges River.

Through the kindness of the New State Fish and Ice Company, and particularly of the manager, Mr. C. W. Mulvey, and Captains H. Flett and J. Forder, of the trawlers, I have been able to examine a number of irregularly shaped sandstone slabs dredged at various points along approximately the seventy fathom line east of New South Wales.

These slabs are composed of coarse rolled sand grains and are sometimes very compact. Almost always they are highly fossiliferous and often these fossils, or perhaps more correctly sub-fossils, occur in bands, intercalated with bands of very compact non-fossiliferous sandstone. Plate VII. shows a portion of one of these slabs dredged

from the seventy fathom line east of Montague Island and gives a very good idea of the fossil content and coarseness of the sandstone. The largest boulder so far brought in measured six feet by three feet six inches by eighteen inches, and comes from the seventy-five fathom line east of Narrabeen. This slab was penetrated in a number of places by irregular branching burrows which were almost circular in cross-section, the major and minor diameters, in general, measuring one and a half inches and one and a quarter inches, respectively. The whole slab, including the burrows, was coated with iron oxide (limonite). It is evident that it was not broken off an outcrop of rock by the trawling net, as no point of attachment existed, and this applies to all the slabs that I have examined. It is important to note that two slabs obtained from the seventy-five fathom line are not as coarse in texture as the remainder from the seventy fathom line.

These slabs have been dredged up for a distance of about two hundred miles along the coast, while they are entirely confined to the 70-75 fathom area. So far, they have been obtained from east of Long Reef, Botany Bay, Kiama, Ulladulla and Montague Island (figure 1).

It is of interest to note that slabs of recently formed sandstone containing shells characteristic of our beaches to-day occur between tide-marks on the present-day shore line. I have examined some of these sandstone slabs on the beach immediately to the south of Long Reef, Narrabeen, in a direct line with Florence Avenue. No less than seven of these slabs were exposed at low tide when I visited the locality and they measured from ten to twenty-one feet in length. A corner of one of them was broken off and in the section so obtained it was seen that the character of the underlying beach sand and the sand grains of the rock were precisely similar in colour and

