

CHAPTER II

BACKGROUND LEVEL OF METALS IN EARTH'S CRUST

This chapter reviews the composition of Earth's crust, and distribution of some elements in various types of rocks prior to the weathering processes, soil and marine sediments.

ELEMENTAL COMPOSITION OF IGNEOUS ROCKS.

The origin of many igneous rocks is a subject of likely debate. Some igneous have formed by the cooling of a melt that has moved as a fluid body, others by extreme metamorphism of sediments in place (Krauskopf, 1967). Granites and basaltic rocks are most of the common rock types. The distribution of elements in igneous rocks can be explained fairly satisfactorily by assuming the slow crystallization of an orderly sequence of minerals from a melt, usually leading to differentiation. Many details of the distribution, both in individual minerals and in rocks formed at different stages of differentiation, can be correlated with such ionic properties as size, charge, and tendency to form covalent bonds. Trace metals, markedly dissimilar to major elements, are largely left out of the principal minerals and concentrated in the residual solutions that ultimately form pegmatites and sulfide veins (Krauskopf, 1967).

The average chemical composition of abundant igneous rocks have been a subject of interest to geochemist for quite a long time. Up to 1954 the best known averages for various rock types were those computed by R.A. Daly in 1933. Since then more reliable data have become available on representative rocks. Nockolds (1954) published his evaluation of a literature survey on analyses from fresh and representative magmatic rocks. Sederholm (1925), Grout (1938) and Shaw (1967) have published averages of igneous rocks weighted for their abundance. Turekian and Wedepohl (1961)

collected several data of the crustal abundances of the elements which have been published to date. The most update is by Mielke (1979) who divided composition of igneous rock by chemical composition into basaltic and granitic rock. Chemical composition of igneous rocks are shown in Table 2.1.

Table 2.1 Concentration of some major and trace elements in igneous rocks in ppm.

Igneous rocks	Al	Fe	Mn	Zn	Cu	Pb
Clarke and Washington (1924)	81212	51069	929			
Sederholm (1925)	76553	34449	310			
Goldschmidt (1954)		50000				
Van Tongeren (1938)*			2200			23
Grout (1938)*	88676	39257	155			
Sandell and Goldich (1943)					70	
Lundegardh (1946)*				132	60	
Nockolds (1954)	78882	33803	619			
Turekian and Wedepohl (1961)	81300	50000	950	70	55	13
Shaw <i>et al.</i> (1967)	77453	30881	527			
Mielk (1979) Basaltic	78000	86500	1500	105	87	6
high calcium Granitic rocks	82000	29600	540	60	30	15
low calcium Granitic rocks	72000	14200	390	39	10	19

* = cited by Rankama and Sahama, 1960

ELEMENTAL COMPOSITION OF SEDIMENTARY ROCKS.

The standard breakdowns in sedimentary rocks are shales, sandstones, carbonate rocks, and other rocks as mixtures of these. This classification is based on the idea proposed by Kay (1951). The processes of weathering and sedimentation, often noted, like a huge and inefficient sort of chemical analysis in breaking down the assemblages of elements in igneous rocks and regrouping them into assemblages that are generally simple. Locally the analysis may be very effective, isolating silica in the form of pure quartz sandstone or chert, alumina in bauxite, iron in residual laterite or in sedimentary oxides, carbonates, and silicates, calcium in limestone or gypsum, sodium and potassium in salt deposition.

Most commonly the breakdown is incomplete, giving only a preponderance of silica in sandstone, of aluminium and silica in clays, and of calcium and magnesium in carbonates. Some minor elements can indeed be separated almost completely from others, simply on the basis of the resistance of their minerals to solution. Much more complicated are the chemical processes that may lead to preferential precipitation of minor elements out of solution. Differences in solubility of compounds, adsorption processes, and activity of organism. In general, these processes are not very effective in separating minor elements from major ones. With the exception of phosphates, borates, nitrates, some manganese deposits, and accumulations of copper, vanadium, and uranium with organic matter, the concentrating of rare elements by purely sedimentary processes is not notable (Krauskopf, 1967).

