

But is this rich composition common to all the protuberances, or limited to a certain number? and do these materials extend throughout the protuberance, or are they confined to a limited portion of it?

Tacchini's observations show that the varied composition in question is limited to a very small height; in other words, to the mere base of the protuberance, whereas the higher portions are composed exclusively of hydrogen and the element  $D_3$ . Now, if the protuberances were the result of violent eruptions, the substances ejected with such force could not fail to attain a considerable height above the base of the protuberance, which is contrary to observation. Moreover, it is not all the protuberances that give a mixed spectrum; that is to say, they are not all formed of numerous materials, as they should be, at least in the majority of cases if they were produced by violent eruptions. According to Tacchini's observations, only 10 out of 100 protuberances give a mixed spectrum, the remaining 90 giving spectra which exhibit only the hydrogen lines and the line  $D_3$ . He also finds that in all the spectra which he has observed, either of protuberances near the sun's edge, or of clouds and filaments of greater height, the hydrogen-lines never occurred alone, but always accompanied by the line  $D_3$ . In one case only were the hydrogen lines and  $D_3$  accompanied by other bright lines in the distinctly higher portions of the protuberances. This was observed on December 19, 1871, on a magnificent protuberance resembling a great conflagration, the central part of which exhibited two red lines.

If the protuberances were formed of materials violently ejected from the interior of the sun, it would follow that at every point of the sun's edge where a mixed spectrum occurs, that is to say, where there is evidence of the presence of numerous materials, there also the corresponding protuberance should exist; but observation shows the contrary.

From his first examination of the protuberances, indeed, Tacchini had been led to conclude that the bright protuberances alone afforded certain indication of a rich variety of materials; \* but observing afterwards some parts of the sun's edge which, though free from protuberances, nevertheless had a peculiar structure, inasmuch as they were formed of a series of flames higher and brighter than usual, he was led to examine the spectrum of these portions more attentively; and he found indeed that there also, in addition to the lines of hydrogen and  $D_3$ , lines appeared corresponding to many other substances. A very careful examination of the sun's edge was accordingly made in August and September 1871, the result of which was to show that in very extensive tracts of the edge, amounting to  $\frac{1}{3}$  of the whole, the entire chromosphere was invaded by the vapours of various metals, although these same parts of the edge were not covered by protuberances, an observation before made by Lockyer.†

These tracts continued to show themselves more or less extensively for many days afterwards in the same part of the sun's limb, representing in their aggregate vast regions of the surface where the hydrogen of the chromosphere was mixed with many other substances which commonly exist at the base of the chromosphere. Thus on the 28th of August and 17th of September, 1871, throughout an area of  $60^\circ$ , from the position  $30^\circ$  to  $90^\circ$ , the edge gave a mixed spectrum, although the constituent substances were not found to be present in the same number at all points of this arc; the greater number indeed were found at the middle of the arc, while at the ends they were reduced to magnesium, hydrogen and  $D_3$  of the chromosphere, so far as this last-mentioned line may be regarded as belonging to a peculiar substance. This order in the number of substances on the portions of the edge which give a mixed spectrum, has been observed so frequently, that the regions of the sun corresponding to the aggregate of these successive tracts may be regarded as isolated portions of the solar surface, in the centre of which there is found a large number of different substances, this number diminishing towards the edge of each of these regions, where it reaches its minimum; and if we leave out of consideration the materials of the chromosphere which are common to the whole surface of the sun, we may say that at the borders of these regions there remains nothing but magnesium. In these tracts or regions, indeed, though the composition might be different in different parts, magnesium was never absent; for this reason Tacchini designates these portions of the surface as *magnesium regions*.

Instead then of special points marked by eruptions, we find

\* Tacchini's observations divide prominences as Lockyer has divided them.  
† Proc. R.S. vol. xviii. p. 75 1879

on the sun's surface large regions exhibiting throughout a complex spectrum, but not covered by protuberances; and this affords the strongest argument for not regarding the protuberances as a phenomenon of true eruption. We cannot therefore admit the existence of a solid or highly resisting liquid stratum, but rather a purely gaseous envelope, such as may permit of the ready mixing of the internal materials with those of the chromosphere on a vast scale, thereby giving rise to the regions above designated as regions of magnesium.

This view, however, does not absolutely exclude the occurrence of eruptive phenomena; for if these materials show themselves in the chromosphere at certain determinate points, they must have issued or been ejected from the centre towards the circumference. Tacchini, however, thinks that he has proved that these eruptions are not violent, and do not take place through a strongly resisting medium.

Contemporaneously with the determination of the angles of position of the protuberances, and of the portions of the chromosphere which exhibited a mixed spectrum, similar determinations were made of the positions of the faculæ and regions of faculæ visible or near the edge. A comparison of the two series of determinations thus made showed the coincidence of the magnesium regions with the regions of the faculæ. The positions of the protuberances on the other hand did not coincide with either.

