

On the Colouring matter of Red Sandstones and
of greyish and white beds associated with them.

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The appearance at certain points of the series of stratified deposits, of red sandstones and other rocks strongly coloured by the peroxide of iron, in regions where the older formations contain comparatively few red beds, and the subsequent partial reconversion of these deposits into rocks of more neutral tints, are phenomena which, though often observed, scarcely seem to be thoroughly understood, either in reference to their causes or to the inferences which may be deduced from them. In the present paper, I propose to state a few facts in the geology of Nova Scotia, which appear to throw light on these subjects.

In Nova Scotia, red conglomerates, sandstones and shales predominate for the first time in the lower part of the Carboniferous system, and they continue to prevail through the whole of that system, and in a later deposit of red sandstone. The following remarks apply more particularly to the Lower Carboniferous formation, though most of them apply also to the preceding deposits. The red colours are not usually very bright, generally inclining to purplish red or brownish red. In the shales and clay, the peroxide of iron which causes the colour, is very thoroughly

disseminated through the mass; in the sandstones and conglomerates it is principally contained in the argillaceous matter which occupies the interstices of the fragments of which they are composed, and it also stains the surfaces of these fragments. Its aspect is decidedly rather that of a chemical precipitate than of a colouring matter triturated mechanically. In addition to the oxide of iron distributed through the beds, there is in the fissures traversing them, a considerable quantity of the same substance, in the form of brown hematite and red ochre. Interspersed with these red strata, there are in the lower carboniferous formation numerous subordinate beds destitute of the red colouring matter, and a consideration of the nature and origin of these subordinate beds may aid in arriving at a satisfactory explanation of the occurrence of red oxide of iron in the other parts of the deposit; they consist first of sandstones and shales of grey and black colours, secondly of limestone in thick beds, and thirdly of gypsum also in thick and conformable beds.

In relation to the first of kind of these subordinate beds, the gray and black sandstones and shales, it may be remarked that they consist of detrital matter similar to that of the red beds, but destitute of the red oxide of iron; in the light

coloured sandstones ferruginous matter is altogether absent or nearly so, in the dark sandstone and shale, it appears in the form of carbonate sulphuret or hydrous peroxide of iron. Where these gray and dark beds occur in any considerable thickness, they always contain either fossil plants, bituminous matter, coal or all of these; and even in thin and isolated layers of this description, vegetable matter is often present. For reasons to be stated in the sequel, I believe that the presence of this organic matter is the cause of the absence of red colour in these cases, and I am also disposed to extend the same explanation to certain marly beds and blotched and variegated sandstones in which vegetable matter does not appear.

The second class, the limestones, contain little detrital matter, and are only in a few instances coloured by red oxide of iron. Many of them are entirely composed of perfect shells and corals, others show under the microscope that they are made up of shelly fragments, the remainder are laminated and crystalline and may have been deposited by water holding ~~carbonaceous~~ lime in the form of bicarbonate. Limestones of all these three kinds occasionally contain small quantities of carbon and bitumen. These thick beds of limestone certainly mark long intervals in the deposit of detrital matter,

in the localities in which they occur; and though the absence of red oxide of iron may in part be attributed to the influence of putrefying organic matter, it also indicates that the red colouring matter was connected with the causes which produced and accumulated detrital substances, and was less abundant in periods of comparative rest.

The third kind of beds destitute of red colour, ^{are} the gypsum deposits, which in this formation are numerous and of great thickness. They are generally very pure and colourless; a few however are blackened by bituminous matter, and I have seen one containing sufficient oxide of iron to give it a light flesh colour. The comparative absence of detrital matter from the gypsum, its constant crystalline texture, and its want of fossils, clearly indicate that it is a chemical deposit; and the same circumstances, in connection with its regular stratification and association with limestone, render it probable that it originated from the action of free sulphuric acid on the calcareous matter previously deposited in the seas of the period. In the series of formations found in Nova Scotia, gypsum as

well as red sandstone, appears for the first time in the Lower Carboniferous series; and this simultaneous appearance of these rocks, which is not confined to Nova Scotia, leads to important results in reference to the origin of the red sandstone.

