of enjoying these things, I say, as fiction. Imaginative advertising, as advertising, has delighted me from the start. I have read them all from "Sunny Jim" to the "Gold Dust Twins." But, after all, could we not purchase more intelligently if we were better posted on composition and less on catch-phrases and cartoons? Is it too much to hope that chemical composition will one day be the public's guide in matters of this sort? Carnation milk, Violet wafers, Butternut bread, Bullfrog beer, Buttermilk soap and Grapenuts! I can see an opportunity for chemistry here!

In conclusion, there may be some present who will think I have praised chemistry and chemists too highly. Some may say that important matters speak for themselves and need no praising. I am not in the least of the opinion that chemistry needs praising; what it does require in this country is, calling the public's attention to its importance.

W. D. Richardson

SOME RESULTS OF THE MAGNETIC SURVEY OF THE UNITED STATES[1]

The United States of North America, embracing nearly one fifteenth of the entire land area of the globe, or an area about equal to that of Europe, constitutes at present the largest land area for which a general magnetic survey, in sufficient detail and of the requisite accuracy, has been made. The three magnetic elements: the magnetic declination, the inclination and the intensity of the magnetic force, have been determined at about 3,500 fairly uniformly distributed points. Of this number of stations about two thirds were occupied during the seven years the speaker had charge of the magnetic operations of the United States Coast and Geodetic Survey, viz., 1899–1906.

[1] Presented before the National Academy of Sciences, Washington, D. C., April 22, 1908.

The stations are, on the average, thirty to forty miles apart, or we may say there is, on the average, one station for every 900 or 1,000 square miles. Of course, in some states, *e. g.*, in the coast states, the distribution of stations is somewhat denser than in some of the interior western states, because the early magnetic work of the Coast Survey was largely confined to the Atlantic and Pacific coasts. However, before many years the distribution for all the states will be practically the same. When this has been accomplished, the plan is to multiply stations in the regions of manifest irregularities. (Two slides were exhibited, one showing the distribution of the stations up to 1899 and the other up to January 1, 1907.)

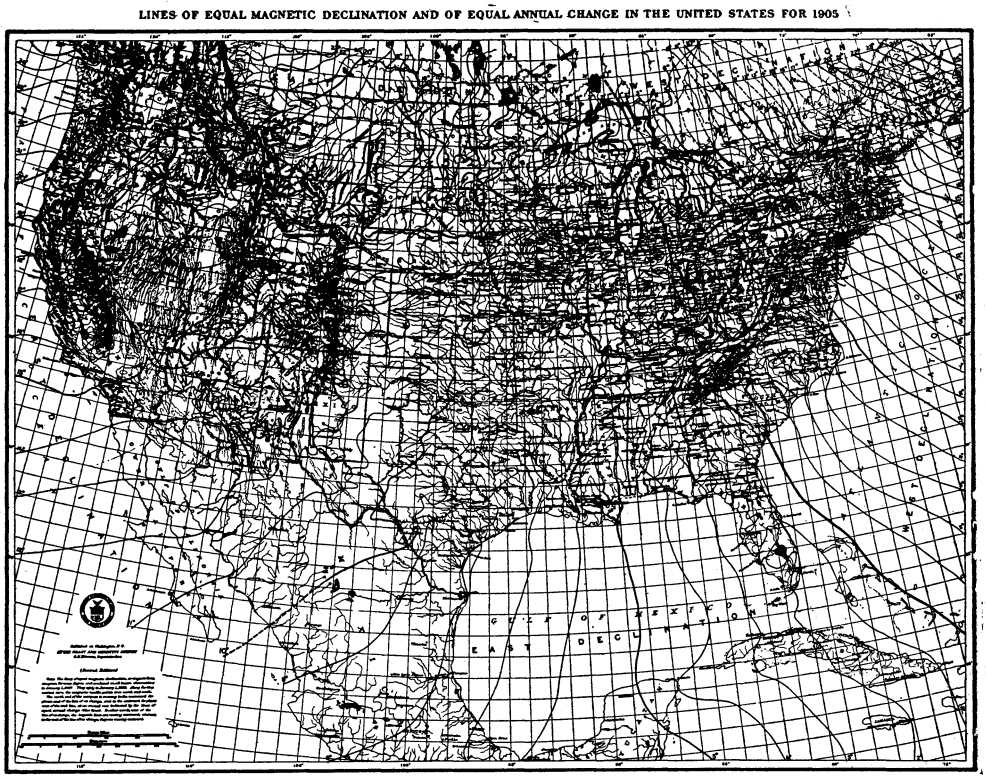
Because of this large amount of accurate magnetic data now available for the United States, I was enabled to construct the magnetic maps of the United States, for the first time as based upon strictly reliable and homogeneous data. My predecessor, the late Charles A. Schott, who had been a member of this academy, was obliged to base his isogonic maps or "lines of equal magnetic declination" very largely upon surveyors' data, owing to the paucity of data, whereas his isoclinic and isodynamic maps had to rest upon even more slender material. In the present instance, however, the charts of the various magnetic elements all depend upon practically the same number of observations made at the same points. They are, hence, strictly comparable and we may, therefore, pursue our investigations respecting the irregularities in magnetic distribution much more successfully than hitherto.

