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D'Entrecasteaux, 1792: Celebrating a Bicentennial in Geomagnetism

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The first surveys of global magnetic intensity, and especially the demonstration of its variation with latitude, are commonly credited (for example, *Chapman*, [1967]) to Alexander Von Humboldt, who played a major role in developing geomagnetism in the late 18th and 19th centuries. Von Humboldt made intensity measurements in South America from 1798–1803 and later encouraged the establishment of a global magnetic observatory network (see, for example, *Malin and Barraclough*, [1991]).

However, as pointed out by *Sabine* [1838] in a review of intensity measurements to that time, the earliest surviving survey of global magnetic intensity, showing it to strengthen away from the equator both north and south, was made by Elisabeth Paul Edouard De Rossel during the 1791–1794 expedition of Bruny D'Entrecasteaux. Even earlier measurements seem certain to have been made by the scientist Robert de Paul, chevalier de Lamanon (always referred to as Lamanon) of the La Pérouse expedition [*Milet-Mureau*, 1799], but any records are evidently lost. Lamanon died when the La Pérouse expedition was in Samoa in 1787, and both ships of that expedition were wrecked on the island of Vanikoro, presumably in 1788 [*Marchant*, 1967; *Spate*, 1988]. All such measurements were of relative magnetic intensity until a method for the determination of absolute intensity was invented by Gauss in 1832. For a recent discussion of this latter topic, see *Jackson* [1992].

The D'Entrecasteaux expedition of two ships, *La Recherche* and *L'Espérance*, was sent to search for the missing La Pérouse expedition. The ships sailed from Brest, France, in September 1791, with the second ship under the command of Huon de Kermadec. The official report of the expedition is that of *De Rossel* [1808], and there is an accompanying atlas of charts by *Beautemps-Beaupré* [1807], which survived various adventures on the return to France. A valuable and engaging account of the expedition is also given by *La Billardière* [1800].

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The expedition arrived in Van Diemen's Land (now Tasmania, Australia) in 1792 and again in 1793. They moored both times in Recherche Bay, which they discovered and named. Between visits they circumnavigated Australia, which was then known as New Holland, carrying out extensive exploration in Papua, New Guinea, and western Australia. The expedition terminated in Java in 1794. Both D'Entrecasteaux and De Kermadec had died in 1793.

The expedition reported six magnetic intensity measurements [*De Rossel*, 1808]. These six measurements are given in Table 1, as tabulated by *Sabine* [1838]. The method of measurement was by timing the oscillations of a vertical dip needle disturbed from rest, usually taking a series of 100 oscillations. The method is described in detail by *De Rossel* [1808], and De Rossel's diagram of the dip needle used is shown in Figure 1. As Sabine pointed out, De Rossel's measurements were especially significant because of the measurements repeated at both Recherche Bay and near the equator,

