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ESTABLISHMENT

The Department of Terrestrial Magnetism, invariably called DTM and referred to briefly in the beginning as the Department of International Research in Terrestrial Magnetism, was the creation of Louis Agricola Bauer and for most of the time of his active participation it was the creature of his will. Bauer was born of German–American parents in Cincinnati in 1865. He completed a doctoral dissertation at Berlin in 1895 on the mathematical analysis of the secular variation of the Earth's magnetic field, and this thesis work so stimulated his interest that he established a scientific journal, *Terrestrial Magnetism: An International Quarterly*, in 1896 when he returned to the United States, the only periodical devoted specifically to geomagnetism, atmospheric electricity and related subjects.

Perhaps the greatest accomplishment of nineteenth-century physics was the creation of a theory that described accurately all of the observed phenomena of electricity and magnetism, a theory that predicted as its crowning achievement the existence of electromagnetic waves. By the end of the century this had given rise to a practical method for maritime communication over distances of hundreds of kilometers, the last of the century's practical applications that were rapidly transforming civilization: worldwide telegraph systems, cities linked by telephone, electric traction for railways and the replacement of dim oil lamps by brilliant electric lights. For all its triumphs, however, the theory left one particularly vexing question unexplained. There was nothing that provided even a clue for the origin of the Earth's magnetic field.

Geomagnetism had been the subject of continual study since the invention of the compass needle around 1300. It was a subject that always presented a new layer of confusion when an older one had been removed. It was quickly learned that the compass did not generally point toward the geographic north pole but varied according to the location of the observer. This was followed by the knowledge that the "variation" itself varied, compelling it to be renamed "declination." When properly balanced, needles were found to lie parallel to the Earth's surface only in the vicinity of the equator with the north-seeking end pointing down as latitude increased to the north, and the south-pointing end pointing down as latitude increased to the south. Further observations disclosed that the model suggested by this, ascribing

the field to a single dipole set at an angle with the Earth's rotation axis, was far too simple to approximate the data. Temporal variation of declination was observed for periods of hours as well as years. Even more disconcerting, the magnitude of the field was found to be decreasing. All these results depended on measurements made primarily in Europe and America.

By the nineteenth century the geomagnetic field was being examined in whatever locations were accessible, and instruments were being developed to allow more accurate measurements to be made. Carl Friedrich Gauss and Wilhelm Eduard Weber provided the discipline with a sound observational and analytical underpinning during the 1830s, but neither an understanding nor a global mapping were at hand. When Bauer proposed his approach to this seemingly endless problem there had been no reliable observations at sea for fifty years, and extensive international data – in one case, the International Polar Year of 1882–83, where their acquisition was an expressed goal – were not reduced to usable form, as no international bureau existed for this rudimentary task. The Pacific Ocean had regions with large declination errors, a serious navigational hazard.

In 1899 Bauer became the first chief of the Division of Terrestrial Magnetism at the US Coast and Geodetic Survey. He seized the possibility offered by the founding of the Carnegie Institution to accomplish what was fixed in his mind: to map accurately the geomagnetic field and study its temporal variation as a first step toward understanding its causes and influences. He saw such an organization as the key to worldwide cooperation. Although national groups were studying geomagnetism in manners similar to that of the Coast and Geodetic Survey, their governmental nature hindered the needed global cooperation. Furthermore, such a survey had to be made during a time short enough to allow the corrections for temporal drift to be small. Observational programs that extended over decades would yield data difficult to normalize and the required accuracy would be lost. Things had to be pushed. Bauer correctly believed that a non-governmental agency could marshal the efforts of various national groups and provide observers for the many parts of the Earth's surface that would not be covered by the others.