Table 2.2 Concentration of some major and trace elements in limestones and carbonate rocks in ppm.

Sedimentary rock	Al	Fe	Mn	Zn	Cu	Pb
Limestone and carbonate Rocks						
Leith and Mead (1915)	4288	3775				
Siebenthal (1915)*						
Limestones					20.2	32.6
Dolomites					12.6	
Clarke (1924)	5400		385			
Goldschmidt (1954)						5-10
Palmqvist (1935)*				<50		
Lundegardh (1948)*						
Vinogradov and Ronov (1956)	11647	12277	542			
Wedepohl (unpubl.)*	9000	16955	619			
Turekian and Wedepohl (1961)	4200	3800	1100	20	4	9
Mielke (1979)						
Bowen (1979)	7000	17000	620	20	5.1	5.7

* = cited by Rankama and Sahama, 1960

Table 2.3 Concentration of some major and trace elements in sandstones in ppm.

Sedimentary rock	Al	Fe	Mn	Zn	Cu	Pb
Sandstone						
Leith and Mead (1915)	25253	9813				
Clarke (1924)	25412	10023	232			
Palmqvist (1935)* Lundegardh (1948)*				<20		
Vinogradov and Ronov (1956)	43412	29138	465			
Horn and Adams (1966)			390		15	
Turekian and Wedepohl (1961) Mielke (1979)	25000	9800	X0	16	X	7
Bowen (1979)	43000	29000	460	30	30	10

Note : X means between 1 and 10 ; X0 means between 10 and 100

* = cited by Rankama and Sahama, 1960

ศูนย์วิทยทรัพยากร
จุฬาลงกรณ์มหาวิทยาลัย

Table 2.4 Concentration of some major and trace elements in shales in ppm.

Sedimentary rock	Al	Fe	Mn	Zn	Cu	Pb
Shale						
Leith and Mead (1915)	81529	47150				
Clarke (1924)	88412	48334	697			
Goldschmidt (1954)						
Minami (1935)						
Shaw (1956)						
Hevesy, <i>et al.</i> (1934)*			890			
Palmqvist (1935)*				200		
Lundegardh (1948)*				- 1000		
Vinogradov and Ronov (1956)	79941	47087	619			
Turekian and Wedepohl (1961)	80000	47200	850	95	45	20
Mielke (1979)						

* = cited by Rankama and Sahama, 1960

ศูนย์วิทยทรัพยากร
จุฬาลงกรณ์มหาวิทยาลัย

For several abundant types, enough analytical data have become available so that average may be computed. Some of the listed averages are more representative of their rock class than others. Chemical composition of sedimentary rocks are shown in Table 2.2 - 2.4. There has been a tendency to favor rarer types for investigation and analysis. The sampling of unaltered sedimentary rocks is often restricted to quarries, where they are well exposed, and to samples of commercial value. Some types such as sandstones in the general sense, have a rather wide range of chemical variation. Fine-grained rock types usually contain mineral constituents averaged from difference source areas, because of the large distances of travel before deposition. Limestone, as one of the listed rocks types, has definitely an age-dependent chemical composition (Wedepohl, 1969).

ELEMENTAL COMPOSITION OF METAMORPHIC ROCKS.

Metamorphism may be defined as the sum of processes that, working below the zone of weathering, cause the recrystallization of rock material. Metamorphism is induced in solid rocks as a result of pronounced changes in temperature, pressure, and chemical environment. These changes affect the physical and chemical stability of a mineral assemblage, and metamorphism results from the effort of establishing a new equilibrium. In this way the constituents of a rock are changed to minerals that are more stable under new conditions, and these minerals may arrange themselves with the production of structures that are more suited to the new environment. Metamorphism accordingly results in the partial or complete recrystallization of a rock, with the production of new structures and new mineral (Mason, 1952).