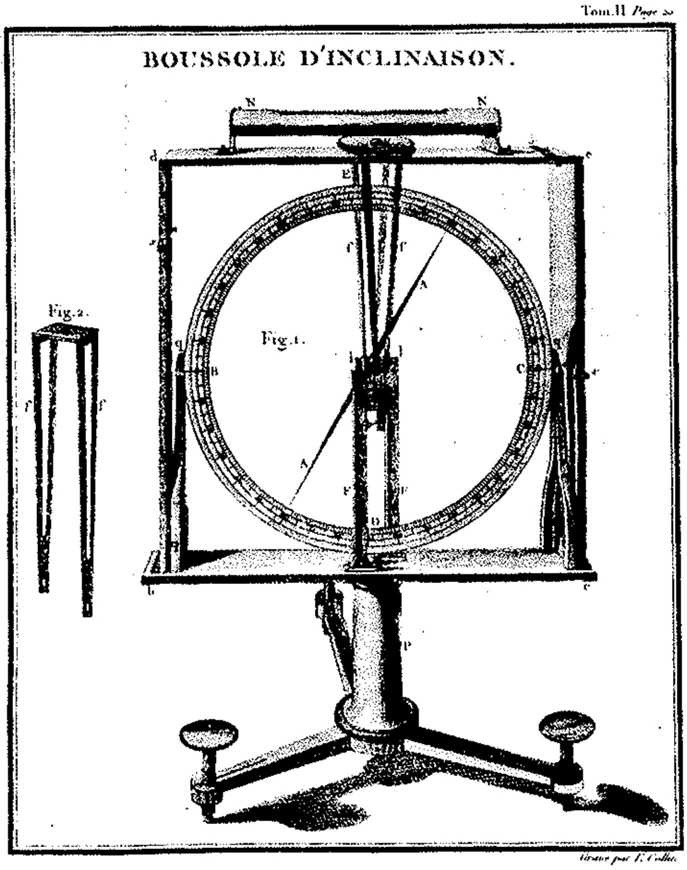

Fig. 1. Drawing of the magnetic dip needle of the D'Entrecasteaux expedition, reproduced from De Rossel *[1808].*

Table 1. Summary of *De Rossel's* [1808] intensity measurements

Station	Date	Latitude	Longitude (E)	Magnetic Dip	Time of Vibration
Brest	Sept. 20, 1791	48°24'N	355°34'	71°30'N	2.02"
Teneriffe	Oct. 21, 1791	28°28'N	343°42'	62°25'N	2.081
Van Diemen's Land	May 11, 1792	43°32'S	146°57'	70°50'S	1.869
Amboyna	Oct. 9, 1792	3°42'S	128°08'	20°37'S	2.403
Van Diemen's Land	Feb. 7, 1793	43°34'S	146°57'	72°22'S	1.850
Surabaya	May 9, 1794	7°14'S	112°42'	25°20'S	2.429

Measurements in terms of the "time of vibration" (period of oscillation) of the dip needle in seconds, from *Sabine* [1838].

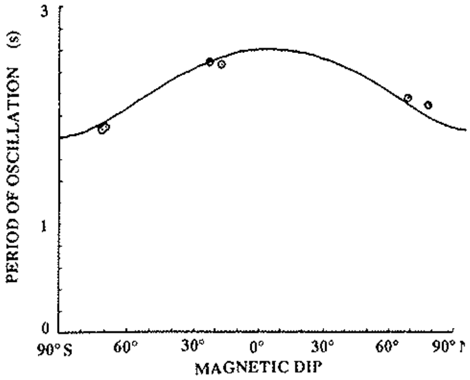

Fig. 2. Data for the 1791–1794 expedition from De Rossel *[1808], plotted as period of oscillation against magnetic dip. A curve for an ideal geocentric dipole is superimposed.*

showing consistency in equipment and experimental method. Due to the position of the south magnetic pole, Recherche Bay has a high magnetic dip for its geographic latitude, which was helpful in investigating the variation of intensity with dip.

Discussing his results, *De Rossel* [1808] (vol. 1, p. 20) comments, "By comparing the experimental results obtained during the expedition with each other it is evident that the oscillations of the needle were more rapid at Paris and Van Diemen's Land than at Surabaya in the isle of Java and at Amboyna; and that therefore the magnetic force is greater near the poles than at the equator."

And Sabine states, "It is this determination which unquestionably entitles Admiral de Rossel to the distinction which he has always enjoyed, of having been the first who ascertained that the magnetic intensity is different at different positions on the Earth's surface: although his observations were not published until after those of M. de Humboldt in 1798–1803, by which the same fact was more largely established."

It is of interest to analyze the *De Rossel* [1808] data using basic theory. In a magnetic field of intensity F, the period T of oscillation of a dip needle is given by

$$T = 2\pi\left\{\frac{A}{MF}\right\}^{1/2} \qquad (1)$$

([*Chapman and Bartels*, 1940]; also see *Parkinson*, [1983]), where A is the mechanical moment of inertia of the dip needle and M is its magnetic moment.

Representing Earth's magnetic field as being due to a magnetic dipole at the center of a sphere, on the surface where the magnetic dip is I, the field intensity will be given by

$$F = \frac{2\mu_0 P}{4\pi R^3}\,(1 + 3\cos^2 I)^{-1/2} \qquad (2)$$

[*Merrill and McElhinny*, 1983], where P denotes the moment of the central dipole, R is the radius of the sphere, and μ_o is the permeability of free space. Combining equations (1) and (2) gives

