NEUMAYER, HUMBOLDT AND THE SEARCH FOR A GLOBAL PHYSICS

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In setting up the Flagstaff Observatory in Melbourne in 1857, the young German geophysicist Georg Neumayer brought new standards of precision to the pursuit of physics in Australia. His wide-ranging research program in geomagnetism, meteorology and oceanography was conceived within an overall approach to science associated especially with the name of Alexander von Humboldt, that saw the Earth and its oceans and atmosphere as an integrated dynamical system. Neumayer also, however, envisaged immediate practical outcomes from his work, whether in determining optimal sailing routes between Europe and Australia, or in locating new mineral deposits. From a personal point of view he regarded his seven years in Australia as, above all, a preparation for the scientific investigation of Antarctica that he dreamed in vain of undertaking.

Key words; Flagstaff Observatory, Melbourne; Humboldt, Neumayer

GEORG Neumayer's arrival in Melbourne on 27 January 1857 with the declared intention of establishing a major geophysical observatory (Home & Kretzer 1991) evidently came as a considerable shock to the tiny group of people active in science in Victoria at the time. They had clearly had no forewarning, and some leading members of the group, centred on the predecessor institution of the Royal Society of Victoria, the Philosophical Institute of Victoria, saw Neumayer's plans as a direct threat to their own scientific ambitions.

Neumayer had brought some limited funding with him and also a suite of the instruments he would need, of the latest design and paid for by the King of Bavaria. However, he was depending on the Victorian Government's assigning him a suitable site for the observatory and then providing both capital funds to erect appropriate buildings—the cost of which Neumayer estimated at £700—and operating funds at the rate of £600 per annum to cover the observatory's running costs. Initially, those who felt threatened by Neumayer's plans were able to thwart them by blocking his funding, but eventually he was allocated a site on Flagstaff Hill for his observatory and funds to run it. As a result, the Flagstaff Observatory became operational early in 1858 (Neumayer 1859, Perdrix 1990).

Flagstaff Hill was not Neumayer's preferred site for his observatory. It was vital for successful recording of the Earth's magnetic field that a site be selected that was free of magnetic disturbances, and so once Neumayer was confident he had won the political backing he needed, he devoted the whole of the months of September, October and November 1857 to a systematic survey of potential sites around Melbourne, to determine which were least affected by magnetic disturbances. From this, he identified a site south of the Yarra River, on a hill close to the Botanic Garden, as the optimal location—indeed, as the only spot that was in every respect suitable for his purposes. There were, however, no buildings there, whereas on Flagstaff Hill the buildings originally erected for the signal station that had been located there were available, and the ground was reasonably free of magnetic anomalies—and so this site was allocated, as a temporary measure as Neumayer always insisted. Eventually, in 1863, when it was decided to merge Neumayer's operation with the small astronomical observatory that had been established at Gellibrand Point, Williamstown, to provide a time service for the shipping, the resulting Melbourne Observatory was established on Neumayer's preferred site next to the Botanic Garden (Ross 1918).

We can easily identify the members of the Victorian scientific community who initially opposed Neumayer's plans, and we can also easily understand why they might have done so. Principal among them, in Neumayer's perception, was William Parkinson Wilson, professor of mathematics and physics at

the recently founded University of Melbourne, who when Neumayer described his project at a meeting of the Philosophical Institute apparently responded (according to Neumayer's report) that this was not a task that should be left to a foreigner and that it should be done by an Englishman.

Wilson had arrived in Melbourne to take up his professorship a couple of years earlier, before that having been professor of mathematics at Queen's University College (now Queen's University) in Belfast. Here, he had got to know the well-known astronomer, Lord Rosse, President of the Royal Society of London at the time and famous for observations on nebulae made with the huge telescope he had erected on his estate in Ireland. Wilson had conceived the idea of extending Rosse's observations to the southern hemisphere (the southern sky being of course not accessible to Rosse). At Wilson's urging, in December 1856, just a month before Neumayer arrived in Victoria, the Philosophical Institute had presented a memorial to the leader of the first elected government under Victoria's new constitution, William Haines, proposing the establishment of an astronomical observatory that would, when completed, 'rank with the first observatories in Europe'. In particular, this observatory should pursue research on southern-sky nebulae, and for this it would need to be equipped with a telescope to rival Lord Rosse's (Philosophical Institute of Victoria 1857). One can well understand why Wilson would have seen Neumayer's scheme as a threat to this ambitious plan. Few members of Parliament would have distinguished one observatory from another, and so might very well have seen it as sufficient to fund just one of them! (In the end, as we know, following the establishment of the Melbourne Observatory, funding was provided for a large telescope, the so-called Great Melbourne Telescope—but this was after Neumayer's time.)

