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ORIGINAL ARTICLES.

I.—On "Tasmanite" and Australian "White Coal."

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(PLATE X.)

THE two substances known as "Tasmanite" and Australian "White Coal," which are the subject of the present communication, have a special interest for the geologist on account of the light which they throw upon the microscopic structure and composition of many Coals. My attention was first directed to them when collecting materials for Professor Huxley's examination into the microscopic structure of Coal. My esteemed colleague, Mr. Etheridge, at that time gave me a specimen of brown laminated substance, labelled "Lignite, the so-called White Coal, Australia," and drew my attention to the fact that it was very largely composed of small seed-like bodies, very similar to, although smaller than, the macrospores[1] of *Flemingites*, which are to be seen in many kinds of British Coal. A specimen of this same kind of White Coal is in the Museum of Practical Geology, and is labelled, "Bituminous Shale (locally called White Coal), New South Wales, Australia." I have likewise been able to examine the specimen of Tasmanite also in this Museum, which is labelled "Tasmanite; combustible matter from the river Mersey on the north side of Tasmania; stratum of unknown thickness, but known to extend for some miles. Presented by Sir Wm. Denison." These specimens are very similar in appearance and structure, but the White Coal is softer than the Tasmanite. Chemical analyses of Tasmanite have been published, but I am not aware of any satisfactory account of its microscopic structure. The only mention of Australian White Coal with which I am acquainted is that in Prof. Huxley's lecture on "On the Formation of Coal" ("Contemporary Review," Nov. 1870). And there is a figure, of a section and some separated spores, given by Sir C Lyell in the 2nd edition of his Student's Elements of Geology, 1874.

The general appearance of the combustible schist, which is now generally known as Tasmanite, is thus described by Mr. J. Milligan,

[1] The bodies existing in Coals which have usually been termed *Sporangia* and *Spores* have been shown by Prof. Williamson to be *Macrospores* and *Microspores*. I believe both Professor Huxley and Mr. Carruthers are prepared to accept this determination.

in the earliest account of this substance which I have yet seen (Report of the Royal Society of Van Dieman's Land, 1852, p. 96): "There is on the right bank of the river [Mersey,] . . . . a series of beds of a brown schist,[1] of a nature highly combustible; its surface is usually finely punctated—it is semi-soft, sectile, fissile, flexible, and slightly elastic, and when held to a candle burns with a strong yellowish-white flame." When the substance thus described is examined with a pocket lens it is seen to be very largely composed of minute discs of a brownish colour, giving to the schist a granular aspect; this is probably the appearance alluded to in the above extract as "finely punctated."

The chemical analyses of Tasmanite made by Prof. Penny (Proceedings of the Royal Society of Van Dieman's Land, vol. iii. 1855, p. 108) and by Prof. Church (Philosophical Magazine, vol. xviii. 1864, p. 465) show that the discs are composed of a kind of resinous material, and that they are imbedded in a matrix of siliceous sand and clay.

It is perhaps worthy of remark that Prof. Penny puts the resinous matter at 26·24 per cent., and pyrites at 2·16 per cent.; while Prof. Church says the resinous matter forms 30 to 40 per cent. of the schist, and makes no mention of pyrites; he states however that the resinous matter contains a very large proportion of sulphur in chemical combination.

It appears from the observations of these two authors that the so-called resinous portion of Tasmanite is not really resinous, for it is insoluble in alcohol, ether, bisulphide of carbon, benzole, turpentine, and paraffin oil. Now the so-called bituminous portions of coal differ from resins in very much the same particulars; and when we find also that Tasmanite "affords a notable quantity of gas, which is similar in quality and powers to that obtained from cannel coal," although less in quantity, we must, I think, consider Tasmanite and Coal to be allied substances.

The large proportion of sulphur, which Prof. Church has shown to be in chemical combination in Tasmanite, is paralleled in the case of certain coals mentioned by Dr. Percy (Fuel, 1875), as being remarkable for the same peculiarity.

By the kindness of Mr. W. J. Ward, I am enabled to give the following particulars regarding the composition of Australian "White Coal":

Combustible Materials ..	29·58
Ash	68·47
Water	1·95
	100·00

After treating this *White Coal*, in a finely divided condition, with hydrochloric and hydrofluoric acids, and separating a small proportion of whitish sand by decanting, there was about 43·61 per cent. of residue, chiefly composed of the discs, but evidently still containing a small proportion of sand or clay, which had not been dissolved by the acids.

[1] Allied to Dysodile.

