- FIG. 4. Right lower jaw of *Enneodon crassus*, Marsh; outer view.
 „ 5. Left lower jaw of *Menacodon varus*, Marsh; outer view.
 „ 6. The same jaw; inner view.
 „ 7. Left lower jaw of *Paurodon valens*, Marsh; outer view.
 „ 8. The same jaw; inner view.
 „ 9. Right lower jaw of *Prineodon ferox*, Marsh; inner view.
a, canine; *b*, condyle; *c*, coronoid process; *d*, angle; *f*, dental foramen;
g, mylohyoid groove; *s*, symphyseal surface.
 Figures 2 and 3 are twice natural size, and the others three times natural size.

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II.—THE RHYOLITES OF WUENHEIM, VOSGES.

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IN a paper recently read before the Geological Society,¹ I ventured the conclusion that the bulk at least of the “pyromerides” of the Continent would be found to be altered lavas of an originally glassy character. The careful drawings and descriptions of various petrographers formed a strong chain of evidence; and the observations of Mr. T. Davies² on materials from Bouley Bay, Jersey, seemed to establish beyond a doubt the connection between rocks authoritatively styled pyromerides and those regarded in this country as ancient rhyolites. Last autumn I visited one of the most typical continental localities, the richly-wooded Tiefenbach valley west of Wuenheim in the Vosges, and a few notes on specimens then collected may possibly be of interest to workers in a similar field.

It is at once apparent in the steep cliff-like exposure, with old slaty and sandy rocks towards its base, situated just beyond the junction of the roads from Wuenheim and Sulz, that one is dealing, not with a massive “porphyry,” but with materials as diverse as those of the famous quarry near the Wrekin. Thus one rock is distinctly banded in tints of grey and yellow-brown, and proves under the microscope to be a devitrified perlite, an old obsidian rather than a stony rhyolite; while the “globular” types, made famous, since their discovery by M. Koechlin-Schlumberger, through the detailed investigations of Delesse,³ occur in considerable variety, as may be seen even in the metal of the neighbouring roads. In some instances the spherulites, 5 millimetres to 1 centimetre in diameter, are purple-red in a yellowish matrix; in other cases they have a grey and flinty aspect. Many have become chalcedonic in the centre, and may have passed through a hollow stage before this final alteration. Radial structure is visible in the spherulites to the naked eye, and the surrounding material is evidently perlitic.

So much did the spherules at the time of their origin partake of the character of the matrix from which they were derived, that the larger lines of perlitic jointing pass frequently from one into the

¹ Quart. Journ. Geol. Soc. vol. xlii. p. 188.

² Min. Mag. vol. iii. p. 118.

³ Mémoires de la Soc. géol. de France, 2me série, tome iv. p. 308, etc.

other, and aid doubtless in bringing about the alteration of the spherulites. It is to this admixture of glass and this slight differentiation from it that I would prefer to ascribe the absence of double refraction in so many incipient spherulites of modern date, rather than adopt the view held by some petrographers that such bodies may largely consist of opal.

Delesse, with his usual perception, detected in the matrix of the rock of Wuenheim the perlitic jointing, the "structure fendillée et globuleuse entrelacée," explaining it as a product of contraction when the mass had become practically solid. Microscopic sections would have revealed it to him in exceptional completeness, and the former glassy condition of these dull felsitic rocks may be considered as proved by the presence of the structure in such perfection. The spherulites, whether grey or red, are alike brown in section, and resemble the well-known type, the "felsospherites" of German authors; while their minute globulitic constitution seems to be still retained, despite the secondary granulation visible under polarised

FIG. 1.—Section of rock of Tolcsa, showing disturbance of the lines of flow between the components of the large irregular spherulites. $\times 80$.

FIG. 2.—Section of altered perlitic lava of Wuenheim, showing rays belonging to two large "skeleton-spherulites." $\times 18$.

light. Vogelsang,¹ indeed, comments on the "surprising resemblance" between the structures of the rock of Wuenheim and certain Hungarian lavas; and it is interesting to note that Faujas de St.-Fond² described, eighty years ago, the similar pyromeride of Corsica under the name of *Roche porphyroïde* rather than *porphyre*, stating his belief that the constituents had consolidated more rapidly than is the case in the latter class of rocks.

