motion, these currents cannot be maintained in a radial direction. A rotary motion, rapidly augmenting, will take place, producing a vortex more powerful than any imagined by Descartes. The radial currents of the vaporous column having assumed a spiral course, will rapidly acquire a velocity exceed that of a cyclone. The practical effect of the powerful movement of the vortex, it is reasonable to suppose, will resemble that of a gigantic carving-tool whose thorough efficiency in removing irregularities has been proved by the exact circular outline presented by thousands of lunar formations. The terraces within the "ring mountains" indicated on Beer and Mädler's chart, it may be shown, were produced by evaporation resulting from low temperature and reduced energy after the formation of the main glacier.

There is another feature in the lunar landscape scarcely less remarkable than its circular walls and depressions. In the centre of nearly all of the latter one or more conical hills rise, in some cases several thousand feet high. Has the rotary motion of the boiling vortex any connection with these central cones? A brief explanation will show that the connection is quite intimate. The under-rated estimate that 10 square feet of surface under the action of slow fire is capable of developing one horse-power proves the presence of a dynamic energy exceeding 5,000,000,000 of horse-power at the base of the vaporous column resting on the boiling water of a pond as large as that of Tycho. No part of this power can be exerted vertically, as already explained, on the ground that the weight of the vapour restrains such movement. The great velocity of the vortex resulting from the expenditure of the stated amount of dynamic energy will of course produce corresponding centrifugal force; hence a maelström will be formed capable of draining the central part of the pond, leaving the same dry, unless the water be very deep, in which case the appearance of a dry bottom will be postponed until a certain quantity of water has been transferred to the glacier. It should be observed that the central part of the bottom, freed from water, will also be freed from the surrounding cold by the protection afforded by the vaporous mass. The quantity of snow formed above the centre, at great altitude, will be small, and of course diverged during the fall. Evidently the dry central part, prevented, as shown, from cooling, will soon acquire a high temperature, admitting the formation of a vent for the expulsion of lava, called for as the moon, whose entire dry surface is radiating against space, shrinks rapidly under the forced refrigeration attending glacier-formation. Lava-cones similar to those of terrestrial volcanoes, and central to the circular walls, may thus be formed, the process being favoured by the feebleness of the moon's attraction. The existence of warm springs on the protected central plains is very probable; hence the formation of cones of ice might take place during the last stages of glacier-formation, when those plains no longer receive adequate protection against cold.

In accordance with the views expressed in the monograph read before the American Academy of Science, continued research has confirmed my supposition that the water on the moon bears the same proportion to its mass as the water of the oceans to the terrestrial mass. I have consequently calculated the contents of the circular walls of the "ring mountains" measured and delineated by Beer and Mädler, and find that these walls contain 630,000 cubic miles. The opposite hemisphere of the moon being subjected to similar vicissitudes of heat and cold as the one presented to the earth, the contents of the circular walls not seen cannot vary very much from those recorded in "Der Mond"; hence the total will amount to 1,260,000 cubic miles. Allowing for the difference of specific gravity of ice, the stated amount represents 1,159,000 cubic miles of water. But "Der Mond" does not record any of the minor circular walls which, as shown by the large photograph before referred to, cover the entire surface of some parts of the moon. On careful comparison it will be found that the contents of the omitted circular formations is so great that an addition of 50 per cent. to the before-stated amount is called for. An addition of 25 per cent. for the ice-fields, whose extent is indicated by cracks and optical phenomena, is likewise proper. The sum total of water on the moon, therefore, amounts to 2,028,600 cubic miles.

Adopting Herschel's estimate of the moon's comparative mass, viz. 0·011364, and assuming that the oceans of the earth cover 130,000,000 square miles, it will be seen that the estimated quantity of water on the moon corresponds with a mean depth of 7250 feet of the terrestrial oceans.[1] This depth agrees very nearly with the oceanic mean depth established by the soundings for the original Atlantic cable, viz. 7500 feet; but the result of the *Challenger* Expedition points to a much greater depth. This circumstance is by no means conclusive against the supposition that the satellite and the primary are covered with water in relatively equal quantities. The correctness of Sir John Herschel's demonstration proving the tendency of the water on the lunar surface to flow to the hemisphere furthest from the earth must be disproved before we reject the assumption that the quantity of water on the surface of the moon bears the same proportion to its mass as the quantity of water on the earth to the terrestrial mass.

JOHN ERICSSON

[1] $\frac{2028600 \times 5280}{130000000 \times 0{\cdot}011364} = 7250$ feet mean depth of terrestrial oceans corresponding with water on the moon.

SCIENTIFIC SERIALS

Rendiconti del Reale Istituto Lombardo, May 27.—Determination of the heat of fusion in the alloys oflead, tin, bismuth, and zinc, by Prof. D. Mazzotto. By the cooling process usually adopted for determining the specific heat of liquids, the author finds the point of fusion and the heat of fusion for these various chemical alloys as under:—

	Point of fusion	Heat of fusion
	°	°
Tin and lead	181	10·29
Tin and zinc	196	16·20
Tin and bismuth	138	11·065
Bismuth and lead	126	4·744

Two of these coincide and two others differ little from the composition of the chemical alloys as given by Rudberg.—Education and crime in Italy, by S. Amato Amati. In order to ascertain the influence of public instruction on the criminal classes in the Peninsula, the author has compiled a number of comparative tables based on official returns ranging from the year 1871 to 1883 inclusive. For the last three years of this period the results are as under:—

	Criminals	Unlettered	Could read and write	Educated
1881	8693	5511	3031	151
1882	7009	4139	2671	199
1883	6490	3741	2596	153

According to the three last census returns the total percentage of unlettered was as under:—

	Males	Females	Total
1861	65·47	81·52	73·50
1871	60·16	77·18	68·64
1881	53·89	72·93	63·45

—Meteorological observations made at the Brera Observatory, Milan, during the month of May.

SOCIETIES AND ACADEMIES

LONDON

Royal Society, May 6.—"Further Discussion of the Sun-spot Spectra Observations made at Kensington." By J. Norman Lockyer. Communicated to the Royal Society by the Solar Physics Committee.

I have recently discussed, in a preliminary manner, the lines of several of the chemical elements most widened in the 700 spots observed at Kensington.

The period of observation commences November 1879, and extends to August 1885. It includes, therefore, the sunspot curve from a minimum to a maximum and some distance beyond.