A portion of the discs carefully separated by sifting and again treated with hydrofluoric acid gave

Combustible material... ...	96·63
Ash (bright red)	3·37
	100·00

In order to ascertain the true nature of the *discs*, in either Tasmanite or White Coal, it is necessary to prepare thin slices of the schist for microscopic examination, and also, for the same purpose, to separate the discs by treatment with hydrochloric or nitric acid.

When the separated discs are viewed by reflected light, they appear as more or less circular bodies, somewhat thickened towards the circumference, many of them having their surfaces raised into irregular folds. If mounted in Canada Balsam, and viewed by transmitted light, many have the appearance represented in Pl. X. Figs. 2, 3, 8, while others exhibit the folds to which allusion has just been made. The more perfect discs are seen to be surrounded by a double contour-line—the optical expression of the fact that these discs are really thick-walled sacs. The saccular character, however, is best seen in transverse sections (Figs. 1, 4, 5), or when the sac is broken (Fig. 8). A closer examination enables one to see that the walls of these sacs are not homogeneous. A view such as Fig. 8 shows numerous dots scattered over the surface, which become somewhat elongated towards the edges of the disc. When examined with a power of about 250 diameters, the dots can be resolved into minute circles about $\frac{1}{3000}$ of an inch in diameter with a still smaller dot in the centre, as shown in Fig. 9. These structures are best seen in the discs of White Coal. It may be thought that these dots are comparable to the granules to be seen upon the surface of some of the macrospores of *Flemingites*; but the study of transverse sections shows at once that these dots are not mere surface-markings, for they can be distinctly traced as minute lines (tubes ?) passing from the outer to the inner surface. These lines are shown in Fig. 5, but owing to the section not being quite in the same plane as the lines, they do not appear to extend quite through. In addition to the fine lines, the walls of the sacs exhibit obscure longitudinal markings, which give them a laminated appearance (Fig. 5).

Neither Mr. Carruthers (Geol. Mag. 1865, p. 432), nor Mr. MacNaughton (Trans. Roy. Soc. Van Dieman's Land, vol. ii. 1855, p. 116), mentions any structure in the walls of these sacs.

The discs vary in diameter, as stated by both these authors, from about $\frac{1}{80}$ to $\frac{1}{30}$ of an inch. Mr. MacNaughton speaks of a thin outer coat to these discs, which may be seen when they are ruptured. I have examined all my preparations, both sections and separated discs, in order to distinguish this outer coat, but have been unable to do so. One easily recognizes in transverse sections, such as Fig. 1, that the walls of the sacs vary much as regards thickness; and among the separated sacs which are mounted in Balsam some may be seen much more transparent than the rest; but I have failed to see any real difference between the thicker and the thinner sacs, or to find them in anything like the relation of an inner and outer coat.

Nearly all the sacs are so compressed that their walls are brought into contact; but occasionally one may be found similar to Fig. 6, containing a quantity of black material differing in appearance from the surrounding matrix, and which appears to consist of minute rounded particles, about $\frac{1}{3000}$ of an inch in diameter.

With regard to the affinities of the discs, or rather sacs, it must be acknowledged that their true nature has yet to be determined. Their general structure seems to indicate that they are the spores or sporangia of some Lycopodiaceous plant; but their true affinities must remain obscure until they are found in their natural relation to the parent plant, or some recent form is discovered with which they can be compared. By the kindly help of Mr. Carruthers, I have been enabled to examine the fructification of several recent forms, but have failed to find anything comparable in structure to these sacs. Prof. Balfour, I believe, considers the Tasmanite discs to be closely allied to *Flemingites*; they differ from them, however, as Mr. Carruthers has pointed out (Geol. Mag. 1865), both in structure and size. All the *Flemingites* macrospores which I have seen have homogeneous walls, and in many of them is seen the triradiate marking, which is so generally present in cryptogamic spores (Prof. Williamson, Macmillan's Mag. March, 1874, p. 409). In none of the Tasmanite sacs have I been able to see this triradiate marking, although their structures are so clearly shown that these markings could not fail to be seen if they were present; and the walls, as we have already seen, have a definite structure. The sporangia of *Lepidostrobus* figured by Dr. Hooker (Mem. Geol. Survey, 1848, vol. ii. part ii. pl. 6, figs. 4, 10, and pl. 7, fig. 7) have somewhat the same appearance as the transverse sections of Tasmanite sacs, that is to say, they show a series of lines perpendicular to the surface. A closer examination, however, of the figure, or, still better, of the original specimens, shows that the two structures are not the same. In the *Lepidostrobus* sporangia the lines are really the walls of the cells of which the sporangia are composed. In the Tasmanite sacs the lines have quite a different appearance, and a surface view shows that they are not merely the lines of junction between cells.

