On the Cliftonite and Tænite of the Meteoric Iron found in 1884 in the Sub-district of Youndegin, Western Australia.

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IN a previous paper, published in 1887,[1] the author described some remarkable crystals of graphitic carbon (Cliftonite) obtained from the meteoric iron of Youndegin, Western Australia; the isolated material weighed only 3 milligrams, and had been left as an insoluble residue after the treatment of 8·32 grams of the iron with *aqua regia.*

1. *Limited distribution of the Cliftonite in the mass.*

In the following year (1888), with a view to isolating more of the graphitic crystals and at the same time other mineral constituents of the mass, a large piece of the same meteoric iron, filed free from rust and weighing 97·25 grams, was submitted to the action of slightly heated dilute hydrochloric acid (1 of S.G. 1·12 with 10 of water), the acid being renewed from time to time as exhaustion took place. The action was allowed to proceed night and day until, after the lapse of a fortnight, evolution of hydrogen was no longer manifest. During this time the undissolved residue was kept as free from disturbance as possible, for the graphitic crystals were known to be brittle and easily reducible to powder. During the action of the acid the first appearance of Cliftonite was carefully watched for, in order that the mode of occurrence of the crystals in the mass might be ascertained; but not a single crystal was seen in the course of the whole operation, and the undissolved residue itself, when afterwards examined, was found to be almost wholly attracted by the magnet, and the unattracted part to be completely dissolved by *aqua regia.* As already recorded,[2] two other fragments, weighing 7 grams and 2 grams respectively, had yielded no graphitic material on solution.

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[1] *Mineralogical Magazine*, 1887, Vol. VII, p. 121.

[2] *Ibid.* p. 125.

The Cliftonite is therefore localised in one or more parts of the mass, and not uniformly distributed through it. The more common variety of graphitic carbon is also similarly local in its occurrence in meteoric iron, being present in various masses as large nodules.

2. *Tænite.*

During the solution small thin lustrous black plates, only slightly if at all attacked by the dilute acid, were seen to be distributed throughout the more soluble material, many of the plates being parallel to each other. Their appearance was so like that of graphite that it was at first expected they would prove to belong to that species; but on examination of the plates initially set free, they were found to consist of a material strongly attracted by the magnet, flexible, completely soluble in strong hydrochloric acid and also in nitric acid of S.G. 1·2; they had an immediate reductive action on a cold solution of mercuric chloride, and in a day or two passed completely into solution. They contained no phosphorus. After standing for two days in water, a plate became oxidised on the surface and lost its brightness.

From these characters it was inferred that, notwithstanding their black colour, the plates consisted of an alloy of nickel and iron belonging to the tænite group.

The thin plates, as set free, were pushed with a thick platinum wire into a separate dish, and were kept isolated from the rest of the undissolved material as being a comparatively definite and homogeneous constituent of the meteorite. When all the plates obtainable had been collected, they were again treated with dilute hydrochloric acid for some days. Further, a small quantity of adherent schreibersite was carefully broken off and removed; it was found through the sense of touch by means of the greater resistance felt when the particles of schreibersite on the flexible plates were pressed with the thick platinum wire: owing to their flexibility the plates themselves are somewhat yielding, and thus give a suggestion of softness when they are pressed with the wire. The plates were washed with water, afterwards with alcohol, and then dried and weighed (0·0870 gram). Later there were added some further plates which had been similarly obtained from small waste fragments of the iron produced during the cutting of the mass; their weight was not determined, but it must have been comparatively small.

In the course of the present year (1899) it was resolved to make a quantitative analysis of the alloy, notwithstanding the smallness of the amount available for the purpose. During the eleven years which had passed since its isolation, the alloy had been lying in a weighing tube inside a closed box. It still retained its lustre, and appeared to have undergone no alteration.

(*a*). The weight, however, was now 0·1026 gram, and the excess (0·0156 gram) over the amount (0·0870 gram) isolated from the large piece was greater than was likely to be due to the plates which were obtained from the small waste bits of the iron, and had been added after the weight of the main material (0·0870 gram) had been determined.

(*b*). The material, though entirely attracted by the compass-needle, did not appear to be as strongly attracted as nickel-iron.

(*c*). Cold solution of mercuric chloride had no perceptible action on the plates even in the course of some days. In this respect the plates behaved quite differently from before; for in 1888, as already stated, the reductive action had been immediate. After a fortnight, although a flake was still apparently unacted upon by the mercuric solution, there was really only a thin crust of undissolved material left; for when touched with a wire the flake completely collapsed. On the other hand, a boiling solution had an immediate solvent action, only a trivial amount of black material being left. This black material was immediately dissolved by strong hydrochloric acid, and was therefore not carbon.

As a cold solution of mercuric chloride has no solvent action on the magnetic oxide of iron, the later behaviour of the plates is such as would result if they had been superficially changed into the black magnetic oxide.

(*d*). The specific gravity of the material, as determined from 0·0669 gram with the use of a 3-cub. cent. pyknometer, was 6·75. This number is so much below those corresponding to iron and nickel that, with every allowance for the difficulty of accurately determining the loss of weight in water for so small an amount of dense metal, it suggests an oxidation of the material. It may be mentioned that during the determination great difficulty was experienced in removing all the interpenetrant air; the plates were composite, and the air was only slowly removed from the intervening spaces by an oft-repeated use of the air-pump.

(*e*). The above-mentioned material, weighing 0·0669 gram, was treated with *aqua regia*, and in a short time was almost wholly dissolved. Long digestion, however, did not produce complete solution; a minute amount of insoluble reddish-purple pulverulent matter was still visible. It was collected and weighed by the double-filter method after being dried at 165° C. The colour had now changed from reddish-purple to black. The material weighed only 0·0006 gram. As it completely disappeared on ignition, it was probably an organic compound, and was possibly due to the action of the *aqua regia* on a trace of Cohenite, a carbide of iron and nickel occasionally present in meteorites.

The solution was analysed according to the methods already described,[1] except that the number of precipitations with sodium acetate was six instead of four.

The resulting numbers were—

Iron	0·0385	gram.
Nickel (Cobalt) ...	0·0236	,,
Phosphorus ...	0·0004	,,
Total	0·0625	,,

Copper was found to be present, but its weight was not determined; though the amount was small, the proportion of the copper was probably larger than for an average piece of the meteoric iron itself. Only a trace of magnesium was found.

There was thus 0·0044 gram still unaccounted for. The deficit was presumably due to combined oxygen, for the analysis had been made with great care, and had proceeded without evident mishap. The still remaining material, weighing 0·0285 gram, was then heated in a porcelain boat in a current of hydrogen, and was found to experience a loss of 0·0018 gram. In the same proportion, 0·0669 gram of the material should lose 0·0042 gram, and the result is thus confirmatory of the above explanation of the deficit.

After the heating in hydrogen, the material was no longer black, but bright tin-white in colour.

If the small amount of phosphorus be deducted, as being in combination with iron and nickel as schreibersite having the formula Fe_2NiP, the percentage composition of the Youndegin tænite is—

Iron	61·87
Nickel (Cobalt)	38·13
	100·00

The alloy is therefore almost identical in chemical composition with that isolated by Cohen and Weinschenk from the Glorieta meteorite, the percentage composition of which was determined to be:—

Iron	63·04
Nickel (Cobalt)	36·96
	100·00

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[1] This volume, p. 170.