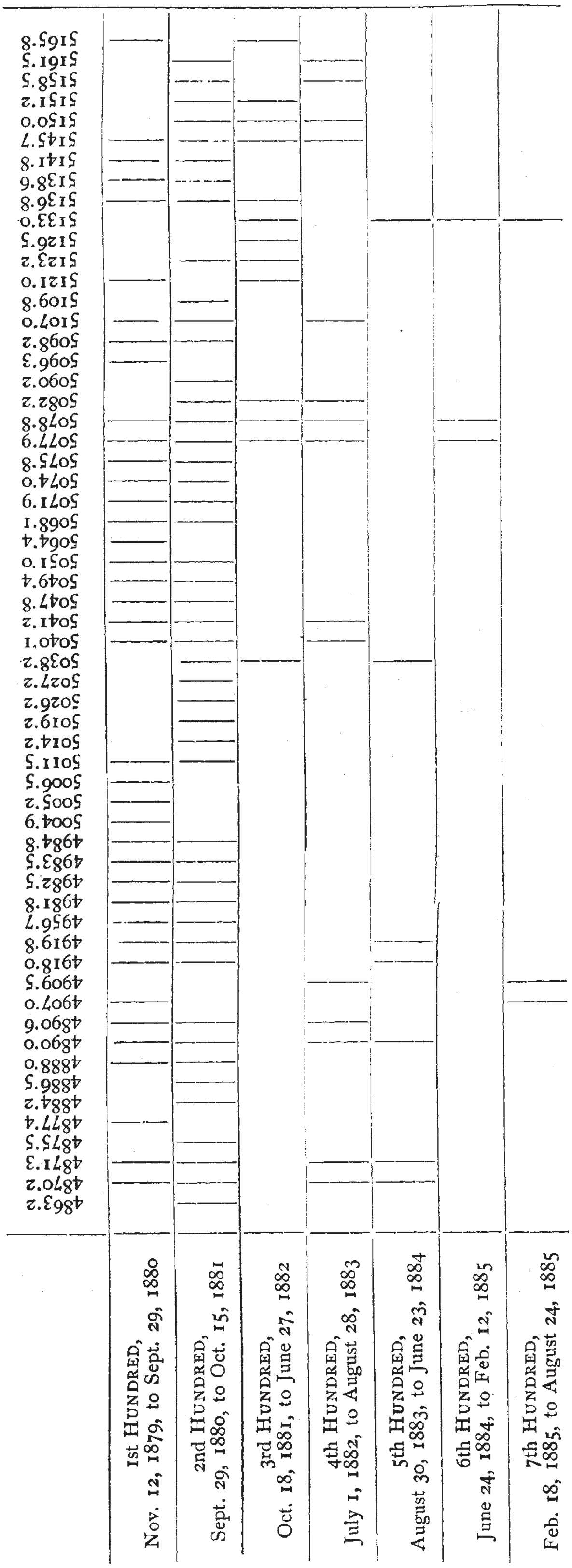
It is perhaps desirable that I should here state the way in which the observations have been made. The work, which has been chiefly done by Messrs. Lawrance and Greening, simply consists of a survey of the two regions F—*b* and *b*—D.

The most widened line in each region—not the widest line, but the *most widened*, is first noted; its wave-length being given in the observation books from Ångström's map. Next, the lines which most nearly approach the first one in widening are recorded, and so on till the positions of six lines have been noted, the wave-lengths being given from Ångström's map, for each region.

It is to be observed that these observations are made without any reference whatever to the origin of the lines; that is to say it is no part of the observer's work to see whether there are metallic coincidences or not; this point has only been inquired into in the present reductions, that is, seven months after the

TABLE A.—IRON

Iron Lines observed in Sunspot Spectra at Kensington among the most Widened Lines



last observations now discussed were made. In this way perfect absence of all bias is secured.

It may further be remarked that the number of lines widened throughout a sunspot period is about the same, so that the conditions of observation vary very little from month to month, and from year to year.

It may be further remarked that the absolute uniformity of the results obtained in the case of each of the chemical elements investigated indicates, I think, that the observations have been thoroughly well made; and, as a matter of fact, they are not difficult.

I first give tables (A, B, C) showing that for each of the

TABLE B.—NICKEL

List of most Widened Lines observed at Kensington

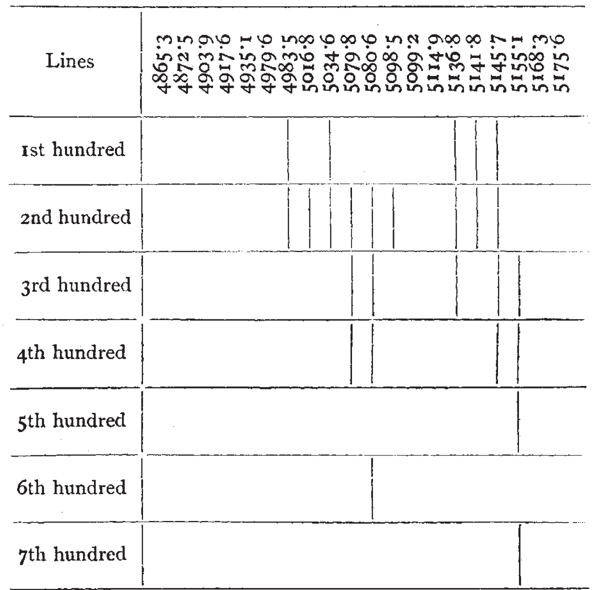
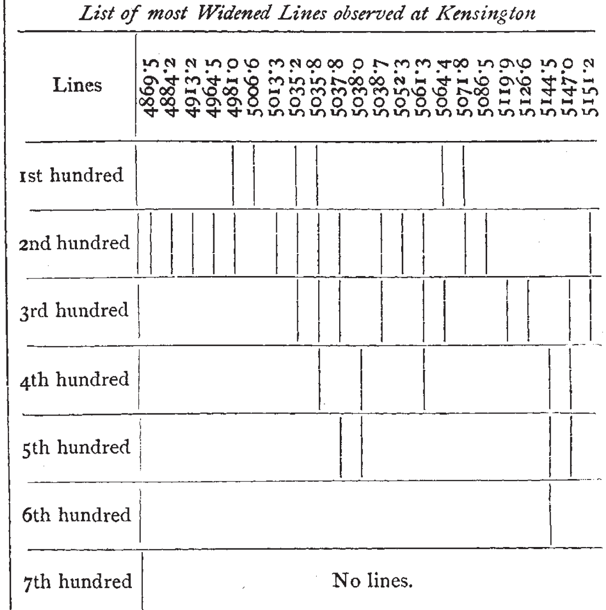


TABLE C.—TITANIUM

List of most Widened Lines observed at Kensington



chemical elements taken—iron, nickel, and titanium—the num- of lines seen in the aggregate in each hundred observations is reduced from minimum to maximum, and that this result holds good for both regions of the spectrum.

I next give another table (D) showing that during the obser-

TABLE D.—*Unknown Widened Lines observed at Kensington*

	1st hundred	2nd hundred	3rd hundred	4th hundred	5th hundred	6th hundred	7th hundred
4865	..	...	...	...	...	1	...
4885	...	...	...	...	...	...	1
4888·3	1	...	...	...	...	...	...
4891·8	...	...	...	...	1	...	...
4910	...	...	...	2	...	...	...
4944	..	...	1	...	...	...	...
5017·2	...	1	...	...	...	...	...
5028·9	...	1	...	...	...	...	...
5030	..	1	...	...	...	...	...
5034·8	11	...	3	...	...	...	...
5037	...	...	...	...	...	1	...
5038·9	...	...	1	1	...	...	...
5042	...	...	3	...	...	...	...
5042·3	...	...	4	...	...	...	...
5043	...	1	...	...	...	...	...
5044·6	...	3	...	...	...	...	...
5061	...	...	2	...	...	...	3
5061·5	..	...	...	...	...	...	2
5062	...	...	...	..	...	...	5
5062·4	...	...	...	...	...	2	...
5062·8	...	...	...	3	...	2	...
5065	...	...	8	...	...	...	...
5067	...	1	...	...	...	...	...
5069·5	...	1	...	...	...	...	...
5070·8	...	1	...	...	...	...	...
5077	...	...	.	1	...	...	...
5079·5	...	...	...	...	...	2	...
5080	...	...	...	1	...	...	...
5081·5	..	...	...	...	...	...	3
5082	...	...	...	...	...	2	...
5083	...	...	...	...	...	2	...
5083·3	...	1	2	3	...	...	...
5084	...	1	...	...	...	...	3
5084·5	...	...	...	...	...	...	2
5086	..	...	17	..	1	...	...
5086·8	..	1	...	...	...	...	...
5087·7	...	1	...	...	...	..	...
5088·1	...	1	...	...	...	...	...
5088·6	...	1	...	...	...	...	...
5089·0	...	...	...	1	...	...	...
5101	...	...	...	...	...	...	1
5103·5	...	...	...	...	1	...	...
5112·1	...	6	22	4	2	1	...
5115·5	...	...	...	...	...	...	9
5116	3	6	24	3	...	...	...
5116·2	...	...	7	...	...	...	...
5118	4	...	14	...	...	...	...
5127	...	...	...	1	...	...	...
5127·5	...	...	1	...	...	...	...
5128·8	...	...	...	...	...	...	1
5129·6	...	17	19	4	...	...	...
5130	...	...	1	..	...	...	...
5132	...	14	21	6	...	...	...
5132·5	...	...	1	...	...	...	...
5132·8	...	...	...	3	...	...	...
5133·5	...	...	1	...	1	3	17
5133·8	...	30	47	43	62	3	27
5134	...	...	...	...	12	41	10
5134·4	...	...	...	...	...	19	...
5135	...	...	...	...	16	36	11
5135·5	...	33	15	...	53	36	20
5135·8	...	...	37	52	13	2	...
5136	...	...	4	...	9	22	27
5136·5	...	...	3	1	...	...	...
5137	...	...	2	2	1	...	...
5137·5	...	...	4	...	72	79	22
5137·8	...	12	35	64	13	10	3
5138	...	...	..	...	1	...	3
5139	...	...	...	...	1	...	1
5139·4	...	1	2	3	...	...	...
5140·4	...	2	...	...	...	...	...
5142·2	13	4	...	1	...	...	...
5142·8	...	21	7	19	2	...	...
5143	...	..	...	...	...	...	20
5143·2	...	...	2	...	...	...	...
5144·2	1	3	...	2	...	...	..
5144·5	...	...	...	...	1	...	...
5145·5	...	...	...	...	...	1	...
5146	..	...	36	12	...	...	...
5146·5	...	...	...	2	...	...	.
5148	...	...	..	...	...	...	1
5148·8	...	...	1	2	...	...	...
5149	2	32	31	36	4	...	35
5149·2	...	...	...	1	...	...	...
5149·5	...	...	..	4	...	...	29
5149·8	...	8	2	8	...	8	...
5150	...	...	...	1	...	...	...
5151·8	...	...	...	...	1	...	...
5153·8	...	...	..	...	1	...	...
5154	...	...	...	...	...	...	1
5155·4	...	...	...	...	1	...	...
5156	1	12	37	74	82	91	95
5156·5	...	...	...	...	8	...	...
5157·2	...	...	...	4	...	...	...
5159	...	...	1	8	13	11	41
5159·5	1	...	31	59	80	86	57
5160	...	...	1	4	...	9	...
5160·4	...	1	...	5	...	...	4
5162	...	...	9	7	61	67	62
5162·2	1	...	23	49	21	30	...
5175	...	...	...	...	...	...	3