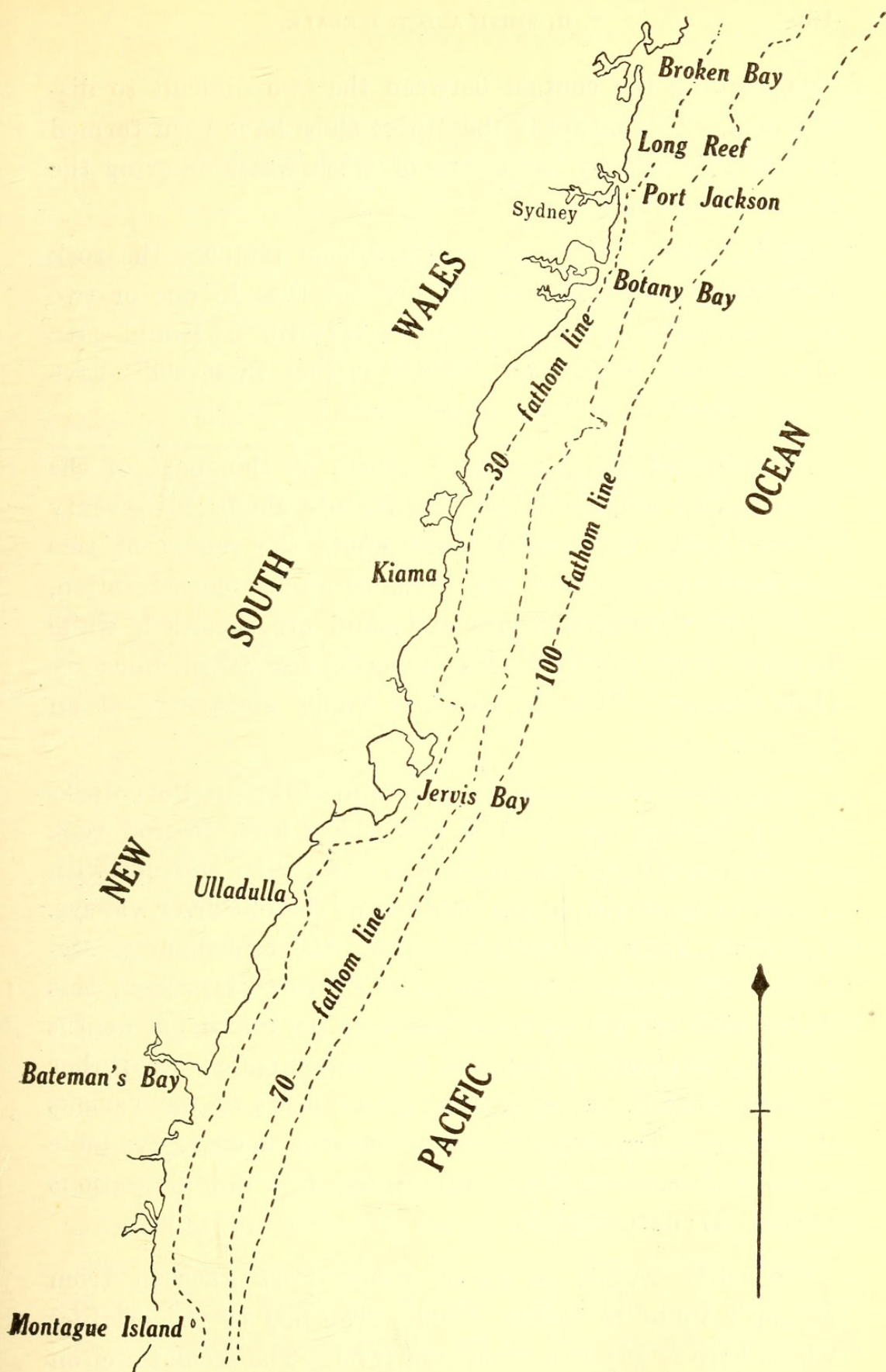


Figure 1.—Map of the area under consideration, showing localities where sandstone slabs have been found, and the 30, 70 and 100 fathom lines.

size, making the contact between the two difficult to distinguish. This suggests that these slabs have been formed probably *in situ* by the action of fresh water entering the sea at this point.

Lithologically the rock at Narrabeen matches the rock from the seventy fathom line, except that in one or two cases the latter is much coarser in texture. It would seem that the only conclusion possible is that these slabs have been formed at or near a sea shore.

A study of the Admiralty charts of this part of the coast reveals another interesting feature about this seventy fathom line. Repeatedly right along the region of this line and even beyond the distance under consideration, coarse sand, gravel, stones and sand are recorded, while inshore from this line such records are conspicuous by their absence. This, in itself, is highly suggestive of an old shore line.

A number of bores have been put down in Port Jackson at various times. The object has been to find rock bottom for the purpose of bridge piers, etc., and not with a view to ascertaining the contour of the old river valleys. Therefore, they can only represent the approximate sections. However, for the purpose of this discussion, this factor does not vitiate their value as the maximum depths given, if not correct, will not be overestimated but rather underestimated. I am indebted to officers of the various Government Departments concerned for making available plans and sections from which the reproduced sections (figure 2) were copied.

The first section is taken across Port Jackson from Milson's Point to Dawes Point. The bed of the original valley here is 151 feet below sea level. The second section is taken across Middle Harbour from Pearl Bay to Sea-

