ART. LXII.—*Magnetic and Gravity Observations on the West Coast of Africa and at some islands in the North and South Atlantic*; by E. D. PRESTON.*

THE value of certain magnetic observations depends on the interval of time between the determinations: gravity observations, when their object is a more accurate knowledge of the shape of the earth, depend for their value on the area over which the stations are scattered. Coast, continental and island stations, as well as those on mountains and plains, each have their own particular evidence to furnish. It must be admitted that this evidence is not always unanimous, but the lack of unanimity may result from a real cause, inherent in the nature of matter, or it may be only apparent and come from the dif-

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ference in instruments and in the interpretation of results. Then again, if it may be assumed that the mean figure of the earth is already known, as closely as the pendulum will give it, research should be carried on by determining local variations of the force of gravity.

It is evident that extended voyages offer exceptional facilities for increasing our knowledge in magnetism and gravitation and should be utilized when possible. Such an occasion presented itself in the fall of 1889 when it was proposed to send an expedition to Africa to observe the total eclipse of the sun on December 22. The eclipse party was under the direction of Professor Todd of Amherst College. Through his courtesy, and by authority of Commodore Dewey, Chief of Equipment and Recruiting, U. S. N., the superintendent of the Coast and Geodetic Survey sent one of the assistants to make magnetic and gravity observations. Originally, work of this nature was only proposed for the eclipse station in Angola. It was noticed, however, that on the return trip, several important stations might be visited without much loss of time, and that these stations had already been occupied by earlier pendulum observers. Permission was therefore granted by the Hon. Secretary of the Navy, for the vessel to stop at the Cape of Good Hope, St. Helena and Ascension long enough to enable the Coast and Geodetic Survey representative, to make his determinations. In addition to this, stops were made at Barbados and Bermuda, and through the kindness of Captain Yates, commanding the "Pensacola," full series of observations were obtained. On the outward trip time was more valuable since it was desirable to reach Angola as soon as possible. For this reason only magnetic work was attempted at the coaling places. There appear then as the result of the trip fourteen magnetic and eight gravity stations, distributed as follows: Azores, Cape Verde Islands, Freetown in Sierra Leone, Elmina on the Gold Coast, St. Paul de Loanda, and Cabiri, in Angola, Capetown, St. Helena, Ascension, Barbados, and Bermuda. On both St. Helena and Ascension the force of gravity was measured at the level of the sea and at the highest elevation practicable. On the former island Jamestown was selected for the lower point, and Napoleon's residence at Longwood, for the upper. The pendulum apparatus was set up in the kitchen of what is known as Napoleon's new house, now leased by Mr. Deason. At Ascension the sea station was at Georgetown—the other was on Green Mountain. Foster's observations at the latter place show a defect of gravity of two oscillations per day as compared with the sea-level—that is to say, that having corrected his oscillations on the summit, for elevation, and for the effect of the mountain, on the supposition that it was solid, he

found the result to be less than the number of oscillations, actually counted at the sea-level. As some recent observations on island mountains give results at variance with this, it was desirable to repeat the Ascension work with modern instruments. Indeed, it was to connect with Foster, and to verify his result for Ascension, that an extension of our gravity work was proposed. The entire voyage lasted eight months, of which 123 days were spent on shipboard. The area covered by the stations extends from Washington on the north and west, to Capetown on the south and east, making a range of 73° in latitude and 96° in longitude. It so happens that the most northern station is also the most western, and the most southern the most eastern. The elevations range from 7 feet at Bermuda to 2,250 at Ascension. The magnetic observations at Azores, Cape Verde Islands, Freetown and Elmina were shortened by lack of time, one, or at most two days being devoted to each place; but at all other stations the declination, dip, and horizontal force, were determined on each of three consecutive days, besides, at a few stations, making hourly observations on several other days. At Cabiri the needle remained suspended during the total eclipse, but no abnormal change was noticed. For the gravity work, at every station about 30 swings were made with each pendulum—using them in both positions, and continuing the observations through the entire 24 hours. The pendulums used were Nos. 2 and 3, of the Peirce pattern, being of the invariable reversible type. The length of the former between the knives is one meter, that of the latter a yard. Besides having been employed at numerous home stations, No. 3 has now been swung at 13 foreign ones; including several in the Pacific.

Of the 14 magnetic stations all but one have been occupied by earlier observers. Determinations were made in the Azores between 1497 and 1829; in the Cape Verde Islands between 1841 and 1853; in Sierra Leone between 1826 and 1842; at Freetown, by Sabine, in 1822; at Cape Coast Castle, seven miles from Elmina, in 1838 and 1841. St. Paul de Loanda has a magnetic observatory, and issues published reports containing results for declination, dip and intensity. The work at the Cape of Good Hope between 1840 and 1850, is well known, and Sabine's account of five years' observations at St. Helena from 1841 to 1845, is one of our classic magnetic volumes. The station at Sister's Walk in Jamestown, was selected by Sir James Ross in 1840, but as the values at this point are not normal the Coast Survey station was chosen some distance back from the mountain and midway between it and Ladder Hill. Sister's Walk is close against the foot cliffs of Rupert's Hill. The dip was measured at Ascension in 1822, and all

three elements were determined by the Challenger Expedition in 1876. Observations have been made eight times at the Barbados between 1726 and 1844 and six times at Bermuda between 1831 and 1876. The Coast Survey determinations at the latter place were made on Nonsuch Island at the extreme eastern end of the group. They are, undoubtedly, the only magnetic observations ever made at this place, and it is more than probable that the station will never be re-occupied. This is to be regretted; but it was necessary to utilize the ten days spent in quarantine in order to make steamer connection. The work had to be done here, if it was to be done at all in Bermuda.

