

Geophysical surveying in Australia by the navigators James Cook and Matthew Flinders



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James Cook at Pier Head in 1770

On Wednesday, 30 May 1770 when heading north along Queensland's tropical coast, and after going ashore from HM Bark *Endeavour*, Lieutenant James Cook climbed an isolated hill on the eastern tip of the coastal Quail Island to make observations with his azimuth compass. He named the hill Pier Head (Figures 1 and 2). Cook found that the local magnetism of the place had serious effects on the compass bearings he was attempting. He wrote:

...the first thing I did was to get upon a pretty high Hill, which is at the North-West entrance of the inlet, before Sunrise, in order to take a view of the Sea Coast and Islands, &c., that lay off it, and to take their bearings, having the Azimuth Compass with me for that purpose, the Needle of which differ'd from its True position something very considerable, even above 30 degrees, in some places more, and in other less, for I try'd it in several places. I found it differ from in itself above 2 points [a point = 11¼ degrees] in the space of about 14 feet. The loose stones that lay upon the Ground had no effect upon the Needle; I therefore concluded that it must be owing to the Iron Ore upon the Hill, visible signs of which appeared not only here, but in several other places.¹

Cook's brief mention and opinion of the effects of the hill's magnetism, and the character of the rocks themselves (from his published journal), are almost certainly the earliest of what could be construed as a geophysical observation in Australia. His last sentence being his interpretation – although this may be stretching things slightly. The information is of interest to us nowadays, and it was also of interest to others much closer to

Cook's era, in particular to Matthew Flinders. In September 1802, on his circumnavigation of Australia in HM Sloop *Investigator* (accompanied up the east coast by HM Colonial Brig *Lady Nelson*), Flinders made a point of investigating the unusual observation that Cook made in 1770.

Matthew Flinders at Pier Head in 1802

On Sunday 5 September 1802, after having sailed through the opening to Thirsty Sound, which separates Quail Island from the mainland, *Investigator* and *Lady Nelson* anchored safely in six fathoms. Almost immediately Flinders' botanists headed for the mainland to investigate, and the expedition's launch was sent by Flinders 'to haul the seine [net] on that side, at a beach a little way up the Sound'. Independently of these scientific activities,

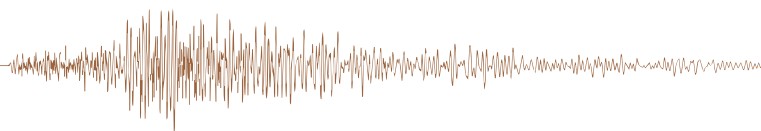


Figure 1. Looking north to Pier Head from the mainland coast between Mackay and Rockhampton.



Figure 2. Pier Head, Queensland. Imagery©2017 Cnes/SpotImage. Digital Globe. Mapdata©2017 GBRMPA. Google.

¹Wharton, Captain W. J. L. (ed.), 1893, *Captain Cook's Journal during his first voyage round the World made in H.M. Bark 'Endeavour' 1768–71. A literal transcription of the Original MSS*, London.



Flinders went ashore at Quail Island and there climbed the 110 metres to the top of Pier Head where later, in his published journal (1814), he recorded that he took bearings 'to the Northumberland Islands, as also of the points and hills of the coast to the east and west' (Figure 3).

Flinders' 1814 description of his magnetic observations on and around Pier Head on that, and the following day, 6 September 1802, is an enlightening historical record. It is not known by many that his journal entries of those observations were in themselves a summary of information he had sent to Sir Joseph Banks in a letter written on 5 March 1804, when he was a prisoner of the French on Isle of France (Mauritius). The 1804 letter is an important document. It was Flinders' first communication on observations he had made onboard *Investigator* of the changes in the terrestrial magnetism observed with his ship's compass when travelling from the northern hemisphere to the southern hemisphere and, importantly, the large observed variations (four degrees or more) in his compass headings with changes in the direction of the ship's head. He included specific examples for Banks, in a set of tables, and then explained his thoughts on the matter with suggestions for correcting the discrepancies.

Flinders' 1804 writings on ship's magnetism to Banks were pioneering, and his thoughts were to become the basis for experiments he later carried out in 1812 onboard Royal Navy vessels after he had returned to England. His 1812 experiments led to another paper, which in turn led to official instructions and orders to all Royal Navy commanders to both experiment and to understand their onboard compass environment, and to standardise and maintain their compass binnacles free from magnetic interferences. Flinders' 1804 letter to Banks finished off with a description of external magnetic interferences, including his Pier Head observations along with a summary of Cook's observations at the same place. Flinders also noted other observations he later made on the west coast of the Gulf of Carpentaria, where on one occasion he observed the needle in his theodolite had turned over fifty degrees from its proper direction, and in another case where he confirmed the existence of a local disturbance by placing a sample rock close to the instrument which 'drew the needle of the theodolite entirely around'. Banks read Flinders' letter to The Royal Society of

London meeting on 28 March 1805, and it was later published in full in the Society's transactions.

