Table B.

*Elements whose Longest Lines coincide with Fraunhofer Lines.*

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| --- | --- |
| Certainly  coincident. | Aluminium, Strontium, Lead, Cadmium, Cerium, Uranium, Potassium, Vanadium, Palladium, Molybdenum. |
| Probably  coincident. | Indium, Lithium, Rubidium, Cæsium, Bismuth, Tin, Silver, Glucinum, Lanthanum, Yttrium or Erbium. |

When we come to bring the chemical evidence together which has been acquired by the examination of separate parts of the solar economy, we find, as has been already hinted, that the apparent similarity in chemical structure suggested by the foregoing tables entirely breaks down. Not only is the chemical nature of each separate solar phenomenon different from that of any other, but the facts of observation are in all cases entirely new and strange, so that very little light is obtained towards the understanding of them from ordinary laboratory work.

We will consider the chemistry of the chief solar features in order.

*Chemistry of the Constituent Parts.*

The spectrum of the spots differs from that of the ordinary surface of the sun chiefly by the widening of certain of the Fraunhofer lines in the spot spectrum,— some being excessively widened. The lines which are most widened change from spot to spot and from year to year. The most extensive sun-spot observations of this nature have been carried on in Kensington, and the conclusions derived from 700 observations on spots be­tween 1879 and 1885 are as follows :—

(1) The spot spectra are very unlike the ordinary spectrum of the sun : some Fraunhofer lines are omitted ; new lines appear ; and the intensities of the old lines are changed.

(2) Only very few lines, comparatively speaking, of each chemical element, even of those which have many among the Fraunhofer lines, were seen to be most widened. It was as if on a piano only a few notes were played over and over again, always producing a different tune.

(3) An immense variation from spot to spot was observed be­tween the most widened lines seen in the first hundred observa­tions. Change of quality or density will not account for this variation. To investigate this point the individual observations of lines seen in the spectrum of iron were plotted out on strips of paper, and an attempt made to arrange them in order, but without success, for, even when the observations were divided into six groups, about half of them were left outstanding.

(4) If we consider the lines of any one substance, there is as much inversion between them as between the lines of any two metals. By the term “inversion” is meant that of any three lines, A, B, C, we may get A and B without C, A and C without B, B and C without A.

(5) Very few lines are strongly affected at the same time in the same spot, although a great many lines of the same substance may be affected, besides the twelve recorded as most widened on each day.

(6) Many of the lines seen in the spots are visible at low temper­atures (some in the oxy-hydrogen flame), and none are brightened or intensified when we pass from the temperature of the electric arc to that of the electric spark.

(7) Certain lines of a substance have indicated rest, while other adjacent lines seen in the spectrum of the same substance in the same field of view have shown change of wave-length.

(8) A large number of the lines seen in spots are common to two or more substances with the dispersion employed.

(9) The lines of iron, cobalt, chromium, manganese, titanium, calcium, and nickel seen in the spectra of spots are usually coinci­dent with lines in the spectra of other metals with the dispersion employed, whilst the lines of tungsten, copper, and zinc seen in spots are not coincident with lines in other spectra.

(10) The lines of iron, manganese, zinc, and titanium most fre­quently seen in spots are different from those most frequently seen in flames, whilst in cobalt, chromium, and calcium the lines seen in spots are the same as those seen in flames.

(11) Towards the end of the first series of investigations there appeared among the most widened lines a few which are not re­presented, so far as is known, among the lines seen in the spectra of terrestrial elements. This change took place when there was a marked increase in the solar activity.

(12) The most widened lines in sun spots change with the sun­spot period.

(13) At and slightly after the minimum the lines are chiefly known lines of the various metals.

(14) At and slightly after the maximum the lines are chiefly of unknown origin.

(15) On the hypothesis under discussion the change indicates an increased temperature in the spots at the sun-spot maximum.

The general result is that in passing from minimum to maximum the lines most affected change from those of the ordinary chemical elements to lines whose significance are not known. The accompanying diagram represents graphic­ally the disappearance of the lines of iron, nickel, and titanium and the simultaneous appearance of unknown lines in the spot spectra in passing from minimum to maximum. In the region of the spectrum for which the curves are drawn six lines were recorded in each observa­tion, and therefore 600 in each series of 100 observations. In the curves the vertical ordinates represent not merely the number of individual lines recorded but the number of occurrences of lines of each substance. The dotted curve shows the variation in the frequency of the iron lines; at the minimum in 1879 practically all the 600 lines observed were iron lines; towards the end of 1881 they had dwindled down to 30 ; and during the three following years they fell to 10. The dot and dash curve shows a similar variation in the nickel lines, and the double line curve that of the titanium lines during the same periods. The continuous curve shows the gradual increase in the number of occurrences of unknown lines in passing from the minimum in 1879 to the maximum in 1884.

The chromosphere when quite quiescent merely gives us a spectrum of hydrogen together with a line in the yellow, which, from its proximity to D1 and D2, is called D3. The chromosphere is disturbed in two ways,—first, by prominences, of which more hereafter, and second, by the formation gradually and peacefully of domes, which are of no great height but sometimes extend over large areas and last for weeks. These last-named phenomena have been termed “ wellings up,” the idea being that they were produced by the gradual uprise of vapours from below ; but it is clear that the same phenomena might be