THE GROUPING OF THE COAL STRATA.

BY E. B. WILLARD.

Mr. President and Gentlemen of the Institute:

Instead of contributing a paper, as requested by our Secretary, I propose to call attention to a feature of the geological formation of the coal strata, which I have not seen referred to, and ask for a discussion of this feature by the members of the institute.

I refer to the regular grouping of strata or formations, connected or associated with each different coal vein. Each coal vein seems to have associated with it a stratum of fire-clay, one of lime-stone of greater or less purity, one of iron-ore and one of sand-rock. These five different strata constitute a group, which appears to have marked a geological epoch. My observation has not been sufficiently extensive to give particulars in regard to all the different coal veins. Beginning at the bottom of the coal formation, we find the hard Sciotoville fire-clay lying close above the Waverly sand-stone, though I would place them in different groups. Often there is found just under this clay, a very good ore immediately on the lime-stone. In fact a great deal of this ore closely resembles the lime-stone ore found on the ferriferous lime-stone. Close above this fire-clay comes No. 1 coal, which in some parts of the State has black band ore associated with it. In Scioto county near the mouth of Pine Creek there are places where No. 1 coal is underlined with a black band ore, which assays about 31 per cent. after calcination, and there is every probability that valuable beds of black band ore may yet be found in that vicinity. Close above No. 1 coal comes a heavy bed of sand rock, which completes the group.

Coal No. 2 has, accompanying it, an impure and very selicious lime-stone, often represented only by large boulders, also a rough ore generally known in southern Ohio as Sand Block. It also has its fire-clay vein, generally very selicious. The Junior Furnace Hearth Rock, which has been used quite successfully as ganister for lining converters and cupolas at the Ashland Steel Works, belongs to this group. Just above No. 2 coal comes a heavy bed of sand rock, completing the group.

No. 3 coal is accompanied by the fire-clay, lime-stone, ore and sand rock. To this group belongs the "Little Red Block" ore, which sometimes lies immediately on a vein of lime-stone three to four feet thick. This is the ore that constituted the main dependence of the furnaces in Green township, Scioto county, and there are large fields of it still there. Numerous analysis show that it actually contains more lime than the vein that is known as the lime-stone ore. A sand rock again completes this group.

No. 4 coal does not have all the members of the group so well defined, but at different points something can be found to identify each member of the group. To this group belongs the "Canary" ore, which sometimes assays as high as fifty-eight per cent. of iron in the calcined ore, and sometimes degenerates into an impure lime-stone.

No. 5 coal belongs to a group, all of whose members are well defined, comprising the ferriferous lime-stone, with its well known ore, accompanied by heavy beds of fire-clay of great value, and completed by the heavy sand rock, which overlies the coal.

No. 6 coal also is accompanied by all the members of the group, though only the coal has been developed sufficiently to show any great value, though there are localities where the ores of this group posess considerable value.

No. 7 coal has all the different members of the group quite well defined. To this group belongs the Black Band ore of Tuscarawas county, which is quite important in some localities. One or two small deposits of Black Band ore has been found associated with No. 7 coal in Lawrence county and it is quite probable that workable deposits of it may yet be found.

Passing over the barren measures we come to the Pittsburgh seam, which is accompanied by the lime-stone, a well defined vein, also by the valuable fire-clay beds, which are so largely worked on the upper Ohio river. I am not sufficiently well posted to point out the ore vein, which constitutes a member of this group. The sand rock however is very apparent.

I have now detailed all the groups belonging to the coal measures, as far as my observation goes and shown that all have full five members that can be identified with considerable certainty.

I would now commence with the Waverly sand stone and go down. There we find the sand rock, then the black slate, which is highly carboniferous and takes the place of coal in this group, then below that the Erie and Huron shales, which correspond to the fire-clay, and then we come to the lime-stone, which completes the group. Here apparently the iron ore mem-

ber of the group is wanting. But to this group as nearly as I can identify it, belongs the great deposit of ore, which has yielded so largely at Olympia in Bath county, Kentucky, and which has been the principal source of supply for the furnaces at Ashland, Kentucky, for a number of years. May we not hope to find a similar deposit of ore somewhere on the Ohio side of the river.

I would seek to carry this grouping still further down and there find the Clinton for the ore member, a heavy deposit of clays just above that corresponds with the fire-clay member, and a very heavy, coarse, impure lime-stone still above that takes the place of the sand rock member. But I do not find anything that will answer for the coal or carboniferous member.

When we go still further down we find iron ore strata, lime-stone, black slates, which contain a large percentage of carboniferous matter and a sand rock formation, but whether or not any stratum that answers for fire-clay, is uncertain.

The inference from all this series of groups, extending almost to the bottom of the sedimentary rocks, and which have so many characteristics which are common to all the different groups, is that there must have been a great similarity of conditions under which these groups were deposited.

The question, which I would like to have the members of the institute discuss and speculate upon is, what caused all of these great sedimentary formations to separate into the well defined strata, which differ so widely in their chemical character, and yet each member of different groups so closely resembles the corresponding member of other groups, and why were not the sedimentary deposits of each group mixed promiscuously together when they were deposited?

THE CHAIR: Gentlemen, you have heard Mr. Willard's paper and I am going to ask Dr. Orton to lead in the discussion.

