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EARLY DISCOVERERS XXXIV

EARLY DISCOVERIES OF THE EFFECTS OF ICE ACTION IN AUSTRALIA

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ABSTRACT. The effects of past glaciation in what is now Australian territory were first recognized on Macquarie Island, probably by David Ramsay, in 1821. The recognition by Darwin in 1836, and reporting by Milligan in 1848 of ice-transported pebbles and boulders in late Palaeozoic marine rocks in Tasmania, showed on the one hand participation in and on the other familiarity with the controversy in Great Britain at that time on the origin of erratics and drift currents. Reports by Clarke (1852), Daintree in 1859, Selwyn (1860), and Gould (1860) of the effects of land ice on Mount Koscuisko (New South Wales), Bacchus Marsh (Victoria), Inman Valley (South Australia), and the Central Highlands (Tasmania), respectively, reflect the increasing recognition in Great Britain of the erosional and depositional effects of glaciers. Daintree, Selwyn, and Gould were all closely connected with A.C. Ramsay, the main British protagonist of the glacial theory at the time, whereas David Ramsay and Milligan were probably influenced by Robert Jameson of Edinburgh.

BACKGROUND

The relatively early dates of recognition of traces of late Palaeozoic and Quaternary glaciation in Australia, including Tasmania, has interesting historical connections with the mid-nineteenth century geological controversy that surrounded the establishment of the glacial theory in the British Isles.

As early as 1723, a Swiss naturalist, Scheuchzer, attributed to glaciers the ability to carry stones, some of great size, an ability accepted by Hutton and Playfair at least for Alpine glaciers. However, in areas such as southern Finland and the British Isles, such large stones were commonly attributed to either cataclysmic torrents of water or to transport by icebergs at higher stands of the sea (Chorley and others, 1964, chapter 13). The idea that ice (glaciers) had previously been more extensive seems to have been first expressed by a Swiss guide, Perraudin, in 1815 and taken up by Venetz in 1821 in a paper read before the Swiss Society of Natural Sciences (Chorley and others, 1964, p. 193) but did not gain currency until much later under the influence of Agassiz.

Although Louis Agassiz had convinced William Buckland in 1838 that the glaciers of Switzerland had been more extensive, it was not until 1840 when Agassiz visited Glasgow at the invitation of Buckland that the possibility of former extensive glaciation in Scotland was publicly stated. On 22 September 1840, Agassiz addressed Section C of the British Association "On glaciers and boulders in Switzerland", and it was presumably as part of the discussion of this paper that Agassiz claimed the likelihood that Scotland had been glaciated. Following the meeting, Agassiz and Buckland made a field excursion through the Scottish Highlands and both were convinced of the evidence for former glaciation.

Agassiz then visited Ireland and returned south through England to London where, on 4 November 1840, he claimed that the British Isles had been enveloped in a thick ice sheet in his paper on "Glaciers and the evidence of their having once existed in Scotland, Ireland, and England" to the Geological Society of London (Agassiz, 1840–41; Davies, 1968). However, he failed to win acceptance for the theory amongst senior British geologists, many of whom espoused the concept that the glacial drifts were the products of sea ice during marine submergence rather than a land-based glacier (Chorley and others, 1964; Davies, 1968). It was not until 1850 when A.C. Ramsay read a paper on "The geological phenomena that have produced or modified the scenery of North Wales", published in 1852 as "On the superficial accumulations and surface markings of North Wales" (Ramsay, 1852), and 1859 when he published "The old glaciers of Switzerland and North Wales" (in *John Bull*, 1859), that many British geologists once again began to take the glacial theory seriously. In the next 15 years, major publications by Jamieson (1862) and Geikie (1863) in Scotland, Close (1866) in Ireland, and Croll (1875) caused the land-ice theory to gain supremacy in the British Isles even though it had been introduced more than a quarter of a century previously.

