

XI. *Application of the Periodic Law to Mineralogy.*

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THE Periodic Law of the Chemical Elements first foreshadowed by Newlands, and subsequently developed by Mendeleeff and Lothar Meyer, states:—(1) *The Properties of the Elements are a Periodic Function of their Atomic Weights.* (2) *The Properties of the Compounds of the Elements are a Periodic Function of the Atomic Weights of their Constituent Elements.* This law was explained and illustrated by several examples in the case of both chemical and physical properties, and attention specially directed to the division of the elements, as arranged in Mendeleeff's table (*Ann. Chem. Pharm.*; Suppl. 1870-72, p. 151) into odd and even series, and to the somewhat peculiar character of the eighth group of that table. These points were further illustrated by a reference to Lothar Meyer's curve of the elements (*Mod. Theor. der Chem.*).

In applying the Periodic Law to Mineralogy, it was pointed out that this could not be rendered so evident as could be wished, since the relationships brought to light by the application of that law in ordinary chemical science referred to chemically pure substances, whereas mineralogy dealt chiefly with bodies whose properties were liable to some variation, owing to their almost always containing more or less of other compounds foreign to their ideal composition, so that any exact relationships which may exist between their composition and general chemical and physical properties are in many cases concealed.

The principal lines indicated in which an application of the Periodic Law to Mineralogy may be of service were as follows:—

(1.) *Reducibility of the Elements of the Free State from their State of Combination.* *Elements belonging to odd series are, as a rule, easily reducible to the free state, whilst those belonging to even series are only reducible to the free state with difficulty.*

(2.) *Occurrence of the Elements of the Free State in Nature.* This is, of course, closely connected with the property of reducibility already considered, so that we may expect a similar relation to hold good. *Elements belonging to even series (except C, N, O, and Group VIII.)*

never occur in the free state in Nature, whereas elements belonging to odd series generally and sometimes frequently do occur free.

(3.) Occurrence of the Elements in the Combined State in Nature. In reference to what is said under this section, F, Cl, Br and I, and the elements of Group VIII. must be neglected. They are referred to below.

*Elements belonging to odd series usually occur in Nature as sulphides or double sulphides (also as selenides, tellurides and arsenides), i.e. in combination with a negative element belonging to an odd series, and only in very few cases as oxides, whereas elements belonging to even series, on the other hand, usually occur as oxides or double oxides (forming silicates, carbonates, sulphates, aluminates, &c.), i.e. in combination with a negative element belonging to an even series, and never (with two exceptions) as sulphides.*

Thus:

*Elements belonging to even series:—*

As oxides, or double oxides	{	<i>Commonly.</i> Li (Lithia mica, &c.), K (nitre, felspar, &c.), Rb, Cs, Be, Ca, Sr, Ba, B, Sc, Y, La, Yb, C, Ti, Zr, Ce, Th, V, Nb, Di, Ta, O, Cr, Tb, W, Mn.
		<i>Frequently.</i> N (in nitre), Mo.
		<i>Rarely or never.</i> None.

The only two of these elements occurring as sulphides are:—

{	<i>Commonly.</i> Mo.
	<i>Very rarely.</i> Mn (also O, as SO <sub>2</sub> in volcanic gases).

*Elements belonging to odd series:—*

As sulphides (selenides, tellurides) .....	{	<i>Commonly.</i> Cu, Ag, Zn, Cd, Hg, Ga, In, Tl, Pb, Sb, S, Se, Te.
		<i>Frequently.</i> As, Bi, Sn.
		<i>Never.</i> Au (occurs only in free state in Nature), Na, Mg, Al, Si, P (for these see Meyer's curve).
As oxides .....	{	<i>Commonly.</i> Na, Mg, Al, Si, P (for these see Meyer's curve) and Sn.
		<i>Frequently.</i> Zn, Cu.
		<i>Rarely.</i> Pb, Sb, Bi, As.

*Group VIII.*—The elements of this group, except Fe, Co, and Ni, never occur in Nature in the combined state, and therefore need not be considered in this connection. As regards the first triad of this group—

Fe occurs *mostly* as oxide, but also *frequently* as sulphide.

Co occurs *mostly* as sulphide and arsenide, but *sometimes* as oxide.

Ni occurs *almost always* as sulphide and arsenide, and only *very rarely* as oxide.