vations the lines recorded as most widened near the maximum have not been recorded amongst metallic lines by either Ångström or Thalèn, and that many of them are not among the mapped Fraunhofer lines, though some of them may exist as faint lines in the solar spectrum when the observing conditions are best.

The reduction of the latitudes of the spots is not yet completed.

The result of these observations may be thus briefly stated. As we pass from minimum to maximum, the lines of the chemical elements gradually disappear from among those most widened, their places being taken by lines of which at present we have no terrestrial representatives. Or, to put the result another way—at the minimum period of sunspots when we know the solar atmosphere is quietest and coolest, vapours containing the lines of some of our terrestrial elements are present in sunspots. The vapours, however, which produce the phenomena of sunspots at the sunspot maximum are entirely unfamiliar to us.

The disappearance of the lines of iron, nickel, and titanium, and the appearance of unknown lines as the maximum is reached, is shown by curves in Fig. 1.

The results, in my opinion, amply justify the working hypothesis as to the construction of the solar atmosphere which I published some years ago (*Proc.* Roy. Soc., 1882, p. 291). In the region of the spectrum comprised between 4860 and 5160, I find in the case of iron, to take an instance, that sixty lines were distributed unequally among the spots in 1879 and 1880, many iron lines being visible in every spot. In the last observations, about the maximum, only three iron lines in all are seen among the most widened lines. These three lines also have been visible in four spots only out of the last hundred. The same thing happens with titanium and nickel, and with all the substances for which the reductions are finished.

I am quite content, therefore, to believe that iron, titanium, nickel, and the other substances very nearly as complex as we know them here, descend to the surface of the photosphere, in the downrush that forms a spot at the period of minimum, but that at the maximum, on the contrary, only their finest constituent atoms can reach it. It may also be remarked that these particles which survive the dissociating energies of the lower strata are not the same particles among the constituents of the chemical elements named which give the chromospheric lines recorded by Tacchini, Riccò, and myself.

Having thus found the working hypothesis to which I have referred stand the severe test which the sunspot observations apply to it, I have gone further, and have endeavoured to extend it in two directions.

First. I found that the view to which the hypothesis directly leads, that the metallic prominences are produced by violent explosions due to sudden expansions among the cooler matters brought down to form the spots, when they reach the higher temperature at and below the photosphere level, includes all the facts I know touching spot and prominence formation. Thus, for instance, the close connection between metallic prominences and spots; the entire absence of metallic prominences with rapid motion from any but the spot-zones; the fact that the faculæ always follow the formation of a spot and never precede it; that the faculous matter lags behind the spot as a rule; the existence of veiled spots and minor prominences in regions outside the spot-zones; the general injection of unknown substances into the lower levels of the chromosphere which I first observed in 1871, and which have been regularly recorded by the Italian observers since that time—all these phenomena and many others which may be referred to at length on another occasion, are demanded by the hypothesis, and are simply and sufficiently explained by it.

With regard to the extensions of volume to which I have referred, I find that if we assume that metallic iron can exist in any part of the sun's atmosphere, and that it falls to the photosphere to produce a spot, the vapour produced by the fall of 1,000,000 tons will give us the following volumes:—

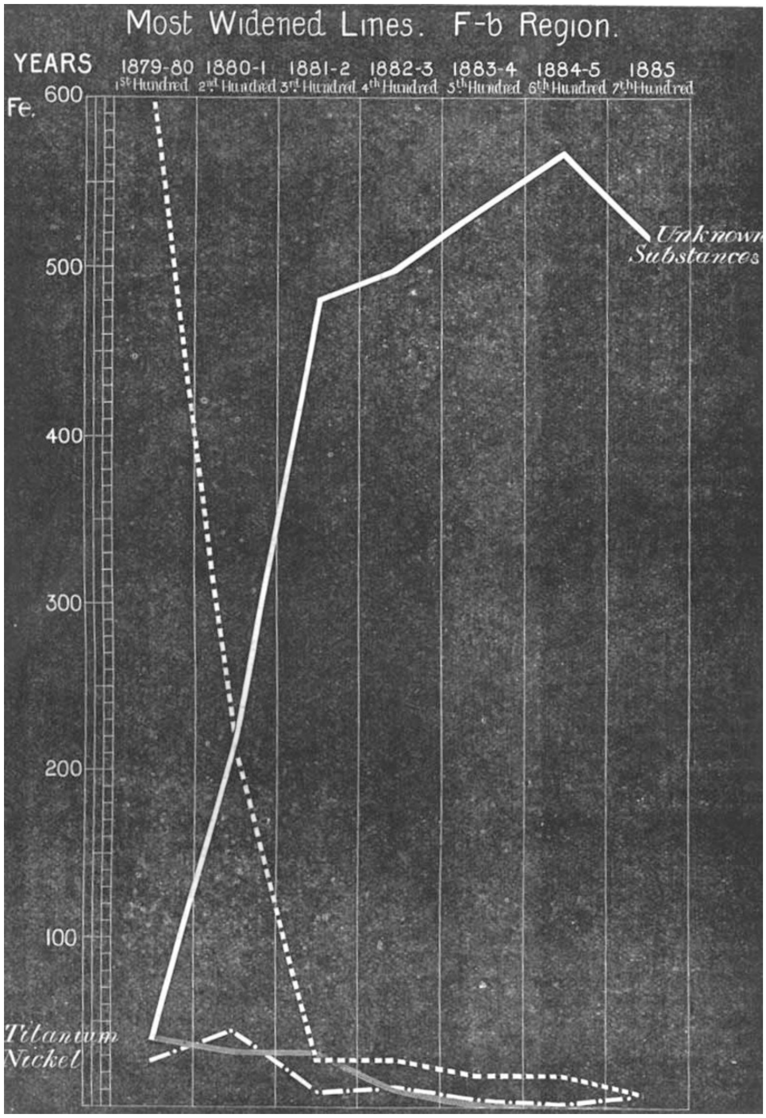


Fig. 1.—Number of appearances of known and unknown lines.

