M. Deshayes, however, has lately remarked that *true Ammonites* (with denticulated lobes, I presume) have been found in strata more ancient than the coal formation, namely, in the environs of Tournay*.

In reference to my successive memoirs on the east and south of Ireland, I will here add the general remark, that it has been my endeavour in both to embody in few words the results of practical experience and observations conducted at intervals in that country during a lapse of more than forty years; and in laying them before the public, it has been my object, in both cases, to exhibit through the medium of condensed abstracts a compendious view of the relations of the tracts described, thus relieving the reader from the labour and tedium of passing through the progressive steps of extended researches. That a minute examination of the ground which I have trodden may lead to further discoveries, particularly in respect of the distribution and number of the organic remains, I am far from disbelieving, and I shall be ready to hail their appearance with pleasure; but as in the development of the main relations of the mineral masses I have endeavoured to be exact, I may be excused if I do not anticipate any very great accession to our knowledge in the latter respect.

[To be continued.]

L. *On the Combinations of Carbon with Silicon and Iron, and other Metals, forming the different Species of Cast Iron, Steel, and Malleable Iron.* By Dr. C. SCHAFHAEUTL, of Munich.

[Continued from p. 50.]

I SHALL now describe another action of acid bodies on iron, which has much resemblance to that which is exerted by the action of sea water on it.

I poured over a parallelepipedic fragment of tilted but very tender and indifferent razor-steel, in a tea-cup, concentrated hydrochloric acid. After the action had for the most part ceased, I changed it for fresh acid, and all visible action of this fresh acid had ceased the next day. The cup was preserved in this state without being disturbed for nearly two months. After this lapse of time I found the fragment, apparently unchanged,

the Royal Academy of Sciences of Berlin, published, with the preceding Memoir, in 1832.

* *Bulletin de la Société Géologique de France—Séance de 19 Février, 1838.*

surrounded by a ring of black sediment, about a quarter of an inch distant from it; this ring, which was about three-quarters of an inch broad, was formed of rays tending towards the centre of the cup and having scarcely any connexion between them; the opposite end of the fragment, which lay in the magnetic meridian, was covered with fibrous bundles of the black sediment like the pole of a magnetic needle dipped into iron filings. I decanted the liquid in order to wash the remaining fragment and to free it from its black covering; but on touching it, I found it converted into a soft black plastic substance. Exposed to the air, it soon changed its black appearance to that of brown, and attracted very rapidly moisture from the atmosphere, until it became nearly liquid. Hydrochloric acid heated did not appear to act upon it; nitric acid first evolved some nitric oxide gas, converting it into a brown pulpy mass of a greater volume; nitro-muriatic acid at a boiling heat dissolved it almost completely; it melted before the blowpipe, after disengaging copious fumes, into a globule of silicate of iron, strongly acting upon the magnet. Twenty grains of it burnt with chromate of lead and chlorate of potassa, developed carbonic acid gas, azote, and water. The greatest part consisted of iron, but only a trace of silica was separated, too small to be weighed.

This leads me to the consideration of a paradoxical phenomenon consisting in the insensitiveness of iron to the action of nitric acid under certain circumstances; a phenomenon which has hitherto excited so much attention, and has been attributed to an electrical inactivity of the iron itself, or to a film of hydrogen or binoxide of hydrogen protecting the surface of the iron. We have seen that when a considerable mass of iron is attacked by acids a black skeleton always remains, which very quickly changes colour when exposed to the air. We have further seen, that cast iron, which is a mixture of carburet of iron and silicon, is even attacked by hydrochloric acid on the surface only; that is to say, that as soon as the surface is coated with a pellicle of that black or brown residuum which we shall soon more accurately describe, all action of the acid and all evolution of hydrogen apparently cease; but we learn from the latter experiment that in time an invisible action always takes place, by which the mass of iron is slowly decomposed, and the remainder assumes a different shape according to the concentration or the different chemical properties of the acid itself.

When the liquid in which the iron is immersed contains free acid, the decomposition of water stops as soon as the iron is covered with a pellicle, which prevents the close contact of

a mass of iron with a mass of acid, and allows only a separated molecular contact between the iron and the acid.