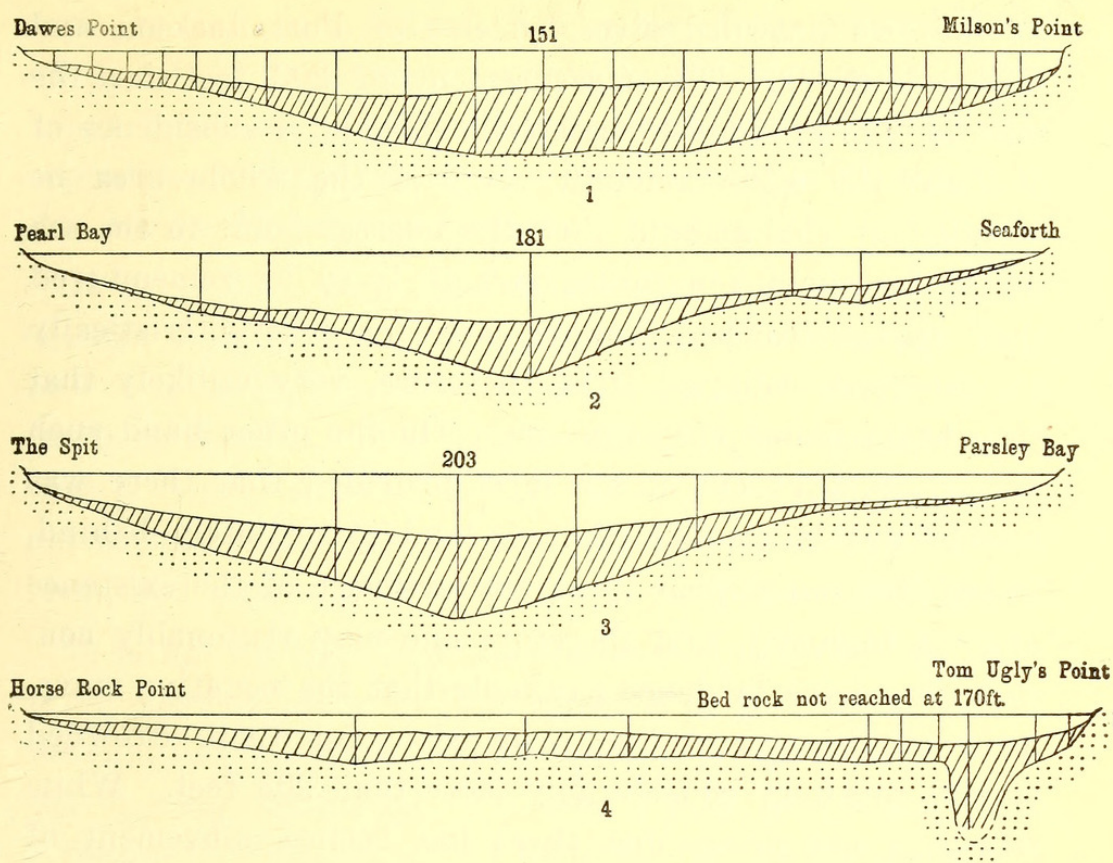


Figure 2.—Sections across Port Jackson (1-3) and George's River (4). The vertical lines represent the position of the bores put down and the numbers are the maximum depths of those bores in feet. The hatched portion consists of sand and clay and the dotted portion bedrock (Hawkesbury Sandstone). The datum line is low water ordinary spring tides.

forth, and here the bed of the valley is 181 feet below sea level. Section No. 3 is also taken across Middle Harbour, from The Spit to Parsley Bay, but a little further downstream, and shows a maximum depth of 203 feet. The original river valley now forming Middle Harbour was a tributary of the river now represented by the main harbour, and consequently the maximum depth of the sections of the former gives an indication of its junction with the latter. Section No. 4 is taken across George's River, which flows into Botany Bay. The bore put down in the deepest part of the section was abandoned at 170 feet without reaching rock bottom. These sections give measurements of the amount of subsidence below sea level

of the two drowned river systems of Port Jackson and George's River. The measurement of 203 feet for the bore at The Spit must necessarily demand a subsidence of at least the same amount. But if the whole area be elevated by this amount then the nearest point to the sea would be about ten miles, and it is to be remembered that these drowned valleys are not characteristically mature river valleys. It is, therefore, very unlikely that they had reached base levelling. On the other hand such gorges could be cut at sea level provided that there was a considerable amount of high land immediately behind. There does not appear to be any evidence of the existence of such highland, and therefore one may reasonably conclude from the evidence available that the negative movement of the strand line responsible for those drowned valleys was very considerably more than 203 feet. While this does not prove that there has been a movement of four hundred feet, it is certainly in harmony with the other evidence indicating a movement of such a magnitude.

From the palæontological evidence it seems fairly definitely established that the age of this movement is not pre-pleistocene, although Mr. F. Chapman states in official correspondence in regard to the rock dredged from east of Narrabeen that "it may be of late Pliocene age, since some of the forms are not exactly typical of the living fauna, or may be new". The rock dredged from east of Botany is in his opinion "in point of age either Pleistocene or Holocene (sub-fossil)".

So well established is the world-wide negative movement of the strand line due to oscillations of the sea level in connection with the Pleistocene ice age, that it seems necessary to reconcile this movement of four hundred feet with it. A careful examination of the soundings on the continental shelf reveals the fact that at about forty

fathoms there is a distinct steepening of the general slope of the shelf, indicating a pause in the movement. This break has been previously recognised and generally accepted as evidence of the world-wide change of sea level due to the Pleistocene ice age.

It is evident then that this major movement can be divided into at least two movements, of which one may be due to further oscillations of the sea level or to orogenic earth movement. They are so nearly equal in magnitude that it is very difficult to say whether the first or second movements were due to the world-wide change of sea level, and I am unable to find any evidence on this point.