Mention should also be made that during the period 1899–1906 special attention was paid to instrumental errors—more frequently inherent in magnetic instruments than generally supposed. All instruments were therefore studied care-

fully and inter-compared and the necessary corrections on standard instruments frequently obtained. It was also recognized that in magnetic survey work one of the chief aims must be to *multiply* stations in order to eliminate, as effectually as possible, station errors which frequently far exceed observation errors. The time previously spent at a station was reduced from two or three days to one day or two days so as to permit doubling or trebling the number of stations per month. By properly systematizing this work and depending for certain corrections upon magnetic observatories established at the same time, it was found that the increased speed in the execution of the work brought about no sacrifice in accuracy. In fact, owing to the care bestowed upon the instrumental errors as well as on other parts of the work, the general accuracy of the work subsequent to 1899 has distinctly advanced.

Another feature enhancing the value of the present maps is due to the fact that in addition to the observations on land, magnetic work at sea was inaugurated in 1903 on the Coast Survey vessels. There were, hence, available the magnetic results obtained by these vessels along our coasts during the four years 1903–1907, as also the results obtained by the Carnegie Institution of Washington, in Canada, Mexico, Central America, and on the Pacific Ocean. (Slide 3 showed the progress to date of the ocean magnetic work.)

LINES OF EQUAL MAGNETIC DECLINATION AND OF EQUAL ANNUAL CHANGE IN THE UNITED STATES FOR 1905



The present magnetic maps apply to the date January 1, 1905. In order to be able to refer all observations to this date, as accurately as possible, special attention was paid to the secular variations of the mag-

netic elements and, accordingly, stations were reoccupied at closer intervals in time, as well as in distance, than had previously been the custom. In consequence, certain unexpected and complicated features of the secular variation could be satisfactorily delineated. It was found that the secular variation had not, in general, progressed in accordance with the predictions from the empirical formula established ten years ago.

We may safely make the claim that in no other country than ours have the phenomena of the secular variation received such careful investigation; the data we possess, in consequence, for this study are unrivaled. Unfortunately, in most other countries, owing to the lack of existing, permanent organizations, the observations have had to be prosecuted more or less intermittently. It is very much hoped that in about ten or fifteen years with the aid of the magnetic data now being accumulated by the Carnegie Institution, it may be possible to extend the investigation of the perplexing phenomena of the secular variation over the globe with the requisite completeness.

It will, of course, not be possible within the brief space of twenty minutes to go into all the various details respecting the magnetic survey of the United States and the results of interest which are being derived from an analytical discussion of the observations. We shall have to content ourselves with the consideration of but one or two of the more important phases of the work.

You have before you one of the magnetic maps constructed on the basis of the available material—the "Lines of Equal Magnetic Declination and of Equal Annual Change for January 1, 1905" (Slide 4). What impresses one most is, doubtless, the manifold irregularities and twists in the various lines. Increased knowledge teaches us that the more numerous the observations the more devious become the lines of equal values. When you see perfectly regular or smoothly flowing lines you may rest assured that they have been either smoothed out or conventionalized or that they depend upon but very few data. Instead of the irregularities being the *abnormal* features, *they* are the *normal* ones, and *regularities* are, in fact, the *abnormal* features. The ocean magnetic work of the Carnegie Institution has likewise shown that practically every land mass exhibits irregularities in magnetic distribution over that which would prevail were the same region covered with deep water.

Similar magnetic maps to the one shown have been constructed for the dip or inclination, the horizontal intensity, the vertical intensity and the total magnetic intensity, as well as certain other special maps, *e. g.*, the magnetic meridians or paths traced out by following the direction pointed by a compass needle, etc. It is hoped that before very long they will pass through the press. These new maps all unite in bearing common testimony to the irregularities in the distribution of the magnetic forces in the United States.

In conclusion, permit me to briefly sketch the general scheme I am following in the analytical discussion of the magnetic conditions prevailing in the United States as exhibited by these maps. Some of you are familiar with the general analytical treatment by spherical harmonics of the earth's magnetic condition, at any stated period, initiated by Gauss. You will doubtless recall that he carried the expansion of the potential to terms of the fourth degree, inclusive, thus involving twenty-four coefficients to be determined by a least square treatment of the available magnetic data. The later analysts have extended the expansion to terms of the

sixth order, inclusive, hence determining forty-eight coefficients. However, in spite of the increase in the number of terms and coefficients, the results as computed from the formula differ from the observed quantities to such an extent that no *practical* use, whatsoever, can be made of them. For example, in the United States the formula would give magnetic declinations differing at *least* 1° to 3° from observed values.

Gauss's formula has only a certain theoretical significance, but, as said, no practical value as an interpolation formula. Why is this? Is it due to imperfection or incompleteness of the underlying data? Yes, to a certain extent. For example, all of the various analyses to date have had to be based on maps depending largely on land data, *i. e.*, on data covering but a fourth of the area of the globe. Nothing was known as to the reliability of the map data over the remaining three fourths—the ocean areas. Thus the Carnegie Institution work has shown that the magnetic map data over the Pacific Ocean are erroneous 1° to 3° in declination and dip, and about one twenty-fifth part in horizontal intensity. So we may confidently expect some improvement with the later more accurate data and it is possible that a new formula as based upon these data will give results sufficiently close in agreement with observation over the ocean areas for *practical* purposes if not for *scientific* purposes.

