best geographers from abroad was of very great value, particularly to many of the younger men. On every hand good fellowship prevailed, and every one present felt a new impulse to work from the inspiration of the meeting. Many of the visitors took the trip to the western coast after the meeting, on which, according to reports, fully as great results geographically were obtained as at the meeting. Not only must Canada feel a new scientific movement of progress from the meeting, but the United States as well must join in the good to be obtained. The visitors from abroad all agreed that they had gained much from the trip more helpful than mere information. All the Americans trust that they have been able to give in return a part of what they have received, and that this international meeting may help the cause of geography on on both sides of the water.

RICHARD E. DODGE.

IS THE DENVER FORMATION LACUSTRINE OR FLUVIATILE?

THE usual interpretation of stratified deposits refers them to accumulation beneath water, either in the sea or in lakes. But many observers have recognized the ability of rivers to form stratified deposits more or less extensive; hence the mere occurrence of stratification might suggest fluviatile as well as lacustrine or marine origin; and some other sign than stratification would be needed to distinguish among these several conditions of deposition. When fossils are contained in the strata it is commonly easy to determine at least whether they were of salt or fresh water origin; but when without fossils, or when containing only fresh water or land fossils, it may be still a question whether the deposits were formed in lakes or rivers. It has been perhaps assumed that river deposits must be local, while lacustrine deposits may be widespread; but the immense fluviatile deposits of the Indo-Gangetic plain must suffice to free the products of aggrading rivers from narrow bounds. Blandford's account of the vast deposits of waste in long sloping plains at the base of mountain ranges in the interior basins of Persia, as well as the description of similar accumulations in our western country, shows that extensive stratified deposits may be formed in regions where even rivers are not a constant or conspicuous agency; and the believer in the competency of small processes to produce great results if time enough is allowed would find it difficult to set limits to the area or thickness of formation of such origin.

The distinction between true lacustrine sediments and true fluviatile sediments may be made in part by their composition and structure and in part by their fossils. River deposits are of variable sequence, coarse and fine, evenly or unevenly arranged, cross-bedded, ripple-marked and sun-cracked. Mid-lake deposits are of fine texture and even structure, becoming coarse and irregular only near their margin. A characteristic lacustrine fauna, enclosed in mid-lake silts, should be easily distinguished from the mixture of land and water fauna that might be preserved in coarser lake-border deposits or in the coarse and fine strata of normal river deposits. In the absence of a fauna, it might be difficult to distinguish lake-border deposits from river deposits; there might indeed be difficulty in separating lacustrine silts from the fine silts of river flood-plains, if fossils were wanting.

Gilbert's interpretation of some of the newer deposits on the Plains of Colorado near the Arkansas river as of fluviatile origin, and the adoption of his idea by the geologists of Kansas for the eastward extension of the same formations, has recently given practical application to the above generalities. Penck gives in his *Morphologie* a number of European examples of deposits ordinarily called lacustrine, but which

he regards as fluviatile. And on my return home from a sight of the Plains this summer, the receipt of Monograph XXVII., U. S. G. S., on the Geology of the Denver Basin, by Emmons, Cross and Eldridge, suggests a further extension of the discussion. It is particularly with regard to the Arapahoe and Denver formations, in Colorado, that the conditions of origin seem open to another interpretation than that given by these authors; for it is noticeable that a lacustrine origin seems to have been almost taken for granted, and that a fluviatile origin is not discussed.

The Arapahoe formation is thus introduced: "After an erosion of the Laramie beds * * *, a considerable fresh-water lake was formed and sedimentation again set in. What the exact area of this lake was it is not possible now to determine; * * * whether the lake was continuous along the mountain front or there were several small isolated basins it is as yet impossible to determine. * * * In it were deposited more than 600 to 800 feet of sediments. * * * Of these sediments the lower 50 to 200 feet were conglomerates, the upper 400 to 600 feet arenaceous clays. Vertebrate remains are found in both the conglomerates and the clays, more abundant and better preserved, however, in the latter." (P. 31, 32.)

The interval between the Arapahoe and Denver formations is thus described: "Between the deposition of the Arapahoe and Denver beds a considerable time-interval occurred, during which, as the record of the rocks shows, the Arapahoe lake was drained and the sediments deposited in its bottom were considerably eroded. The movement which caused the drainage of the lake was, as far as present indications go, rather local in its effects, and produced no important deformation of the beds already deposited. * * * This movement was succeeded, after a considerable lapse of time, by a depression sufficient to allow of the formation of a second lake in the Denver basin. * * * The nature of the depression which produced such lakes without admitting marine waters to any extent within the area affected is not readily conceivable, yet its effects are shown to have been widespread by the considerable thicknesses of fresh-water beds consisting largely of eruptive débris." (P. 32.)

