and method of presentation. The numerous illustrations are wisely chosen and well rendered and the few errors noticed in the text are mostly typographical. A misleading misprint occurs in the statement that the first successful dirigible balloon in 1885 sailed from Calais to Paris and returned to its place of departure, which really was Chalais-Meudon, a suburb of Paris.

A. LAWRENCE ROTCH[1]
BLUE HILL METEOROLOGICAL OBSERVATORY

SPECIAL ARTICLES

HEATING OF LOCAL AREAS OF GROUND IN CULEBRA CUT, CANAL ZONE[2]

THE marl shales, through which Culebra Cut extends, in the region opposite the Culebra railway station, have, from time to time, on exposure to the atmosphere, become hot. The intensity of this heat has varied from noticeably warm to a temperature sufficient to readily char wood, without, however, causing it to burst into a flame. The duration of this heating has been from a few days to several weeks. These shales are dark, thin bedded, soft and easily crumbled, and some of the layers are largely fine basic tuff, loosely cemented by lime. Other beds contain more carbonaceous material, with some local partings of lignite an inch to a foot or more thick. The relatively unweathered character of these basic sediments is evidence that they were derived from nearby volcanic mountains, and the carbonaceous and lignitic layers in them indicate shallow water and swamp conditions of deposition. The presence of fossil oysters, pelecypods, corals and foraminifera show that these shallow estuaries were marine, and that they existed in early Tertiary time. Dr. T. Wayland Vaughn, of the U. S. Geological Survey, examined some of the specimens on the ground and gave it as his opinion that they are Oligocene in age. The evidence so far points to a shallow water connection between the Atlantic and the Pacific during Oligocene time.

[1] This review was written immediately before the lamented death of Professor Rotch.—ED.

[2] Published by permission of the chairman of the Isthmian Canal Commission.

After exposure to the atmosphere by drilling, or blasting, certain local areas of this formation become, in the course of a few days, warmed up, and as the heating goes on the carbonaceous matter in the shales is gradually oxidized off and they tend to assume a gray to dull reddish color. The first working hypothesis entertained in looking toward a solution of this heating phenomenon was that possibly the heavy blasting had furnished heat enough to break down the calcium carbonate present to the oxide form, and that ground water and atmospheric moisture reacted on this to slake it and thus probably generate sufficient heat to start the oxidation of the carbonaceous material. This hypothesis was, however, rendered untenable by three lines of evidence:

1. The heating was much more local than the calcium carbonate, and the carbonaceous matter.

2. The heating bore no definite relation to the lime and carbon content of particular beds.

3. Colonel Gaillard, in charge of the Division, informs me that in some instances the heat began in the holes some time after they had been drilled, but before the ground had been blasted at all.

Another line of inquiry was suggested by finding a small amount of pyrite in some of the beds which were heating. It was suspected that this, through its oxidation, was a factor in furnishing the initial heat of the action. In April, 1911, samples of the beds then heating were sent to the chemical laboratory of the U. S. Geological Survey with instructions to make qualitative tests for sulphur and other products that might serve, through oxidation, as the mainspring of the action. These tests revealed the presence of sulphuric acid to the amount of 1.92 per cent., also minute crystals of gypsum. This confirmed the hypothesis that pointed to the pyrite present as the substance acted on by atmospheric oxygen to develop the initial heat.

The most aggravated case of heating so far noted is now going on in Culebra Cut, about 350 yards north of the foot of the stair at the observation tower near Culebra Station. The mass of heated ground here is about 500 feet long by 20 feet wide, and the action reaches a depth of perhaps 15 or 20 feet. Blue smoke, which contains a high percentage of sulphur-dioxide, issues from vents in the mass, and fragments of wood inserted in these are readily charred and consumed. A small amount of steam may also be detected emanating from local moist spots, but this is mainly due to the vaporization of ground water. In the investigation of this heated mass samples were taken, and these were tested qualitatively for sulphuric acid and for sulphates of calcium, aluminium and magnesium. The tests were made by Mr. Jacobs, of the Hospital Laboratory Staff at Ancon, and they revealed the presence of all of the above substances, both in the shale and as the white coating on the moist spots and steam vents of the mass. The yellow deposit near the larger vents is sulphur. Sulphuric acid, especially, was shown to be present in considerable quantity. The origin of the sulphuric acid here was at first a puzzle, because the examination of many samples, with the naked eye and with the microscope, failed to reveal the presence of pyrite. Finally samples of eight to ten pounds were taken, ground with water in a large mortar for some minutes, and then concentrated to a few ounces by washing or "panning." This concentrate showed a high content of pyrite, much of which could scarcely be seen with the naked eye. Under the microscope very small crystals of pyrite were noted; also considerable magnetite, present as black sand, and some sub-angular to fairly rounded grains of quartz.

The mainspring of the action here then, as in the other instances observed, has undoubtedly been the oxidation of the pyrite. The reasons why this oxidation has been so rapid and effective, seems to be as follows:

(*a*) The finely divided, almost microscopic, character of the pyrite gives maximum surface exposure to atmospheric agencies and greatly promotes oxidation.

(*b*) The very warm, moist atmosphere. The tropical sun shining directly on dark rock surfaces produces a temperature sufficiently high to greatly promote oxidation, especially in the presence of slight moisture.

(*c*) Once oxidation of the pyrite has been started the heat thus generated tends to accelerate chemical action and thus the heating increases in geometric progression.

(*d*) When the heat of pyrite oxidation reaches the comparatively low temperature of oxidation of the hydrocarbons present in the lignitic shale, they, too, become oxidized and still further add to the temperature. Finally the fixed carbon content tends to become oxidized, at least in part, and gives maximum intensity to the action.