The gravity stations in common with other observers were Capetown, St. Helena and Ascension. Foster's celebrated series includes all of these. Sabine determined gravity at Ascension in 1822 and deFreycinet observed at the Cape in his voyage around the world in 1819. Besides the idea of verifying Foster's result, that Ascension Island is too light, it was highly desirable to connect his service with our own, which now includes island as well as continental stations. But it was assumed sufficient to have the series exactly coincident at two points. Lemon Valley was therefore not re-occupied at St. Helena. Moreover, the Ascension stations are practically identical in the two series, and St. Helena was occupied at the sea as well as at the summit, which gives a third connection with Foster, and supplies a check on his Ascension result.

In order that an approximate estimate might be made for the matter lying above the sea-level at St. Helena, many heights were determined barometrically by Professor Abbe of the U. S. Signal Service. By using these, some idea of the attraction of the mountain may be had, and it will then be seen, whether the islands in the Atlantic and Pacific differ essentially as regards internal structure. Rock specimens were brought from both St. Helena and Ascension. Their densities may give an indication of what we should look for in the gravity results, providing that both islands were subject to the same laws of formation.

The "Pensacola" staid at St. Helena but sixteen days. During this time two stations were selected, the pendulums were swung through six consecutive days and nights at each place, magnetic observations were made on six different days and the instrumental outfit transported to and from the mountain top. Equally rapid progress was made at Ascension, where the conditions were similar in many respects. This amount of work could not have been accomplished, however, without the able and generous assistance of the naval cadets attached to the "Pensacola," and of Professor Bigelow of the eclipse party, to all of whom I wish here to express my obligations. I wish

also to tender thanks to Captain A. R. Yates, commanding, and to Lieut. Commander Hanford, executive officer of the "Pensacola." The landing and shipping of the instruments was always a matter requiring care, and was often done under difficulty, yet in the numerous transfers nothing was ever broken or lost.

An account of the trip would be incomplete without a due acknowledgment of the services rendered by the government officials at the different stopping places.

At Loanda the governor of the province of Angola gave us free passes for all railroad travel from the coast to Cabiri, where the party went to observe the eclipse on December 22. At the Cape of Good Hope every facility was given. Her Majesty's Astronomer, Dr. Gill, kindly furnished myself and aid with quarters at the observatory, and made a special time determination every night for pendulum work. The railroad authorities gave passes for a trip to the diamond fields at Kimberly, 600 miles in the interior. As a week was necessary for this, the kind offer could only be accepted by those unoccupied with scientific work. At St. Helena Gov. Antrobus offered the use of the public park for the magnetic observations, and the library room of the police court for the gravity work. The unique character of the island government at Ascension placed us under more than ordinary obligations. As there are no civilians at this place we were necessarily the guests of Her Majesty's Government. Capt. R. H. Napier, R. N., placed at our disposition an entire building in Bunghole Square for the observations at the garrison. The pier was built for the transit, tents were erected for magnetic and astronomical work, and guard duty performed by the marines. A ration per day from the island stores was served to each member of the party during the stay. At Barbados and Bermuda we were again on English soil and received the usual generous welcome. At the former place Governor Sendall came to Hastings and made a personal examination of the instruments and methods of observing. At Bermuda General Newdegate kindly gave us the use of the government launch for the transportation of the instruments from Quarantine Island to St. Georges, besides showing other attentions of an unofficial character.

The definite results, from the observations on this voyage, may be expected before the next meeting of the Association. Whether they show the Atlantic islands to be light or heavy as compared with the continental masses, they will at least add considerable new material for the determination of the earth's figure.

The following table contains a list of the stations with their approximate positions, date of occupation, kind of determinations and initials of observers.

Stations.	Approximate Position.			Kind of Determinations.	Epoch.	Observers.
	ϕ	λ	feet			
Washington, Coast Survey Office and Smithsonian	+ 38° 53'	+ 77° 1'	34	Magnetic and Gravity.	1889. Sept. and Oct.	P. F.
Azores (Fayal)	+ 38 32	+ 28 39	30	Magnetic.	Nov.	P.
Cape Verde Islands (Porto Grande)	+ 16 53	+ 24 59	15	Magnetic.	Nov.	P.
Sierra Leone (Freetown)	+ 8 30	+ 13 14	10	Magnetic.	Nov.	P.
Gold Coast (Elmina)	+ 5 5	+ 1 20	10	Magnetic.	Nov.	P.
Angola, Loanda	- 8 49	- 13 7	150	Magnetic and Gravity.	Dec.	P. M.
Angola, Cabiri	- 8 47	- 13 59	200	Magnetic.	Dec.	P.
Capetown Royal Observatory	- 33 56	- 18 29	37	Magnetic and Gravity.	1890. Jan. and Feb.	P. Pa.
St. Helena, Jamestown	- 15 55	+ 5 42	33	Magnetic and Gravity.	Feb.	P. M. Mac B.
St. Helena, Longwood	- 15 57	+ 5 40	1750	Magnetic and Gravity.	Mar.	P. M. Mac B.
Ascension, Georgetown	- 7 56	+ 14 25	15	Magnetic and Gravity.	Mar.	P. M. W. B.
Ascension, Green Mountain	- 7 57	+ 14 22	2250	Magnetic and Gravity.	April.	P. M. W. B.
Barbados, Bridgetown	+ 13 7	+ 59 36	60	Magnetic and Gravity.	May.	P. M. W. Mac.
Bermuda, Nonsuch Island	+ 32 21	+ 64 39	35	Magnetic.	May.	P.
Bermuda, St. Georges	+ 32 23	+ 64 40	7	Gravity.	June.	P.
Washington, Smithsonian	+ 38 53	+ 77 1	34	Gravity.	July.	P. F.

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