the lines of any metal varies with the amount of the metal in the charge, but in some cases variations of intensity occur among the lines of one metal as observed in the spectra photographed at Crewe in 1893; especially is this the case with some lines in the visible spectrum of iron.

These variations are due to changes in temperature; as the temperature of the flame rises, some lines fade almost away, others become stronger. The changes are more marked in the arc spectrum and still more in the spark spectrum of iron.

Lines of potassium and the edges of manganese bands are shown to have been intensified by the proximity of iron lines in some cases, but this is doubtless a result of low dispersion. The two violet rubidium lines nearly coincide with two lines of iron.*

A new line of potassium with variable intensity. This line, wave-length approximately 4642, varies in intensity within somewhat wide limits. In a given flame its brilliancy is increased by diminishing the quantity of metallic vapour in the flame: this does not appear to depend altogether on the weakening of the continuous spectrum; it is probably due, in part at least, to the increased freedom of motion permitted to the molecules of the metal.

"The Mineral Constituents of Dust and Soot from various Sources." By W. N. HARTLEY, F.R.S., Royal College of Science, Dublin, and HUGH RAMAGE, A.R.C.Sc.I., St. John's College, Cambridge. Received November 20, 1900—Read February 21, 1901.

Baron Nordenskjöld has described three different kinds of dust which were collected by him.† Of two of these, one consisted of diatomaceæ and another of a silicious and apparently felspathic sand: both were found on ice in the Arctic regions. The third variety was quite different and appeared to be of cosmic origin. He observed that some sand collected at the end of a five or six days' continuous fall was mingled with a large quantity of sooty-looking particles, consisting of a material rich in carbon. It appeared to be similar to the dust which fell, with a shower of meteorites, at Hessle near Upsala in the beginning of the year 1869. As in this particular instance it might be supposed that the railways and houses of Stockholm had contributed some of this matter to the atmosphere, and that the snow had carried it down, he requested his brother, who then resided in a desert district of Finland, to give his attention to the subject, with

* 'Roy. Dublin Soc. Proc.,' vol. 8 (N.S.), Part VI, p. 705.

† 'Comptes Rendus,' vol. 78, p. 236.

the result that he collected a similar powder. The snow gathered in the latitude of 80° N. in an expedition to Spitzbergen, and that collected from floating ice in the Arctic regions and on the glaciers of Greenland, leaves, after it has melted, a greyish residue, which consists largely of diatomaceæ, but mixed with these organisms there were also particles of a carbonaceous dust of considerable size, which on analysis were found to contain metallic iron, cobalt, and nickel, also silicon, carbon, and phosphorus. The origin of this mineral matter was at first doubtful. Two of its constituents, cobalt and nickel, were believed to be of very uncommon occurrence in terrestrial matter, while on the other hand they are elements invariably associated with the metallic iron of meteorites, the nickel being more particularly in large proportion. If we suppose that this dust is discharged from the mouth of a distant volcano, or that it may be sand carried up by a whirlwind, we have yet to explain the peculiarities in its composition which render it similar to that of meteorites.

Nordenskjöld arrived at the conclusion that it was meteoric matter which had descended upon the earth in a shower similar to that which occurred near Upsala. By the facts which he had collected it appears to have been proved that cosmic dust is falling imperceptibly and continually. It seems that this view is either generally not accepted, or that the facts are not commonly known.

Very little is really known about the composition of atmospheric dust, notwithstanding that searching investigations were made by Pasteur and Angus Smith, aided by the microscope, and later by Liveing and Dewar by the aid of the spectroscope.

Professor O'Reilly, M.R.I.A., supplied us with small quantities of a material concerning the nature of which he was desirous of obtaining information. On inspection it appeared to be of an unusual character for mere town dust, and accordingly we submitted it to a spectrographic analysis, and determined the principal metallic elements which enter into its composition. The following specimens in particular have been examined with care :—

(I.) Solid matter which fell in or with hail in a hail-storm on Wednesday, April 14, 1897, and was collected by Professor O'Reilly at a window facing the large open space of Stephen's Green, at the Royal College of Science, Dublin. It contained iron, sodium, lead, copper, silver, calcium, potassium, nickel, manganese a trace; gallium and cobalt gave doubtful indications.