The rapidity with which the Department was formed following Bauer's proposal was in striking contrast to the thoughtful organization of the remainder of the Institution. The Trustees established 18 committees in the first year for advice as to what subjects of scholarship were to be considered, and terrestrial magnetism was not represented. In spite of this the Department received its initial funding without significant discussion. This success in persuading the founders of the Institution to support the plan may have lain in a greater public awareness of magnetism as an accessible and interesting science than would be the case today. Most people were familiar with the compass that accompanied them on the Sunday walks, which were then common. They

knew of its deviation from true north and appreciated it as the basis for marine navigation and knew it as a scientific mystery. This is illustrated in the 1911 edition of *Encyclopaedia Britannica*, which devoted 34 pages to terrestrial magnetism and magnetometers. The 1993 edition had only 13, most being about the effects attributable to the solar wind.

Bauer's success in this venture owed much to his inspiring international outlook. Given no middle name at birth, he provided himself with "Agricola," the Latin word for farmer, to match his German "Bauer"; he also insisted that his first name be given the French pronunciation.[1] This outlook was obvious in his journal, *Terrestrial Magnetism*, declared open to papers in "all languages that can be printed with Roman characters." His proposal was backed by letters from the heads of the US Coast and Geodetic Survey, the German Naval Observatory, the Bureau Central Météorologique, the Bureau des Longitudes, the University of Manchester and the Prussian Meteorological Institute among others.

Of special significance, however, was the selection of Robert Simpson Woodward as Institution President at the same time as Bauer's appointment as the Department Director. Woodward was the Dean of the School of Pure Sciences of Columbia University, but more to the point, he had been Chief Geographer at the Geological Survey, a discipline that would have naturally been supportive of an international effort to determine finally the nature of the Earth's magnetic field. The Coast and Geodetic Survey had given Bauer's proposal strong support, and two years after the Department's establishment Henry S. Pritchett, Superintendent of the Survey, was elected as a Carnegie Trustee where he soon served on the important three-member Finance Committee.

From the time of its establishment in 1904 the Department occupied quarters rented in the Ontario Apartments located to the north of Columbia Road on a promontory overlooking the Zoological Park in northwest Washington (Fig. 1.1). The impressive building was constructed in 1904 by a company of which Charles D. Walcott, Secretary of the Institution, was president.[2] It remains there today as a cooperative apartment house and retains all its early stateliness. Initial requirements were only to provide space for the administrative and logistic support of the far-flung operations and for the personnel needed to reduce to usable form the huge amount of magnetic data that began to arrive and that had accumulated from varied sources over the previous years. Bauer maintained a residence there for himself and his family as well as another apartment for visitors. In January 1908 a small machine shop was set up, certainly an anomalous fixture for a fashionable residence, at least according to the more dainty modern zoning practices. By the time the Department moved to the Broad Branch Road location, a total of 16 rooms were required in the Ontario. Observational research was carried out in two non-magnetic huts overlooking the Zoo about 300 feet from the building.

Figure 1.1 The west wing of the Ontario Apartments. Completed in 1904 when DTM was one of the first tenants. An additional wing was built the following year. (Archives of the Ontario)

Figure 1.2 Buildings and site of the Department, 3 December 1919. Photograph taken by Dr. W. F. Meggers of the Bureau of Standards from an airplane at 4000 feet. The Main Building is prominent; the wooden Standardizing Magnetic Observatory is located at the right rear; the new Experiment Building is to the left, partially hidden by trees.