Temperature		Pressure		Volume in cubic miles
2,000° C.	...	380 mm.	...	0·8
10,000	...	760 ,,	...	1·8
20,000	...	5 atmos.	...	0·7
50,000	...	760 mm.	...	8·8
50,000	...	190 ,,	...	35·2

If we assume the molecule of iron to be dissociated ten times by successive halving, then the volume occupied will be 1024 times greater, and we shall have—

Temperature		Pressure		Volume in cubic miles
50,000° C.	...	760 mm.	...	9,011
50,000	...	190 ,,	...	36,044

In these higher figures we certainly do seem nearer the scale on which we know solar phenomena to take place; the tremendous rending of the photosphere, upward velocities of 250 miles a second, and even higher horizontal velocities according to

Peters, are much more in harmony with the figures in the second table than the first.

I may mention, in connection with this part of the subject, that the view of the great mobility of the photosphere which this hypothesis demands, so soon as we regard metallic prominences as direct effects of the fall of spot material, is further justified by the fact that, if we assume the solar atmosphere, that is the part of the sun outside the photosphere, to be about 500,000 miles high, which I regard as a moderate estimate, the real average density of the sun is very nearly equal to one-tenth that of water, instead of being slightly greater than that of water, as stated in the text-books.[1]

We can then only regard the photosphere as a cloudy stratum existing in a region of not very high pressure. It is spherical because it depends upon equal temperatures.

The second direction in which I have attempted to develop the hypothesis has relation to the circulation in the sun's atmosphere. I have taken the facts of the solar atmosphere as a whole, as they are recorded for us in the various photographs taken during eclipses since 1871, and also in drawings made before that time, the drawings being read in the light afforded by these photographs.

I find that the working hypothesis at once suggests to us that the sunspot period is a direct effect of the atmospheric circulation, and that the latitudes at which the spots commence to form at the minimum, which they occupy chiefly at the maximum, and at which they die out at the end of one period in one hemisphere, probably at the moment they commence to form a second one in the other (as happened in 1878-79), are a direct result of the local heating produced by the fall of matter from above descending to the photosphere, and perhaps piercing it. The results of this piercing are the liberation of heat from below and various explosive effects due to increase of volume, which, acting along the line of least resistance, give, as a return current, incandescent vapours ascending at a rate which may be taken as a maximum of 250 miles a second, a velocity sufficient to carry them to very considerable heights.

The view of the solar circulation at which I have arrived may be briefly stated as follows :—

There are upper outflows from the poles towards the equatorial regions. In these outflows a particle constantly travels, so that its latitude decreases and its height increases, so that the true solar atmosphere resembles the flattened globe in Plateau's experiment (see photographs, 1878, and Fig. 3).

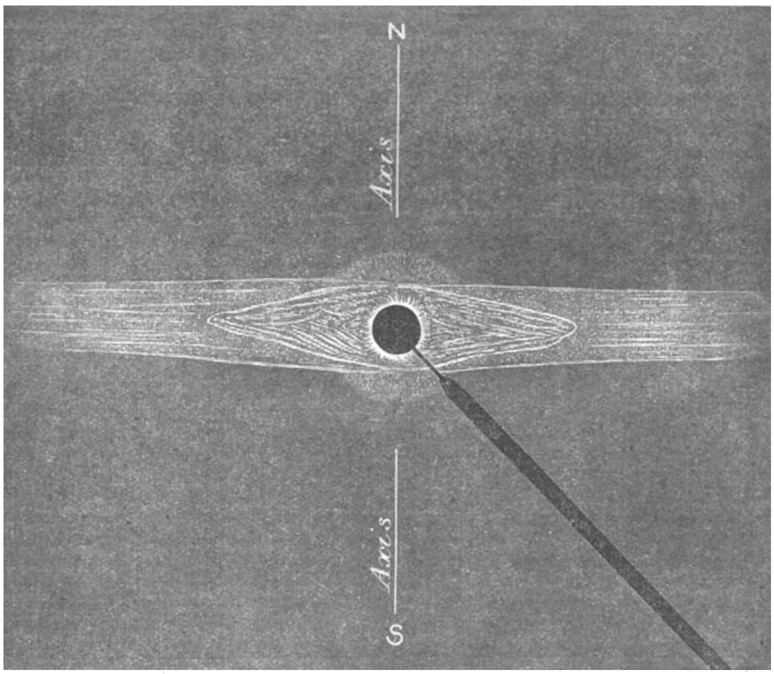


FIG. 2.—Minimum. Tracing of Newcomb's observation of 1878, the brighter portion of corona being hidden by a screen. Shows the equatorial extension and concentric atmospheres.

These currents, as they exist in the higher regions of the atmosphere, carry and gather the condensing and condensed materials till at last they meet over the equator.

There is evidence to show that they probably extend as solar meteoric masses far beyond the limits of the true atmosphere, and form a ring, the section of which widens towards the sun, and the base of which lies well within the boundary of the atmosphere (Fig. 2).

If we assume such a ring under absolutely stable conditions, there will be no disturbance, no fall of material, therefore there will be no spots, and therefore again there will be no prominences. Such was the state of things on the southern surface of the ring from December 1877 to April 1879, during which period there was not a single spot observed the umbra of which was over 15-millionths of the sun's visible hemisphere.

Assume a disturbance. This may arise from collisions, and these collisions would be most likely to happen among the particles where the surface of the ring meets the current from the poles. These particles will fall towards the sun, thereby disturbing and arresting the motion of other particles nearer the photosphere, and finally they will descend with a crash on to the photosphere, from that point where the surface of the ring enters the atmosphere some distance further down.

The American photographs in 1878 supply us with ample evidence that this will be somewhere about lat. 30°, and here alone will the first spots be formed for two reasons.

(1) In the central plane of the ring over the equator, the particles will be more numerous ; a rapid descent, therefore, in this central plane will be impossible, for the reason that the condensed matter has to fall perhaps a million of miles through strata of increasing temperature ; there will, therefore, be no spots ; and practically speaking, as is known, there are no spots at the equator, though there are many small spots without umbræ between latitudes 3° and 6° N. and S.

Above lat. 30°, as a rule, we have no spots, because there is no ring, and further the atmosphere is of lower elevation, so that there is not sufficient height of fall to give the velocities require to bring down the material in the solid form.

The lower corona, where the corona is high, and it is highest over the equator, acts as a shield or buffer ; volatilisation and

[1] The density referred to water = 1·444 and to the earth 0·255, according to Newcomb.

dissociation take place at higher levels. Where this occurs, spots are replaced by a gentle rain of fine particles slowly descending, instead of the fall of mighty masses and large quantities of solid and liquid material.

Volatilisation will take place gradually during the descent, and at the utmost only a veiled spot will be produced.

We know that when the solar forces are weak, such a descent is taking place all over the sun, because at that time the spectrum of the corona, instead of being chiefly that of hydrogen, is one of a most complex nature—so complex that before 1882 it was regarded by everybody as a pure continuous spectrum, such as is given by the limelight.

The moment the fall of spot material begins we get the return current in the shape of active metallic prominences, and the production of cones and horns which probably represent the highest states of incandescence over large areas and extending to great heights; and, besides these, the production of streamers (see Fig. 4).

Two results follow:—

(1) In consequence of the increased temperature of the lower regions, the velocity of the lower currents towards the poles, and therefore of the upper currents from the poles, is enormously increased. The disturbance of the ring will therefore be increased.