Metamorphic rocks are assumed that it generally retains a chemical composition similar to their unmetamorphosed equivalent. However, often a schist is sampled free of quartzo-feldspathic segregations. In such a case the schist will be higher than the original rock in the concentration of the elements associated with mafic minerals. The whole rocks, however, will

probably show the composition of the original unmetamorphosed rock (Turekian and Wedepohl, 1961). Two types of metamorphic rocks, most interested to geologist, are phyllites and mica schists. Chemical composition of some metamorphic rocks are shown in Table 2.5.

Table 2.5 Concentration of some major and trace elements in metamorphic rocks in ppm.

Metamorphic rock	Al	Fe	Mn	Zn	Cu	Pb
Phyllites (Simonen ,1953)	87565	59347	542			
Mica Schists (Simonen ,1953)	86876	73086	696			
Metamorphic rocks of granitic shell (Ronov and Yaroshevesky, 1972)	80047	41939	851			
Metamorphic rocks of granitic shell similar to granitic rock.(Turekian and Wedepohl, 1961)	82000	29600	540	60	30	15

ELEMENTAL COMPOSITION OF SOILS.

Numerous investigations (e.g. Ure and Berrow (1982); Martin and Whitfield (1983)) agree that the total elemental content of a soil is basically determined by the content of parent material. Because of weathering, the elements naturally occurring in the parent rocks become released in to soil. Consequently, the particle size is now small and thus, making, it easily to undergo chemical reactions, such as oxidation and reduction (Fergusson, 1991). The main chemical structure of particle in soils are aluminosilicates or clay mineral. The clay minerals are abundant in most weathered

material, and vary wide in chemical composition and ion-exchange capacity, making them worth further consideration in some detail. The crystal structures of all the common clay minerals are characterized by a layered structure. The structure layers consist of linked between $MA_3Si_3O_8$ and $MA_3Si_2O_8$ where M = Na, K, and Ca (Rose, 1979). As for trace metals, it is reported to adsorb or exchange at the layer of aluminosilicate. Chemical composition of soil are shown in Table 2.6.

Table 2.6 Concentration of some major and trace elements in soils in ppm.

soils	Al	Fe	Mn	Zn	Cu	Pb
Mitchell (1944)			>200			
Rankama and Sahama (1960)					20	
Ure and Berrow (1982)	67000	32000	760	60	26	29
Martin and Whitfield (1983)	71000	40000	1000	90	34	35

ELEMENTAL COMPOSITION OF DEEP-SEA SEDIMENTS.

All the elements found in crustal rocks are probably present in deep-sea sediments, although not all of them have yet been identified. With the exception of Fe and Mn, most of the major elements are present in similar concentrations in deep-sea and continental sediments. However, some deep-sea sediments have trace element assemblages which are characteristically different from those of continental and near-shore sediments. The concentration of elements in deep-sea sediments are given in Table 2.7. One of the most important geochemical features of the deep-sea sediment is that they are also enriched in the certain trace metals relative to near-shore and continental sediments.

Table 2.7 Concentration of some major and trace elements in deep-sea sediments in ppm.

Deep-sea sediments	Al	Fe	Mn	Zn	Cu	Pb
Turekian and Wedepohl (1961)			6700	165	250	80
El Wakeel and Riley (1961)* Pacific deep-sea sediment			12500		570	162
Turekian and Imbrie (1966)* Atlantic deep-sea sediment			3982		115	52
Chester (1965)* Ferro-Mn nodules (wt. %)		14.58 %	22.06 %	0.35 %	3300	1500
Mielke (1979) Carbonate	20000	9000	1000	35	30	9
Clay	84000	65000	6700	165	250	80
Martin and Whitfield (1983)	95000	60000	6000	120	200	200

* = cited by Chester, (1990)

ศูนย์วิทยทรัพยากร
จุฬาลงกรณ์มหาวิทยาลัย