The following description is given of the Denver deposits: "The beds deposited in the Denver Lake reached a thickness of over 1,400 feet along the flanks of the mountains, but were probably somewhat thinner toward the middle of the basin. * * * That the Denver beds were deposited in shallow waters is shown by the frequent cross bedding observable both in sandstone and conglomerate, and by the plant remains and standing tree stumps that abound at certain horizons. * * * The Archean material contains large boulders, and the sand grains are angular." (P. 33.)

The vertebrate paleontology of the Denver basin is treated by Professor Marsh in the later pages of the monograph. Nearly all of the typical vertebrate fossils of the Denver region here discussed "were essentially land animals, but not a few of them, especially of the Reptilia, lived near the water and there met their fate. The preservation of their remains was probably, without exception, due to their entombment beneath the waters of the great fresh-water lakes which existed in this region during Mesozoic and Cenozoic time." (P. 525.) The plants discussed by Knowlton are land plants, not lacustrine. The table of invertebrate fossils (p. 78, 79) gives none to the Arapahoe beds, and only six to the Denver beds, all of which imply 'fresh water,' and most of which suggest, according to my colleague, Dr. R. T. Jackson, a fluviatile rather than a lacustrine origin.

Now waiving for the time all reference to

the silty and probably lacustrine deposits on the plains farther east of the mountains than the region here described, may not all the facts of composition, structure and fossil contents, above set forth, be explained as well by fluviatile as by lacustrine conditions? Instead of assuming a series of warping and tilting movements by which lake basins were made and drained, is it not equally legitimate to assume changes of altitude, attitude, climate, drainage areas, etc., by which the rivers of the region altered their behavior from aggrading to degrading? The decision between these alternatives must, of course, not be attempted by an observer away from the ground; but in the meantime the lacustrine origin of the Arapahoe and Denver beds does not seem to be fully substantiated.

If they should finally be shown to be fluviatile, several corollaries that follow from the acceptance of a lacustrine origin would require modification. For example: "Movements of elevation and subsidence, rather of an epeirogenic or continental nature, are indicated by both Tertiary and Pleistocene deposits that have a lacustrine origin, since the present inclination of the plains region, which shows an average descent, in round numbers, of 10 feet to the mile from the foothill region to the valleys of the Missouri and Mississippi, would not admit of the holding of lake waters on its surface." (P. 40.) Fluviatile deposits are, on the other hand, characteristically inclined; and the present slope of the Plains may be not far different from their slope when the Arapahoe, Denver and later beds were formed, if they were spread out by aggrading rivers. I cannot help wondering whether even the peculiar cases of lapsing and overlapping strata, so well worked out by Eldridge about Golden and Boulder, may not find at least some part of their explanation by alterations of fluviatile accumulation and denudation, prompted by changes in grade, climate, drainage, area, etc., rather than depend altogether on movements of elevation and depression. The latter interpretation seems to postulate essential horizontality and rather regular continuity of strata at time of deposition; the latter permits or even requires significant declivity, inequality of thickness and irregularity of overlaps at time of deposition. Indeed, since the question of the fluviatile origin of some of the younger deposits on the Plains has been accepted by geologists familiar with that great field, the possibility of a fluviatile origin for some of the older formations springs to mind. The coarser and non-fossiliferous strata of the foothill belt in particular may, perhaps, be the fluviatile equivalents of finer and fossiliferous strata of lascustrine or marine origin farther eastward on the Plains.

W. M. DAVIS.

CAMBRIDGE, MASS., September, 1897.

THE GRANT SARCOPHAGUS.

ON one of the most beautiful sites on the Island of Manhattan stands the mausolæum which the gratitude of a nation has erected to the memory of its illustrious hero.

The altar in this temple of the dead is the sarcophagus, beautiful and imposing in its severe simplicity. The stone out of which it is hewn is a dark red granite, quarried at Montello, Marquette county, Wisconsin.

Concerning the granite of this region Professor Allan D. Conover wrote :* "The rock shows almost no tendency to decompose. It has a medium grain, close texture, is of a bright pinkish color, and without sign of arrangement of the ingredients in lines. These are: Rather large flaked, pinkish, cleavable feldspar, predominating;

* Gannett's Report on the Building Stones of the United States and Statistics of the Quarry Industry for 1880.