The materials of the lower Carboniferous rocks of Nova Scotia have not been derived from very distant sources. At the period of their deposition, the Silurian and metamorphic rocks seem already to have formed ridges traversing and separating the basins in which they were accumulated, and furnishing large quantities of detritus which can easily be recognised in the Carboniferous sandstones, ~~and~~ conglomerates and shales, and indeed constitutes the map of these deposits. The limestones have evidently resulted from the growth of shells and corals, and the gypsum is almost wholly of local origin, since it is much more probable that it resulted from the production of sulphuric acid by comparatively local causes, than that the seas of this period were charged either with sulphuric acid or sulphate of lime, over wide areas. If, in accordance with the above views,

we seek in the Metamorphic and Silurian rocks now in the vicinity of the Carboniferous beds, for the colouring matter of these latter, we find that it cannot be attributed to the degradation of red coloured rocks, since there form a very trifling proportion of the older formations. Neither can this colouring matter have resulted from the mechanical tituration of Iron ores, since though large deposits of specular iron ore exist in the Silurian system, this mineral is far too hard and obdurate to have furnished the finely divided colouring matter of the red sandstones and shales. The only other form in which large quantities of iron exist in the older formations is that of Br-sulphuret of Iron or Iron pyrites, and it is to the decomposition of this substance that I believe the appearance of red coloured rocks should be attributed.

Iron pyrites abounds in the Silurian and Metamorphic rocks of Nova Scotia, ~~and~~ occurring in disseminated grains and crystals and also in veins and strings of various dimensions, and we may safely assume that in the large masses of these ancient rocks which have been removed to form the Carboniferous strata, it was equally abundant. This large quantity of pyrites may have been removed

or transferred to the new deposits, either mechanically cluded into mud or sand, decomposed by atmospheric agency into sulphate and Hydrous peroxide of Iron, or more entirely changed by the aid of heat into Peroxide of iron and Sulphuric acid. I shall confine my attention to the last case, as more especially applicable to my present object.

The older formations in question have been greatly changed by igneous agents before the deposition of the carboniferous beds; and under such influences the pyrites which they contained may have been changed in three ways. First, in the deeper parts of the deposit it may have remained chemically the same as before, but may have assumed a more crystalline structure or aggregated itself into masses and veins, as it now appears in the remaining portion of the metamorphosed deposits. Secondly, in other circumstances its sulphur might be withdrawn, and the iron be left buried in the deposits, or in low states of oxidation enter into the composition of molten rocks, as is perhaps the case in modern volcanoes which produce sulphur. Or thirdly, it may have been converted into peroxide of Iron and Sulphuric acid, in the superficial parts of the deposit by the action of air and heat, or in parts left near the surface by the production

of oxides of Iron and sulphuretted Hydrogen, and the subsequent oxidation of the latter in passing through moist pyrites, a process which there are good reasons to believe is largely carried on in some recent volcanoes. It is evident that assuming the existence of a quantity of pyrites sufficient for the purpose, it might when subjected to the last mentioned process, afford the red oxide of iron necessary for coloring the mechanical deposits of the carboniferous period, and also the sulphuric acid which enters into the composition of its gypsum. The oxide of iron produced would be in a state favorable for suspension in water and diffusion through the detrital beds, and the sulphuric acid carried by streams and springs into the sea and coming into contact with the calcareous matter there accumulating, would produce beds of Gypsum.

I do not so far overrate the force of the remarks above made, as to suppose that they indisputably prove that the oxidation of Iron pyrites has been the only cause of the red colours of sedimentary rocks. They may however lead geologists to enquire if in other countries the first appearance of red sandstones and shales is connected with the presence of gypsum or other sulphates; and whether the materials of the red beds have been derived from rocks containing iron pyrites, and which have before or during the deposition

of these beds been subjected to igneous action. If these circumstances are of general occurrence, they will go far to establish the view above advocated.