Combining the information from both Flinders' 1804 letter and his published 1814 journal we have a good record of what occurred at Pier Head. In his 1804 letter he wrote that he took back bearings to 'Extensive Mount' (later renamed by Flinders to Mount Westall) some 34 miles away and observed a difference of $4^{\circ}35'$ to the right and to an island some thirty miles away, a difference of $4^{\circ}45'$ also to the right. Conscious of Cook's reported disturbances, Flinders moved his theodolite three yards to the westward and the same two objects bore $2^{\circ}10'$ to the right of the back bearings. He then moved the instrument to a place three yards to the southeast from the original place and they differed 2° to the left. On moving the theodolite again, to a place four yards to the north, the same objects bore $1^{\circ}10'$ to the right. These unusual discrepancies were enough to prompt Flinders to return the following day (Monday 6 September 1802). His letter finished with a detailed description of his Pier Head magnetic observations:

... On the following morning I determined to try the magnetism more particularly. Taking the theodolite and dipping-needle, I landed upon the shore of the Head, whence the top of the hill bore N50°W, about one-third of a mile. The variation of the theodolite in this place I observed to be 8°2'E, and the inclination of the south end of the dipping needle 50°50', the needle stood vertical when the face of the instrument was S2°E. I then took the following bearings: Extensive Mount [Mount Westall] 108°30', the same exactly as by back bearing. Double Peak 143°30'; from hence I rowed round the Head, and landed on a rock, whence the top of the hill bore SSW one-sixth of a mile; Extensive Mount bore 110°14', the inclination of the dipping-needle 50°29', and the needle stood vertical when the instrument faced S3°E. Thus the difference was $1\frac{1}{4}^{\circ}$ in the horizontal, and $\frac{1}{2}^{\circ}$ in the vertical direction of the needle. Ascending the hill, I made the following observations on the top: Extensive Mount 113°50', a island 133°52', Double Peak 148°32'; the inclination of the needle was 53°20', and it stood vertical at S3°E. The differences here are $5^{\circ}10'$ in the horizontal, and $2^{\circ}30'$ in the vertical direction, from what the needle stood at in the first morning's place. On moving ten yards SSE, the bearings were, Extensive Mount 108°44', Double Peak 143°25'; the inclination was $52^{\circ}18'$, and the needle was vertical when the instrument faced S5°W. In this 4th set of observations, the horizontal direction of the needle is only a few minutes different from the first place, but the vertical direction is $1^{\circ}28'$. From the top of the hill I now moved twenty yards to the north-eastward, when Extensive Mount bore 110° , Double Peak $144^{\circ}42'$; the inclination of the dipping needle was now $50^{\circ}35'$, and it stood vertical at S3°W. Thus it appears that the polarity of the magnetic needle is most interrupted at the top of the hill, both according to the theodolite and dipping-needle. Whether this may arise from some particular magnetic substance lodged in the heart of the hill, or from the attractive powers of all the substances which compose Pier Head being centered in a similar point to what I have supposed to take place with all the ferruginous bodies lodged within a ship, I shall not attempt to decide. The greater differences in the horizontal direction of the needle observed by Captain Cook, might have arisen from his using a common azimuth compass,



Figure 3. Part of Flinders 1814 published chart, showing his and Cook's routes, Pier Head and West Hill Island (top left). From facsimile of original held by D. Morrison.

which was probably not further elevated from the ground than to be placed on a stone.

MATTHEW FLINDERS

Isle of France

March 5th, 1804.²

In Flinders' published 1814 journal he summarised, with vector adjustments and corrections, his Pier Head variation and dip observations. He again commented on Cook's original discrepancies and contemplated the causes of the geological interference, he wrote:

Azimuths were taken, and the bearing of Mount Westall, distant thirty-four miles, was set at S. 63°28' E. (true), whilst the theodolite remained in the same place; and from a comparison between this bearing and those of the same object at different parts of the head [i.e. Pier Head], the variations were deduced. The dip was observed with both ends of the needle, and the face of the instrument changed each time. [followed by observations at eight locations] (Figure 4)

There are here no differences equal to those found by captain Cook; but it is to be observed, that he used a ship's azimuth compass, probably not raised further from the ground than to be placed on a stone, whereas my theodolite stood upon legs, more than four feet high. The dipping needle was raised about two feet; and by its greater inclination at the top of the hill, shows the principal attraction to have been not far from thence. The least dip 50°28', taken at the shore on the north side of the head, was doubtless the least affected: but it appears to have been half a degree too much, for at Port Bowen, twenty-two miles further south, it was no more than 50°20'. An amplitude taken on board the ship in the Sound by Lieutenant Flinders, when the head was S.S.W., gave variation 8°39', or corrected to the meridian, 7°40' east. ...