(*e*) Some heat is also generated by the action of the free sulphuric acid on the calcium carbonate for the formation of gypsum. Other minor chemical actions added their quota to the total heat.

As the temperature rises all chemical activity is vastly stimulated and the heating increases to a maximum. After the most readily oxidizable substances are consumed the heat gradually dies down toward normal temperatures, which may be reached in a few weeks or months. The intensity and duration of the heat depends largely upon the percentage of finely divided pyrite, volatile matter and fixed carbon in the rocks.

Some of the geological considerations suggested by a study of this phenomenon are:

(*a*) Chemico-thermal springs. Whenever jointing fissuring or change of groundwater level gives free access of oxygen-bearing surface waters to beds which contain the necessary finely divided pyrite, and carbonaceous matter, a heating up of such beds is likely to result. Groundwater flowing over such heated beds, and coming to the surface in the general vicinity of them, would constitute thermal springs.

(*b*) Should a rise of land surface bring pyrite-bearing beds from subaqueous to terrestrial conditions, oxidation of the pyrite might, in the course of a year, give local redbeds that would otherwise require centuries of atmospheric action to produce. Of course it is recognized that no very extensive redbeds could be produced in this way.

(*c*) The very fine pyrite sparingly disseminated through the carbonaceous shales, herein described, seems to have resulted from the action of sulphur, from decaying animal and vegetable life, on the ferro-megnesian silicate fragments which are abundant in these sediments.

DONALD F. MACDONALD,
Commission Geologist

CULEBRA, C. Z.,
April 1, 1912

THE ASTRONOMICAL AND ASTROPHYSICAL SOCIETY OF AMERICA

WASHINGTON MEETING, DECEMBER, 1911

THE thirteenth session of this society was held at the Carnegie Institution in Washington, D. C., on December 27–29, 1911, with President E. C. Pickering in the chair. There were sixty-four members of the society in attendance besides many friends. Nine persons were elected to membership, making a total of more than 270 members.

Six sessions were held, two of which were joint meetings with Section A of the American Association for the Advancement of Science. At the joint sessions Professor E. B. Frost presided in the double capacity of vice-president of Section A and first vice-president of the Astronomical and Astrophysical Society of America; and for these sessions a special program was arranged comprising addresses by Professor Lewis Boss on "Recent Researches as to the Systematic Motions of the Stars," by Professor E. H. Moore, retiring vice-president of Section A, on "The Foundations of the Theory of Linear Integral Equations" and by the Reverend Joel H. Metcalf on "The Asteroid Problem."

The society's scientific program included thirty-two papers and also reports from the committees on comets, photographic astrometry and cooperation in the teaching of astronomy. A new committee on asteroids was created with members, E. W. Brown (chairman), J. H. Metcalf, G. H. Peters and A. O. Leuschner.

The following members were in attendance at the Washington meeting: Misses L. B. Allen, H. W. Bigelow, A. J. Cannon, M. M. Hopkins, E. A. Lamson, Mary Proctor, S. F. Whiting, Messrs. A. T. G. Apple, E. E. Barnard, S. G. Barton, L. A. Bauer, L. Boss, J. A. Brashear, E. W. Brown, C. A. Chant, H. S. Davis, C. L. Doolittle, E. Doolittle, R. S. Dugan, J. C. Duncan, J. R. Eastman, W. S. Eichelberger, F. E. Fowle, E. Frisby, E. B. Frost, C. H. Gingrich, A. Hall, W. M. Hamilton, J. C. Hammond, H. B. Hedrick, G. A. Hill, W. J. Humphreys, H. Jacoby, H. H. Kimball, W. F. King, F. B. Littell, F. H. Loud, E. O. Lovett, C. A. R. Lundin, Jr., J. H. Metcalf, W. I. Milham, J. A. Miller, S. A. Mitchell, W. M. Mitchell, H. R. Morgan, C. P. Olivier, G. H. Peters, E. C. Pickering, J. S. Plaskett, R. W. Prentiss, W. F. Rigge, F. E. Ross, A. L. Rotch, H. N. Russell, F. Schlesinger, A. N. Skinner, H. T. Stetson, O. Stone, E. D. Tillyer, A. B. Turner, F. D. Urie, R. W. Willson, D. T. Wilson, R. S. Woodward.

New members were elected as follows: John August Anderson, Johns Hopkins University, Baltimore, Md.; Zaccheus Daniel, Allegheny Observatory, Pittsburgh, Pa.; Walter M. Hamilton, 2307 Washington Circle, Washington, D. C.; H. H. Kimball, Weather Bureau, Washington, D. C.; William Francis Rigge, Creighton University; Harlow Shapley, The Observatory, Princeton, N. J.; Vesto Melvin Slipher, Flagstaff, Ariz.; Albert Harris Wilson, Haverford, Pa.; Charles Clayton Wylie, Laws Observatory, Columbia, Mo.

The program of the meeting included the following papers and reports:

A Device for Facilitating Various Forms of Computation: E. W. BROWN.

The device consists of a frame and a carrier which supports a number of tapes. On these tapes small oblong pieces of cardboard are pasted, the members to be summed being written on the pieces of cardboard. It is essentially a device for avoiding the frequent rewriting of the same number when it has to enter into a calculation in many different ways. It is being used for the summation of many small harmonic terms at numerous time-intervals and for the formation of double-entry tables which consist of ten or more terms of the type $A \cos (i\theta + j\phi + \alpha)$ where i, j are integers, α, A constants and θ, ϕ increase uniformly with the time. It will probably be also used for the analysis of numerous observations at equal time-intervals into harmonic terms whose periods are known or have been previously determined, as, for example, in obtaining the tidal constants of a port from hourly observations of the tide height.

The Lesson of Joseph Piazzi's Life: H. S. DAVIS.

Piazzi's career is followed from his birth, through