Neumayer, in a document that a colleague and I published some years ago (Home & Kretzer 1991: 241), identified W. P. Wilson's university colleague, Frederick McCoy, as another source of opposition to his scheme. As the University's Professor of Natural Science and now also director of the National Museum established in Melbourne a couple of years earlier, McCoy was a very prominent figure in Melbourne's scientific community and well placed to cause trouble for Nemayer if he wanted to—but I know of no evidence to show that he did, independently of Neumayer's accusation.

An enemy whose machinations against him Neumayer failed to detect was Robert Brough Smyth, officer in charge of the colony's expanding network of meteorological observing stations that were at this time being administered by the Department of Lands under the Surveyor-General, Captain Andrew Clarke, as Minister (or Commissioner). One can see why Smyth, who was more or less self-taught in science, might have felt threatened by Neumayer's plans, which included undertaking systematic meteorological observations—especially if Neumayer, after inspecting Smyth's arrangements, had indicated, as he later did when writing to Germany (Home & Kretzer 1991: 238), that he thought those arrangements left a lot to be desired. For public consumption, Smyth—already a master of underhand political and bureaucratic manoeuvering (Hoare 1973)—published anonymously an article (reprinted separately as a pamphlet) decrying the scientific value of Neumayer's proposed research (Smyth 1857). (We know he was the author from his correspondence with W. B. Clarke in Sydney, to whom he crowed about having simultaneously undercut both Wilson's plans for a big telescope and 'the Magnetic-cum-Earthquake wonder', Neumayer.) But Smyth also clearly had his Minister's ear, since the same arguments against what Neumayer was proposing reappeared, in virtually the same words, in a speech Andrew Clarke made in opposing Neumayer's plans in Parliament.

As already indicated, the local scientific establishment was at first able to thwart Neumayer's plans. By then, however, Neumayer had already won powerful support from outside the scientific community. He had the Melbourne press very much on his side; petitions were presented to Parliament supporting his case, from both Melbourne's Chamber of Commerce and, most impressively, the captains of all the ships then anchored in the Port of Melbourne; most impressively of all, Melbourne's German community rallied to raise almost £500, in just a few days, towards meeting Neumayer's expenses (Kosmopolit 1857). Neumayer was able to have an interview with the Chief Secretary, William Haines, who was persuaded that the advice he had previously obtained from leaders of the local scientific community had been far from disinterested, and that Neumayer's project was well worthy of support from the Government—and so Neumayer was home free, with his funding assured.

What, though, was all the fuss about? Who was Neumayer, and what was it that he wanted to do?

Georg Balthasar Neumayer was born at Kirchheimbolanden, in Germany's Rhine Valley, on 21 June 1826, in an area known as the Pfalz (in English, the Palatinate) which, though physically separated from

Bavaria, was an integral part of the King of Bavaria's territories (Günther 1906; Kretzer 1984). It was thus natural that for his tertiary studies, Neumayer went to the Bavarian capital, Munich, where he studied at the Polytechnische Schule (precursor of the later Technische Hochschule) and then at the more specialised Engineering School, in preparation for sitting, in late 1849, the Bavarian *Staatsexamen* in Engineering. His success in this examination made him a professionally qualified engineer. He never, however, practised as an engineer. Instead, he worked for some months at Munich's Bogenhausen Observatory under its director, Johann von Lamont, and simultaneously as Assistant to the professor of physics at the University of Munich, the undistinguished Karl Joseph Reindl. Whether he was paid at the Observatory is moot; he probably was paid at the University. However, he does not seem to have had to worry very much about such things: his family seems to have been very comfortably off. His father was a successful notary, and the family home in Kirchheimbolanden was a very large house near the centre of the town; and Neumayer seems to have been able to follow his inclinations as he built his career in science, without being constrained by financial pressures.