(II.) Solid matter from hail and sleet collected by Professor O'Reilly from a window-sill of the Royal College of Science, Dublin, during a very heavy shower, from 2.30 till 3 o'clock, in the afternoon of March 28, 1896.

Total weight of the dust 0·1018 gramme, of which 0·08 gramme was burnt in the oxyhydrogen flame. The colour of the dust was steel

grey and it was magnetic. It contained iron, copper, and sodium, lead, calcium, potassium, manganese, nickel, silver, thallium a trace, gallium and rubidium a trace, doubtful.

(III.) Pumice from Krakatoa eruption 1883; from Professor O'Reilly. By decomposing the silicate with ammonium fluoride and sulphuric acid, and precipitating the solution with ammonia, the following bases were separated: iron, copper, silver, sodium, nickel, potassium, rubidium, manganese, gallium, and indium a trace.*

The salt separated by filtration and evaporation of the filtrate contained sodium, potassium, calcium, copper, silver, strontium, nickel a trace, rubidium, and manganese. With the very notable exceptions of strontium, nickel, and cobalt we have found these constituents in ninety-seven irons, ores and associated minerals.† On the other hand, in the examination of six meteoric irons, we have found the same elements invariably associated with nickel and cobalt, the last-named being always in much smaller proportion than the nickel.‡ Had it been possible to operate on larger quantities, we quite expect that cobalt would have been found in this dust, but the small amount of 8 centigrams is insufficient for such a purpose, even in the case of most meteoric irons. It is rather a striking fact that in the dust No. 2 there is a trace of thallium. This is rather suggestive of its being probably pyrites flue dust, a substance which might occur in hail or rain in a neighbourhood where sulphuric acid is manufactured. It might possibly come from an admixture of soot yielded by a coal containing thalliferous pyrites.

There are three vitriol works within 2 or 3 miles of the College, but after taking all the facts into consideration, we are not able to admit this source as a probable means of contamination, for as will be seen from analyses to be presented, there is one notable constituent we have found in flue dust which is absent from the samples I and II, namely, indium.

In 1897, in order to push this inquiry somewhat further, dust was collected in porcelain dishes placed upon a grass plot in the garden of a residence just on the outskirts of Dublin§ during a period from the 15th November to the 15th December. A considerable fall of a carbonaceous-looking matter occurred on the 16th and 17th of November; some of the particles were 2 or 3 mm. in diameter, and had a steel grey appearance rather like hard coke or graphite. These particles all sank in the rain-water which collected on the 17th or 18th, while a large number of sooty particles floated; as the dish became over-filled, the sooty matter was automatically washed away

* 'Trans. Chem. Soc.,' vol. 79, p. 61, 1901.

† Nickel was found in twenty-three. 'Trans. Chem. Soc.,' vol. 71, p. 533, 1897.

‡ 'Sci. Proc. Dublin Soc.,' New Series, vol. 8.

§ At the back of my house and remote from any factory chimneys.—W. N. H.

and only the heavier particles remained. The contents of the dishes were poured into glass cylinders, and after the heavier particles had been deposited the water was removed by decantation.

Subsequently it became interesting to ascertain what substances are to be found in ordinary soot and flue dust—dust from volcanic eruptions, &c. We have tabulated the results and arranged together those substances which we know to have the same origin.

The specimens of soot required no preliminary treatment before being burnt, and the analysis of each is given in the tabular statement only, but the different kinds of volcanic dust and flue dust were dissolved and the silica removed, after which the bases were separated into groups, and the spectra of these groups were photographed; each spectrum receives a detailed description preceding the tabulated statement.

Flue Dust.

Plate 386.—Dust from the flue of Crewe gasworks. May 28, 1899. The silica was removed from 1 gramme by treatment with ammonium fluoride.

Spectrum 1.—The insoluble residue contained—

Ca, Sr, Na, Pb, Fe, Cu, Ag, K.

,, 2.—The precipitate yielded by sulphuretted hydrogen—

Pb, Cu, Ag, Ca, Na, Fe, K.

