Father Julian Tenison Woods and The Hawkesbury Sandstone

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ABSTRACT

Tenison Woods' paper "The Hawkesbury Sandstone" presented to the Royal Society of NSW in 1882 bears clear testimony to his considerable stature as a scientist and pioneer Australian geologist. His interpretation of the Hawkesbury Sandstone as a wind-blown formation is supported by his observations of its geometry, lithology, sedimentary structures and fossil content; by comparison with aeolian and other formations in Australia and in various other parts of the world, either through the literature or by personal observation; by experiments he conducted with wind-blown sand, and by personal observation of aeolian processes in the field. Although his interpretation of the origin of the Hawkesbury Sandstone as a whole is not accepted today (he did not have available to him the detailed knowledge we now have of the processes and products of fluvial and other environments) his method was sound and his competence undoubted.

INTRODUCTION

Julian Tenison Woods' paper "The Hawkesbury Sandstone" (1882: J. Proc. Roy. Soc. N.S.W., 16, 52-116) was read before the Royal Society of N.S.W. on 10 May, 1882. As published it covers 36 pages of text in the Journal and Proceedings, together with an appendix of two pages. The ensuing discussion (contributions by Mr Wilkinson, Professor Stephens and Professor Liversidge) and the reply by Tenison Woods occupy a further 26 pages.

Given the length of the reporting, the diversity of views expressed and the forcefulness of the arguments, it was obviously a major contribution to the Society's publication, and to the development of geological thought about the Sydney region. The aim of the present paper is to furnish an assessment of Woods' competence as a scientist, as evidenced by his Hawkesbury Sandstone paper.

THE HAWKESBURY SANDSTONE

The Hawkesbury Sandstone is the flat-lying Triassic quartz sandstone that dominates the landscape within a 100km radius of Sydney. It is particularly well exposed in coastal cliffs north and south of Sydney Harbour. It has an extent of approximately 20,000 km² and a maximum thickness of 250m.

It should be pointed out that the term Hawkesbury Sandstone, as used by Tenison Woods, included some sedimentary rocks which are regarded today as not being part of this formation.

The origin of the Hawkesbury Sandstone has been a matter of interest and study since Charles Darwin speculated about it on his visit to Sydney in 1844. Since then, various workers have interpreted it as having been formed in the sea (with or without the influence of ice), in lakes, by the wind or by rivers. It is only in very recent times that we have arrived at an understanding of present-day rivers which enables us to explain satisfactorily many of its puzzling features.

INTERPRETATION OF DEPOSITIONAL ENVIRONMENTS

The approach to interpreting the environment of deposition of a sedimentary rock is through comparison of various features of the rock with those of the sediments being deposited today in a range of environments.

The features found to be most helpful are:

Geometry: the overall shape of the sedimentary deposit. This is particularly useful in the recognition of channels.

Lithology: the texture and composition of the sediment. Grainsize and grain-shape provide information about the method of transport and deposition; composition is largely a function of the source rock.
Sedimentary structures: bedding and other structures resulting from physical or biological action. These are particularly useful, assemblages of structures often being characteristic of particular environments; cross-bedding is especially important in indicating the kind of environment and the direction of transport of sediment.

Palaeocurrent patterns: overall patterns of transport of sediment interpreted from cross-bedding and other directional indicators. These require a considerable areal spread of data but can distinguish between different large-scale environments.

Fossils: the remains of animals or plants preserved in the rocks. These are important indicators of depositional environment as most living things are restricted to particular habitats.

Because the present is the key to the past it is obvious that detailed knowledge of large-, medium- and small-scale features of the sediments accumulating in the whole range of sedimentary environments on the earth at the present time is needed if we are going to be able to interpret the origin of sedimentary rocks with confidence.

DEPOSITIONAL ENVIRONMENT OF THE HAWKESBURY SANDSTONE

Geologists today would in general agree that the Hawkesbury Sandstone is essentially of fluvial origin. Its features can be explained by regarding it as the product of a large, low-sinuosity river system characterised by periodic strong current flow, comparable with the Brahmaputra River of the present day (Conaghan & Jones, 1975). Both channel and floodplain environments are represented in the Hawkesbury Sandstone.

In the light of Tenison Woods' interpretation to which we will turn next, the following quote from Conaghan and Jones is of interest: "Although wind transport cannot be excluded on the basis of bedding characteristics, it seems unlikely to be the dominant process considering the angularity, size and sorting of the constituent grains of the Hawkesbury Sandstone" (op. cit. p.278).

TENISON WOODS' INTERPRETATION

The purpose of Tenison Woods' paper was to establish the origin of the Hawkesbury Sandstone as aeolian, although he readily acknowledged that "We must not suppose that in an immense deposit like the Hawkesbury rocks one explanation will suffice for all the appearances met with" (Tenison-Woods, 1882, p.72.). His main conclusion was that "the Hawkesbury sandstone is a wind-blown formation, interspersed with lagoons and morasses, with impure peat" (op. cit. p.87).

In support of this interpretation he marshalled evidence under all the headings given above, with the exception of palaeocurrent patterns:

Geometry: the Hawkesbury Sandstone is an essentially horizontal sheet of great areal extent, subdivided into large irregular undulating layers; it shows no evidence of having been uplifted, so has been formed above sea level. Tenison Woods placed great stress on this "non-upheaval" of the sandstone and regarded it as conclusive evidence of its aeolian origin. The following evidence however he described as "quite as significant".