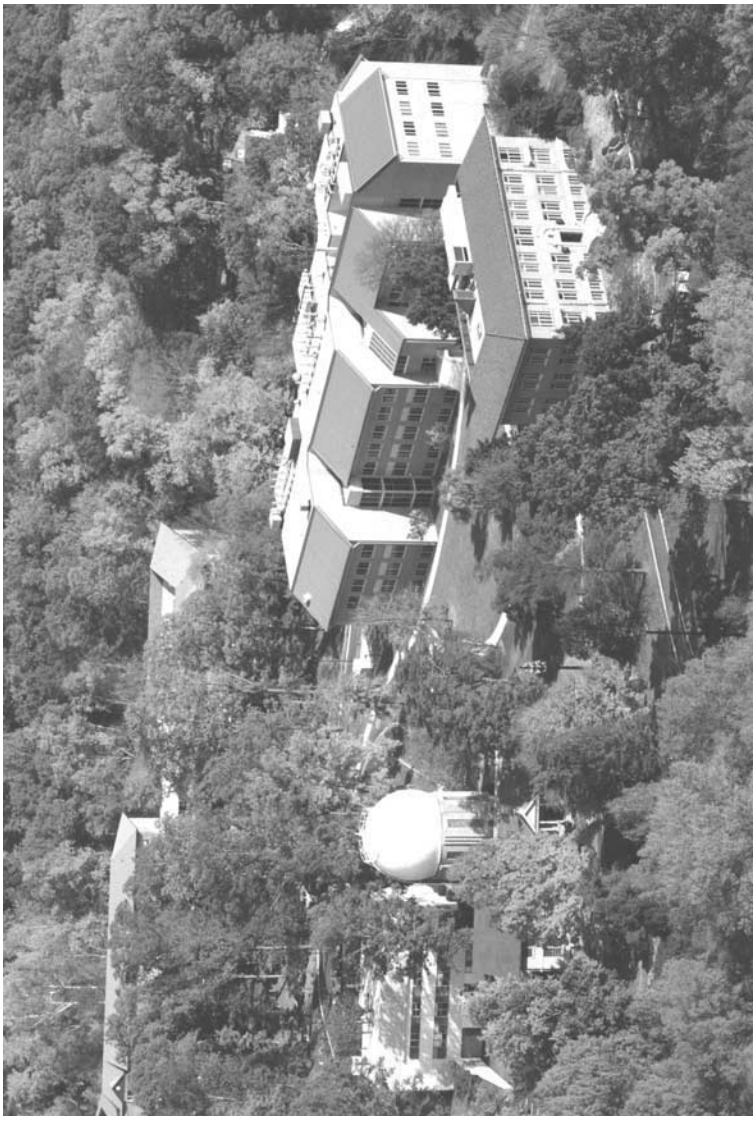

Figure 1.3 The renovated campus of the co-located Department of Terrestrial Magnetism and Geophysical Laboratory in fall 1991. The Main Building, later named the Abelson Building, is readily identified at the right front. The Geophysical Laboratory moved from their previous home on Upton Street, NW and occupied the left two thirds of the large building, called the Research Building. DTM occupied the right third of the Research Building and the Cyclotron Building, partly obscured by the trees and to the left of the prominent Van de Graaff. The Experiment Building and its Annex are at the left, partially obscured by trees. The Standardizing Magnetic Observatory was demolished.

Two staff members joined Bauer in the first months of the Department's operation: John Adam Fleming and James Percy Ault, both magnetic observers. Fleming immediately became Bauer's chief assistant with responsibility for testing instruments and with administrative abilities that became increasingly important in the functioning of the Department. Ault was temporarily assigned to the Coast and Geodetic Survey to secure training for magnetic observations at sea and demonstrated the characteristics of a mariner that soon earned him a license as master mariner.

The expanded needs of the Department for experimental work and for fireproof storage of the accumulating records led the Trustees to allot $127 200 for acquiring 7.4 acres of land and build permanent quarters at the present location. The large size of the tract and its location were chosen to reduce magnetic disturbances to a minimum. No industrial activity was anywhere near and the Connecticut Avenue electric streetcar line was 2100 feet to the west. Most of the employees found the new location out in the country, and for their convenience a shelter was built on the corner of Connecticut and 36th Street. Later the commuters wanted a parking lot, strikingly absent in the first ground layout.

Design of the main building, rendered in the style of the Italian renaissance, and a non-magnetic wooden building for instrument standardization came from the prominent Washington architect, Waddy B. Wood (Fig. 1.2). A contract was awarded to the Davis Construction Company on 29 April 1913 and the work completed on 14 February of the following year. Other buildings came later (Fig. 1.3).