(2) Violent uprushes of the heated photospheric gases, mounting with an initial velocity of a million miles an hour, can also disturb the ring directly.

In this way the sudden rise to maximum in the sunspot curve, and the lowering of the latitude of the spots, follow as a matter of course. And the part of the ring nearest the sun, its base, so to speak, is, it would appear, thrown out of all shape, and we get falls over broad belts of latitude N. and S.

Does this hypothesis explain, then, the slow descent to minimum and the still decreasing latitude? It does more, it demands it. For now the atmosphere over those regions where the spots have hitherto been formed is so highly heated and its height is so increased, that any disturbed material descending through it will be volatilised before it can reach the photosphere.

The best chance that descending particles have now to form spots is if they fall from points in lower latitudes. The final period, therefore, of the sunspot curve must be restricted to a very large extent to latitudes very near the equator, and this is the fact also, as is well known.

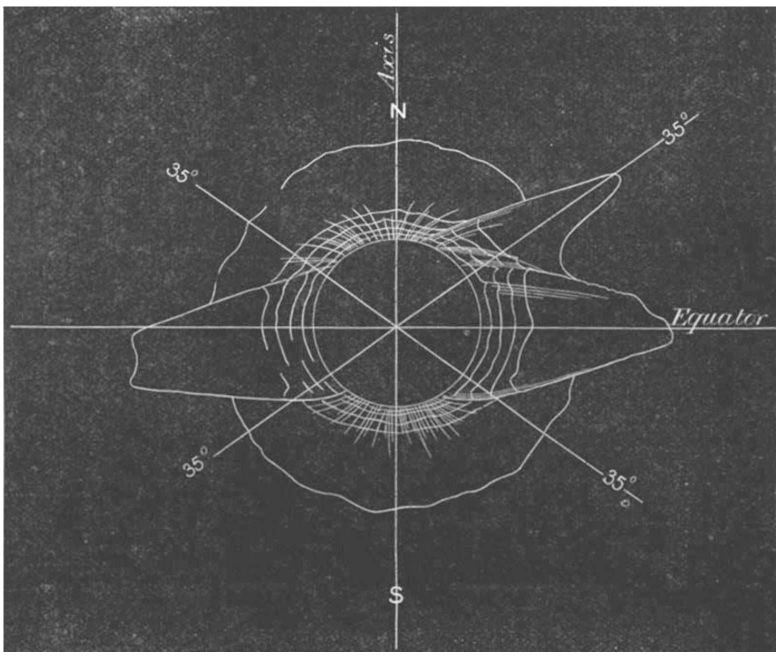


FIG. 3.—Minimum. Tracing of the results obtained by the cameras in 1878, showing inner portion of equatorial extension, and how the surfaces of it cut the concentric atmosphere in lat. 35° N. and S., or thereabouts.

It will be seen that on this view, as the brightness, and therefore the temperature, of the atmosphere, as we know, increases very considerably from minimum to maximum, the masses which can survive this temperature must fall from gradually increasing heights.

It may be pointed out how perfectly this hypothesis explains the chemical facts observed and associates them with those gathered in other fields of inquiry.

At the minimum the ring is nearest the sun, the subjacent atmosphere is low and relatively cool.

Particles falling from the ring, therefore, although they fall in smaller quantity because the disturbance is small, have the best chance of reaching the photosphere in the same condition as they leave the ring, hence at this time the widening in many familiar lines of iron, nickel, titanium, &c.

The gradual disappearance of these lines from the period of minimum to that of maximum is simply and sufficiently explained by the view that the spot-forming materials fall through gradually increasing depths of an atmosphere which at the same time is having its temperature as gradually increased by the result of the action I have before indicated, until finally, when the maximum is reached, if we assume dissociation to take place at a higher level at the maximum, dissociation will take place before the vapours reach the photosphere, and the lines which we know in our laboratories will cease to be visible.

This is exactly what takes place, and this result can be connected, as I have stated elsewhere, with another of a different kind. This hypothetical increasing height of fall demanded by the chemistry of the spots is accompanied by a known acceleration of spot movement over the sun's disk, as we lower the latitude—which can only be explained, so far as I can see, by a gradually increasing height of fall as the equator is approached.

There are two other points. (1) The sunspot curve teaches us that the slowing down of the solar activities at the maximum is very gradual. We should expect, therefore, the chemical conditions at the maximum to be maintained for some time afterwards. As a matter of fact, they have been maintained till March of the present year, and only now is a change taking place which shows us chemically that we are leaving the maximum conditions behind. (2) The disappearance of the lines of the metallic elements at maximum is so intimately connected with an enormous increase in the indications of the presence of hydrogen that there is little doubt that we are in the presence of cause and effect. The hydrogen, I am now prepared to believe, is a direct consequence of the dissociation of the metallic elements.

It will be convenient to refer here to the facts which have been recorded during those eclipses which have been observed at the sunspot minimum and maximum.

At the minimum the corona is dim; observations made during the minimum of 1878 showed that it was only one-seventh as bright as the corona at the preceding maximum. There are no bright lines in its spectrum, and both photographic and eye-observations proved it to consist mainly of a ring round the equator, gradually tapering towards its outer edge, which some observations placed at a distance of twelve diameters of the sun from the sun's centre.

The same extension was observed in the previous minimum in 1867, and the polar phenomena were observed to be identical in both eclipses. At the poles there is an exquisite tracery curved in opposite directions, consisting of plumes or *panaches*, which bend gently and symmetrically from the axis, getting more and more inclined to it, so that those in latitudes 80° to 70° start nearly at right angles to the axis, and their upper portions droop gracefully, and curve over into lower latitudes.

Although indications of the existence of this ring have not been recorded during eclipses which have happened at the period of maximum, there was distinct evidence both in the eclipses in 1871 and 1875 of the existence of what I regard as the indications of outward upper polar currents observed at minimum.

The fact that the solar poles were closed at the maximum of 1882, while they were open in 1871, is one of the arguments which may be urged that at times the whole spot-zones are surmounted by streamers, with their bases lying in all longitudes along the zones.

It was probably the considerable extension of these streamers earthwards, in 1882, which hid the finer special details at the poles, while in 1871 the part of the sun turned towards the earth was not rich in streamers of sufficient extension.

Touching these streamers, it is an important fact to be borne in mind, that no spots ever form on the poleward side of them.

It is obvious, therefore, that spots are not produced by the condensation of materials on their upper surfaces, for in that case the spots would be produced indifferently on either side of them, and the width of the spot-zones would be inordinately increased.

Although in the foregoing I have laid stress upon the indications afforded by the observations of 1878 of the existence of a ring, it should be remarked that, so far, the eclipse appearances

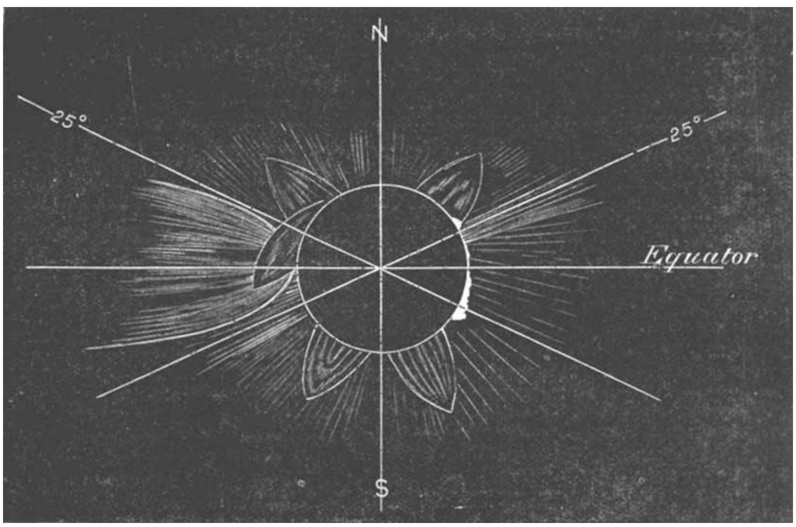


FIG. 4.—1½ years from maximum, 1858. Tracing of drawing by Liais, showing "cones."

on which the idea rests have not been observed at maximum. This, however, is not a fatal objection, because precautions for shielding the eye were necessary even in 1878 when the corona was dim; and if it is composed merely of cooled material it would not readily be photographed.