$$T = c.f(I) \qquad (3)$$

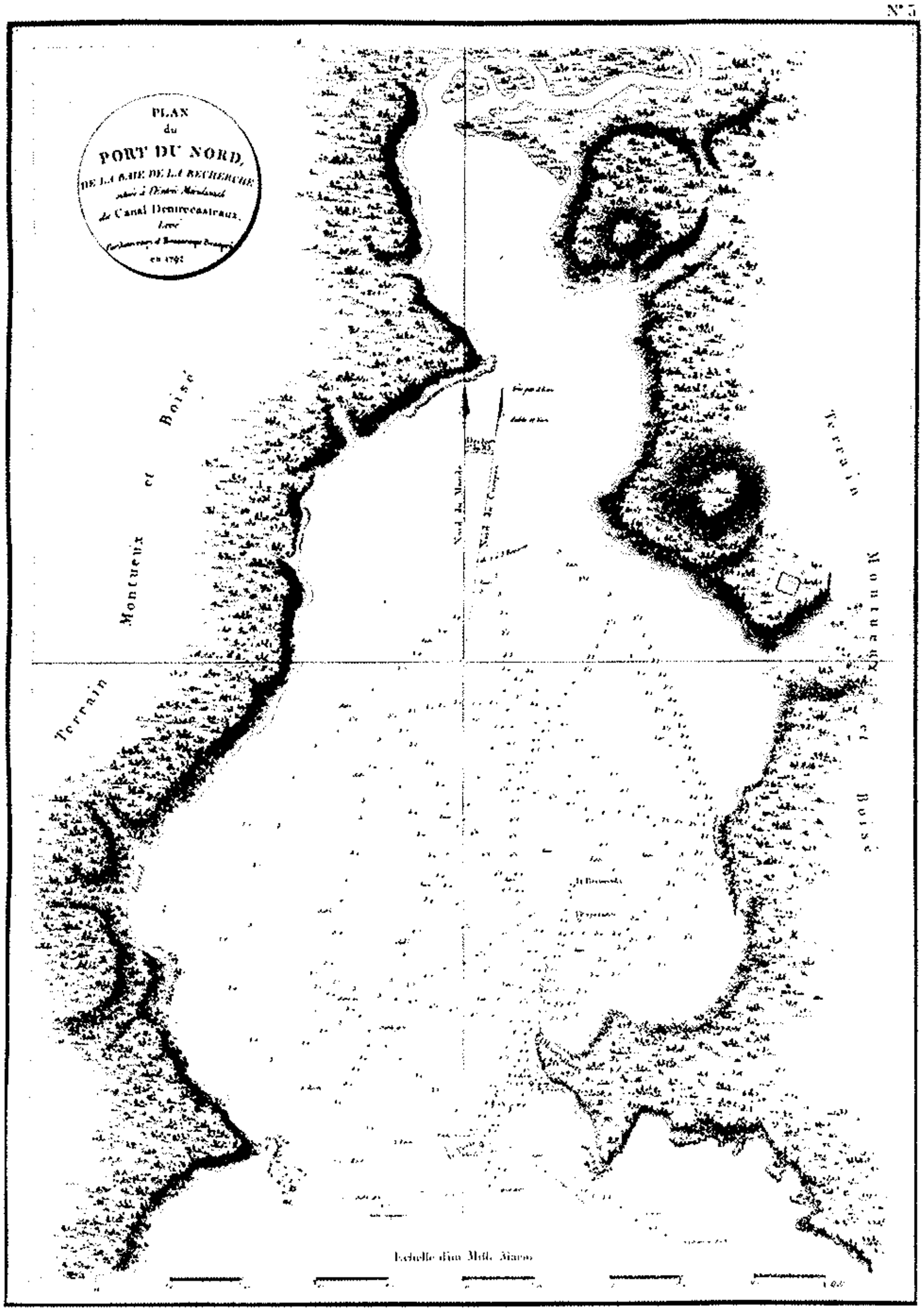

Fig. 3. The chart of the first anchorage of the two D'Entrecasteaux vessels, in Port du Nord of Recherche Bay. The 1792 Observatory is on the point jutting into the bay in the lower right of the figure, which is now called Bennetts Point.

where
$$c = 2\pi\left\{\frac{2\pi A R^3}{\mu_0 M P}\right\}^{1/2} \qquad (4)$$

and
$$f(I) = (1 + 3\cos^2 I)^{1/4}$$

Each De Rossel observation thus gives a value for c in equation (3); the six observations give six values, of mean 1.79 and standard deviation 0.06. The units of c are seconds.