When the liquid contains a great deal of *free acid*, after the evolution of hydrogen has ceased, and the air has free access to it, the residuum, after the following invisible action has ceased, will be more or *less plastic*. If the liquid contains very little free acid and the air is excluded, a basic protochloride of iron is formed by the liquid attacking only the carburets of iron, leaving the sulphurets of iron, the carburets of silicon, and the higher carburets of iron, as a skeleton behind; a similar effect takes place when the solutions contain only chlorides of magnesium and sodium. When the air has access, the metal becomes oxidized by the air contained in the liquid, and forms invariably basic salts with the chlorides in solution, which, when washed away (as is the case when iron is immersed in the sea), the skeleton of carburets of iron, silicon, &c. remain behind, which, from its highly spongy nature, condenses and compresses in its pores, when exposed to the atmosphere, atmospheric air in great quantity; part of the iron is oxidized, and when the iron is in very large masses, the temperature is generally increased to the boiling point.

The action of oxygen, by the presence of acid and water, on a solution of chlorides, presents one of the cases of chemical decomposition by which two or more chemical bodies enter into a new combination by the sole presence of another chemical body, which during the whole decomposition remains entirely unchanged. Berzelius explained this by a reference to a new force, which he called *catalytic force*. I shall, in another place—in my theory of “*the final action of chemical forces*,”—endeavour to demonstrate, that in fact *no chemical combinations of two bodies* takes place without the catalytic presence of a third, or in fact, that *all chemical combinations and decompositions* are produced by *catalytic force*.

All cast iron, when dissolved in acids, provided the fragments retain their form after the action has ceased, show, after being washed on a filter, the same property of condensing air in their pores, and of increasing the temperature by the oxidation of the iron left in a lower state of carburation. If the liquid contained very *little free acid*, very soon a basic salt is formed; and where the access of air is prevented during the progress of the solution, the remainder, when placed on a filter, oxidates extremely rapidly, and a hydrate of oxide of iron goes with the water through the filter, even after a week's incessant washing. Similar and often highly-interesting results are obtained by a peculiar sort of chemical action, where one body slowly separates from others, by combining with a third, with-

out setting the remaining parts of the compound in perfect freedom, and enables them to replace the lost body by another chemical equivalent, or to allow their molecules to follow their own attractive tendency, and to form, after being set free, a new individual body for themselves.

The action of bodies in their utmost molecular division is quite otherwise than when their molecules had been sufficiently moveable to follow, after separation, their own mutually attractive forces and to neutralize them in one centre.

A body whose chemical force had been neutralized by another, now deprived of that neutralizing body, without having sufficient freedom of its molecules to follow their forces of mutual attraction set at once at liberty, is in the state of a body surrounded by an atmosphere of electricity and in a different relation and condition of tension to the surrounding bodies.

This relation is visible in all bodies placed under such circumstances in contact with others: the instance of the reduction of iron at a low temperature by a current of hydrogen is well known; the following fact seems less so. A lump of malleable, hammered, or rolled iron raised to a white heat, over which water is poured, exerts a very feeble decomposing power on the water. Let us now take a similar mass of iron out of the puddling furnace, just ready to be placed under the hammer, and pour a basin of water upon it. No hissing noise is perceptible, no generation of steam visible*, and the water is at once decomposed, the flames of hydrogen enveloping the white-hot ball and rising very often to a height of four or five feet. I need scarcely remark, that the iron taken out of the puddling furnace is in the same state as iron treated with acids; a skeleton of each grain of cast iron remains, with this difference only; that with iron treated with acid, electro-positive metals are partially removed from the compound; but by treating cast iron in a puddling furnace, the relative electro-negative bodies are taken instead, without destroying the mechanical texture. A few strokes of the hammer destroy this property of the white-hot iron.

When a constituent of a decomposed body is separated from another, in a solid state, by chemical action, the so-separated body is never left in the same state as that in which it existed when forming a corresponding part of another body; and each body set at once free by chemical action, with per-

* On the subject of the subitaneous formation of steam by red-hot or white puddling slag, oxide of iron, and malleable iron, I mentioned some curious instances in my paper "On the conversion of water into steam at the higher degrees of temperature," &c., in the *Mechanics' Magazine*, vol. xxx. pp. 138, 294, and 339.

fect liberty of its molecules, combines with other bodies or takes a new form of very different quality, under which all precipitates, separated from the solvent liquid, exist.