Lithology: the absence of thin alternating beds of sand, clay and/or limestone argues against formation in rivers, estuaries or lakes; the quartz grains in the sandstone are rounded and abraded whereas fine water-borne sand he believed to be always angular; also present is fine aeolian dust; the small rounded pebbles present could have been carried by wind; larger pebbles in conglomerates mainly near the base of the deposit represent residual deposits left when the sand originally with them was blown away.

Sedimentary structures: the sandstone layers are cross-bedded, "subdivided by laminae with every kind of dip and direction, rarely exceeding 23°. this structure only belongs to eolian rocks" (op.cit.p.63).

Fossils: in the sandstone itself there are no marine fossils or fresh water shells; plant fossils indicate a terrestrial origin and the presence of well preserved fern fronds argues against formation by rivers.

TENISON WOODS' RESEARCH METHOD

It is apparent from the above that Tenison Woods had a sound grasp of the principles of interpretation of sedimentary rocks in terms of their environment of deposition, and that his approach was comprehensive and thorough.

In addition he had a wide knowledge of studies of
seds in other parts of the world and showed an 
extensive knowledge of the literature. In the course 
of his paper he made reference to occurrences in 
Arabia, Bermuda, China, Egypt, France, India, 
Mexico and Switzerland. Closer to home he cited the 
Pliocene aeolian sands along the Victorian-South 
Australian coastline, the dunes and unconsolidated 
sandy deposits on the edge of the Murray desert, and 
the desert sandstone west of the main range in 
Queensland, all of which he had examined personally. 

In studying the origin of cross-bedding he even 
adopted an experimental approach, designing and 
carrying out small-scale experiments using variously 
coloured sand. 

Most significantly of all, Tenison Woods made 
personal observations of aeolian processes at work in 
the field, and made direct comparisons between the 
effects he observed and the features of the 
Hawkesbury Sandstone. He quoted his observations 
the stratification of sand dunes at Wide Bay, 
Queensland, and on the movement, grain size and 
stratification (including the relationship between the 
dip of the cross-laminae and velocity of the wind) of 
loose drift-sand in the bed of the Burdekin River, 
Queensland. At Low Island, inside the Great Barrier 
Reef, he studied the movement and lamination of a 
particular sand dune under varying wind conditions. 
He drew also on his knowledge of the processes he 
saw operating in the stony deserts of Central 
Australia. 

On the basis of his research therefore Tenison Woods 
wrote of the Hawkesbury rocks: "Do these 
sandstones correspond in every particular with 
exposed sections of aerial sands? This I have 
answered by showing from many actual instances that 
they do" (op.cit.p.111).

EVALUATION

Tenison Woods' study of the Hawkesbury Sandstone 
was extraordinary in its scope and detail. He was a 
competent and careful researcher with acute powers 
of observation, was well acquainted with the 
principles of interpretation of sedimentary rocks, and 
combined field observations with an experimental 
approach. He was familiar with the work of his 
contemporaries and with work on similar geological 
phenomena around the world. He pursued large-, 
medium- and small-scale aspects of his research 
problem, offering evidence at the sedimentary basin, 
outcrop and sand grain levels of scale. He had the 
ability to handle large quantities of information, to 

assess its validity and relevance, and to integrate it 
into a convincing explanation for his observations.

His method was sound. Why then did Tenison Woods 
reach a conclusion about the origin of the 
Hawkesbury Sandstone as a whole which is not 
accepted today? Before attempting to answer this it 
is worth noting in passing that many of the views of 
his contemporaries are not accepted today either: 
Clark and Daintree thought that the Hawkesbury 
Sandstone was formed in a fresh water lake; Darwin, 
Wilkinson, Liversidge and others believed it to be the 
result of deposition in a shallow sea; Wilkinson in 
particular held that ice action was also involved 
and was responsible for the boulders and conglomerates.

I suggest that what Tenison Woods and the other 
geologists of his day lacked was a detailed knowledge 
of the wide range of sedimentary environments on 
the earth at the present time. Aeolian environments 
and their deposits are much more accessible and 
easier to study than are subaqueous ones. It is only in 
the last 30 years or so that data from a wide range of 
modern environments has become sufficiently 
abundant and detailed for interpretations of ancient 
sediments to be made with confidence. Technological 
advances in areas such as echo-sounding, aerial and 
underwater photography, laboratory studies of 
hydrology and sedimentation, underwater sampling, 
scuba diving and the like have all played a part.

Tenison Woods did not have available to him the 
knowledge we now have of fluvial processes and 
their products. If he had, his conclusions may well 
have been different. What he did was to integrate a 
great amount of information from many and diverse 
sources into a coherent and persuasive model for the 
origin of the Hawkesbury Sandstone. The model 
fulfilled the main functions of any scientific model in 
providing a defensible explanation for the data and in 
successfully generating debate and further research. 
What he did was to apply his considerable gifts in a 
masterly way to the unravelling of a geological 
problem of great complexity - a problem on which, 
one hundred years later, the last word has certainly 
not been said.
REFERENCES


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