To this point, Neumayer's career seemed to be developing along orthodox lines for a bright, scientifically inclined young man—though his going to engineering school rather than university (Heidelberg would have been the obvious choice, Kirchheimbolanden being not far from there) suggests a practical bent rather than commitment at that time to pure science. But then, in August 1850, he did something completely out of the ordinary for someone with his education and from his social background: he went to Rotterdam, the great port at the mouth of the Rhine, and bought himself a berth as a trainee on a 300-ton barque out of Hamburg, *Luise*, bound for Brazil via Newcastle-upon-Tyne (Kretzer 1984). One presumes he travelled as a trainee ship's officer rather than as a deckhand—if he went as the latter, why would he have had to pay for his berth?—and that during the voyage he was able to apply the knowledge of astronomy and instrumentation he had acquired at the Bogenhausen Observatory to practical questions of navigation. But still this would have been a most unusual thing for someone of his background to do at the time, especially someone from southern Germany, land-locked and far from the sea.

Neumayer's venture on *Luise* ended in Hamburg, Germany's chief port and the hub of its commercial shipping activities, in April 1851. Here he sought out Christian Carl Rümker, director of the city's observatory and navigation school.

Rümker had Australian connections. Born in Mecklenburg and educated in Berlin, he taught mathematics in Hamburg for a time during the Napoleonic wars before going to England, where he served in the East India Company's navy. In 1813, he was press-ganged into the Royal Navy while walking on a London street. Fortunately, the captain of the ship on which he found himself recognised his talents and training and appointed him navigation instructor, with officer rank. While teaching naval cadets during the next few years, he also cultivated an interest in astronomy that led to his being engaged in 1821 by Sir Thomas Brisbane, the new Governor of New South Wales, to accompany him to Australia to run the astronomical observatory he proposed to establish there—the so-called Parramatta Observatory. When Brisbane was recalled in 1825, the observatory was taken over by the New South Wales Government and Rümker was appointed director. In 1828, he was granted leave to go to England to obtain new instruments for the observatory, but in fact he never returned to Australia and instead became director of the Navigation School in Hamburg. By the time Neumayer met him in 1851, he was generally regarded as Germany's leading authority on navigational science. He evidently took a liking to Neumayer—most people did—and admitted him not just to the school but to his home. Within a few weeks, Neumayer sat the *Schifferexamen*, the formal examination that qualified him for his mate's certificate. He then lectured in Rümker's school for several months before signing up in late 1851 for a voyage to Australia on the ship *Reiherstieg*, belonging to the famous Hamburg shipping company of J.C. Godeffroy und Sohn.

In Australia, Neumayer was often referred to as 'Professor' Neumayer, and he does not seem to have demurred at the use of the title. In Germany, as in the USA, 'Professor' is not necessarily a statement of academic rank applicable to someone holding a professorial-level appointment in a university, but can be a courtesy title for anyone teaching at tertiary level—that is, for anyone who professes their subject. It was surely in the latter sense that Neumayer was given the title in Australia; presumably it referred to his having been a teacher at the Hamburg Navigation School, and perhaps also to his earlier assistantship at the University of Munich.

Reiherstieg, with Neumayer aboard, arrived at Port Jackson in August 1852, whereupon the entire crew deserted and headed for the nearby gold-fields,

leaving only Neumayer and the ship's officers on board. Eventually they found another crew and traded around the Australian coast for a time, between Wide Bay in Queensland and Port Lincoln in South Australia. In due course, Neumayer sought release from his contract and also went to the goldfields, where he seems to have done quite well; and in January 1854—that is, about 18 months after he arrived in Australia—he sailed again for Europe.

It seems to have been during this first visit to Australia that Neumayer conceived the idea of establishing a geophysical observatory there. Back in Germany, he set about finding the necessary financial support. He tells us he gave lectures in 'most of the capital cities of Germany' about conditions in Australia (Home & Kretzer 1991: 229)—advice intended for prospective emigrants or gold-seekers, of course—but also about his geophysical project. Eventually, it paid off: Justus von Liebig, the famous chemist, then principal adviser on technical matters to the King of Bavaria, heard one of his lectures, was persuaded by it, and arranged for Neumayer to be outfitted with the instruments he needed at the King's expense. Neumayer was then able to use the fact that he had this support to persuade the Hamburg shipping magnate Gustav Godeffroy to give him free passage to Australia on one of the Godeffroy company's ships, *La Rochelle*, and control of the ship's navigation en route. Through Godeffroy, the Senate of the City of Hamburg was persuaded also to contribute money towards Neumayer's project.

