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## THE LITHOGENESIS OF THE SEDIMENTS.

FRANCIS M. VAN TUYL.

There are few lines of investigation in geology which promise more fruitful returns than the lithogenesis of the sediments. The sedimentary rocks have from the first been sadly neglected although the igneous and metamorphic groups have been systematically and more or less intensively studied both in the field and in the laboratory. Even the megascopic characters of the sediments have for the most part been indefinitely and vaguely described and petrographic examinations have until recently rarely been made. Descriptive terms have been indiscriminately used and such important features as mud cracks and many others equally as significant have in many cases been wholly overlooked. Moreover, until within the last ten years few serious attempts were made to determine the conditions of deposition of the clastic sediments. It is little wonder then that the application of more refined methods of study to these rocks bids fair to revolutionize the fields of physical stratigraphy and paleogeography.

The importance of careful study of recent sedimentary deposits of both the continental and marine types as a basis for interpreting the history of the ancient sediments cannot be too strongly emphasized, as was pointed out recently by both Andrée<sup>1</sup> and Goldman.<sup>2</sup> Indeed some of the greatest contributions to stratigraphy have come through such studies. The importance of Drew's recent investigation on the deposition of limestone through the agency of bacteria in the modern seas<sup>3</sup> as bearing on the origin of the ancient thick, fine-grained limestones which in themselves furnish no positive clue as to their mode of formation must be admitted by all.

Witness also the valuable contributions of Grabau and Barrell, who, working independently, have been able not only to prove beyond a reasonable doubt that many of the thick Paleozoic clastic formations of the Appalachian region which were formerly believed by all to be either of marine or estuarine origin

<sup>1</sup>Petermann's Mitteilungen Vol. 59, part 2, 1913, p. 117 ff.

<sup>2</sup>Am. Jour. Sci., 4th ser., Vol. 39, p. 287.

<sup>3</sup>Published by Carnegie Institution, Washington, Pub. 182, 1914, pp. 9-45.

really represent great continental delta fans, but also to outline the probable climatic conditions which existed at the time they were formed by comparing them with similar recent and near recent deposits of known origin.

Studies such as those made by Sherzer<sup>4</sup>, who found upon examining recent sand grains formed by various agencies that each type possessed characteristics to a certain degree of its own, also promise to be of great value in deciphering the history of the ancient sediments. For instance there are strong reasons for suspecting that certain sandstone formations made up of sand grains possessing all the characteristics of recent wind blown sand are of eolian origin, or at least consist of eolian sands reworked by the sea as it transgressed upon the land.

Similarly Walther and Huntington and others by their descriptions of the characteristics of modern desert deposits have contributed valuable data which already have been applied in interpreting the history of the sediments of the past. Thus, wind carved pebbles similar in every way to those described by Walther and others from the Libyan desert have been found, according to Grabau<sup>5</sup> "in the pre-Cambrian Torridon sandstone of Scotland, the basal Cambrian sands of Sweden, the Rothliegende of Germany, the Buntersandstein of Thuringia and elsewhere" thereby suggesting strongly the existence of desert conditions at the time these beds were formed. In like manner a type of cross-bedding shown by Walther to be characteristic of the modern sand dunes of the deserts of Egypt, and observed by Huntington in Persia, Transcaspia and Chinese Turkestan has been observed by Huntington<sup>6</sup> in certain Mesozoic sandstones of Utah and by Grabau and Sherzer in the Sylvania sandstone of Silurian age, of Michigan<sup>7</sup>.

But in spite of the great advancement of physical stratigraphy within recent years resulting from the field study of sediments, we may expect even greater advances in the future, especially as the result of more detailed examination of the sediments with the aid of the microscope. Here lies a great field almost untouched, although its possibilities have been shown by the studies of Sorby, Cayeux, Mackie, G. S. Rogers, Gold-

<sup>4</sup>Bull. Geol. Soc. America, Vol. 21, 1910, pp. 625-662.

<sup>5</sup>Principles of Stratigraphy, p. 54.

<sup>6</sup>Bull. Geol. Soc. America, Vol. 18, 1907, p. 351.

<sup>7</sup>Mich. Geol. and Biol. Survey, Pub. 2, Geol. Series 1, 1910, p. 61 ff.

man and others. There can be no doubt that the additional evidence furnished by petrographic study as to the composition and structure of the ancient sediments will aid greatly in interpreting the conditions of their deposition as well as the nature of their source. Sorby<sup>8</sup> showed the possibilities in this line several years ago, by his petrographic examination of clays and shales. He found the structure of these to differ greatly, a fact which argues for their formation under very different conditions. That such characteristics are fairly constant for any given formation is suggested by the experience of Denckmann who found that a widely distributed Silurian formation of Silesia possessed distinct petrographic peculiarities by means of which he was able to identify it at those localities where fossils were either rare or entirely wanting<sup>9</sup>. It seems certain that to some extent at least, the nature and constitution of the sediments of any given formation are directly related to the climatic conditions which existed during deposition as well as to the source from which they were derived. If then we may determine in what way climatic changes are registered in the sediments by converging all lines of evidence we shall be able to decipher more accurately by means of the microscope the climates of the past as well as the nature of the ancient lands. Some steps have already been taken in this direction by Mackie<sup>10</sup> who has suggested that the kinds and degree of freshness of the feldspar grains in sandstones may be used as a key in determining the climatic conditions under which the sandstones were formed, and who has demonstrated also that the nature of the parent rock is indicated by the kinds of minerals present and by the nature of their inclusions.

It is believed that studies of this type will go a long way toward solving the problem of the origin of certain little understood formations such as the red beds and the Coal Measures in addition to furnishing more accurate data regarding the geography of the past. When all these things are better known we shall have the basis also for a much more complete classification of the sedimentary rocks than the one which we now possess.

<sup>8</sup>Quart. Jour. Geol. Soc. Vol. 64, 1908, pp. 171-233.

<sup>9</sup>Cited by Andrée, Geol. Rund., Vol. 2, 1911, p. 61.

<sup>10</sup>Trans. Geol. Soc. Edinburgh, Vol. 7, pp. 443-468.