It is known that local oscillations of sea level do take place corresponding to local changes of glaciation, but so far the magnitude of these movements is not known. With our present knowledge, it seems highly improbable that a change of sea level of two hundred feet due to glaciation could be limited to the area under consideration. Until evidence is produced of a similar movement at least affecting the whole of the Pacific Ocean, it seems necessary, for the present, to accept this negative movement of the strand line of four hundred feet as being divided into at least two movements, one of which is due to earth movements.

Accepting the seventy fathom line as the Pleistocene shore line, the continental shelf would be only a few miles wide at most. This suggests a subsidence of this old continental shelf, and in this connection it is interesting to note that on the Admiralty chart at latitude $35^{\circ} 38'$ at 112 fathoms, sand and stones are recorded and at latitude $36^{\circ} 46'$ at 109 fathoms coral sand. Unfortunately the majority of soundings beyond the hundred fathom line do not reach bottom, and consequently the evidence is not sufficiently conclusive on this point.

Part 2.—Biological Evidence by Tom Iredale.

The characteristic forms found in the boulders examined are as follows:—

<i>Pecten meridionalis</i> Tate.	<i>Antigona lagopus</i> Lamarck.
<i>Venericardia amabilis</i> Deshayes.	<i>Sigapatella calyptræformis</i> Lamarck.
<i>V. bimaculata</i> Deshayes.	<i>S. hedleyi</i> Smith.
<i>Glycymeris tenuicostatus</i> Reeve.	<i>Turritella</i> sp.
<i>Limatula strangei</i> Sowerby.	<i>Terebra</i> sp.
<i>Cardium pulchellum</i> Gray.	<i>Estea bicolor</i> Petterd.
<i>Gari livida</i> Lamarck.	<i>Marginella mayii</i> Tate.
<i>Macrocallista disrupta</i> Sowerby.	<i>M. ochracea</i> Angas.
<i>Lioconcha angasi</i> Smith.	<i>M. kemblensis</i> Hedley.
<i>Dosinia</i> aff. <i>grata</i> Deshayes.	<i>Friginatica beddomei</i> Johnston.
<i>Arcoperna scapha</i> Verco.	<i>Astraea aurea</i> Jonas.
<i>Neolepton novacambrica</i> Hedley.	<i>Peculator verconis</i> Iredale.
	<i>Cancellaria purpuriformis</i> Valenciennes.
	<i>Cocculina tasmanica</i> Pilsbry.

The slab examined from 70 fathoms off Montague Island (Plate VII.) is composed of coarse gravelly sand, suggesting the littoral debris of a rock edged beach. The sand is very familiar to the shore worker, and does not suggest any depth nor does it agree with sand from the middle of a long beach. The block shows the flat valves of a scallop (*Pecten meridionalis* Tate) in profusion, intermingled with other bivalves in less number, and rarely a few univalves are met with. Among the coarser patches minute molluscan shells may be seen, and these are apparently lying loose among the particles of sand and not crushed at all. The occurrence of the flat valves of the scallop with only a rare convex valve suggests that this block was formed in very shallow water near shore, the

scallops when dead separating into two pieces, and the wash of the waves driving the convex valves on shore leaving the flat valves behind. Near a shallow water scallop bed the convex valves may be commonly met with on the beaches, but very rarely can a flat valve be found. If a dredging in anything beyond ten fathoms be made near a scallop bed the valves will be found in equal numbers, or a majority of convex valves, according as the dredge works. The presence of a few odd rock-living gastropods indicate the vicinity of rocks. That the boulder was formed in very shallow water appears to be a necessary conclusion from examination of the mollusca content. So little is known exactly regarding the molluscan faunula of the continental shelf that it would be unwise to dogmatise, but collation of published results and examination of much unpublished material suggest a somewhat uniform fauna extending from off Green Cape in the South to Newcastle or higher in the North. The faunula living on the 40-70 fathoms ledge is of a deep water, compared with a littoral faunula, facies, but none of the characteristic forms of that faunula appear in the present rock. As an item of interest, living on the top of the rock were some of these 40—70 fathom mollusca, while the most remarkable feature of the slab shells, which may yet lead to important results, is their littoral southern facies. The deep water, 40—70 fathom, mollusca have proved to be very closely allied to the uppermost beds of the Murray Creek, now classed as Kalimnan (Lower Pliocene), so that they are scarcely separable. I have suggested that the best means of expressing the relationship would be the usage of a trinomial nomenclature, thereby neither affirming nor denying their specific status. These dwellers on the continental shelf of New South Wales appear to be of southern relationship, even when collected

as far north as Narrabeen. The molluscan content of the slabs under review cannot be separated in the majority of cases by even the most determined "Splitter" (e.g. myself) from recent species, but they must be compared with living species from Victoria or Tasmania, not Sydney.