The limits of the regions of magnesium and of the faculæ, on either side of the sun's equator, were found to be as follows:—

Regions of Magnesium, August 1871	+ $60^\circ$
	- 27
September	+ $60^\circ$
	- 32
Regions of the Faculæ, August	+ $43^\circ$
	- 32
September	+ $64^\circ$
	- 32

Considering now the magnesium regions above described, and the intensity of the phenomena there exhibited, it is clear that at any given epoch, the luminous intensity of the solar disc may vary considerably, and exhibit great differences as compared with that of the general envelope. At such times the solar atmosphere will not be uniformly illuminated, but will include a number of cones, varying in extent and brightness according to the different magnesium regions existing on the sun; and Tacchini suggests that in the case of total eclipses of the sun, during which the solar atmosphere becomes visible to us in the form of an aureola, this aureola which is differently illuminated in different parts, and therefore presents the appearance of plumes perpendicular or oblique to the edge of the moon, may arise from the cones embracing a large extent of surface corresponding to that of the magnesium regions.

Whilst Tacchini was studying the magnesium regions, Lorenzoni obtained evidence that the temperature of the sun's surface is least at the poles. The regions occupied by the metallic vapours corresponding to a certain line, which probably belong to the spectrum of iron, are called by Tacchini iron regions; they do not coincide with the regions of magnesium and of the faculæ, or with those of the protuberances, which are more limited.

Since the vapours of iron are diffused in the chromosphere on so vast a scale, and the magnesium regions also are so large as has been previously shown, Tacchini asks is it possible to admit the existence of a state of solidity or viscosity in those envelopes, or a temperature so low as some persons suppose? He regards such a view as totally inadmissible, and considers that all the observations above detailed point to the conclusion that the time is yet very distant when the sun will approach to those transformations which have reduced the earth to its actual state; and that the sun is still an entirely gaseous mass, relatively hotter at the centre, and cooler in the superficial strata, which we distinguish by the names of photosphere and chromosphere.

## ASTRONOMY

### On the Meteors of April 30-May 1\*

PROF. SCHIAPARELLI, in his list of meteoric showers whose radiant-points are derived from observations made in Italy within the last few years, describes one as occurring on April 30 and May 1, the apparent position of whose radiant is in the Northern

\* From *Silliman's Journal* for July, 1872.

Crown, R. A. 237°, N. P. D. 55°. The same shower has also been recognised by Robert P. Greg, F. R. S., of Manchester, England. This meteor-stream, it is now proposed to show, is probably derived from one much more conspicuous in ancient times.

In Quetelet's "Physique du Globe," pp. 290-297, we find meteoric displays of the following dates. In each case the corresponding day for 1870 is also given,\* in order to exhibit the close agreement of the epochs.

1.	A. D.	401,	April 9;	corresponding to	April 29,	for 1870
2.	"	538	" 6	"	" 25	"
3.	"	839	" 17	"	May 1	"
4.	"	927	" 17	"	April 30	"
5.	"	934	" 18	"	May 1	"
6.	"	1009	" 16	"	April 28	"

The epochs of 927 and 934 suggest as probable the short period of seven years. It is found accordingly that the entire interval of 608 years—from 401 to 1009—is equal to 89 mean periods of 6·8315 years each. With this approximate value the six dates are all represented as follows:—

From A. D.	401 to A. D.	538	we have 20 periods of 6·85 years
"	538	" 839	" 44 " 6·84 "
"	839	" 927	" 13 " 6·77 "
"	927	" 934	" 1 " 7·00 "
"	934	" 1009	" 11 " 6·82 "

This period corresponds closely to those of several comets whose aphelion distances are somewhat greater than the mean distance of Jupiter. So long as the cluster occupied but a small arc of the orbit, the displays would evidently be separated by considerable intervals. The two consecutive showers in the tenth century indicate, however, an extensive diffusion of the cluster at that epoch; so that the preceding part passed the node April 30, 927, and the following part, May 1, 934; the interval being somewhat more than one complete period. The comparative paucity of meteors in modern times may be partially explained by the fact that the ring has been subject to frequent perturbations by Jupiter.

It is not impossible that this meteor-stream was connected in its origin with the comet which passed its perihelion on April 29, B. C. 136. DANIEL KIRKWOOD

SOCIETIES AND ACADEMIES

LONDON

Geologists' Association.—The excursion to Ludlow and the Longmynds on July 22 and five following days, the concluding and most important field meeting of the season, was under the direction of Prof. Morris, F. G. S., Mr. R. Lightbody, F. G. S., and the Rev. J. D. La Touche, B. A. After the members had assembled in Ludlow Castle the Upper Ludlow rocks on the right bank of the Teme were examined, and Mr. Lightbody gave his reasons for considering the Aymestry Limestone to be represented at a point near the old bridge, although *Pentamerus Knightii* is not found here. The Upper Ludlow contains *Chonetes lata* in great abundance, and scarcely a fragment of the rock was picked up without this species being seen on the surface. From the high ground by the river side the valley of the Teme may be advantageously seen. The river here flows through a gorge in the Upper Ludlow rocks, with the castle and town of Ludlow picturesquely situated on the left bank; while the "Old Red" country extends beyond to the Clee Hills, the igneous summits of which commandingly rise to the east, surrounded by the coal measures. The well-known section in Ludford Lane, showing the "bone-bed," was next visited. This bone-bed, or "gingerbread," as it is sometimes called from its appearance, is in places not more than a quarter of an inch thick, and is found only after careful search. The fragments of the remains of fish, of which it is partly made up, were until comparatively recently the oldest fish remains known. The following day (Tuesday) was devoted to an examination of sections of the Aymestry Limestone, Lower Ludlow, and Wenlock rocks, occurring in the course of a route of about twenty miles. The journey was performed by means of carriages, but abundant occupation was given for the hammers of the party at the various exposures of the richly fossiliferous rocks above named. Graptolites from the Lower Ludlow were obtained in abundance, and fine specimens of *Phacops longicaudatus* were found in the Wenlock, exposed in the bed of the Teme, near Burrington; while