,, 3.—The ammonium hydrate precipitate—

Fe, Ga, Cu, Ag, Pb, In, Ni trace,
Ca, Na, K.

,, 4.—The ammonium sulphide precipitate—

Mn, Na, K, Cu, Ag, Ni, Fe.

,, 5.—The less soluble sulphates—

Ca, Sr, Cu, Na, K.

,, 6.—Magnesia and the alkalies—

Na, K, Ca, Sr, Ni, Rb trace.

Plate 388. Spectra 4 and 7.—Insoluble residue after treating the dust with hydrochloric acid—

Fe, Ga, Na, K, Ca, Cu, Ag, Ni, Mn.

Plate 347.—Flue dust from Cleveland iron furnaces.

Spectrum 1.—Samuelson's samples, No. 6—

Na, K, Ca, Fe, Rb, Pb, Mn;
traces of Cu, Ag, Ni, Ga, Tl.

Spectrum 2.—Flue dust from basic iron furnace. Samuelson's No. 9—

Na, K, Ca, Fe, Rb, Pb, Mn;
traces of Cu, Ag, Ni, Tl, Ga, In, Cs, Sr.

,, 3.—Flue dust, Gjers, Mills, and Co.—

Na, K, Ca, Fe, Rb, Pb, Mn;
traces of Cu, Ag, Ni, K, Ga, In.

Plate 354.

Spectrum 4.—Flue dust, Gjers, Mills, and Co.—

Fe, Ca, Cu, Mn, Na, K, Pb, Rb;
traces of Ni, Tl, Ag.

Plate 325. 1.—Flue dust from Nicholson's copper smelting works, Hunslet, Leeds—

Na, Cu, Pb, Tl, Ag, In, Fe, K,
Ca, Ga, Rb.

Plate 312.—Iron pyrites from coal—

Fe, Cu, Tl, Pb, Ag, and possibly a trace of gallium.

Volcanic Dust.

Specimens received from Professor J. P. O'Reilly.

Plate 311.—*Te Ariki.* After complete solution of the substance the heavy metals were precipitated with ammonia and the filtrate with ammonium oxalate, after which the solution containing magnesia and the alkalies was examined.

Spectrum 1.—The ammonia precipitate—

Fe, Ca, Pb, Na, K trace, Ga trace, Cu trace.

,, 2.—The ammonium oxalate precipitate—

Ca, Sr, Mn, traces of Na, K, Pb, Fe, and Ag.

,, 3.—Magnesia and the alkalies—

Na, K, MgO, Mn, Rb, Cu;
Ni the merest trace.

Taurunga.

Plate 311.

Spectrum 4.—The ammonia precipitate—

The constituents are similar to No. 1.

,, 5.—Ammonium oxalate precipitate.
Similar to No. 2.

,, 6.—Magnesia and the alkalies—
Similar to No. 3.

Le Hape-o-Torva.

Plate 312.

Spectrum 1.—The ammonia precipitate-

Similar to Nos. 1 and 4.

" 2.—The oxalates—

Similar to Nos. 2 and 5, but the silver was not so strong.

" 3.—Magnesia and the alkalies—

Similar to Nos. 3 and 6.

It is necessary to explain that the symbol for magnesium and the alkaline earth metals refers generally to the oxides. With magnesium, in fact, this is always so, since the bands of the oxide magnesia alone are visible. In the case of calcium, the blue line 4226 is photographed when only a small quantity is present, but the bands of calcium oxide are the chief feature of the spectrum when the base is in larger proportion. Where the symbol is printed in italics it indicates a trace of the substance, and where followed by a note of interrogation it is not quite certain if even a trace is present, as, for instance, where only one of two rubidium lines is seen, there being two iron lines occupying almost the same positions; or where one of the gallium lines is barely visible, and the second is enveloped by manganese lines. The relative strength of the lines, as seen by comparing the different spectra, is, in some instances, indicated on the tabulated statement by suffixes, the number 1 indicating the weakest line and 10 the strongest.