What, though, was Neumayer's project and what were the motivations that lay behind it? In the submission in which he sought support for it from the Victorian Government (Home & Kretzer 1991: 228-232, Home 1991), Neumayer outlined four major lines of geophysical inquiry that he wished to pursue and in fact did subsequently pursue, the roots of which we can easily recognise in his earlier career as just outlined, as follows:

1. collecting and analysing the logs of all ships entering the port of Melbourne for information about prevailing winds and currents on the routes to Melbourne;
2. maintaining a system of hourly recording of the elements of the Earth's magnetic field—the declination, inclination (or dip) and horizontal intensity;
3. systematic recording of various meteorological variables; and
4. carrying out a magnetic survey of the colony.

In his initial submission, Neumayer also proposed making systematic observations that could be related to the significance for navigation of the increasing amounts of iron being used in the construction of ships—the so-called problem of 'ship's magnetism'—but in the event he seems not to have pursued this in any explicit way (though he would doubtless have argued that the other things he was doing were highly germane to this problem). The problem had first been clearly identified by Matthew Flinders during his circumnavigation of Australia in the first years of the nineteenth century (Flinders 1805), but the advent of iron ships in the 1850s made it an increasingly pressing issue. Only a few months before Neumayer returned to Melbourne, the well-known Arctic explorer William Scoresby had journeyed to Australia specifically to investigate the effect of his ship's magnetism during the voyage, and while anchored in Hobson's Bay had swung his ship to determine its magnetism (Scoresby 1859). Neumayer did not propose anything quite so dramatic, but argued instead for the importance, for measurements involving ship's magnetism, of knowing 'the values of the magnetic constants' at fixed observatories, 'because they give a factor by which to reduce the observations made on board of iron ships, thus making known to us the deviation of the compass'.

Such concerns on Neumayer's part are obviously linked to his more general interest in navigational matters and his commitment to these by going to sea as a young man. His desire to collect logs of ships entering the port of Melbourne is even more closely connected with this, and bears testimony to the influence on him of the writings of the American oceanographer, Matthew Fontaine Maury. Beginning in the mid-1840s, Maury revolutionised sailing routes on the world's oceans by systematically collecting information about winds and currents. He developed standard forms that he distributed to ships' captains and, from the information so obtained, issued recommended optimal directions for some of the principal commercial routes, especially in the Atlantic Ocean (Maury 1848–60). Incorporated in Maury's recommendations was the idea of sailing as closely as possible—given the knowledge of winds and currents furnished by the responses to his questionnaire—to great circles on the Earth's surface.

Neumayer evidently became acquainted with Maury's ideas at an early stage—he claimed, in fact, to have introduced them to the Navigation School in Hamburg (Neumayer 1984: 23)—and he would have been aware that they had only just begun to be applied to Australian sailing routes. When he was given charge of the navigation of *La Rochelle* for its voyage to Australia in 1856, it was to test Maury's notion of

following, as closely as possible, a great-circle route. This would involve sailing more or less due south in the Atlantic to the vicinity of Rio de Janiero, from whence the great circle to Melbourne comfortably cleared the Cape of Good Hope. This would take one too far south in the Indian Ocean to be safe from ice, and so it would be necessary to deviate somewhat to the north of the exact great-circle route; part of Neumayer's task was presumably to investigate how far south one could safely go.

While sailing this route, *La Rochelle* passed close by a group of islands in the southern Indian Ocean that were not on the ship's charts, and so when he reached Melbourne Neumayer announced their discovery (Kosmopolit 1857: 243) and wrote excitedly to Munich seeking permission to name them the König-Max-Inseln (King Max Islands) in honour of his royal patron. Unfortunately for Neumayer, others, too, had begun sailing the great-circle route and his 'discovery' had been pre-empted by the British ship's captain after whom they are now known as the McDonald Islands, who had already reported their existence. One can imagine Neumayer's embarrassment in having to tell the authorities in Munich of this! His claim to the discovery was also subjected to stern criticism by the great geographical authority August Petermann in his journal, *Petermann's geographische Mittheilungen*. Neumayer ought to have known, Petermann said, of the earlier reports, especially as one of them had appeared in the Melbourne press (Petermann 1858).