The conversion of red into grey beds has been of frequent occurrence, and is in many cases to be explained by supposing a reversal of the above process, or the reconversion of the peroxide of iron into the sulphuret. I shortly referred to this process in a paper sent to the Geological Society in 1845, but did not state the facts on which my views were founded. My attention was first directed to it by observing it actually in progress in the harbour of Pictou. This harbour receives the waters of three rivers and several smaller streams, which in seasons of flood carry into it reddish mud, sometimes in so great quantity as to discolour its whole surface. This mud, with alluvial sediment from the shores of the harbour, is deposited in the bottom and there undergoes a remarkable change of colour. When recently taken from the bottom, the mud is of a dark grey colour and emits a strong smell of sulphuretted hydrogen. When dried it loses this smell, and its colour is a pure gray without any trace of red. If a portion of the dried mud be heated to incipient redness, it emits a strong sulphureous odour and at once becomes nearly brick red. It thus appears that the iron of the clay red clay has entered into combination with sulphur; and

This is probably obtained from the sulphates contained in the sea water, by the decomposing influence of decaying vegetable matter, the greater part of which seems to be furnished by the Eel grass (*Zostera marina*) which grows abundantly on the mud flats. So complete is the decomposition of this vegetable in many parts of the deposit, that no visible fragments remain, and the only organic remains present are fragments of the trunks and branches of trees, small bony shells and the vitreous coverings of animalcules which abound in this deposit.

It is evident that this modern deposit is quite analogous to many grey beds in the Carboniferous ^{and other} systems, containing sulphuret of iron associated with organic matter, and becoming red when heated. And in all such cases, ~~where~~ it is probable that sulphuretted hydrogen, produced as above stated, has been the agent in effecting the change of colour.

Another modern cause of change of colour in red sands & clays, is the action of acids produced in the putrefaction and decay of most vegetable matter. This is the

usual cause of the whitening of the subsoils of peat bogs & swamps, and in such places the oxide of iron is often redeposited in the form of nodules and crusts of Bog ore, at the outlets of these bogs. This process also probably prevailed extensively in the freshwater deposits of former periods, and may have changed the colours of clays and sands, and collected their red colouring matter into nodules and bands of carbonate and hydrous peroxide of iron. Beds bleached in this way of course do not resume their colour when heated.

It is evident that the formation of red sediment and its subsequent decoloration in the ways above described, may have frequently alternated in the same locality, and may have occurred simultaneously in different localities, according to the prevalence of organic matter capable of decolorising sulphates or of metamorphic influences tending to decompose and oxidise sulphurates. When viewed in this way, they possess some interest independently of the explanation of the colours of rocks. But they satisfactorily account for the rarity of fossil remains in red beds, since

red oxide of iron suspended in water, and sulphuric acid, must both be unfavourable to the existence of aquatic life, and, conversely, if organic matter had abounded in the red detritus it would have changed its colour. It thus appears that in some instances the abundance of red detritus may have caused the deficiency of fossils, and in others this deficiency may be the reason that the red colour remains. Secondly, they show the cause of the almost constant association of large quantities of coal and other vegetable remains with carbonate and sulphuret of iron. Thirdly, they may in some cases ~~serve~~ to distinguish marine from freshwater beds, since on the above hypothesis sulphurets would be formed in large quantities only where sea water had access to the deposits, while the carbonate or hydrous oxide of iron or bleached beds should predominate in localities where organic matter accumulated in freshwater. In some instances however, the small quantities of sulphates contained in waters accounted for, or in mineral springs, might produce a sufficiency of sulphurets to invalidate such conclusions. Fourthly, the occurrence of grey beds and patches in red formations, may often indicate the former existence of fossils whose forms have perished; and it may even be worthy of inquiry ~~how~~ whether the large quan-

tity of sulphuret of iron contained in some ancient non-fossiliferous deposits, may not indicate the former presence of organic matter in these formations.

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