Iron, the first member of the triad, thus more nearly resembles elements of the even series; whereas Nickel, the last member, more nearly resembles elements of the odd series. This shows, therefore, in a marked manner that in Group VIII. we have a gradual passage from even series on the one hand to odd series on the other.

The halogens Cl, Br, I and F, being the most electro-negative of the elements, occur in nature in combination with the most electro-positive metals as chlorides, bromides, iodides and fluorides, &c. and are never (if we omit a few metallic oxychlorides and sulphochlorides) found in combination with either oxygen or sulphur.

The only other point necessary to mention is that as regards the odd members of any one group, the tendency to occur in nature as sulphides increases, whereas the tendency to occur as oxides or double oxides diminishes, as the atomic weight increases, thus:—

Group I.	}	Na*	frequently occurs as double oxide (silicates, Chili salt-petre, &c.), and never as sulphide.
		Cu	occurs commonly both as sulphide (Cu, S, Cu S, Cu Fe S <sub>2</sub> , &c.), and as oxide or double oxide (Cu <sub>2</sub> O, Cu O, malachite, &c.)
		Ag	generally as sulphide and never as oxide.
		Au	only in free state.
Group II.	}	Mg	always occurs as double oxide (Mg CO <sub>3</sub> , &c.) and never as sulphide.
		Zn	most commonly occurs as sulphide, but sometimes also as oxide.
		Cd	only found as sulphide and never as oxide.
		Hg	only found as sulphide or in metallic state, and never as oxide.
Group IV.	}	Si	always occurs as oxide or double oxide (silicates).
		Sn	almost always occurs as oxide, but sometimes as sulphide.
		Pb	almost always occurs as sulphide, and only rarely as oxide (minium).

And a similar thing for groups III. V. and VI.

The whole of the above facts may be expressed in terms of Lothar Meyer's curve as follows:—

*Elements standing on falling portions of the curve are reducible with difficulty, and never occur in the free state in Nature, or in combina-*

\* Omitting its occurrence as chloride, since it does not affect the present question.

tion as sulphides, but always in combination with oxygen, forming oxides or double oxides (silicates, sulphates, carbonates, &c.), whereas elements standing on rising portions of the curve are easily reducible and almost always occur (more or less) in the free state in Nature, and also in combination with sulphur and but rarely with oxygen.

4. The hardness, specific gravity, and fusibility of the elements also vary periodically with the atomic weight, as is best seen by reference to Meyer's Curve.

5. The hardness and specific gravity of compounds (occurring as minerals). So far as data will allow of a conclusion we have the following relationships. (a.) *Sulphides of the elements of odd series.* The specific gravity of the natural sulphides of the elements in any one group increases with the atomic weight, whilst the hardness diminishes. The specific gravity of the sulphides of the elements in any one series diminishes as we pass along the series from the positive to the negative end, whilst the hardness increases up to the middle of the series and then diminishes. (b.) *Oxides of the elements of odd and even series.* The specific gravity of the oxides of any one group of even or of odd elements (odd not being comparable with even elements) increases with the atomic weight.

6. *Colour.* (a.) As shown by Mr. Ackroyd, many bodies when heated undergo alterations in colour, such that as the temperature rises the colour passes more and more towards the red end of the spectrum, and finally, if the temperature be high enough, to brown and black. (b.) As also shown by Ackroyd, an increase in the quantity of the electro-negative element in a simple binary compound produces a colour change toward the red end of the spectrum.

(c.) The influence of atomic weight on the colour of compounds may be stated thus:—Take any series of compounds  $A_xR_y$ ,  $B_xR_y$ ,  $C_xR_y$ , &c., in which  $R$  is any element or group of elements, whilst  $A$ ,  $B$ ,  $C$ , &c., are elements belonging to the same sub-group of Mendeleeff's Table of the Natural Classification of the Elements. Then as the atomic weight of the elements  $A$ ,  $B$ ,  $C$ , &c., increases, the more does the colour of the compound pass towards the red end of the spectrum, and then (in many cases) to brown and black.

In conclusion, a theory was propounded whereby these colour relationships are apparently fully accounted for.

Finally, it should be said that the points mentioned in the paper were brought forward rather as suggestions for future research than as final and definite conclusions.