*Pentamerus Knightii* was seen in great profusion in the Aymestry Limestone of Ruactree. Near Comus Wood (so called from being the scene of Milton's "Comus") a very extensive view is obtained of the "Old Red" district of Herefordshire, with the Malverns distinctly seen in the distance. In the evening the members were entertained at a *soirée* given by H. Salway, Esq., of "The Cliff," Ludlow. During Wednesday the Upper Ludlow rocks in the valley of the Teme were subjected to further examination, and the party proceeded as far as Downton, where the uppermost members of the series are seen at the Tin Mills section. At one point on the road to Downton the physiography of the district to the north of Ludlow is well seen, and here Prof. Morris pointed out the principal features of the extensive landscape, and showed how entirely due they were to their geological structure, and that the coal measures of the Clee Hills had been preserved by the old volcanic outbursts which had formed the central masses of hard "Dhu-stone" composing the summits and caves of these lofty hills. On Thursday the party ascended the Longmynds at their southern extremity, where masses of quartzose conglomerate of Cambrian age protrude from the surface. The Rev. Mr. La Touche described the topography and the geology of the district seen from the elevated ground on which his hearers were assembled, and, subsequently, Dr. Hicks explained the order of the succession of the Cambrian and Lower Silurian rocks of St. David's, which he had been re-examining during the previous fortnight, and which he considers to have representatives in some of the beds of the Longmynds. The Llandovery conglomerates lying on the uplifted beds of the Cambrians at an angle of 22° were found to be exposed on the eastern slope of the hill, and the "Pentamerus limestone," with its characteristic *Pentamerus oblongus*, was also seen. The party then proceeded to the quarries of Caradoc sandstone in the Onney valley, at one of which Prof. Morris gave a general description of the Silurian system and the extension in England of its various members. Friday was occupied by a journey in carriages to the mining district of Shelve, and by an inspection of the very interesting hill-country between that place and Church Stretton. Quarries in the Cambrian rocks at the south end of the Longmynds and in Llandovery beds near Norbury occasioned stoppages, and afterwards a visit was paid to Linley Hall, the residence of Mr. Jasper Mare, who courteously invited the party to inspect his fine model of the South Shropshire mining districts, the famous pig of lead of Roman age, with the name of the Emperor Hadrian upon it, found near Shelve, and specimens of the mineral products of the locality of extraordinary size and beauty. The members were then entertained at luncheon, after which they left Linley Hall and traversed a long, narrow, and very beautiful valley in the park, and terminating at the Stiper Stones. At a little distance from the park enclosure a mass of felspathic ash in Lower Llandeilo rocks is quarried for road metal, and the Llandeilo beds thus laid bare were eagerly and most successfully searched for fossils. After a brief visit to the White Grit Mine, the carriages were finally left, and the party commenced the ascent of the Stiper Stone ridge, from the summit of which is seen a fine panorama of the Welsh mountains, with the old volcanic Corndon in the foreground, and Cadir Idris and Plynlimmon in the extreme distance. The extraordinary masses of obtruding hard white quartzite rocks called the Stiper Stones were objects of great interest to the party, some of the members of which were not satisfied with the evidence of their being the equivalents of the Lingula flags. The Longmynds ridge, extending for nearly fifteen miles, bounds the view to the east, and this range had now to be crossed. The intervening valley affords several sections, at one of which was seen what was considered by Murchison to be the junction of the Silurians with the Cambrians. Near the summit of the Longmynds a very fine exposure of Cambrian conglomerates occurs; and further along the edges of the vertical green and purple shales and slates are seen beneath the feet as the mountain road is traversed. On the eastern side of the range the rocks are well exposed, and the indenting gorges numerous and picturesque. Caer Caradoc stands boldly out at a little distance to the north-east, with the Wenlock and Aymestry limestone ridges beyond, and bounding a valley of great beauty and extent, terminated northwards by the volcano-like cone of the Wrekin, at the foot of which the Severn flows through a deep gorge. The morning of the concluding day, Saturday, was given to an examination of the Upper Ludlow rocks, the "Bone-bed," and the Downton sandstone in the neighbourhood of Mortou.

\* Making proper allowance for the precession of the equinoxes.