Fortunately for Neumayer, Petermann's comments remained unknown in Melbourne, where the young German's oceanographical project was seen in a very favourable light, especially in the local Chamber of Commerce, which threw its support behind him, and among the captains of the ships tied up in the harbour. Neumayer had clearly tapped into a widespread feeling that a better understanding of the Australian sailing routes was needed, and convinced people that he knew what he was doing and that what he was proposing was what needed to be done. True to his undertaking, when Neumayer in 1864, prior to his returning to Germany, published a fat volume of his meteorological and nautical observations, he including in it charts and other details embodying his recommendations for navigators sailing to and from Australia (Neumayer 1864). He also set out much of the relevant information on a large scroll that he presented to the Melbourne Chamber of Commerce, that is now held at the Victorian Public Record Office.

Neumayer's oceanographical work thus had a very practical bent. Later in life, he said (Neumayer 1984: 53) that his German patriotism had been a powerful factor in arousing his interest in nautical questions, in particular his reading of Friedrich List's book, *Das nationale System der politischen Oekonomie* (List 1841), in which List argued the importance of sea power to national prosperity—an argument that in Neumayer's mind was confirmed by Germany's impotence in the 1848 war with Denmark over Schleswig-Holstein. Concerns of this kind would naturally have pointed Neumayer towards the more practical aspects of nautical science.

Neumayer was also driven, however, by more abstract scientific concerns. Like many other young Germans of his and the preceding generation, he had been profoundly influenced by the writings of the renowned scientist and traveller, Alexander von Humboldt (1769–1859), who in his famous expedition to South America, 1799–1804, had developed a new and exciting approach to science (Humboldt 1810).

Humboldt has often been presented as a Romantic and there is no doubt that his travels were highly romantic in character. Humboldt was no armchair theorist, however, but a well-trained and hard-headed scientist who travelled for serious scientific purposes. He provided a vision of the Earth and its atmosphere and oceans as an integrated physical system—a common idea today but novel in the way Humboldt expressed it in the first years of the nineteenth century (Cannon 1978: 73-110). Instead of doing what he disparagingly called 'inventory science'—studying species of plants or animals or rocks in isolation, or doing isolated experiments in the laboratory—we should approach them as part of a connected inquiry into the dynamical structure of the world and its inhabitants. Moreover, that inquiry should be quantitative wherever possible, building on then-recent developments in the construction of scientific instruments to measure all kinds of physical variables in order to establish the connections between them on a firm empirical basis. Some sciences are particularly 'Humboldtian' in character and were especially inspired by Humboldt's influence, namely meteorology, oceanography, geology, geomagnetism, biogeography—in fact, geography in general is the quintessential Humboldtian science. In pursuit of the Humboldtian vision, the Humboldtian scientist must travel, taking his measuring instruments with him so that he can maintain his scientific observing regime. Neumayer's study of ocean currents and wind patterns is very much of a piece with this overall schema.

Humboldt himself was a very wealthy man and was able to take an astonishing array of scientific instruments and apparatus on his travels, carried along by the army of porters he could afford to employ. He had tried, he said, 'to collect in one point of view', for the whole of the Americas lying within the torrid zone from sea level to the top of the highest peaks of the Andes,

> the vegetation, the animals, the geological relations, the cultivation of the soil, the temperature of the air, the limit of perpetual snow, the chemical constitution of the atmosphere, its electrical intensity, its barometrical pressure, the decrement of gravitation, the intensity of the azure colour of the sky, the diminution of light in its passage through the successive strata of the air, the horizontal refractions, and the heat of boiling water at different heights (Humboldt 1852: vol. 1, xi, xiii).

In pursuit of such an agenda, the general observations to which earlier generations of travellers had confined themselves were wholly inadequate—precise measurement was what was required.