The difference in the number of the iron lines is a measure of the quantity of iron present as metal or otherwise, and a comparison of the strength of the lines also indicates the relative quantity of substances. The results in many cases are quantitative, inasmuch as the same weight of material was taken.

On the Nature of Dust from the Clouds.

The principal characteristic of dust which has fallen directly from the clouds or collected by hail, snow, sleet, or rain, is its regularity in composition—each specimen appears to contain the same proportions of iron, nickel, calcium, copper, potassium, and sodium. The proportion of carbonaceous matter must be small, otherwise a diminution in the proportion of the metals present would render the metallic lines weaker. There is a very considerable difference between the dust from sleet, snow, and hail suddenly precipitated, the difference being in the proportion of lead, which, in the dust from sleet, is much larger than in the other specimens, though dust from hail and one quantity collected from rain contain more than is found in any other specimens

The Composition of Dust from Various Sources.

	Sodium.	Potassium.	Rubidium.	Cæsium.	Copper.	Silver.	Magnesium.	Calcium.	Strontium.	Aluminium.	Gallium.	Indium.	Thallium.	Iron.	Nickel.	Cobalt.	Manganese.	Chromium.	Lead.
Dust from sleet, fell 28th March, 1896	Na	K	Rb?	..	Cu	Ag	..	Ca	..	..	Ga	..	*Tl*	Fe	Ni	..	Mn	..	Pb
Dust from hail, fell 14th April, 1897	Na	K	..	..	Cu	Ag	..	Ca	..	..	Ga?	..	..	Fe	Ni	..	*Mn*	..	Pb
Dust from the clouds, fell 16th and 17th November, 1897	Na	K	..	..	Cu	Ag	..	Ca	..	..	Ga	..	*Tl*	Fe	Ni	..	Mn	*Cr*	Pb
Dust from rain, 13th to 15th November, 1897	Na	K	..	..	Cu	Ag	..	Ca	*Sr*	..	*Ga*	..	*Tl*	Fe	Ni	..	*Mn*	..	Pb
Volcanic dust from New Zealand—																			
(1.) Te Ariki	Na	K	Rb	..	Cu	*Ag*	MgO	Ca	Sr	..	*Ga*	..	..	Fe	*Ni*	..	Mn	..	Pb
(2.) Tauranga	Na	K	Rb	..	Cu	*Ag*	MgO	Ca	Sr	..	*Ga*	..	..	Fe	*Ni*	..	Mn	..	Pb
(3.) Te Hope-O-Torca	Na	K	Rb	..	Cu	*Ag*	MgO	Ca	Sr	..	*Ga*	..	..	Fe	*Ni*	..	Mn	..	Pb
Pumice from Krakatoa	Na	K	Rb	..	Cu	Ag	..	Ca	Sr	..	Ga	*In*	..	Fe	Ni	..	Mn	..	Pb
Lead chloride from crater of Vesuvius.	Na	K	Rb	..	Cu	..	..	..	..	..	..	..	Tl	Fe	..	..	..	..	Pb
Soot from chimneys—																			
(1.) A bedroom chimney	Na_9	K_4	*Rb*?	..	Cu_2	..	..	Ca_7	Sr_1	..	Ga_1	..	Tl_1	Fe_8	Ni_1	..	Mn_1	..	Pb_4
(2.) A kitchen chimney	Na_3	..	..	..	..	..	..	Ca_3	..	..	..	..	..	Fe_2					