Figure 2 presents the De Rossel data plotted as T against I, with a curve for the mean value of c superimposed. Departures of the data from the curve represent not only experimental error, but also departures of Earth's magnetic field from the simple dipole model. Fitting the curve in Figure 2 effectively calibrates the instrument in Figure 1. Taking for P and R values of 8.0×10^{22} A.m^2 and 6.371×10^6 m, respectively [*Merrill and McElhinny*, 1983] gives, using equation (4), a ratio of

$$\frac{A}{M} = 5.0 \times 10^{-6} \text{ S.I. units}$$

This ratio indicates, quite reasonably for the 1792 instrument, a combination of parameters for the dip needle such as 10^{-6} for A and 0.2 for M (S.I. units).

The chart showing the site of the 1792 observatory in Recherche Bay is reproduced in Figure 3. Magnetic intensity having been measured there on May 11, 1792, and again on the same day and month in 1992, marked

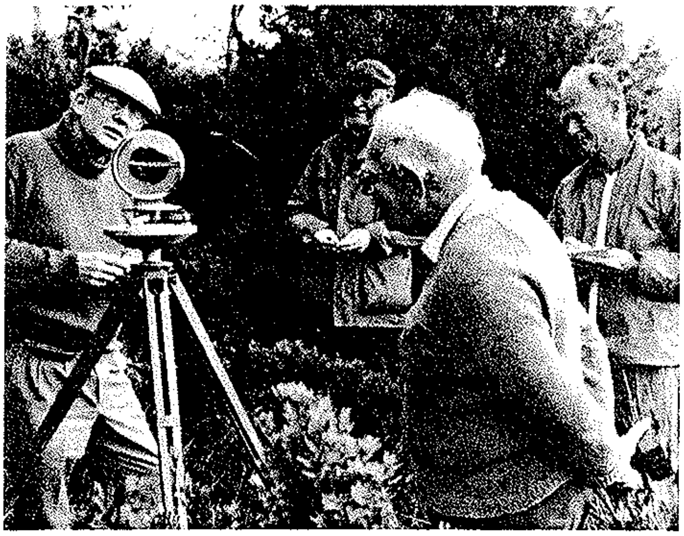

Fig. 4. Oscillating a dip needle at the 1792 site, on May 11, 1992. (From left to right: Ted Lilley, Peter Stevenson, Jim Dooley, Dudley Parkinson.)

a bicentennial in Australian geophysics. As *Day* [1966, 1991] has pointed out, the De Rossel measurement of magnetic intensity marked the first deliberate scientific experiment on Australian soil intended to answer a specific question about Earth.

To mark the occasion of the bicentennial, the Specialist Group on Solid-Earth Geophysics of the Geological Society of Australia held a special 3-day meeting in Tasmania. The meeting began on May 9, 1992, with a tour of the remaining buildings of the Rossbank Magnetic Observatory, which operated in Hobart from 1840 to 1854, just 150 years ago. The observatory site is within the grounds of Government House, Hobart, and participants were first welcomed by the governor of Tasmania, General Sir Phillip Bennett, who opened the meeting.

A symposium, "Progress in Geomagnetism in Australia, 1792–1992; a Bicentennial Review," was held near the Hobart waterfront at the Commonwealth Scientific and Industrial Research Organization Marine Laboratories. The symposium was open to the public and attracted an audience of approximately 100. Eight speakers covered the range of modern geomagnetism and its remarkable developments. W. Dudley Parkinson gave a description of Earth's magnetic field and its measurement, and F.E.M. (Ted) Lilley spoke on the creation of magnetic fields by fluid motion. Geological information from magnetic maps was described by David E. Leaman, and paleomagnetism and continental drift were discussed by Charles E. Barton. In the second half of the symposium, following afternoon tea, Ian McDougall spoke on reversals of Earth's magnetic field and seafloor spreading, and James C. Dooley described mapping the magnetic field of Australia and its change with time. Daily magnetic changes and the history of observatories since 1840 were discussed by Denis E. Winch.

The symposium concluded with a description of Earth's magnetic field in space and aurorae by Gary B. Burns. Following the symposium, a bicentenary dinner at a waterfront restaurant was held, where Alan A. Day gave an account of the circumstances of the expedition 200 years ago and proposed a toast to D'Entrecasteaux and the early scientists. Subsequently, an abrupt knock at the door announced the arrival of the figure of an 18th century French naval commander (alias Patrick G. Quilty), who responded to the toast with much applause.