Amazingly, in the far-off newly explored land of Australia, evidence for two periods of glaciation widely separated in time had been recorded before the glacial theory had gained widespread acceptance in the British Isles.

THE EARLY RECORDS

As early as 1821, the effects of glaciation had been recognized on what is now Australian soil. On 3 September 1821, Edward Wollstonecraft, merchant and landowner of Sydney, New South Wales (Stephen, 1967, p. 631), wrote to Captain Thomas Raine of *Surry* asking him to enquire into the natural history of Macquarie Island (lat. 55°S., long. 159°E.), and included the comment "I trust that Dr. Ramsay will ... take many of them [queries] in hand". Wollstonecraft's main interest was in furs and oil derived from animals living on and around Macquarie Island. Raine replied to Wollstonecraft in January 1822 *inter alia* "On top of the island are many lakes ... probably glacial ... evidence everywhere that the island has been covered by ice in the

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past" (Goddard, 1940, p. 305). Ledingham and Peterson (1984) reviewed work on the glacial lakes on Macquarie Island and raised the possibility of other origins.

When Charles Darwin examined the Permian marine rocks with "very few rounded pebbles" (see Banks, 1971, p. 9) near Hobart Town (lat. 42°53′ S., long. 147°20′ E.), Tasmania, in February 1836, he wrote in his notebook (R.N., p. 21) "There is a resemblance at Hobart Town between the older strata [i.e. Permian] and the bottom of the sea near T. del Fuego". He had already noted the action of sea ice in depositing such blocks in marine sediments near Tierra del Fuego. This note was not, however, published by Darwin.

The earliest published record of the effects of ice transport in Tasmania, and probably in continental Australia, is that of Joseph Milligan, who explained the presence of a granite boulder in clay formed by *in situ* weathering of Permian sedimentary rocks near Southport (lat. 43°26′ S., long. 146°59′ E.) as due to "glaciers, or – and which is more probable – icebergs" (read, September 1848; published 1849, p. 18). Such boulders, as noted by Darwin and Milligan, are common in marine late Carboniferous and Permian rocks in Tasmania. All are markedly larger in grain-size than the enclosing marine sediment, some are demonstrably dropstones, and a very few are faceted and striated. All observers have recognized them as dropstones, most regarded them as having been transported by and dropped from icebergs. Recently, however, deposition from some form of sea ice has received increasing support (Banks and Clarke, in press).

Although Murray (1843, p. 203) had published claims of evidence of ice action (in the form of moraines in the Pyrenees, north-east of Ararat, Victoria) prior to Milligan, his evidence has not been substantiated.

In March 1852, Clarke inferred the former presence of glaciers on Mount Koscuisko (lat. 36°29′ S., long. 148°18′ E.) in the Australian Alps from "more than one unmistakeable *bloc perché* ..." (Report XI, pt. 1; reprinted 1860, p. 225), thus providing the first subsequently substantiated evidence of Quaternary glaciation in continental Australia (e.g. David and others, 1901). This inference was not published until 1860.

In the meantime, W.A. Tully had made a privately sponsored expedition into western Tasmania in the summer of 1858–59. After his return he reported drift of quartz and greenstone between Derwent Ford and Mount Arrowsmith (lat. 42°13′ S., long. 146°04′ E.), and spoke of quartz "drift" of two ages in western Tasmania (*Courier and Hobart Town Gazette*, 26 April 1859). On 2 May, in commenting on Tully's report, W.B. Clarke (*Hobart Town Gazette*) wrote that the "drifts" seem rather to be local detritus ... probably they are partially moraines, the product of snow and ice of a colder epoch than at present".

It is noteworthy that many surveyors had worked in glaciated country in Tasmania prior to 1859. At least two people with a geological background, Milligan in 1842 and Strzelecki a little later, had been through the area where Tully reported drift and Charles Gould subsequently reported possible glacial effects. Neither reported glaciation.