In may be urged by some that the phenomena observed in 1878 may only after all have been equatorial streamers.

It is obvious, therefore, that this point deserves the closest attention during future eclipses, until it is settled one way or the other.

Geological Society, June 23.—Prof. J. W. Judd, F.R.S., President, in the chair.—The President announced that he had received from Prof. Barrois an intimation that the Geological Society of France would hold a special country meeting in the district of Finistère from the 19th to the 28th of August next, during which a variety of interesting excursions would be made under the guidance of MM. Barrois, Davy, and Lebesconte. Prof. Barrois, in writing, expressed the pleasure which it would give the members of the Geological Society of France if they were joined by some of their English *confrères*, but at the same time stated that as the accommodation for travellers was limited in the district, he would be glad to have timely notice from any one intending to take part in the meeting. Particulars were to be obtained from the Assistant Secretary, who would also communicate with Prof. Barrois.—The following communications were read:—On some perched blocks and associated phenomena, by Prof. T. McKenny Hughes, M.A., F.G.S. The author described certain groups of boulders which occurred on pedestals of limestone rising from 3 to 18 inches above the level of the surrounding rock. The surfaces of these pedestals were striated in the direction of the main ice-flow of the district, while the surrounding lower rock in no case bore traces of glaciation, but showed what is known as a weathered surface. He inferred that the pedestals were portions of the rock protected by the overhanging boulder from the down-pouring rain, which had removed the surrounding exposed parts of the surface. When the pedestals attained a certain height relatively to the surrounding rock the rain would beat in under the boulder, and thus there was a natural limit to their possible height. He referred to the action of vegetation in assisting the decomposition of the limestone, and considered that there were so many causes of different rates of waste and so many sources of error, that he distrusted any numerical estimate of the time during which the surrounding limestone had been exposed to denudation. Considering the mode of transport of the boulders, he thought that they could not have been carried by marine currents and coast-ice, as they had all travelled, in the direction of the furrows on the rock below them, from the parent rock on the north. Moreover, marine currents would have destroyed the glaciation of the rock and filled the hollows with debris. Furthermore, the boulders and striæ are found in the same district at such very different levels and in such positions as to preclude the possibility of their being due to icebergs. Nor could the boulders represent the remainder of a mass of drift which had been removed by denudation, for the following reasons: (1) they were all composed of one rock, and that invariably a rock to be found in place close by; (2) any denudation which could have removed the clay and smaller stones of the drift would have obliterated the traces of glaciation on the surface of the rock; (3) the boulder which had protected the fine glacial markings below it from the action of the rains would certainly in some cases have preserved a portion of the stiff boulder-clay; (4) the margin of the boulder-clay along the flanks of Ingleborough was generally marked by lines of swallow-holes, into which the water ran off the boulder-clay; and when the impervious beds overlying the limestone had been cut back by denudation, a number of lines of swallow-holes marked the successive stages in the process; but there was not such evidence of the former extension of the drift up to the Norber boulders; (5) the boulders themselves were not rounded and glaciated in the same way as the masses of the same rock in the drift, but resembled the pieces now seen broken out by weathering along the outcrop of the rock close by. Having thus shown the improbability of these boulders having been let down out of a mass of drift the finer part of which had been removed by denudation, or of their having been masses floated to their present position on shore-ice, he offered an explanation of their peculiar position, which he thought was not inconsistent with the view that they belong to some part of the age of land-ice. That they were to be referred to some exceptional local circumstances seemed clear from the rarity of such glaciated pedestals, while boulders and other traces of glaciation were universal over that part of the country. He therefore pointed out, in explanation, that they occurred always where there was a great obstacle in the path of the ice: at Cunswick the mass of Kendal Fell curving round at the south and across the path of the ice; at Farleton the great limestone escarpment rising abruptly from Crooklands; at Norber the constriction of the Crummack valley near Wharfe, and the great mass of Austwich grit running obliquely across its mouth. In all these cases the ice had to force its way up hill; and there would be a time when it would just surmount the obstacle after a season of greater snowfall, and fall back after warm seasons, until it fell back altogether from that part. During the season of recession, boulders would be detached below the ice-foot; during the seasons of advance they would be pushed forward; and in those exceptional localities of isolated hills from which the drainage from higher ground was cut off, the boulders were left on a clean furrowed surface of limestone, which was then acted upon by rainwater and the vegetation, except where protected by the boulders. The author said that the reason why he objected to any numerical estimate of the time which had elapsed since the boulders were left on the glaciated surface was that we did know that the rate of weathering in the limestone was most unequal. He gave cases from Devonshire and the Lake District of extensive weathering in a few years. He had called attention to the great acceleration of decomposition where the vegetation encroached on the limestone, and he maintained that we had no constant measure to apply.—On some derived fragments in the Longmynd and newer Archæan rocks of Shropshire, by Dr. Charles Callaway, F.G.S. Further evidence was added to that given in the author's previous paper (*Q.J.G.S.*, 1879, p. 661) to show that the Longmynd rocks of Shropshire were chiefly composed of materials derived from the Uriconian series, and that the Uriconian series itself (Newer Archæan) was partly formed from the waste of pre-existing rocks. This evidence consisted of (1) the presence, throughout the greatly developed Longmynd conglomerates and grits, of purple rhyolite fragments, recognised by microscopical characters as identical with the Uriconian rhyolites of the Wrekin, and the occurrence of grains, probably derived from the same rhyolites, in the typical green slates of the Longmynd; and (2) the existence of conglomerate beds containing rounded fragments of granitoid rock in the core of the Wrekin itself, whilst the Uriconian beds of other localities, and especially those of Charlton Hill, contained water-worn pebbles, chiefly metamorphic. These pebbles appeared to have been derived from metamorphic rocks of three distinct types. The views put forward were founded on microscopical evidence, of which some details were given in the paper, and were supported by the views of Prof. Bonney, who had furnished notes on the microscopical characters of the rocks.—Notes on the relations of the Lincolnshire carstone, by Mr. A. Strahan, M.A., F.G.S. The Lincolnshire carstone has hitherto been supposed to be correlative with the upper part of the Speeton series, and to be quite unconformably overlain by the red chalk (*Quart. Journ. Geol. Soc.*, vol. xxvi. pp. 326–47). But the overlap of the carstone by the red chalk, which seemed to favour this view, is due to the northerly attenuation, which is shared by nearly all the Secondary rocks of Lincolnshire. Moreover, the carstone rests on different members of the Tealby group, and presents a strong contrast to them in lithological character, and in being, except for the derived fauna, entirely unfossiliferous. It is composed of such materials as would result from the "washing" of the Tealby beds. In general it is a reddish-brown grit, made up of small quartz-grains, flakes and spherical grains of iron-oxide, with rolled phosphatic nodules. Towards the south, where it is thick, the nodules are small and sporadic. Northwards, as the carstone loses in thickness, they increase in size and abundance, so as to form a "coprolite-bed," and have yielded specimens of *Ammonites speetonensis*, *A. plicomphalus*, *Lucina*, &c. When the carstone finally thins out, the conglomeratic character invades the red chalk, similar nodules being then found in this rock. The presence of these nodules, with Neocomian species, taken in connection with the character of the materials of the carstone, points to considerable erosion of the Tealby beds. On the other hand, there is a passage from the carstone up into the red chalk. It would seem, then, that the carstone should be regarded as a "basement-bed" of the Upper Cretaceous rocks. The Lincolnshire carstone is probably equivalent to the whole of the Hunstanton Neocomian, the impersistent clay of the latter being a very improbable representative of the Tealby clay. It therefore follows that the whole Speeton series is absent in Norfolk, and also in Bedfordshire. The unconformity at the base of the carstone becomes greater southwards, and the nodules have been derived from older rocks. Similarly north of Lincolnshire, where the Speeton series is overlapped, the nodules in the red chalk, marking the horizon of the carstone, have been derived from oolitic rocks. In the south of England it would seem that equivalents of the Speeton series reappear. The Atherfield clay contains an indigenous Upper Speeton fauna, while a pebble-bed near the base of the Folkestone beds is described by Mr. Meyer as containing derived oolitic pebbles, and being probably the representative of the Upware deposit, and presumably, therefore, also of the Lincolnshire carstone.—The geology of Cape Breton Island, Nova Scotia, by Edwin Gilpin, Jun., F.R.S.C., Inspector H.M. Mines. After referring to previously published descriptions of Cape Breton geology, the author stated that the various formations found in the island had been thus classified by the officers of the Geological Survey:—