Sunday, May 10 was spent on a ferry cruise from Hobart down the D'Entrecasteaux Channel to Recherche Bay and back. Some 170 members of the public joined the meeting registrants, filling the ferry to capacity. Hobart geologist Max R. Banks pointed out features of interest, and in Recherche Bay the ferry visited both the 1792 and 1793 mooring sites. While returning to Hobart in the darkness of an early winter evening, a spectacular aurora was seen to the south and overhead. This aurora continued through the night and was reported as far north as Queensland. It thus heralded in the bicentenary day, May 11, 1992. On this day, a party of some twenty-one revisited the May 11, 1792, observatory site, crossing the Port du Nord (see Figure 3) in a Zodiac craft of the Australian Antarctic Division. A dip needle was oscillated (see Figure 4) to reenact the De Rossel measurement, and the steady dip measured 73° 21′. This latter result showed the movement of the south magnetic pole closer to Tasmania since De Rossel's reading of 70° 50′. Also, to span 200 years, a proton-precession magnetometer was operated to measure magnetic intensity.

Fig. 5. The plaque emplaced at Bennetts Point, Tasmania, on May 11, 1992.

A plaque was fixed to an outcrop of dolerite nearby, looking out over the entrance of Recherche Bay, and unveiled with a speech by David F. Branagan, chairman of the Earth Sciences History Group of the Geological Society of Australia (see Figure 5). The speech concluded with a toast to the next 200 years of geophysics.

References

Beautemps-Beaupré, C. F., *Atlas du voyage de Bruny-Dentrecasteaux . . . en 1791, 1792 et 1793 . . .*, Paris, Depot general des cartes et plans de la marine et des colonies, 1807.

Chapman, S., Perspective, in *Physics of Geomagnetic Phenomena*, vol. 1, edited by S. Matsushita and W. H. Campbell, pp. 3–28, Academic Press, New York, 1967.

Chapman, S., and J. Bartels, *Geomagnetism*, 2 vols., Oxford University Press, London, 1940.

Day, A. A., The development of geophysics in Australia, *Proc. R. Soc. N.S.W.*, *100*, 33, 1966.

Day, A. A., Bicentenary of geophysical research in Australia, *Geophysics Down Under*, *14*, 4, 1991.

De Rossel, E. P. E., *Voyage de Dentrecasteaux, envoye a la recherche de La Pérouse*, 2 vols., de l'imprimerie imperiale, Paris, 1808.

Jackson, A., Historical data for geomagnetic field modelling, in *Types and Characteristics of Data for Geomagnetic Field Modelling*, edited by R. A. Langel and R. T. Baldwin, Conf. Pub. 3153, NASA, Greenbelt, Md., 1992.

La Billardière, J. J. H., *Voyage in Search of La Pérouse* (English translation) 2 vols., John Stockdale, London, 1800.

Malin, S. R. C., and D. R. Barraclough, Humboldt and the Earth's magnetic field, *Q. J. R. Astr. Soc.*, *32*, 279, 1991.

Marchant, L. R., Comte de Jean-Francois de Galaup La Pérouse, in *Australian Dictionary of Biography*, edited by D. Pike, vol. 2, pp. 85–86, 1967.

Merrill, R. T., and M. W. McElhinny, *The Earth's Magnetic Field; Its History, Origin and Planetary Perspective*, Academic Press, Edinburgh, 1983.

Milet-Mureau, L. A., *A Voyage Round the World Performed . . . . by the Boussole and Astrolabe, under the command of J.F.G. de la Pérouse* (English translation), 2 vols. plus atlas, London, 1799.

Parkinson, W. D., *Introduction to Geomagnetism*, Scottish Academic Press, Edinburgh, 1983.

Sabine, E., Report on the variations of magnetic intensity observed at different points on the Earth's surface, in *Report of the Seventh Meeting of the British Association for the Advancement of Science*, vol. VI, pp. 1–85, Br. Assoc. for the Adv. of Sci., Liverpool, England, 1838.

Spate, O. H. K., *Paradise Found and Lost; the Pacific since Magellan*, vol. III, Australian National University-Pergamon Press, Sydney, 1988.