In the following summer, Charles Gould, Geological Surveyor of Tasmania, saw large numbers of greenstone (dolerite) boulders in the Cuvier Valley (lat. 42°07′ S., long. 146°10′ E.) of central Tasmania which he interpreted as having possibly been transported by glacial action and noted the resemblance of "an enormous accumulation of boulders which chokes the lower end of the valley and, somewhat like a dam, extends completely across it" (Gould, 1860, p. 11) to a terminal moraine. Gould held back from regarding a glacial origin as clear because he did not find polished, grooved, or striated surfaces. These effects, as those in the Mount Koscuisko area, resulted from Quaternary glaciation (see, for example, Derbyshire, 1972). Gould, however, failed to recognize as tillite the "breccia" at the base of the Upper Palaeozoic series from the Eldon Range and from the area between Lake St Clair (lat. 42°07′ S., long. 146°11′ E.) and Frenchman's Cap, a "breccia" which Gould (1860, p. 12) noted as the source of the granitic rocks recorded by Strzelecki (1845, p. 74) in the area.

The resemblance of rocks at Bacchus Marsh, Victoria (lat. 35°57′ S., long. 144°43′ E.) to glacial deposits had been recognized in 1859 by Richard Daintree, a discovery not made public until 1861. Then, in 1860, A.R.C. Selwyn (1860, p. 4) recognized striated pavements, in the Inman Valley (lat. 35°33′ S., long. 138°27′ E.), of South Australia, as caused by glacial action. In the following year, he reported the discovery of the glacial deposits at Bacchus Marsh (Selwyn, 1861, p. 183–84). The glacial effects at Bacchus Marsh were then and those in Inman Valley subsequently recognized as late Palaeozoic. Selwyn (1861, p. 184) attributed the Bacchus Marsh deposits to "marine glacial transport". Subsequent discoveries to the end of last century have been reviewed by David (1896).

THE DISCOVERERS

It is not quite clear who discovered the glaciation on Macquarie Island. Certainly, Thomas Raine received and answered the request concerning the natural history. The surgeon on *Surry*, Dr David Ramsay, accompanied the ship on the visit to Macquarie Island (Goddard, 1950, p. 304). It is difficult to see where Raine would have garnered knowledge of glaciation during his education at Westminster School and his maritime training. He was already an officer in *Surry* by the age of 21. His family background – his father was a lawyer, his mother a parson's daughter – does not suggest any pronounced interest in natural history, and the site of his home (Newcastle-upon-Tyne) and school (London) suggest at best vacational or chance acquaintance with glaciated country.

Dr David Ramsay, on the other hand, was born in Perth, Scotland, situated not far to the east or to the south of glaciated country, and received his medical education at the University of Edinburgh (M.D., 1817). It might be recalled that it was at Edinburgh that James Hutton received his medical education. Edinburgh was the home of John Playfair, Professor of Natural Philosophy, 1805–19, Hutton's publicist early in the nineteenth century, and a centre of active controversy with Playfair (1802) taking the Huttonian stand and the Professor of Natural History, Robert Jameson, the Wernerian stance (Chorley and others, 1964, p. 74-75). It may be noted that both Hutton and Playfair accepted the role of glaciers in transporting large boulders (Chorley and others, 1964, p. 193). David Ramsay's father, John, maintained a collection of specimens which he donated to the nation. David himself possessed a library including books on comparative anatomy, plants, entomology, and a book entitled *Studies of Nature* by I. Pierre. After establishing himself in Sydney he is known to have purchased insects (Brodsky, 1960, p. 9). On the balance of probabilities, Ramsay is thought to have been the discoverer of glaciation on Macquarie Island. Even so, the recognition was a remarkably early one and not entirely explicable on known information. Perhaps the controversy at the University of Edinburgh fixed young Ramsay's interest, and excursions in his home territory fostered it. It might well be noted here that Edward Wollstonecraft, initiator of the enquiry on the natural history of Macquarie Island, was an original member of The Philosophical Society of Australasia but neither Raine nor Ramsay were (Branagan, 1972, p. 123-24).