The minute black bodies mentioned above as filling the cavities of some of the discs are very much smaller than any of the microspores mentioned by Prof. Williamson (Macmillan's Mag. March, 1874, p. 408), and they do not show any cell wall.

In the abstract of a paper by Mr. Thos. S. Ralph (Trans. Roy. Soc. Victoria, vol. vi. 1865, p. 7), the discs of Tasmanite are referred to Algæ. This, I venture to think, is improbable.

There can be no question as to the *Tasmanite* sacs being vegetable organs, although at present we do not know the plant to which they belong. Their size and form seem to indicate that they are more nearly allied to Lycopodiaceous macrospores than to anything else.

The inconvenience of having an object without a distinctive name induces me to propose one for the spores (?) found in Tasmanite and Australian White Coal (the two being, as I believe, identical in structure); and in order to retain existing titles as far as possible, I would

suggest that Prof. Church's name *Tasmanite*, which is so generally used in reference to the schist as a whole, be retained for this substance, and that the spores (or rather the plant to which they belong) should be called *Tasmanites*, with the specific title of *punctatus*, in allusion to their surface-markings.

The piece of *Tasmanite* drawn in Figure 1 was chosen on account of its exhibiting portions in which the spores are unusually far apart, and others where they are more numerous and compressed. It is this compressed portion which so closely resembles the structures seen in many coals, and which Prof. Huxley believes to be masses of spores and sporangia (Contemporary Review, Nov. 1870). Improbable as it may seem to some persons that the combustible portions of a bed of coal several feet in thickness should be for the most part composed of spores, yet such is undoubtedly the fact in the case of Tasmanite and Australian White Coal. In both these substances the combustible portion consists entirely of sacs (*spores* ?), no other vegetable matter whatsoever being traceable.

If a section of Better Bed Coal, such as that mentioned by Prof. Huxley, be compared with one of Tasmanite or Australian White Coal (see Figures 1 and 10), the similarity of their structures will be at once apparent. The chief difference between them being, that while in the two last there are only large spores and the spaces between these are filled with sandy matters, in the former the interspaces between the larger spores are filled in with multitudes of minute spores mixed with mineral charcoal.

With regard to the mode of occurrence of Tasmanite, Mr. Milligan, in addition to the extract given above (page 338), says: "The same brown combustible schist [Tasmanite] presents itself a mile higher up the river, and on the same side, but at an elevation of more than 100 feet above the water, and then it appeared to dip slightly into a high and rather steep hill, etc.

"The brown combustible schist exhibits at the elevation last mentioned a thickness of six to seven feet in one distinct seam, passing upwards into laminated clay rock of a yellowish colour, interstratified with thin layers of the schist.

"Below the six-feet seam there is, for a space, the same alternations as above, but uninterrupted beds of compact yellowish and bluish white clays succeed, etc.

"The occurrence of thick beds of fine clay and clay schists without organic remains above the fossiliferous masses [rocks previously mentioned as occurring below the brown schists and clays], denote a tranquil condition of superstant waters, compatible only with the character of a capacious and sheltered bay, or deep and extensive lake; to which supposition the subsequent deposit of repeated layers of a highly combustible schist of undoubted vegetable origin lends great probability.

"An extended and close examination of these beds, and the formations with which they are associated, and a careful comparison of their fossil contents, will be required thoroughly to establish

their ages in relation to each other, and to geological changes and epochs generally."

The changes in the physical condition of the land necessary for deposition of several alternations of beds of clays and schists, some of which are of considerable thickness, and the subsequent elevation of the whole to 100 feet above the level of the river, show that these Tasmanite schists cannot be of very recent origin, although the distinct and unaltered appearance of the spores might have led one to suppose that they were. The alternations of layers of the schist with beds of laminated clay rock, and the presence of masses of fossiliferous rocks below this series, are extremely suggestive, on account of their resemblance to the succession of strata in the Carboniferous Epoch; indeed, it seems highly probable, from Mr. Milligan's observations, that these beds of Tasmanite were deposited under conditions very similar to those under which Coal is now generally considered to have been deposited.

I have at present been unable to ascertain under what conditions the Australian White Coal occurs; its great resemblance to Tasmanite renders it highly probable that it occurs under very similar conditions.