DR. ORTON: Mr. President and Gentlemen, the subject is so wide a one that we shall, like the fallen angels, I am afraid, "find no end, in wandering mazes lost". Mr. Willard's paper has brought before us the great doctrine of cycles in geology and of sub-cycles in the carboniferous period. I rejoice that he has come upon that track independently. Dr. Newberry presented the first formal theory of cycles in geology, but he puts in the whole carboniferous period as one cycle. His theory was that sand-stones make the base of every great geological formation, that lime-stone follow it in the center, and that the cycle is

terminated by a deposit of shale. Sand-stone stands for the presence of the sea, for strong currents, the moving of material. The water grows clear, then lime-stone is formed. The sea begins to retire from the region and now a deposit of fine sand or shale follows. Each of these periods may stand for more years than eternity in the ordinary conception of the term would embrace. All our great formations consist of these three elements, and among them the coal formation. But there are certainly sub-cycles to which Mr. Willard has pointed, but he must bear in mind that the lime-stone is not always above the coal. It is sometimes below. Now when you get a fossiliferous lime-stone, like the Mercer lime-stone or the ferriferous or gray lime-stone, or the Cambridge that lies higher in the series, it would seem that there ought to be an end of controversy. The facts are clear as light. All these are the direct products of marine life. Now the order of arrangement that is followed is universal in some of its features. The fire-clay underlies the coal. This the coal miners were the first of all to learn. The geologists got hold of that only about the beginning of the present century. Sir William Logan was the first man to mark that connection. He showed that there was always an under-clay or "seat" for the coal, sometimes sandy and sometimes carbonaceous, or a poor form of coal. If the clay is white, there is reason to expect iron beneath it, especially if there is a lime-stone below the clay. If you will call to mind the Kittanning coal, which is over the ferriferous lime-stone—you will have the true order, you remember the Kittanning clay as you follow its banks in and out in southern Ohio, looking like snow banks in summer. You can recall miles of it. Underneath this white clay you will find the famous "lime-stone ore".

Now a coal seam stands for a swamp. It is at first a little too low for vegetation to grow, but there is some movement of the crust of the earth that brings it up so that vegetation establishes itself there. There is a chance for coal. Generation after generation of forest grows. Sir William Dawson says it takes a hundred forests to make one foot of coal, for it is only a remnant that is saved. Most of the vegetation passes back into the air

again. But by these slow accumulations there is a coal seam at last. Then follows the submergence of the swamp by the sea, which has not been very far off. The sea comes in and covers this up. If it brings good luck to the coal swamp, it covers it with a thin deposit of mud or shale. The miner loves to find a covering of shale over the coal, because it is a witness that the coal below will be found of good character. The mud settles, the water grows clear, then the lime-stone grows and terminates the submergence. A belt of shale covers that and then, perhaps, a layer of sands-tone. That cycle is repeated again and again in the lower coal measures, especially in the conglomerate coal series. Whatever our theories are, that cycle obtains. We find just that order, viz. : sand-stone, lime-stone, coal with intercabated beds of shale. Now I love to group these elements into two great series. I put the elements of every coal series into two classes, the vital, or organic, and the inorganic. The sand-stone and shale which make the great bulk of the interval are limeless. But down here at this vital node comes the lime-stone, which is of animal life. Then the coal, which is vegetable life. Then comes the iron ore below, which is made soluble by vegetable acids. So the iron ore is as much a proof of vegetation as coal itself.

The mischief which comes from the use of numbers for the coal seams, comes out, I think, very plainly in Mr. Willard's paper. He calls the lime-stone coal No. 5 I believe.

MR. WILLARD: Yes sir, that is what we call it in southern Ohio.

DR. ORTON: Well, it is not called by that number elsewhere, and this case shows the error in the system. If you will call this seam the Clarion coal there will be no misunderstanding. If you find the coal under the gray lime-stone and have a name like that—

MR. WILLARD: Did you say under the gray lime-stone?

DR. ORTON: Yes sir.

MR. WILLARD: Well, I meant above. Right along the river we don't have the lime-stone.

MR. ROY: The first vein below the Sheridan coal is your No. 5.

DR. ORTON: Yes sir, coal No. 5 of Newberry lies immediately above the Kittanning clay. That is the No. 5 of southern Ohio. When you rise higher in the scale, instead of finding the lime-stones and iron ores above the coal, you find them underneath the coal. The two Freeport coals, the lower and upper, which are No. 6 A and No. 7, each has the buff lime-stone beneath it. But as I said at first, we shall not find any end to this discussion and I will not continue it further.

MR. WILLARD: I would like to ask Prof. Orton a question. He says the lime-stone is proof of animal life. I have found twice in the lime-stone what I thought was a hickory nut, but another gentleman said it was not a hickory nut.

DR. ORTON: We will not quarrel about that. We find some forms that look like forms we find in fresh water or in the vegetable kingdom to-day and they are roughly identified on the basis of such resemblances.

THE CHAIR: Is there any further discussion on this paper? We have been instructed by Dr. Orton's opening. Do you wish to follow it up. If not, we will go back in our programme and take up some of the papers that we have been obliged to skip. I would like to ask if Mr. Phillips, of Akron, is here yet with his paper. If he is not here, I will call next for the paper of Mr. J. L. Mitchell, the secretary will read his paper.

SECRETARY HASELTINE: Mr. Mitchell wrote me that he expected by this time to be in this part of the country and expected to be present at the meeting. But he wrote me a few days ago, which has just arrived, that he finds it impossible for him to complete his work in time to be here. So he has forwarded the paper.