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CRUISES AND WAR

Bauer submitted a plan to the Institution on 3 October 1904 to undertake a magnetic survey of the Pacific Ocean. While the general state of accurate knowledge of the terrestrial field worldwide was poor at the time, the knowledge of the Pacific was particularly bad for the obvious reason that it depended on a few occasional expeditions undertaken many years before and on observations at various islands, many of which had strong local effects. Bauer's ultimate goal was explaining at some level the origins of the terrestrial field, but he had nothing against helping mariners, who had to sail the Pacific with the worst compass corrections of the globe and with the gyrocompass still in the future. Such a project required a vessel whose construction had a minimum of magnetic materials that might interfere with the measurements. Although the construction of a special ship with that in mind was discussed immediately, it was thought prudent to gain experience in a chartered wooden vessel from which as much of the iron had been removed as possible. A few cruises would provide important guidance for the design of a special non-magnetic research vessel as well as gather experience in the difficult task of making the measurements at sea.

The brigantine *Galilee* proved to be a suitable choice. Built in Benicia, California in 1891 it had been engaged originally in carrying passengers between San Francisco and Tahiti but was then carrying freight to various South Pacific islands. Iron furnishings were removed, the steel standing rigging replaced by hemp, and a bridge running fore and aft between the masts was constructed 12 feet above the deck for mounting the instruments. The removal of iron did not convert the *Galilee* into a perfect research vessel but it did produce "magnetic constants" substantially lower than those of any ship previously used for this purpose. The charter called for the Department to pay $1400 per month for the vessel, master and crew (Fig. 2.1).

On 5 August 1905 the *Galilee* sailed from San Francisco with J. F. Pratt, an officer of the Coast and Geodetic Survey, in command of the expedition but with Captain J. T. Hayes as sailing master. There were three others in the scientific party, including J. P. Ault, who would become both commander and sailing master on later cruises of the *Carnegie*. The first passage was an experimental trip to San Diego during which proficiencies in observational techniques were developed under the supervision of the Director. Especially