The foregoing consideration regarding the composition, microscopic structure, and mode of occurrence of Tasmanite, must, I think, lead to the conclusion, that this deposit is a bed of coal in process of formation; very inferior coal no doubt, on account of the large admixture of sand and clay, but nevertheless of such a character that it would be considered a true coal. The study of Tasmanite will, I think, enable us better to understand the appearances presented by certain coals: and certainly not the least important fact to be noticed is, that the combustible portion of this deposit, which is closely allied to coal, several feet in thickness and miles in extent, is formed entirely of spores.

EXPLANATION OF PLATE X.

FIG. 1.—Section of Tasmanite, cut perpendicular to the plane of bedding, × 50 diameters. In the upper two-thirds of the figure the spores are further apart than is usually the case; in the lower third they are very numerous and more compressed.

FIG. 2.—A large spore of *Tasmanites punctatus* which has been ruptured, × 50 diameters: showing the double contour and dotted surface.

FIG. 3.—A similar but smaller spore, with air in the interior; × 50 diameters.

FIG. 4.—Transverse section of a spore, the walls of which have been pressed together from the same section as Fig. 1; × 50 diameters.

FIG. 5.—Portion of Fig. 4, × 250 diameters, to show the perpendicular lines and laminated structure.

FIG. 6.—Spore filled with black material × 50 diameters.

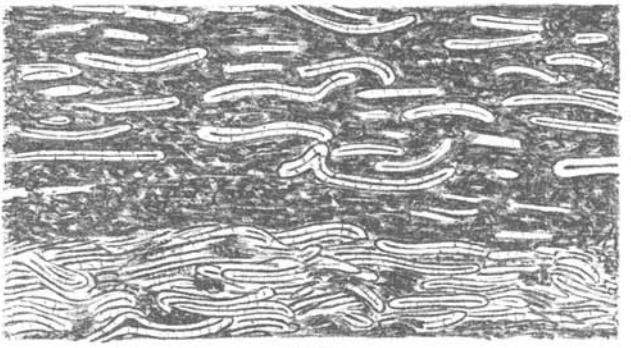
FIG. 7.—Portion of similar spore × 250 diameters, shows three of the minute rounded bodies separated from the mass.

FIG. 8.—Spore of *T. punctatus*, from the Australian White Coal, × 50 diameters.

FIG. 9.—Portion of Fig. 8, × 250 diameters, to show the dots and extremely fine granulation of the intermediate portions of the surface.

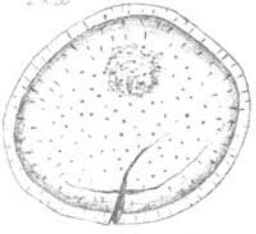
FIG. 10.—Section of Better Bed Coal, cut perpendicular to the bedding, × 25 diameters. The large sac-like bodies are macrospores (*Flemingites*); the intermediate granular-looking portion is composed of microspores and a black material, probably mineral charcoal.

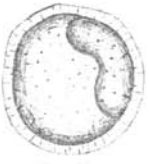
FIG. 11.—Section of same coal cut in the plane of the bedding, × 150 diameters. Small portion of intermediate part, with microspores.



1 × 50.

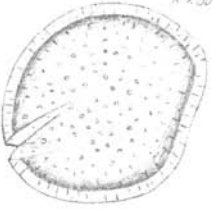
2 × 50.





3 × 50.

8 × 50.

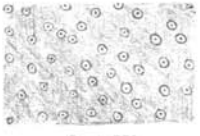


4 × 50.

5 × 250.

11 × 150.

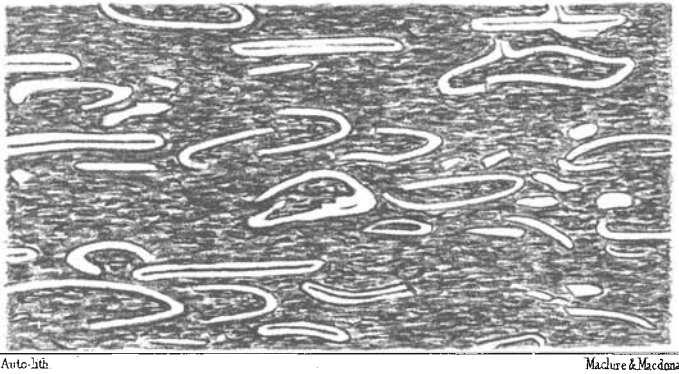
7 × 250.



9 × 250.

6 × 50.

10 × 25.



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