Charles Darwin needs little comment in view of the many treatments of his life and work. It suffices to note in this context that he was a friend of Lyell, included Volume One of Lyell's (1830) *Principles of geology* in his library on *Beagle* and received Volume Two (Lyell, 1833) at Monte Video in October 1832 (de Beer, 1963, p. 34 and 41) prior to his work in Tierra del Fuego. Furthermore, he spent considerable time in 1833 and 1834 studying, *inter alia*, the effects of ice erosion and transport there (Darwin, 1845, p. 187, 225-26, and 248-49). He was well prepared to detect signs of ice deposition in ancient rocks by the time he reached Hobart Town.

Joseph Milligan was born at Dumfries, Dumfriesshire, where Buckland noted a moraine near Thornhill in 1840 (Buckland, reported in *Proceedings of the Geological Society of London*, 1840–41, p. 333). He attended medical classes at the University of Edinburgh in the 1828–29 session (letter, Dr J.T.D. Hall, University of Edinburgh, 16 December 1985). At that time, Robert Jameson, Professor of Natural History (Boulger, 1891–92), may have been invoking

glaciers to explain erratics in Scotland (Davies, 1968, p. 267–68 during his lectures. Certainly, prior to 1840, Jameson was publishing translations of works on glaciation by de Charpentier and Agassiz in *The Edinburgh New Philosophical Journal*. There is no evidence that Milligan attended Jameson's classes but he was making geological observations (1832) soon after his arrival in Tasmania as a surgeon to the Van Diemen's Land Company. He collected fossils from Ordovician limestones on the Gordon River when he accompanied Sir John and Lady Franklin to western Tasmania in 1842. He was closely associated with Sir John Franklin – Lieutenant-Governor of Van Diemen's Land, a noted Arctic explorer, a Fellow of the Royal Society, and one-time Council member of the Geological Society of London (*Proceedings of the Geological Society of London*, 1830, No. 15) – in the Tasmanian Society. Milligan was one of a number of Tasmanian residents who collected plants for W. Hooker and his son J.D. Hooker (Hooker, 1859, p. CXVII; Burns and Skemp, 1961; Hoddinot, 1967). Indeed, a plant genus, *Milligania*, was named in his honour by Hooker (*fil.*) in 1853 (Hooker, 1853). Joseph Hooker himself was a Fellow of the Royal Society, a member of the Council of the Geological Society of London, and contributed to the glacial controversy (Thiselton-Dyer, 1912). In 1843, J.E. Bicheno, a Fellow and former Council Member of the Geological Society of London, a Fellow of the Royal Society (*Proceedings of the Geological Society of London*, 1826–27, No. 1, p. 16; 1927–28, No. 6, p. 62), reached Hobart Town as Colonial Secretary. Either Bicheno or a W. Westcott presented volumes of the *Proceedings of the Geological Society of London* for 1827–45 to the library of the Royal Society of Tasmania prior to or during 1850. These volumes included the 1840–41 volume with comments on papers by Agassiz and Buckland on glaciation (*Reports of the Royal Society of Tasmania*, 1850 [1851], p. 29). The work in which the dropstone was reported by Milligan was commissioned by Lieutenant-Governor Sir William Denison, with whom Milligan was closely associated in the infant Royal Society of Tasmania, and who was interested in geology (Currey, 1972). With Milligan's background, as noted above, it might almost seem inevitable that he should have recorded the effects of ice when he came upon it in his geological work. He did not, however, recognize the signs of Pleistocene glaciation along the route taken by the Franklins in 1842.