Few of Humboldt's followers could afford to equip themselves on the same lavish scale as the master, but even as they reconciled themselves to pursuing a more limited set of questions, they adopted his overall agenda for science. A small army of scientifically trained travellers seized the new opportunities created by the spread of European power throughout the world to investigate in a Humboldtian manner regions previously inaccessible to scientific study. Neumayer was one of these: and he, like the others, did not hesitate to proclaim his intellectual debt to 'the greatest scientific traveller who ever lived', as two other great scientific travellers, Charles Darwin and Joseph Hooker, acknowledged Humboldt to be (Brock 1993: 367; Home 1995, 1998). At the end of his introduction to his first formal report on his Melbourne observatory's operations, Neumayer quoted Humboldt:

> Weak minds complacently believe that in their own age humanity has reached the culminating point of intellectual progress; forgetting that by the internal connection existing among all natural phenomena, in proportion as we advance the field to be traversed acquires additional extension, and that it is bounded by an horizon which incessantly recedes before the eyes of the enquirer (Neumayer 1860: v).

Earlier, in Germany, while Neumayer was trying to garner support for his Australian project, Rümker gave him an introduction to the then 86-year-old Humboldt himself. Humboldt listened politely while Neumayer explained his scheme but, to Neumayer's disappointment, was not prompted thereby to provide active support. He must surely, however, have approved the spirit of what Neumayer had in mind (Wiederkehr & Schröder 1989).

The study of the Earth's magnetic field was a paradigmatic Humboldtian endeavour, something pursued by Humboldt himself with notable success. Later, he supported the efforts of the Göttingen professors Gauss and Weber in the 1830s to establish a network of magnetic recording stations across much of Europe (Cawood 1977), and was instrumental in persuading the British Government to launch a 'magnetic crusade' in the 1840s, to secure a better understanding of the field and its variations (Cawood 1979; Morrell & Thackray 1981: 512ff). A major feature of the British 'crusade' was the three-year voyage of James Clark Ross, 1840–42, in far southern waters, mapping the intensity and direction of the magnetic field as he sought to approach as closely as possible to the South Magnetic Pole. In addition, Ross established fixed observatories along his route to monitor variations in the field, one of these being the so-called 'Rossbank' observatory in Hobart that continued in operation from 1840 to 1854 (Savours & McConnell 1982). From data recorded at Hobart and at Toronto in Canada, Edward Sabine in England established a wonderfully Humboldtian generalisation, extracting from the data evidence of an 11-year cycle in the variation in the Earth's field that he was able to link with the then very recently discovered 11-year cycle in sunspot activity, thus establishing a direct new physical link between events on the Sun and on the Earth (Sabine 1851-2).

Neumayer as a young man read and was excited by Ross's account of his Antarctic voyage (Ross 1847), and seems at that time to have formed an ambition to go to Antarctica. There are, I believe, good reasons to see his going to sea and pursuing nautical science so enthusiastically as part of a long-term plan to fit himself for doing this. So, too, was his going to Australia. Once he returned to Germany in 1864, he launched a vigorous campaign to promote Antarctic exploration, arguing as he did so that the person to lead such an expedition must be 'both a seaman and a man of science, and no mere dilettante discoverer' (Neumayer 1872)—in other words, someone just like he had trained himself to be! For a time, it seemed that he would be given command of an Austrian naval expedition, but his hopes were foiled by the death

of his principal supporter in the Austrian Navy and the almost simultaneous outbreak of war in Europe.

Ross's book was probably what also first pointed Neumayer in the direction of geomagnetic research, and this would have been mightily consolidated by the period he spent working with Johann von Lamont at the Bogenhausen Observatory, because Lamont was Germany's leading authority on magnetism in the generation after Gauss. The magnetic instruments Neumayer took to Australia were of Lamont's design, and before sailing he undertook with them, at Lamont's suggestion, a magnetic survey of part of the Palatinate. In other words, by the time he left for Australia, Neumayer had been thoroughly trained in magnetic science and equipped with the most up-to-date instruments by one of the world's leading magnetic authorities. He arrived in Melbourne knowing exactly what he was doing. He also had a specific research question in mind, framed by his over-arching Humboldtian outlook: he was going to look for connections between variations in the Earth's magnetic field and variations in the condition of the atmosphere (Home & Kretzer 1991: 229). His research program therefore led him to undertake systematic meteorological as well as magnetic recording.

The idea that there might be a connection of the kind Neumayer was looking for was by no mean far-fetched—indeed, the evident relationship between the Earth's magnetism and the occurrence of aurorae, which were surely atmospheric phenomena of some kind, indicated that there definitely was such a connection. Today, of course, we know that there is, but that it occurs much higher in the atmosphere than Neumayer's recording could reach, in the ionosphere.