Notwithstanding this very sensible effect upon the needle, both horizontally and vertically, I did not find, any more than captain Cook, that a piece of stone applied to the theodolite drew the needle at all out of its direction; nevertheless I am induced to think, that the attraction was rather dispersed throughout the mass of stone composing Pier Head, than that any mine of iron exists in it. The stone is a porphyry of a dark, bluish colour.³

The published Australian 1:250 000 geological map (Port Clinton, SF 56-9) broadly identifies Pier Head as being within an area mapped and described as a 'trachyte plug, andesite intrusion' (*sic*). The steepest magnetic dip observed by Flinders turned out to be at the top of Pier Head. It should also be considered that the place had, and has been, for aeons, subject to lightning strikes (Figure 5).

²Flinders, M., 1805, Concerning the differences in the magnetic needle, on board the Investigator, arising from an alteration in the direction of the ship's head: *Philosophical Transactions of the Royal Society, London* 95, 186–197. In a letter to Sir Joseph Banks, read to the Royal Society 28 March 1805.

³Flinders, M., 1814, A voyage to Terra Australis; undertaken for the purpose of completing the discovery of that vast country, and prosecuted in the years 1801, 1802, and 1803, ...etc. London, vol. II, chapter III, pp. 53–57.

At the highest top of Pier Head,	Var.	3° 25' E.	Dip 53° 20' S.	
West, three yards from it,	-	-	6 10	
S. E. three yards,	-	-	10 5	
S. S. E., ten yards,	-	-	8 6	52 19
North, four,	-	-	6 55	
N. E., twenty,	-	-	6 50	50 35
N. N. E., one-sixth mile, at the water side,	7	6		50 28
S. E., one-third mile, at ditto,	-	-	8 2	50 50

Figure 4. An image of Flinders' original journal table from his 1814 Journal Vol II.

A few days after departing Pier Head, on the morning of Thursday 9 September 1802 and on climbing 'West Hill', i.e. West Hill Island, a prominent conical peak of some 300 metres, Flinders took further bearings (including one back to Pier Head) and following his experience with the geological effects on his observations at Pier Head he noted:

The stone of the hill [i.e. West Hill Island] had in its specks of quartz or feldtspath, and was not much unlike that of Pier Head; but it had a more basaltic appearance. A piece of it applied to the theodolite, drew the needle two degrees out of its direction, and yet the bearings did not show any great differences from the true variation ...⁴

Flinders was obviously becoming very aware of the local magnetic environments of his observations. Undoubtedly he was, by this time, forming his opinions on the serious errors being observed with compasses both onboard and onshore from the local geological environment – all in addition to his dedicated studies on his ship's deficiencies in compass observation and in tracking a true course. His later, 1812, compass and heading experiments with Royal Navy ships at Sheerness, Portsmouth and Plymouth were, in part anyway, a last opportunity to fine tune his expedition bearings before publication⁵.

Flinders 1812 experiments, made just two years before his premature death (aged 40), included procedures for magnetic compensation of compass heading errors by the strategic placing of soft iron rods near the binnacle compass, procedures that soon became standard – highly significant and essential procedures for iron and steel constructed vessels. Many years later such ship soft iron compensation bars and rods became identified as 'Flinders bars', they still are.

Flinders, in Appendix II of his 1814 Journal, when discussing and philosophising the heading errors of compasses and his 'precautions for obviating their effects in marine surveying', made the following comment:

... there are few masses of stone totally devoid of iron, and that all iron which has long remained in the same position will acquire magnetism, or a power of attracting one end of the magnetic needle towards one part of it, and the opposite end towards another, is, I believe, generally admitted. The kinds of stone which I have observed to exert the greatest influence on the needle, are iron ore, porphyry, granite, and

⁴*Ibid* p. 60.

⁵Ingleton, G. C., 1986, *Matthew Flinders Navigator and Chartmaker*: pp. 405–413.