Fellowship of the Geological Society of London, an active and enquiring mind and continuing, almost professional, geological field work may have ensured W.B. Clarke's interest in and appreciation of the diluvial and glacial controversies current in Britain. Under these circumstances, it is perhaps not surprising that Clarke recognized the evidence for glaciation on Mount Koscuisko where previously Strzelecki, a Wernerian and discoverer of the mountain, had not. In addition, Clarke corresponded with several British geologists. But Sir Roderick Murchison, one of his correspondents, is hardly likely to have inspired him to recognize glaciation – Murchison being distinctly conservative on this question. It is perhaps surprising that Clarke and his visitor of 1840, James Dwight Dana, did not recognize the ice-rafted origin of the lonestones in the Permian rocks of the Illawarra district of southern coastal New South Wales.

Whether or not W.A. Tully took the drifts he saw in western Tasmania in the summer of 1858–59 as evidence of glaciation is unclear. Tully gained a B.A. from Trinity College, Dublin, in 1852 (Duffy, 1976). No connection of Tully with geology or geologists is known but his surveying reading probably involved some geology.

However, it is clear that the geologist Charles Gould recognized the evidence of glaciation near Lake St Clair in the summer of 1859–60. Gould had studied mineralogy and chemistry at the Royal School of Mines, London, under Thomas Huxley, A.C. Ramsay, and others (1853–56) (Banks and Yaxley, 1972), and subsequently worked as a geologist with the Geological Survey of Great Britain and was appointed Geological Surveyor of Tasmania in 1859. Ramsay was one of Gould's sponsors in his election to Fellowship of the Geological Society of London in April 1859.

Richard Daintree was an early member (1854–56) of the Geological Survey of Victoria. After this initial spell with the Survey he went to London and studied assaying, metallurgy, and photography at the Royal School of Mines (Bolton, 1972). Subsequently (1858), he returned to the Survey under A.R.C. Selwyn (Dunn, 1910).

Finally, we come to Selwyn who, after a private education, joined the Geological Survey of Great Britain in which he worked as a geologist from 1845 to 1852, some of this time as an assistant to A.C. Ramsay in Wales, Scotland, and elsewhere (Dunn, 1910, p. 8). In 1852, Selwyn founded the Geological Survey of Victoria. Charles Gould spent 3–4 weeks with Selwyn in Victoria immediately prior to taking up his post as Geological Surveyor in Tasmania.

THE DISCOVERIES IN CONTEXT

The discovery of glaciation on Macquarie Island is remarkably early. It cannot plausibly be connected with the work of Perraudin and Venetz in Switzerland as noted earlier. David Ramsay may have been familiar with the works of de Saussure (1779–96) but, even so, the statement in Raine's letter goes beyond the postulations of de Saussure. Ramsay had, incidentally, considered taking up medical studies in Paris (McMartin, 1967), so presumably was familiar with French. What early work there was on glaciation emphasized ice movement, and glacial transport and deposition of large rocks, but not the formation of glacial lakes (Chorley and others, 1964, p. 191–94). The Macquarie Island discovery did not reach the scientific world until Branagan noted it, but it had *no* influence on the subsequent controversy in Britain. It is hardly surprising that Darwin recognized the effects of deposition from floating ice in the Permian rocks near Hobart. His friendship with Lyell, his reading of Lyell's *Principles* ..., and his own work off Tierra del Fuego and elsewhere (Darwin, 1839, 1842) provided a more than adequate background. His failure to publish early in the 1840s his deduction as to the origin of the Tasmanian rocks may have been due to a hesitancy to invoke an ancient glaciation. A.C. Ramsay (1852) did not even suggest such until the early 1850s and only in 1855 explicitly wrote of a glaciation (Permian) significantly older than the present one. Although the inferred Permian glaciation of the West Midlands of England had not been substantiated, it is interesting that late Palaeozoic glaciation was soon to be established in Australia, which was never visited by Ramsay.

Milligan's (1849) explanation of the granitic boulder at Southport was entirely in keeping with the iceberg theory, initiated in the early 1830s and the most popular theory at the time.