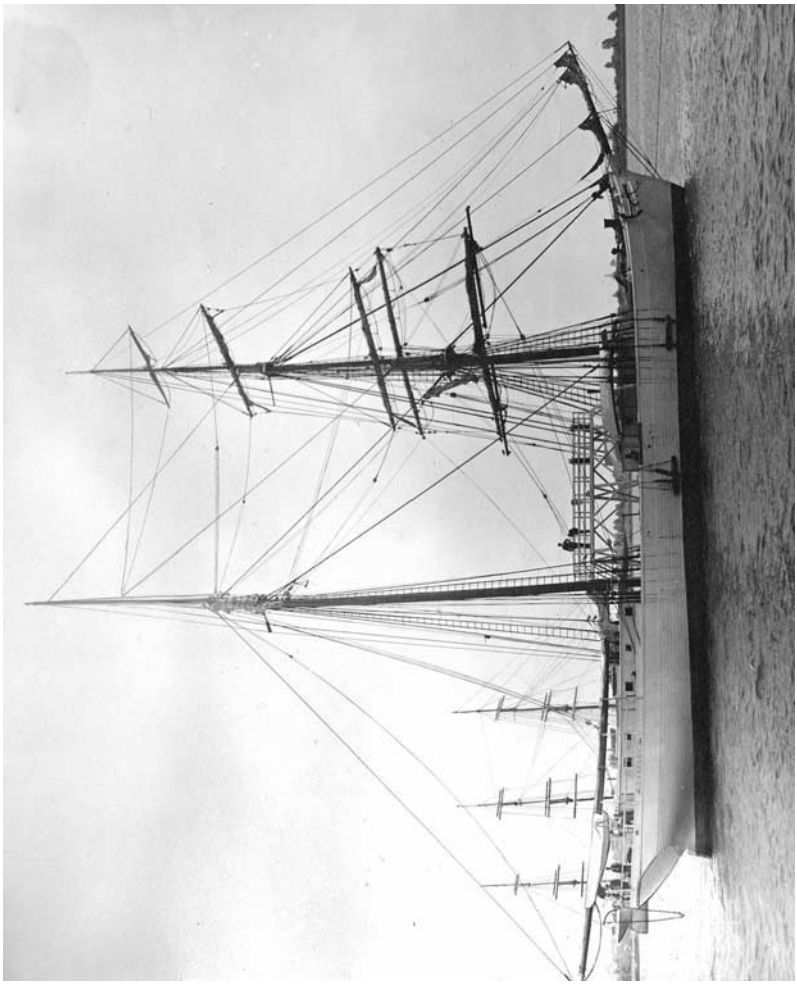

Figure 2.1 The *Galilee* in San Francisco harbor on 2 August 1905. This vessel was chartered from 1905 to 1908 for the first cruises. Magnetic fittings were removed to the extent structural integrity allowed. The bridge is seen above the deck and between the masts for mounting instruments as far as possible from magnetic disturbances.

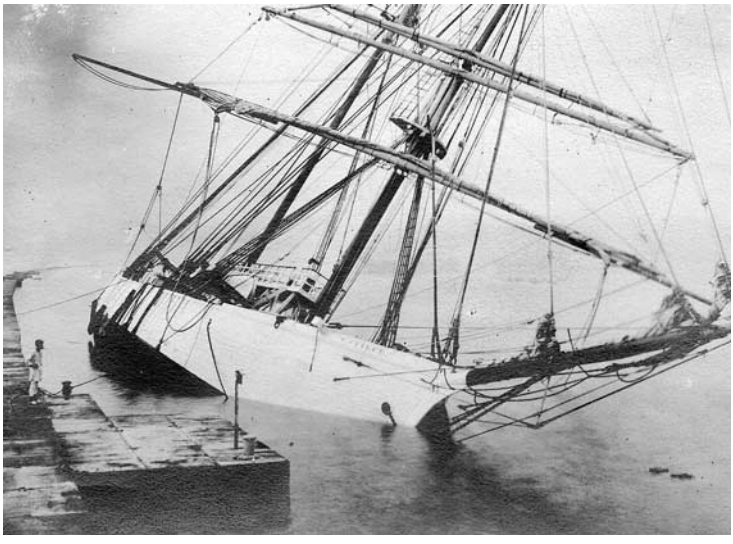

Figure 2.2 The *Galilee* was caught by a typhoon in August 1906 while in Yokohama harbor. The water was pumped out and it was soon on its way.

important was learning to determine the corrections that had to be applied to the raw data as a result of the iron that remained in the vessel, a procedure called swinging ship because of the need to orient the vessel into several different directions. This was followed by a voyage to Hawaii and beyond, returning to San Diego.

After this first cruise, alterations were made to the vessel as seemed advisable based on the early experience; the observers from the Coast and Geodetic Survey returned to their normal duties ashore, and a second more extensive Pacific cruise began on 2 March 1906, one enlivened by the ship sinking in Yokohama harbor as a consequence of a typhoon (Fig. 2.2).

The *Galilee*'s final cruise, under the command of William John Peters with Hayes as sailing master, ended on 5 June 1908 in San Francisco, and the vessel was returned to the owners (Figs. 2.3 and 2.4). Peters had joined the Institution in 1906 on returning from the Ziegler Polar Expedition of 1903–05 in which he had served as second in command and chief of its scientific work. He had worked for the Geological Survey, carrying out topographical work in the western United States and Alaska. He remained with the Department until his retirement in 1928.

On 8 December 1908 the Trustees of the Institution let a contract to the Tebo Yacht Basin Company of Brooklyn for the construction of a non-magnetic vessel under the supervision of Captain Peters, who controlled all metals that went into the fabrication. It was launched on 12 June of the following year, christened *Carnegie* by Dr. Bauer's daughter, Dorothea Louise,