Pre-Cambrian (Laurentian)
  including { The Felsite series.
       The Crystalline Limestone series.
Lower Silurian.
Devonian.
Carboniferous, including
  Lower Coal-formation.
  { Gypsiferous series.
   Limestones, &c.
  Millstone-Grit.
  Middle Coal-formation.

He then proceeded to give an account of each system and its subdivisions in order, commencing with the most ancient, and adding a few detailed sections of the rocks belonging to some of the principal series. He described the distribution and relations of the several divisions. The paper concluded with a few notes on the superficial geology of the island. There is a general absence of moraines and of the fossiliferous Post-Pliocene marine clays of the Lower St. Lawrence. The older beds are generally exposed, but deeper soils and deposits with erratic boulders are found overlying the Carboniferous beds. Marks of recent ice-action are found on the shores of some of the lakes, and are due to the ice being driven by the wind.—On the Decapod Crustaceans of the Oxford Clay, by James Carter, F.G.S. The author commented on the paucity of these fossils as indicated in British lists, only three or four species having hitherto been recorded. The discovery of considerable numbers of Decapod Crustaceans in the Oxford Clay of St. Ives has enabled the author to increase the list materially. Many have been collected by Mr. George, of Northampton. These fossils occur in the clay immediately beneath the St. Ives rock, and therefore presumably in the uppermost zone of the Oxford Clay. Many of the specimens are more or less mutilated, but some fifteen or sixteen distinct species have been made out. None of these have been recorded as British except *Eryma Babeaui*, mentioned by Mr. Etheridge as having been found in the Kimmeridge Clay. Seven species are identified as foreign forms, and seven are new to science. They are distributed as follows:—

Eryon	1	species.
Eryma	5 or 6	,,
Glyphea	2	,,
Magila	2 or 3	,,
Mecochirus	2	,,
Goniochorus	1	,,
Undetermined	3	,,

Nearly all the forms being to the type of the Macrura, the Brachyura being doubtfully, if at all, represented.—Some well-sections in Middlesex, by W. Whitaker, B.A. Lond., F.G.S. Accounts of many well-sections and borings having been received since the publication of vol. vi. of the Geological Survey *Memoirs*, the author now gave more or less detailed descriptions of fifty-six of these, all in the Metropolitan county, and all either unfinished or, in a few cases, with further information as to published sections. The depths range from 59 to 700 feet, more than half being 300 feet or more deep. Nearly all pass through the Tertiary beds into the Chalk, and most have been carried some way into the latter. Papers descriptive of like sections in Essex, Herts, and Surrey have been sent to Societies in those counties.—On some Cupriferous Shales in the Province of Houpeh, China, by H. M. Becher, F.G.S. This communication contained some geological observations made during a visit to a locality on the Yangtse River, near I-chang, about 1000 miles from the sea, for the purpose of examining a spot whence copper ore (impure oxide with some carbonate and sulphide) had been procured. The principal formations in the neighbourhood of I-chang were said to be Palæozoic (probably Carboniferous) limestones of great thickness, overlain by brecciated calcareous conglomerate and reddish sandstones, which form low hills in the immediate vicinity of the city. About fifty miles further west the limestones pass under a great shale-series with beds of coal, the relations of which to the sandstones are not clearly ascertained. The copper ore examined by the writer came from the shales, which contained films and specks of malachite and chrysocolla, and in places a siliceous band containing cuprite, besides the oxidised minerals, was interstratified in the beds. Occasionally larger masses of pure copper ore are found embedded in the strata. The ground had not been sufficiently explored for the value of the deposits to be ascertained.—The Cascade Anthracite Coal-field of the Rocky Mountains, Canada, by W. Hamilton Merritt, F.G.S. The coal-field named occurs in the most eastern valley of the Rocky Mountains, that of the Bow River, and, like other coal-fields of the country, consists of Cretaceous rocks, which lie in a synclinal trough at an elevation of about 4300 feet above the sea. The underlying beds, of Lower Carboniferous, or possibly Devonian, age, rise into ranges 3000 feet higher. Further to the eastward the Jurassic and Cretaceous coal contains a large percentage of hygroscopic water and volatile combustible matter, and has the mineral composition of lignite. The average composition is:—

	Per cent.
Fixed carbon...	42
Volatile combustible matter ...	34
Hygroscopic water	16
Ash	8
	100

As the mountains are approached, the amount of hygroscopic water is found to diminish by about 1 per cent. for every 10 miles, and 15 miles from the range the percentage is about 5. In the foot-hills the lignites pass into a true coal, with 1·63 to 6·12 per cent. of hygroscopic water, and 50 to 63 per cent. of fixed carbon. In the Cascade River coal-field the average character of the coal is that of a semi-anthracite, with the following composition:—

	Per cent.
Fixed carbon	80·93
Volatile combustible matter ...	10·79
Hygroscopic water	·71
Ash	7·57
	100·00

The coal-seams have been subjected to great pressure, and the change in the quality of the coal appears to be due to metamorphic influence.—On a new Emydine Chelonian from the Pliocene of India, by Mr. R. Lydekker, B.A., F.G.S. The author described the shell of an Emydine tortoise from the Siwaliks of Perim Island, Gulf of Cambay, which he regarded as decidedly distinct from any of the previously described Siwalik species, and proposed to refer to the genus *Clemmys*, with the name of *C. watsoni*, in compliment to the donor of the specimen.—On certain Eocene formations of Western Servia, by Dr. A. B. Griffiths, F.R.S.E., F.C.S. Communicated by the President. A great thickness of paper-shales containing paraffin occurs near the River Golabara; these extend over 30 square miles of country. Small beds of clay with rock-salt are also found: the whole is said to resemble the paraffin and salt districts of Galicia. The paraffin shale is free from bituminous impurities. It contains:—

	Per cent.
Paraffin wax	1·75
Water of combination	3·02
Ammonia	1·18

The mineral constituents of the shale are:—

	Per cent.
Alumina	32·86
Iron oxide...	5·20
Magnesia	1·26
Lime	1·21
Potash	2·17
Soda	0·41
Silica	56·85
Loss	0·04
	100·00

The brown coal of the neighbourhood, whose natural distillation has most probably yielded the hydrocarbon in the shales, contains:—

	Per cent.
Carbon	49·2
Hydrogen	1·1
Water, combined	30·2
Water, hygroscopic	19·5
	100·00

The beds containing these coals have been invaded by eruptive porphyry and trachytic rocks, of which the former contains 75½ and the latter 61 per cent. of silica. The clays from which the shales were originally formed contain abundance of marine Diatomaceæ and Foraminifera (chiefly Nummulites), as also species of *Ostrea*, *Cyrena*, *Cerithium*, *Voluta*, and *Nautilus*, together with the remains of Placoid and Teleostean fishes.