The most remarkable rock from the "globular" series of Wuenheim is one of limited occurrence, in which the spherulites, about 1 centimetre in diameter, are closely crowded together, apparently to the almost complete exclusion of the matrix. Instead of being compact and homogeneous, these spherulites are seen on broken surfaces to be composed of alternating red and lighter rays, suggesting the

¹ Die Krystalliten, p. 168.

² Essai de Géologie, tome ii. p. 246.

presence of a coarse granophyric structure. Under the microscope, however, while the red rays resemble in constitution the ordinary spherules, the intervening matter proves to represent the matrix, now petrosiliceous, it is true, but retaining the characteristic perlitic curves, marked out often by ferruginous stains and granular products of alteration. The spherulites are, in fact, imperfect, being constructed of radially-grouped rods, circular in cross-section, stretching outwards from a more compact and normal centre. That the alternating and more transparent layers consist, not of original quartz, nor chalcedony, but of a devitrified glassy matrix, the specimen figured leaves, I think, no room for doubt. (FIG. 2.)

Further alteration might convert this material into the semblance of chalcedonic veinules, or might even replace it by bands of secondary quartz. The frequent mention by older writers—Monteiro,¹ for example—of interlamination of “quartz and felspar” in the nodules of pyromerides makes one certainly prepared for the development of granophyric structure in such masses on a handsome scale. Delesse² even held that the “quartz” in the rock of Wuenheim exerted some influence on the globular forms of the spherules at the time of their development, and that the alternating bands were due to a primary separation of the constituents. But in another place³ he shows that the more siliceous fibres are probably chalcedonic, since the etching of polished surfaces of the rock with hydrofluoric acid destroys them more rapidly than the feldspathic rays. M. Michel Lévy,⁴ accepting the siliceous rays and veinules in the pyromeride of Gargalong as consisting of chalcedony, believes them to be primary, and to characterise a distinct type of rock, peculiar to Permian and Triassic days; that is, a rock intermediate in structure between the micropegmatites with their radial quartz and the modern lavas with spherules largely made of opal.

The example from Wuenheim, however, recalls forcibly a structure occurring in glassy rocks of comparatively recent date. Von Richt-hofen⁵ noted in the perlites of Tolcsva and Erdobeny in Hungary certain groups, one or two inches across, of radially divergent rays, interpenetrated by the homogeneous magma, and regarded them as coarse spherulites extended outwards in this open fibrous manner until they were checked by coming into contact. Vogelsang,⁶ seeking for an explanation of this abnormal mode of growth, observed that the general direction of flow of the rock, as indicated by the lines of trichites, was the same in the spherulitic rays as in the matrix, but that local disturbances in this arrangement occurred in the glassy interspaces, where the trichites seemed even to follow the outlines of the several rays. He was thus led to the conclusion

¹ Journal des Mines, tome xxxv. (1814), pp. 347 and 407.

² Bull. de la Soc. géol. de France, tome ix. p. 177.

³ Mém. de la Soc. géol. de Fr. 2me série, tome iv. p. 313.

⁴ Bull. de la Soc. géol. de Fr. 3me série, tome iii. (1875), p. 226. Cf. Noury. “Géologie de Jersey,” p. 33.

⁵ Jahrbuch der k.k. geol. Reichsanstalt, vol. ix. (1860), p. 180.

⁶ Die Krystaliten, p. 148; also plate xvi. fig. 1.

that the spherules had originally been formed as compact and normal aggregations, but that the rock had undergone a second fusion; the glass had then penetrated the spherulites along their lines of radial structure, corroding but not destroying them, nor yet disturbing, by shifting of their parts, the parallelism of the earliest-formed crystallites within. Each spherule became thus split up into a bundle of diverging and rounded rays; and Vogelsang remarks in a later passage¹ on the similarity between this structure and that of certain felsospherites in the "kugelporphyr" of the Vosges, in which the place of the glass, however, is taken by a granular siliceous aggregate affecting polarised light.