The Composition of Dust from Various Sources—*continued.*

	Sodium.	Potassium.	Rubidium.	Cæsium.	Copper.	Silver.	Magnesium.	Calcium.	Strontium.	Aluminium.	Gallium.	Indium.	Thallium.	Iron.	Nickel.	Cobalt.	Manganese.	Chromium.	Lead.	Zinc.	Cadmium.	Tin.
Soot from chimneys—*continued.*																						
(3.) A laundry chimney	Na_9	K_4	*Rb ?*	.	Cu_4	Ag_1	..	Ca_7	Sr_1	..	Ga_2	..	Tl_2	Fe_9	Ni_3	..	Mn_3	Cr_1	Pb_5			
(4.) Assay laboratory fusion furnace.	Na_9	K_8	*Rb ?*	..	Cu_4	Ag_4	..	Ca_2	..	..	Ga_3	..	Tl_3	Fe_7	Ni_3	..	Mn_1	..	Pb_9			
(5.) Assay laboratory gas muffle.....	Na_7	K_3	..	..	Cu_3	Ag_2	..	Ca_3	..	..	*Ga ?*	..	Tl_1	Fe_7	..	..	Mn_1	..	Pb_8			
(6.) Heating apparatus furnace ..	Na_9	K_4	*Rb ?*	..	Cu_3	..	..	Ca_9	Sr_2	..	*Ga ?*	..	Tl_1	Fe_9	Ni_1	..	Mn_6	..	Pb_3			
Flue dust*—																						
(1.) Gasworks, Crewe	Na	K	*Rb*	..	Cu	Ag	..	Ca	Sr	..	Ga	In	..	Fe	Ni	..	Mn	..	Pb			
(2.) Boyd's chemical works, Dublin..	Na	K	..	..	Cu	Ag	..	Ca	..	..	..	In	Tl	Fe	..	..	..	..	Pb			
(3.) Nicholson's copper works, Leeds, 0·5 grm.	Na	K	Rb	..	Cu	Ag	..	Ca	..	..	Ga	In	Tl	Fe	..	..	..	..	Pb			
Do. do. 20 grms.†	Na	K	Rb	*Cs*	Cu	Ag	..	Ca	Sr	Al	Ga	In	Tl	Fe	Ni	*Co*	Mn	Cr	Pb	Zn	Cd	Sn
(4.) Ferro-manganese furnace, Pittsburg, U.S.A. ..	Na	K	Rb	..	Cu	..	..	Ca	..	..	..	..	Tl	Fe	Ni	..	Mn	..	Pb			
(5.) Ferro-manganese furnace.......	Na	K	Rb	*Cs*	Cu	Ag	..	Ca	..	..	Ga	*In*	Tl	Fe	..	..	Mn	..	Pb			

* Lithium was found in all these dusts. † Bismuth was found in this dust.

The Composition of Dust from Various Sources—*continued.*

	Sodium.	Potassium.	Rubidium.	Cæsium.	Copper.	Silver.	Magnesium.	Calcium.	Strontium.	Aluminium.	Gallium.	Indium.	Thallium.	Iron.	Nickel.	Cobalt.	Manganese.	Chromium.	Lead.
Flue dust—*continued.*																			
(6.) Cleveland iron furnace, Samuelson, Middlesbrough	Na	K	Rb	..	*Cu*	*Ag*	..	Ca	..	..	*Ga*	..	*Tl*	Fe	*Ni*	..	Mn	..	Pb
(7.) Cleveland iron furnace	Na	K	Rb	..	*Cu*	*Ag*	..	Ca	..	..	*Ga*	*In*	*Tl*	Fe	*Ni*	..	Mn	..	Pb
(8.) "Basic iron" furnace..........	Na	K	Rb	*Cs*	*Cu*	*Ag*	..	Ca	Sr	..	*Ga*	*In*	*Tl*	Fe	*Ni*	..	Mn	..	Pb
(9.) South Wales iron furnace	Na	K	Rb	..	*Cu*	*Ag*	..	Ca	..	..	*Ga*	*In*	..	Fe	..	..	..	..	Pb
Examples of Well-known Meteorites.																			
Meteoric stone, Alfianello............	Na	K	..	..	Cu	Ag	MgO	Ca	..	..	*Ga*	..	..	Fe	Ni	..	Mn	Cr	Pb
Meteoric stone, Pultush	Na	K	..	..	Cu	Ag	MgO	Ca	..	..	..	..	..	Fe	Ni	..	Mn	Cr	Pb
Meteoric stone, Mocs	Na	K	..	..	Cu	Ag	MgO	Ca	*Sr*	..	..	..	..	Fe	Ni	..	Mn	Cr	Pb
Siderolite, Atacama..................	Na	K	..	..	Cu	Ag	..	Ca	..	..	..	..	..	Fe	Ni	..	Mn	Cr	Pb

with such an origin. The only meteorite which contains as much lead as this is the siderolite from Atacama.