Paris

Academy of Sciences, July 5.—M. Jurien de la Gravière, President, in the chair.—Memoir on the life and works of Louis-François-Clement Bréguet, Member of the Academy of Sciences, born at Paris on December 22, 1804, died October 27, 1883, by M. de Jonquières.—Obituary notice of M. H. Abich, Corresponding Member of the Section for Mineralogy, who died at Vienna on July 1, 1886, by M. Daubrée.—Preliminary note on the principles and method employed in a study on the movement of the hydro-extractor, about to be presented to the Academy, by M. de Jonquières.—Experiments on a new apparent paradox in hydraulics, by M. A. de Caligny.—Final objections to M. de Bussy's formulas on the roll of vessels, by M. A. Ledieu. It is pointed out that M. de Bussy's theorising is of a purely speculative character, of very little practical utility. After the protracted studies of Froude and Rankine in England, published in the *Transactions* of the Institution of Naval Architects (1861–64), and of MM. Bertin and Bénazé in France, the subject may be regarded as exhausted.—On the real position to be assigned to the fossil flora of Aix, in Provence, by M. G. de Saporta. It is argued against the views of M. Fontannes on stratigraphic grounds that the whole series of varied and numerous deposits giving birth to the flora of Aix, cannot be reduced to the gypsum alone, or to the section of this gypsum contiguous to the beds at Cyrènes. In a further paper it will be shown that the palæontological indications are equally opposed to M. Fontanne's opinion. —Note and photographs of the thunderstorm of May 12, 1886: spiral form of lightning, by M. Ch. Moussette. The photographs taken at Auteuil on this occasion seem to indicate a general law that the electrical discharges between the clouds and the earth assume the normal form of irregular spirals.—Observations of the new planet 259 made at the Paris Observatory (equatorial of the West Tower), by M. G. Bigourdan.—On the development in series of the potential of a homogeneous revolving body, by M. O. Callandreau. In this paper the author verifies the two formulas of Legendre and Laplace relative to the exterior and interior points of a spheroid usually defined by the equation $r = a(1 + \alpha y)$. —Memoir on the rowing-vessels of antiquity, by M. Corazzini. The author attempts to solve the difficult problems associated with the construction of the *naves longæ*, and reconstructs the Roman polyremes in a manner which seems to harmonise best with the monuments and the descriptions of classic writers.—On the refraction of carbonic acid and of cyanogen, by MM. J. Chappuis and Ch. Rivière. The results of the authors' researches on the refraction of carbonic acid at 21° and up to 19 atm. are resumed in the formula—

$$n - 1 = 0{\cdot}000540p(1 + 0{\cdot}0076p + 0{\cdot}0000050p^3),$$

in which n denotes the index for the ray D, and p the pressure in metres of mercury. The refraction of cyanogen has also been studied at different temperatures between the pressures of 1m. and 2m. or 3m. of mercury, the series of experiments relative to a determined temperature being resumed in a formula of the form $n - 1 = ap(1 + bp)$.—On the electrical conductivity of the mixtures of neutral salts, by M. E. Bouty.—On the decomposition of the perchloride of iron by water, by M. G. Foussereau. The author had already employed the measure of electric resistance to determine the nature and proportion of foreign substances contained in water and alcohol, and the conditions under which these fluids acquire the greatest degree of purity. He now applies the same method to the study of the progressive alterations of fluids, and especially of saline solutions under the influence of the dissolvent. The present paper deals specially with the perchloride of iron.—Note on a transmitting dynamometer with a system of optical measurement, by M. P. Curie. This apparatus consists of a horizontal arbor supported by two bearings. Two pulleys at the extremities of the arbor serve to transmit the motion from the motor to the receiver, and the work done is measured during the motion by the torsion of the arbor between the two pulleys.—Temperature of the deep waters in the Lake of Geneva, by M. F. A. Forel. Observations taken during the years 1879–86 show that at great depths the temperature never falls below 4°, and varies normally between 4°·6 and 5°·6. From his experiments the author also infers that the heat penetrates to the lower layers mainly through the mechanical intermingling of the upper with the deep waters under the action of the winds. The same explanation, he argues, should be applicable to all lakes and to all seas confined by bars, notably the Mediterranean, whose deep waters have a mean temperature of 13°.—Absorption-spectra of the alkaline chromates and of chromic acid, by M. P. Sabatier.—On the heat of transformation for vitreous selenium to metallic selenium, by M. Ch. Fabre. Vitreous is transformed to metallic selenium by heating it to 96° or 97°, the transformation being accompanied by a considerable development of heat, which is here directly determined by means of M. Berthelot's calorimeter.—Action of vanadic acid on the alkaline haloid salts, by M. A. Ditte.—On the fluorides of the metalloids, by M. Guntz. By practical tests the author has verified his hypothesis that the fluoride of lead is decomposable by all the chlorides of the metalloids. With the oxychloride of phosphorus the reaction is so regular that it gives a convenient process for preparing the oxyfluoride of phosphorus. —On the hydrate of baryta, BaO, H_2O_2, by M. de Forcrand.—A contribution to the study of the alkaloids, by M. Œchsner de Coninck.—Isomery of the camphols and of the camphors, by M. Alb. Haller.—Researches on the chemical composition of the grease of sheep's wool, by M. A. Buisine. The grease of Australian wool yielded for 100 of dry residuum 7·1 of acetic acid, 4 of propionic acid, 2·6 of benzoic acid, 2·59 of lactic acid, 1 of capric acid.—Acidimetric analysis of sulphurous acid, by M. Ch. Blarez.—Researches on the development of beetroot; study of the leaf, by M. Aimé Girard.—Comparative studies on the influence of the two orders of vaso-motor nerves, on the circulation of the lymph, on their mode of action, and on the mechanism of lymphatic production, by M. S. Lewachew.—On a process of indirect division by threes of the cellules in tumours, by M. V. Cornil.—The house-bug and the seat of its fetid secretion: the dorsal abdominal glands of the larva and nymph; the sternal thoracic glands of the adult, by M. J. Künckel.—On the influence of certain Rhizocephalous parasites on the exterior sexual characters of their host, by M. A. Giard. —On the circulatory system of the Echinidæ, by M. R. Kœhler. —On the seeds of Bonduc, and their active principle as a febrifuge, by MM. Ed. Heckel and Fr. Schlagdenhauffen. These seeds are supplied by two closely allied exotics: *Guilandina Bonducella, L.* (*Cæsalpinia Bonducella*, Tlem.) and *Cæsalpinia Bonduc*, Roxb. Their therapeutic properties are shown to reside in the bitter principle, which acts against intermittent fevers as efficaciously as the salts of quinine.—On the Triassic system of the Eastern Pyrenees, in connection with M. Jacquot's recent communication, by M. A. F. Nogués.—Invertebrate fauna of the Mentone grottoes, Italy, by M. Emile Rivière. In these caves the author has discovered 171 species of invertebrates, comprising 20 fossil, 125 living marine, and 26 land species. Amongst the living marine species 50 are at once Mediterranean and oceanic, 62 exclusively Mediterranean, and 6 oceanic.

BOOKS AND PAMPHLETS RECEIVED

"A Word for Ireland," by T. M. Healy (Gill, Dublin).—"Inorganic Chemistry," by Ira Remsen (Macmillan)—"British Fungi, Lichens, &c.," by Holmes and Gray (Sonnenschein).—"Journal of the Mathematical Society of St. Petersburg," vol. vi.—"Outlines of the History of Ethics," by H. Sidgwick (Macmillan).—"Proceedings of the Academy of Natural Sciences of Philadelphia," part 1 (Philadelphia).—"The Handy Guide to Emigration to the British Colonies," new edition, by W. B. Paton (S.P.C.K.).—"Notes from the Leyden Museum," vol. viii., No. 3, July (Brill, Leyden).

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