When we come to *land* areas, however, it is questionable whether any general terrestrial formula can be established which will represent the land observations sufficiently closely, even if the expansion be carried farther than it has already been, viz., beyond the sixth degree. The prime reason for this has been made evident from our study of the magnetic field of the United States. We find, namely, that we must deal with irregularities in magnetic distribution of various gradations covering areas of varied extent, a locality, county, state or an entire continent. Thus we may have the magnetic forces observed at any given point in the United States as the resultant effects of (1) a general or terrestrial magnetic field due to the general magnetic condition of the earth, (2) a general, terrestrial disturbing cause which distorts the general magnetic condition of the earth at the place of observation, (3) a continental disturbing effect, due largely to that portion of the North American continent above the general ocean bed, (4) a regional disturbance due to low-lying magnetized masses or earth currents covering a certain region, and (5), a local disturbance due to the magnetized masses or currents in the immediate vicinity.

Now a formula based upon the entire earth can, of course, not include also disturbances of such restricted areas as embraced under the last two heads, viz., regional and local disturbances, but it appears that the present formulæ do not even adequately represent the *continental* effects. In these formulæ we have the various terms advancing and recurring by trigonometric functions of multiples of the longitude and the latitude. Thus a term involving six times the longitude is supposed to continue around the earth six times in unaltered manner. However, such a term arising from the North American continental shelf which in the United States has a width in longitude of about 60°, would not continue around the earth, but would in all probability die out before the European or the Asiatic continent is reached. In other words, it must be recognized that with the recurrent or continuous terms embraced in the higher harmonics of Gauss's formula, we can at the best but "counterfeit" the facts of nature but never get at the actual truth.

Here we are brought face to face with the question: How far is it really worth while to go in the establishment of the formula? The geodesist contents himself with the determination of at most two constants for the figure of the earth. No one, to my knowledge, has succeeded in establishing a formula which represents the actual shape of the earth and exhibits at least the most marked of the earth's manifest irregularities of surface. Professor Love, I believe, has established a formula representing the irregularities of the first, second and third degrees, but has not deemed it worth while to go beyond this extent. And so it would appear to me that the time has come to halt in the establishment of a complex formula involving forty-eight unknowns or more which at the very best can give but an inadequate representation of the actual facts of the earth's magnetism. It would seem more logical to stop with a certain finite number of terms involving a limited number of unknowns which represent, from a physical standpoint, the chief and principal facts of the magnetic condition of the earth. The magnetization resulting from this limited expression we should call our "normal field," or "field of references" as the geodesist calls his adopted figure, the *spheroid of reference*. The residuals from this field of reference would then receive separate or special treatment in accordance with their extent and their character. In conclusion an application of this mode of treatment to the United States was shown (Slide 6).

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SCIENTIFIC BOOKS

Revision of the Pelycosauria of North America. By E. C. Case. Publication No. 55 of the Carnegie Institution, Washington, July, 1907.

This important monograph deals with the most remarkable group of the Permian vertebrata. The Pelycosauria, popularly known as "fin-back lizards," have been known hitherto only from brief and scattered descriptions principally by the late Professor Cope, mostly based upon very incomplete material. Dr. Case's studies of the last few years, aided by a grant from the Carnegie Institution, have done a great deal towards clearing up our understanding of the structure and relationships of the order. In the present memoir he has brought together all the earlier descriptions, and has redescribed and fully illustrated all the better-known types from the more complete material now available.

The rich and varied vertebrate fauna of the Permian beds of northern Texas and the adjacent parts of Oklahoma was first made known to science by Cope in 1878 and succeeding years. The collections upon which his earlier descriptions were based were obtained for him by Jacob Boll and J. C. Isaac in 1878–80, and by Professor W. F. Cummins, the well-known Texas geologist, in 1881–4. In 1895–7 Professor Cope's collections were greatly increased by the energy of the indefatigable collector, Charles H. Sternberg. All these collections are now in the American Museum of Natural History, along with additional material since obtained by Mr. Sternberg and Dr. Case. Dr. Case has also made considerable collections for the University of Chicago, and the Paleontological Museum of Munich has acquired a large and valuable collection through the exertions of Mr. Sternberg. So far as the reviewer is aware, there are no important collections of vertebrates from the Texas Permian, except in the three institutions named. The preparation of the specimens for study or exhibition is exceptionally difficult and tedious, since the bones are usually encased in a hard flinty concretion which can be removed only by laborious and painstaking chipping. The progress of our knowledge of this wonderful fauna is greatly hindered by this difficulty in preparation.

The vertebrate fauna of the Texas Permian consists chiefly of armored amphibians (Stegocephalia), large and small, and primitive reptiles of several groups. Its prime interest lies in the fact of its great antiquity.