Of Volcanic Dust.

If we examine the spectra of specimens of volcanic dust it is noticeable that the heavy metals are, without exception, in comparatively small proportions—lead and iron, for example—while lime, magnesia, and the alkalies are the chief basic constituents. The spectra of the heavy metals, the alkaline earths, and the magnesia with the alkalies appear on separate photographs.

Of Soot from different Chimneys.

The nature of soot from different sources is characterised by the small proportion of iron in most specimens and of metals precipitated as hydroxides; its large proportion of lime and the greater variability in the proportions of its different constituents distinguishes it from other kinds of dust collected from the clouds or in the open air. It was certainly unexpected when nickel, calcium, manganese, copper, and silver were found to be constant constituents of soot from different chimneys and flues. The proportions of lead, silver, and copper are much larger in the soot from the assaying furnace and the laundry chimney.

To illustrate the differences observable in dust and soot of various kinds, a list is appended of the wave-lengths of the iron lines observed in the spectra from soot obtained from the laundry, laboratory, kitchen, and bedroom chimneys. A second list gives the wave-lengths of lines belonging to other elements and observed in other substances as well as dust and soot.

It will be seen that there is an extraordinary difference between the kitchen and the laundry soot, which is probably caused by a higher temperature and more complete combustion of the fuel in the laundry fire.

Flue Dust.

In flue dust from different sources the chief characteristics are the presence of lead, silver, and copper in larger proportions than in other varieties of dust or of coal ashes which have also been examined. Nickel and manganese also are in larger proportions. But the most striking feature is the quantity of rubidium, gallium, indium, and thallium in all samples examined.

It is evident now that we can state with absolute certainty whether two kinds of dust have the same composition or in what constituents they differ substantially.

When dust is collected in the open air it is liable to become mixed

The Lines of Iron observed in different kinds of Soot.

	Laundry.	Laboratory.	Kitchen.	Bedroom.	
Na D	5893·0				
	4404·9				
	4383·7	4383·7			
	25·9				
G	08·0				
	4289·8				
	16·3	4216·0			The two rubidium lines 4215·8 and 4202·4 almost coincide with two iron lines 4216·3 and 4202·1.
	02·1				
	4144·0	4144·0			
	32·2				
	4063·7				
	45·9				
	3930·4	3930·4		3930·4	
	28·0	28·0		28·0	
	23·0	23·0		23·0	
	20·4	20·4		20·4	
	06·6	06·6		06·6	
	3899·9	3899·9		3899·9	
	95·8	95·8		95·8	
	86·4	86·4	3886·4	86·4	
	75·7	78·7	Extremely feeble	78·7	
	72·6	72·6			
	65·6				
	60·0	60·0	3860·0	3860·0	
	56·5	56·5	Very feeble	56·5	
	50·1	50·1			
	40·5	40·5			
	34·3	34·3			
	26·0	26·0		3826·0	
L	24·5	24·5	3824·5	24·5	
	20·5	20·5	Barely visible	20·5	
	15·9	15·9			
	13·1	13·1			
	3799·6	3799·6			
	98·6	98·6			
	95·1				
	88·0	88·0			
	49·6	49·6	3749·6	3749·6	
	45·7	45·7	45·7	45·7	
	35·0	35·0	35·0	35·0	
	33·4	33·4	33·4	33·4	
M	27·7	27·7			
	22·6	22·6	3722·6	3722·6	
	20·0	20·0	20·0	20·0	
	09·3	09·3	The six last lines are very feeble	09·3	
	05·7	05·7		05·7	
	3687·6	3687·6		3687·6	
	80·0	80·0			
	77·8	77·8		3677·8	
	47·9	47·9			
	31·6	31·6			
	18·9	18·9			
N	3585·5	3585·5			
	81·3	81·3			
	70·2	70·2			

Wave-lengths of other Lines than Iron in Spectra from various kinds of Dust and Soot, and in Meteorites.