Pecten meridionalis Tate.—In a paper published in the Linnean Society's Proceedings*, I have briefly indicated from an independent review of specimens, my results as being in complete agreement with those of Tate, propounded some forty years previously. Since that paper was written I have been accumulating more facts, and a large series of valves from Stockton near Newcastle, given me by Mr. A. Broadfoot, of Manly, who collected them, are all deep convex valves and separable at a glance from the Tasmanian *meridionalis*. The whole of the valves in the slab from off Montague Island agree in the most minute detail with South Tasmanian specimens, and reach very large dimensions, the largest one unbroken measuring 155mm. \times 124mm. There is no variation seen, but I have recorded that specimens from shallow water in Twofold Bay are intermediate in some of their features, and some shells since received from the same locality but from deeper water show more variation, but these do not agree with the slab shells.

Venericardia amabilis Deshayes.—This species is the next most common form and is associated with *V. bimaculata* Deshayes. While the former is abundant in shallow water in southern New South Wales, the latter is as common in the same station in South Tasmania, but is at present unknown from New South Wales.

Dosinia aff. *grata* Deshayes.—Two valves of a *Dosinia* are smaller than the specimens available for comparison.

* Proceedings Linnean Society N. S. Wales, 1924, pt. 3.

from Victoria, but otherwise agree in sculpture and are not *crocea*, the common New South Wales form. The species *grata* has not otherwise been recorded from New South Wales.

Macrocallista disrupta Sowerby.—The specimens agree better with the South Tasmanian shells than with the New South Wales specimens regarded as conspecific.

Glycymeris spp.—This group causes more trouble than almost any other and I have endeavoured to untangle some of the skeins in my essay above noted. The valves seen in this boulder do not agree well with any of the forms, but some appear to belong to a form of *tenuicostatus* Reeve, recognised from South Tasmania. The others show teeth varying a little from recent shells I have so far examined, but none have the form of *cainozoicus* Ten.-Woods, the only fossil smooth species so far distinguished. On the beach at Narrabeen hundreds of valves of *Glycymeris* are washed up and these show three or four species. No long series from Tasmania has yet been examined.

Arcoperna scapha Verco.—This is a southern species, whose occurrence was unexpected, and its association with *Gari livida* Lamarck, *Antigona lagopus* Lamarck, *Cardium pulchellum* Gray, *Limatula strangei* Sowerby, *Lioconcha angasi* Smith and *Neolepton novæcambrica* Hedley, all commonly found in shallow water, suggests its occurrence here also.

Astraea aurea Jonas.—This is the most remarkable find, as this species is a rock-living form found between tide-marks in Victoria and Tasmania, but has not hitherto been found in New South Wales. It would have been regarded as a characteristic Adelaidean form, and its presence here allows of extraordinary surmise, which, however, is not the object of this note.

Cancellaria purpuriformis Valenciennes.—This is another southern form which has not yet been recorded from this State, and the other univalves met with, *Sigapatella calyptraeformis* Lamarck, *S. hedleyi* Smith, *Friginatica beddomei* Johnston, *Peculator verconis* Iredale, *Estea bicolor* Petterd, *Marginella mayii* Tate, *M. ochracea* Angas, *M. kemblensis* Hedley, *Turritella* sp. and *Terebra* sp., may be regarded as of southern affinity in preference to northern origin.

The surmise hinted at may be developed at leisure, but this boulder points to a southern shoreline coexistent with the East Coast of Tasmania, which was drowned when Bass' Straits were formed, and this break took place recently, and the Kalimnan beds only belong to this period.

Conclusions.

From the Geological and Biological evidence we conclude that an old shore line exists along the 70 fathom line over the length under review.

This shore line probably exists both to the north and south of this area and from the Biological evidence it extended right down to the East coast of Tasmania.

This negative movement of the Strand Line took place certainly not earlier than Pleistocene and probably in quite recent times.

The movement may be divided into at least two stages of approximately the same amount.



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