GEOMAGNETIC RESEARCH IN THE 19th CENTURY

W SCHRÖDER¹ and K-H WIEDERKEHR²

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The development of geomagnetic research in the 19th century is discussed in detail. Beginning with the Göttinng Magnetic Society (Gauss-Weber), scientific activity developed under von Humboldt’s influence and reached a peak during the First International Polar Year (1882-1883). This was a broad international co-operation, for which new instruments were constructed and new aspects of the geomagnetic studies were opened, including solar-terrestrial physics (Sun – aurora – Earth’s atmosphere).

Keywords: geophysics; geomagnetic main field; Göttinng Magnetic Society; history of geomagnetism; international co-operation; solar-terrestrial physics

1. Hansteen, Humboldt and the Göttinng Magnetic Society

In the first decades of the 19th century geomagnetism assumed a special interest for many scientist as this field of science, which had been previously isolated, became linked to electricity. Hans Christian Oersted discovered electromagnetism in 1820, Thomas Johann Seebeck thermoelectricity in 1821 (called by Seebeck “thermagnetism”) and Michael Faraday electromagnetic induction in 1831. Geomagnetic research, however, had developed even earlier due to impetuses by Alexander von Humboldt and the Norwegian Christopher Hansteen (1784–1873). Humboldt regularly carried out magnetic measurements during his trips in America and in Russia and determined the geomagnetic horizontal intensity by oscillating a rod magnet. These measurements were nevertheless only “relative” to the weakest field at the geomagnetic equator (inclination 0°). Hansteen published in 1819 a monograph entitled “Studies of the Magnetism of the Earth”. He supposed that the geomagnetic field is due to two rod magnets near to the centre of the Earth. He studied intensively the slow movements of the geomagnetic poles (secular variation) and the daily variation of the geomagnetic force (which had already been previously observed). He tried to explain this variation in terms of a remote magnetic effect of the Sun.

The great mathematician, Carl Friedrich Gauss, devoted himself to concrete tasks motivated by special events. His most significant works in physics deal with magnetism; they became pioneering works. At the conference of German naturalists and physicians in 1828 in Berlin he became acquainted with a young promising physicist, Wilhelm Weber, who was Assistant Professor at the University of Halle. When the chair of physics became vacant at the University Georgia Augusta,

¹Hechelstrasse 8, D-28777 Bremen, Germany (corresponding author)
²Birkenau 24, D-22087 Hamburg, Germany

Gauss recommended this inventive experimenter and attracted him to Göttingen. Thus Weber’s ambition to improve himself through Gauss’s proximity was fulfilled (Wiederkehr 1997). This was the beginning of a close co-operation which is seldom experienced and it is difficult to separate the individual contributions by the two scientists. Weber followed up, and consequently realized, Gauss’s ideas in later years. The impetus for new research in geomagnetism came from Humboldt’s letter to Weber at the end of 1831. After his trip in Russia Humboldt initiated simultaneous measurements at several locations and requested co-operation from Göttingen, too. Gauss had dealt with geomagnetism theoretically and later discovered the applied potential laws (Schafer 1929). In 1833 Gauss and Weber established a geomagnetic observatory and joined Humboldt’s observational network. They designed new geomagnetic instruments, including the unifilar magnetometer for declination and its variations and the bifilar magnetometer for horizontal intensity. The first published paper was Gauss’s famous “Intensitas vis magneticae terrestris ad mensuram absolutam revocata” (The intensity of the geomagnetic force in absolute measure, 1832). Absolute measurements are contrasted here with the relative measurements as previously carried out by Humboldt. Gauss established for this purpose the now well known main positions of a magnet named after him. Both the horizontal intensity and the magnetic moment of the applied rod magnet could be exactly determined by this method. Humboldt’s measurements implied a constant magnetic force of the rod magnet — a condition which was not always fulfilled. Gauss introduced in “Intensitas” the system with three basic units, namely the units of length, mass and time. Such systems were later called absolute systems. The Göttingen Magnetic Society was founded due to Humboldt’s and Gauss’ reputation. The leadership of the Society was in Gauss’s and Weber’s hands as initiated by Humboldt. The Society was a voluntary association of co-operating scientists from many countries who carried out measurements at predetermined times, often with identical instruments. The Göttingen Magnetic Society was the model for later programmes of geophysical co-operation, including the First Polar Year 1882-1883 and the International Geophysical Year 1957–1958. The Göttingen Observatory and its equipment became prototypes for later similar observations. Weber contributed to the publications through a series of annual reports, called “Results” (Wiederkehr 1964). Beginning in 1836, six volumes were published, together with an “Atlas of Geomagnetism”. In the “Results of 1838”, Gauss published his pioneering work “General Theory of Geomagnetism”. It remains to this day one of the pillars of the mathematical treatment of the geomagnetic field. It is not a theory in the present sense of the word, as it does not cover the causes of geomagnetism. Based on the sparse observational material at his disposal Gauss described in this work, using his potential laws and spherical functions, the geomagnetic field at the Earth’s surface. The question of whether it is caused by great magnets in the Earth’s interior or by electric currents remained open. The main source was anyway, according to Gauss, within the Earth’s body. Nevertheless, he considered it possible that part of the variations of the geomagnetic force could be caused by electric currents in the atmosphere — this was at that time a remarkable prediction. Weber introduced in the “Results of 1840” the first absolute electric current unit. This was the basis for the absolute