	Sodium.	*Calcium.*	*Chromium.*
D lines.	5896·1, 5890·2 } Mean 5893·0	4226·9 A line.	4289·9, 4274·6, 4254·4 } A triplet.
	3303·1, 3302·5 } Mean 3302·3	*Calcium Oxide.*	3605·3, 3593·7, 3578·8 } A triplet.
	Potassium.	5598·0 to 5485·0 } A strong band.	*Manganese.*
	5805·0	6253·0 to 6116·0 } A band.	4034·5, 4033·2, 4031·0 } Lines which often appear like one broad line.
	4047·4, 4044·0 } Mean 4045·7	6075·0 to about 5985·0 } A weaker band.	*Copper.*
	Lithium.	*Magnesium Oxide.*	3273·6
	4602·3	3929·0 to 3856·0 } A band, strong, diffuse.	3247·0
	3232·7	3834·0 to about 3805·0 } A band, strong, diffuse.	*Silver.*
	Cæsium.	*Strontium.*	3383·5
	4557·0	4607·0	3282·1
	Rubidium.	*Lead.*	*Nickel.*
	4215·7	4057·6	3618·5, 3609·8, 3571·2, 3461·0, 3433·0 — The lines observed are near the positions of such as are here indicated, and are probably identical with them. There is also a line 3525, the only one observed in Cleveland pig iron. It does not appear in these analyses.
	4202·4	3682·9	
	Thallium.	3639·2	
	5349·6		
	3775·6		
	Gallium.		
	4172·2		
	4033·0		
	Indium.		
	4511·0		
	4102·0		

Some of the lines were measured with a micrometer and the wave-lengths deduced from a curve on an enlarged scale drawn from Rowland's measurements of iron lines in the solar spectrum.

with other dust and soot, and we cannot be certain whether it comes from only one source or not, but soot, as a rule, can be separated by washing it away from the heavier matter. The occurrence of nickel in soot and flue dust was certainly unexpected. It is probably disseminated in extremely minute traces in coal, and its concentration in soot is owing to the conditions in a coal fire being favourable to the formation of nickel tetra-carbonyl and its subsequent decomposition

Conclusions.

(1.) The presence of nickel, as shown by the examination of soot, is not positive evidence that the dust from the clouds comes from other than a terrestrial source.

(2) The dust which fell on the 16th and 17th of November, 1897, with its regularity in composition and its similarity to meteorites, being magnetic, also its comparative freedom from extraneous matter, exhibits properties which are quite in favour of its cosmic origin. Moreover, its composition is totally unlike that of volcanic dust and flue dust from various chemical and metallurgical works. This dust for the most part fell on a perfectly calm fine night, and there was no rain for twenty-four hours or more afterwards.

We beg to draw attention once more to the very wide distribution of gallium in minute proportions; it occurs in all aluminous minerals, flue dust of very different kinds, soot and atmospheric dust, also in a great variety of iron ores. Bauxite contains it in larger proportion than any other mineral, but the quantity even in this substance is very small. We have hopes of finding it concentrated in some mineral, as thallium, cæsium, germanium, and indium are. Indium and thallium, the other members of the same group of elements, are found in blende and pyrites, and accordingly we might expect gallium to occur in a concentrated state in a sulphide, arsenide, or similar compound. Judging, however, from its analogy with aluminium, there does not seem to be much probability of this.

"Notes on the Spark Spectrum of Silicon as rendered by Silicates." By W. N. Hartley, F.R.S.

Received November 19, 1900—Read February 21, 1901.

The interesting account by Mr. Lunt* of his identification of three lines of silicon, corresponding with three unknown lines in the spectra of certain fixed stars, contains the following remarks:—

"It is a curious fact that Hartley and Adeney, and Eder and Valenta, who alone give us any extended list of lines due to silicon, appear not to have examined the spectrum of this element in the region of the three rays here considered. Their published wave-lengths show only lines in the extreme ultra-violet, and the majority of them are quite outside the region which can be examined by the McClean star spectroscope."

There is an inaccuracy here, and a similar mistake as to authorship occurs in the paper of Eder and Valenta. Silicon was not one of the sixteen elements whose spark spectra were investigated by Hartley

* 'Roy. Soc. Proc.,' vol. 66, p. 44.