In my theory of "*The final action of chemical forces*" I shall endeavour to show, that one of *the first principles* of the formation of the productions of animated life is in fact only an action of the before-mentioned chemical forces *under different circumstances*, which may be expressed in the short sentence: *extremely fine division* (molecular separation), during an uninterrupted motion.

When very gray cast iron is treated by hydrochloric acid, the residuum is a white substance, mixed with black scales of graphite, which Karsten considers as being mechanically mixed with the mass of the iron before solution, and contrasts it with the black precipitate which separates from white cast iron, which has a dull earthy appearance; but when this so-called dull and earthy powder of white cast iron is produced by a tolerably diluted acid, and viewed, while still in suspension in the liquid, under a certain angle of vision, all the small particles appear to consist *likewise of scales*, as we shall hereafter perceive, which reflect the light with the same power as the scales of graphite, their only difference from them consisting in a different chemical composition. They are therefore more easily decomposed, and apt from their softer nature to adhere rather closer to each other, in which state their scaly or foliaceous nature is not so easily to be discovered.

To ascertain the relative combinations of the elementary constituents of the different sorts of iron of commerce, the treatment by means of acids is indispensable, and I prefer the hydrochloric and nitric acids to all others.

The quantity and in part the quality of the different combinations obtained by treatment of the iron with hydrochloric acid, depends a great deal on the density of the bodies brought into chemical contact, or, in other words, on their specific gravity.

If irons of different specific gravity are dissolved in hydrochloric acid of the same specific gravity, the residuums will have a different appearance.

If filings of Swedish iron, for example, double bullet iron of the specific gravity 7.810, is dissolved in hydrochloric acid of the specific gravity of 1.169 in comparison with English iron of the specific gravity 7.60, the residuum of Swedish iron will appear in distinct heavy grayish scales, that of English iron in brown flocculent *rags*, partly remaining on the bottom of the phial and partly suspended in the liquid. But if the specific gravity of the acid is increased, the resi-

duum of the Swedish iron will assume the same appearance as the English, and so in the reverse case; this circumstance explains why anchors made of English iron, although tougher than those made of Swedish iron, are almost twice as soon destroyed by the action of sea water.

The same rule holds good, when iron, with other chemical agents, is treated in the dry way. For instance, at the same degrees of heat as those in which malleable iron of the specific gravity 7·4 has combined with the greatest quantity of carbon necessary for it to become liquid,—at the same degree of temperature Swedish iron of the specific gravity 7·7 (called Hoop L), or 7·8 (called double bullet), just begins to crystallize, forming steel, and sinking down to a specific gravity of 7·5.

The quantity of the residuums of iron of the same description bears a very remarkable relation to the specific gravity of the acid, as is evinced by the following table, showing the different quantity of residuums of 35 grains of Welsh iron from the Maesteg iron-works, specific gravity 7·407.

Specific gravity of the acid.	Residuum.	Sulphuret of Lead.
1·160 . . .	6·770 . . .	1·73
1·140 . . .	9·244 . . .	1·71
1·103 . . .	13·711 . . .	1·703.

Mottled iron from the forges at Alais, departement du Gard, in the south of France:

Specific gravity of the acid.	Residuum.	Sulphuret of Lead.
1·16	7·51	6·06
Acid very much diluted	11·42	0·6475
Acids still further diluted	21·49	1·015

In the fourth example I poured water over the fragments of iron in a retort, the beak of which was connected with two bottles of a solution of nitrate of lead, and I dropped only into the retort so much hydrochloric acid as to cause a very moderate evolution of hydrogen. In the last sample I put only a few drops of acid into the retort, just sufficient to cause a very slight attack of the iron. The third column of all the samples contains the quantity of sulphuret of lead obtained. The evolution of gas continued for several days, and when it ceased, the addition of acid had no further visible effect*.

* As I repeated the last experiment but one, I put some fragments of the cast iron in the upper part of the beak of a new retort in order to witness the effect of the evolving gas on iron fragments. The next day I found the fragments converted into a black crumbly and rather unctuous mass, soaked with a yellowish liquid, which fastened it to the glass. On nearer

By treating iron with *diluted* hydrochloric acid, the sulphur escapes *almost* entirely as sulphuretted hydrogen; the same is the case with antimony escaping as antimoniuiretted hydrogen. On the contrary, scarcely any portion of the arsenic escapes with the hydrogen.