That Vogelsang's explanation will not satisfy certain cases, while it may probably in others be regarded more as an ingenious than an inevitable deduction, is clear from sections of Hungarian "strahlige sphaerolithe" in the collection of the Normal School of Science and Royal School of Mines. In the instance figured (Fig. 1), the fluidal structure of the obsidian passes continuously through the matrix and the spherulitic matter, and is merely disturbed, not broken, in the interspaces between the rays. While this continuity excludes the idea of a second fusion, the local disturbances must have arisen from the opposition offered by the rays themselves. In a glassy lava moving with some rapidity, large spherulites are impossible, the separated globulitic materials being carried out into parallel bands. As the movement becomes slower, however, and as consolidation proceeds, nodular aggregations appear locally along this banding, and, if the crystallisation is finally arrested at this stage, their outer margins are seen to be ill-defined and ragged, set with, in fact, irregular but fairly radial rays.² It is conceivable that as we frequently meet in rocks with the mere skeletons of crystals planned on a scale too ambitious for the time occupied in the consolidation of the mass, so even *skeleton-spherulites* may arise, the whole product being similar in structure to the arrested external layers of the instances above described. The diverging rays, set at all angles to the direction of flow, will gradually interfere, after the manner of embedded crystals, with the further uniform progress of the glass; and the last movements in the mass, together with the pressure of upper layers, will serve to distort the lines of crystallites between the rays, or even to break them through and rearrange the particles into local lines of flow.

In some of the Hungarian cases examined, the interstitial matrix has itself become finally spherulitic, but on a minute and delicate scale, showing a mosaic of dark-cross areas when viewed between crossed Nicols. In the rock of Wuenheim, however, it seems for the most part to have remained glassy until the period of its secondary alteration into granules. The individualised fibrous structure of the spherulitic rays, which are well compared to axiolites by Rosenbusch,³ would in itself assign to them an origin independent of one another in all but the tendency to develop in groups about

¹ *Ibid.* p. 168

² See Quart. Journ. Geol. Soc. vol. xli. plate iv. fig. 1.

³ Mikroskop. Physiogr. 2nd edit. (1886), p. 395.

certain centres. The second, third, or fourth series of spikelets attaching themselves to one of the rays of a skeleton-crystal of magnetite may be considered as independent of the similar additions, whether simultaneous or not, made during consolidation to the other primary arms. One arm, moreover, in such examples frequently attains to a much greater development than the rest, and corresponding phenomena may be expected among skeleton spherulites.

I would submit these few observations as further evidence in favour of regarding the pyromerides as the altered representatives of the rhyolites of to-day, of which they reproduce, not only the familiar, but also some of the rarer types. It is interesting to observe that, equally with those of Jersey, the Wuenheim lavas are held to be of Permian age.

In the microscopic work relating to this subject, I have been much indebted to preparations made in the Geological Laboratory of the Normal School of Science and Royal School of Mines.

III.—ON SOME REMAINS OF SILUROID FISHES FROM BRITISH EOCENE FORMATIONS.

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AMONG the early Tertiary Fishes in the British Museum, there are a number of detached spines and cranial fragments from the Middle and Upper Eocene beds of Bracklesham and Barton, which are undoubtedly referable to extinct members of the family of Siluridæ. With the exception, however, of three specimens figured and briefly noticed by Dixon in his work on the fossils of Sussex,¹ all have remained hitherto undescribed; nor is it an easy task to base any satisfactory identifications upon such fragmentary materials. But as it has sometimes been asserted that no traces of this family have yet been discovered in European formations,—and, as moreover, at least one important generalization has been based upon the supposed fact,²—it will perhaps be of interest to offer a few notes upon these fossils, to show that their non-recognition is due rather to the imperfection of the geological record, than to their actual absence in the rocks. And some slight notice is all the more desirable, since Dixon's reference of the Bracklesham specimens to the temperate genus *Silurus* is obviously erroneous, and the mistake has escaped correction in the second and revised edition of his great work.

It is impossible, of course, to attempt any precise specific diagnoses equivalent to those recognized by the zoologist among living forms; for no evidence is yet forthcoming as to the arrangement and proportions of the fins, which constitute so prominent a character of note in systematic works. But there is very good reason to believe

¹ F. Dixon, "Geology and Fossils of Sussex," 1st edit. 1850, p. 204, pl. xi. figs. 11-12 [2nd ed. p. 244, pl. 11, figs. 11-13.]

² "The Siluroids . . . came into existence after the Cyprinoids, fossil remains being known only from Tertiary deposits in India, none from Europe." (A. Günther, "Study of Fishes," 1880, p. 216.)