The recognition of glaciation on Mount Koscuisko by Clarke in May 1852 is not surprising as he was, in effect, a practising geologist, clearly familiar with the contemporary British geological concerns. What is perhaps surprising is that he opted for the glacier rather than for the marine ice explanation, the latter being more popular at that time. It is faintly possible that he had heard of Ramsay's views on glaciation in Wales (read 26 March 1851) but, as the paper was not published until after 16 June 1852 and would not have reached Clarke until some months later, he may not have been aware of the views expressed therein. Even had he read that paper, he may not have been influenced to adopt a glacier explanation, as the main thrust of Ramsay's 1852 paper was towards an iceberg explanation, although he did postulate glaciers to produce moraines in North Wales. It is more likely that he was aware of the work of Agassiz or his co-scholars in continental Europe, or of the paper by Buckland (1841) on glacial effects in Snowdonia.

How Tully used the word "drift" is not quite clear, whether in the original sense of Murchison (1839, Vol. 1, p. 509; quoted in Gary and others, 1972, p. 211) for diluvium, most of which is now known to be glacial, but regarded by Murchison as marine, or in the more general sense of any superficial deposit as seems more consistent with his text. Clarke, in commenting on Tully's discovery, certainly postulated a glacial origin but did not make the basis of his postulate clear.

Gould, Daintree, and Selwyn all recognized evidence of terrestrial glaciation. Such an explanation was becoming more popular in Britain following publication of Ramsay's

paper on Permian glacial deposits in 1855. Furthermore, all three had had direct connections with Ramsay, Gould, and Daintree as students at the Royal School of Mines, where Ramsay taught and Selwyn was his assistant in the Geological Survey at a time when Ramsay's views on glaciation were being developed. Another two of the early discoverers, David Ramsay and Joseph Milligan, had connections with the University of Edinburgh and Robert Jameson. It is interesting to note that the glacier theory was being actively advanced in Australia (Clarke, Daintree, Selwyn, and Gould) at a time when it was being strongly opposed by some geologists in the British Isles, notably Murchison, and when Charles Lyell had reverted largely to the iceberg theory.

The debt owed to A.C. Ramsay has been expressed in the appreciative action by Charles Gould of honouring his name in Mount Ramsay (lat. 41°35′ S., long. 145°30′ E.) in western Tasmania. It is ironical that Mount Ramsay bears no sign of glaciation, whereas other mountains named after British geologists by Charles Gould do. Gould started the practice of naming peaks of the West Coast Range of western Tasmania after British geologists by applying the names to Mount Murchison, Mount Lyell, and Mount Owen; others followed with Mounts Tyndall, Geikie, Sedgwick, Jukes, Huxley, and Darwin. All of these mountains bear signs of Quaternary glaciation (Colhoun, 1985) and one of them, Mount Sedgwick, also of late Palaeozoic glaciation (Banks and Ahmad, 1962).

The history of the early discoveries of the effects of ice action in Australia involves an active protagonist of the marine glacial theory in Charles Darwin and others with close connections in person or by correspondence with participants in the glacial debate in Great Britain. Such connections explain the otherwise surprising earliness of the discoveries in a continent so newly opened to European influence and with so few scientifically inclined or trained people.

Darwin, Milligan, Daintree, and Selwyn saw evidence of late Palaeozoic glaciation, and recognized its age, but the evidence was slender and the discoveries too early in that not until 1855 did Ramsay first even hint at such ancient glaciation. David Ramsay, Clarke, and Gould first noted evidence for Pleistocene glacier action in the only three areas to show such within continental Australia and its Dependencies.

The early discoveries were predominantly of ice-transported sediment, the exception being that of glacial lakes on Macquarie Island. Gould drew attention to glacial land forms and Selwyn to glacial erosional effects. This predominance also reflected the pre-occupation of British geologists with the depositional effects, the diluvium, and drift, in the Diluvial controversy and later.

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