The case is different when iron is treated with nitric acid. When fragments of iron are treated with nitric acid of such a specific gravity that the iron is moderately attacked in a retort whose beak is connected with a solution of carbonate of barytes and acetate of copper or lead, and only a slight evolution of binoxide of nitrogen takes place, the nitric oxide is then first absorbed by the air in the uppermost part of the retort, and a partial vacuum is produced which makes the liquid rise in the beak of the retort several inches. A few hours afterwards pure azote is evolved, acting neither on the carbonate of barytes nor on the acetates or nitrates of metals. Shortly after, the evolution of gas again ceases, and after the action of the acid on the iron stops, a new partial vacuum is produced and the liquid is found to stand in the beak of the retort several inches above its level.

For example, I took 20 grains of dead gray cast iron from the forges of Creuzot, departement de Saone et Loire, treated it with hydrochloric acid specific gravity 11.5, and left residuum

inspection I found those lumps covered with stalks of a black vegetation, exactly like the mould on ink or sour starch paste, and differing only in colour; the stalks were from about a half to three-quarters of a line in height, and terminated with a little knob on the top. The next day the little knob on the top assumed an orange red, and on further exposure to the air, the stalks became of the same colour.

Viewed through the microscope, these little mosses appeared opaque, of a varnished yellow colour like the petals of Everlasting, and having a long curved cylindric capsule on the end. The capsule was alternately expanded and contracted very similar to the duodenum of animals, and curved into a circle, so that the end almost met the point when the capsule was attached to the stalk; and when viewed under the microscope superficially, the knobs appeared to consist of a perfect ring fixed to the stalk. I found only one stalk, which shot forth two of these capsules from the same point, curved up just like the horns of a ram. No operculum could be discovered; the end of the capsule was found perfectly rounded like a globule with rather a narrow neck, and when pressed with a fine needle, the capsule burst, emitting extremely fine seeds, exactly like the genus *Phascum*. No traces of leaves could be detected, unless we reckon some entangled and interwoven black filaments on the surface of the decomposed iron. Not being sufficiently acquainted with the cryptogamic branch of botany, I am not able to decide on the generic character of these small vegetations.

On the retort being packed up in moss and afterwards washed with rain water, the seeds of the moss must have been derived from one of these sources; but the most extraordinary circumstance is their becoming fixed in these decomposed fragments of cast iron, serving as a very fertile mould, and growing rapidly in hydrochloric acid gas and sulphuretted hydrogen.

= 7.08 grains. The same quantity of the same iron treated in the above-mentioned manner with nitric acid of 1.10 specific gravity left residuum 3.24 grains; no trace of sulphuric acid could be discovered in the liquid. By boiling the remainder in a platinum crucible with strong nitric acid, the greatest part of the sulphur was separated, which adhered slightly as a yellow riband to the side of the crucible, and no traces of sulphuric acid were to be found in the solution. The sulphur thus separated from 1.55 grains of the residuum weighed 0.180 grains, and this burnt on a platinum foil left 0.100 sulphuret of iron. That which the nitric acid had dissolved during the boiling was precipitated with caustic ammonia and consisted of

Iron	0.443
Phosphorus	0.155
And left residuum .	0.31
Humine	0.33

We see therefore that the sulphur had been in combination with the iron, approaching in this formula $F^3 S$, that is in a certain well-known state of chemical proportions.

Another remarkable circumstance is the difference of the products of solution according to the difference of the specific gravity of the acid, which throws a light on several chemical products, which arise from different degrees of concentration of chemical agents, and the varying products obtained by the various degrees of heat.

In hydrochloric acid we have a juxtaposition of atoms of chlorine and hydrogen intermixed with atoms of hydrogen and oxygen; and the interposition of a certain quantity of atoms of water betwixt a certain number of atoms of chlorine and hydrogen, alone determines how many atoms of the iron shall combine with chlorine to form protochloride of iron, and how many atoms of hydrogen shall form compounds with carbon and azote.

The description of the residuums left by treating iron with acid was always a matter of great speculation. Berzelius says the remainder of the solution of iron in sulphuric acid was black, in hydrochloric acid gray, and sometimes white.

The colour of the residuum, as shown, depends partly on the specific gravity of the iron and partly on its chemical composition.

The residuum of white cast iron prepared with coke as fuel, in hydrochloric acid is always brown, yellowish brown or greenish brown; the remainder of very *gray coke iron* is always light gray, in different shades approaching to white.

[To be continued.]