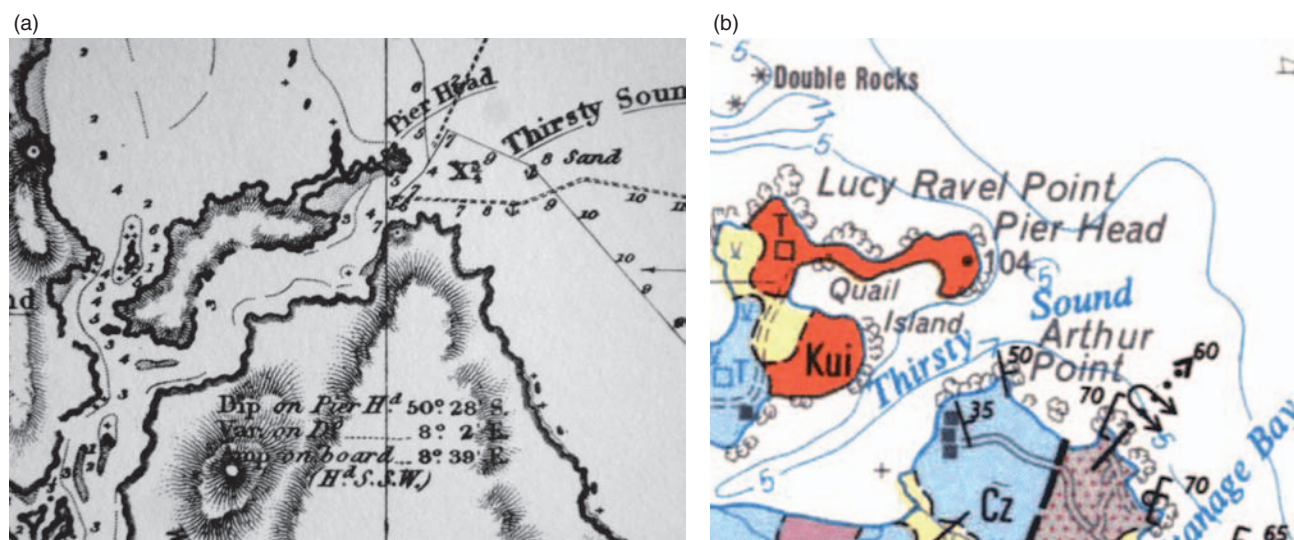
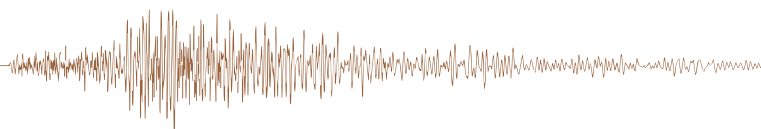


Figure 5. (a) From Flinders 1814 chart. (b) Geology from the Port Clinton 1: 250 000 geological map.

basaltes, and the least, are sand or free stone, and calcareous rock, and the argillaceous earths very little⁶.

Flinders was assisted in his geological investigations by Robert Brown, the expedition's botanist. Brown had been tutored, before the voyage, in geology and mineralogy. Together with his assistant, John Allen (a miner), and the ships's horticulturist, Peter Good, Brown collected and documented rock specimens throughout the voyage. Some of the expedition's rock specimens, and Brown's geological collection catalogues, have survived and are held in the British Museum, but many specimens, stored in barrels, were lost in the wreck of HMS *Porpoise* in August 1803. No rock specimen survives from Pier Head but two specimens survive from West Hill Island⁷.

A plaque commemorating the visits of both Cook and Flinders to the top of Pier Head was set in concrete on Pier Head in December 1959 by a group of central Queensland residents. It is not known whether the plaque is still there.

Biography

Doug Morrison has been an ASEG member for 35 years. He joined Aero Service Corporation in February 1962 as a 'geophysical data compiler' on the Bass Strait aeromagnetic survey. He studied land and engineering surveying at night. Doug has supervised geophysical data processing for governments, exploration companies and contractors on numerous projects over the years. In the 1970s he was Project Manager on major surveys from Alaska to Zambia and later Operations Manager for Geometrics International Corporation in Australia. Doug has contributed a number of geophysical history papers and articles to journals including *Preview* and in 2012 was awarded an ASEG Service Certificate for his contributions and promotion of the exploration geophysics industry.

⁶Flinders, 1814, *op. cit.*, Volume II, Appendix II, pp. 512–532.

⁷Vallance, T. G., and Moore, D. T., 1982, Geological aspects of the voyage of HMS Investigator in Australian Waters, 1801–05, *Bulletin of the British Museum (Natural History)*, historical series, vol. 10, no. 1, 28 January, pp. 1–43.