Part of Neumayer's magnetic research program involved making a magnetic survey of Victoria. Again, such research, seeking to link variations in the magnetic field from place to place with other factors and with the local geology in particular, was very much in the Humboldtian mould. There is a wonderful sketch by Nicolas Chevalier, who accompanied Neumayer on some of his journeys around Victoria, of Neumayer on the trail (Fig. 1). The object projecting from his pack is not a gun but a standard piece of Humboldtian scientific equipment, the mercury barometer that he used to determine his altitude.

Once again, however, Neumayer saw very practical outcomes to his research, as well as scientific ones. It was evidently important for navigation purposes to improve understanding of the local magnetic field. Neumayer also claimed, however, on the basis of his experience in Germany, that

> there exists a relation between the productiveness of a tract of land and the values of the magnetic constants. Further, there exists a relation between the same quantities and some geological formations, for instance Coal-beds.... It is [also] more than probable that there exists a relation of terrestrial magnetism and the great tracts of auriferous land in Australia (Home & Kretzer 1991: 230).

Hence a magnetic map should point to new deposits. Again, this is an idea that has subsequently borne much fruit in geophysical prospecting. Neumayer's instruments, however, were probably not good enough for this, and his mapping was not detailed enough for the idea to work at the time (Neumayer 1869).

None of Neumayer's instruments were automatically recording, they all had to be read manually. Not until a few years after Neumayer returned to Germany did the Melbourne Observatory obtain a set of automatically recording instruments to take over from the ones Neumayer had left behind. The operation of Neumayer's observatory was thus very labour-intensive and salaries therefore a large component of the observatory's running expenses, even though Neumayer himself, at least initially, was not drawing

Fig. 1. Neumayer on the trail. Sketch by Nicholas Chevalier, reproduced from Kretzer (1984: 15).

a salary. Neumayer seems to have been adept at hiring good people, and also at training them in making the required measurements. The techniques involved were, as noted already, at the forefront of science at the time. Neumayer brought to Australia new standards of work in physical science, an insistence on meticulous, precise observation that constituted a veritable sea-change from what had gone before (except at Rossbank Observatory, perhaps). Furthermore, he inculcated these standards in his assistants, so that they were maintained after he left, especially at Melbourne Observatory where the observing program he had launched was kept going (Baracchi 1896).

As for the concrete results of Neumayer's labours in Victoria, one cannot point to any special 'grand discoveries', but rather an extensive body of reliable geophysical data. Most of the data were published in four fat volumes, two published by Victoria's Government Printer during Neumayer's sojourn in the colony, the other two published in Germany after he returned there, under the supervision of Britain's leading magnetic authority, Edward Sabine (Neumayer 1860, 1864, 1867, 1869). Neumayer also published a number of papers arising out of his work; some of these were published at the time or soon afterwards, but others did not appear until many years later. More generally, one can point to at least three significant outcomes from the time he spent in Victoria:

1. an on-going (and long continued) program of magnetic recording;
2. a well bedded down network of meteorological observing stations scattered around Victoria, mostly along the coast;
3. above all, Neumayer returned to Germany having established a reputation for himself as a highly competent geophysical investigator that formed the basis of his subsequent career.

By the time Neumayer left Victoria, he was universally looked up to as one of the foremost members of the local scientific community. Even those who opposed his plans initially had been won over. Neumayer was, however, just one of many scientifically trained Germans who came to Australia in these years, a significant number of whom came, as Neumayer did, to occupy positions of leadership in Australian science (Home 1995a). There is, I believe, a straightforward explanation for this. In almost every case, those involved were inspired to come to Australia by Humboldt's vision for science, which led to large numbers of young Germans, well trained in science, to spread to all parts of the globe in the middle decades of the 19th century in pursuit of Humboldt-style scientific goals. Moreover, because the German system of higher education was the best in the world at the time and was producing research-orientated specialists rather than simply well-rounded young gentlemen, those involved very often found themselves in positions of leadership when they got to their respective destinations. This was not a phenomenon peculiar to Australia, it happened all over the world.

Neumayer is a perfect example of the wider trend. But of course he also brought his own individuality with him. Charming, politically astute, hard-working, scientifically more than competent, he made a remarkable contribution to science in his adopted home for as long as he stayed, and he continued to exert an influence on Australian science for many years after he left.

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