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ASSIGNMENT

CLAY MINERALS AND THEIR DISTINCT PROPERTIES

Clay minerals are the plastic part of ceramics, and it is because of this plasticity that ceramics can be made. As one might expect, not all clay minerals are the same. They form different mineral groups which are defined in geology and soil science by their chemical composition. Again as one would expect, changes in chemistry will result in different physical changes also. To a certain extent, the chemistry of clays can control their interaction with water, and their plastic properties. Also differences in chemical composition will determine their behavior under conditions of firing in the ceramic process. Some clays are destroyed or for all purposes become a glass or amorphous at different temperatures, depending upon their chemistry. Therefore it is important to know a little about clay mineral composition in order to understand why a potter has chosen a given clay type to make his pots. Also the clay type will determine the need to use more or less tempering material.

What is a clay mineral? The general definition of clay minerals is that of particle size. In most disciplines, particles of less than 2 pm (micrometres)

(0.002 mm) diameter are considered to be clays. This is, of course, not a definition of a mineral type or group. Minerals are defined as a function of their chemistry and crystal structures. Then why do we call particles of less than 2 pm clay minerals? The reason is that most of the grains in nature of this size have a common structure and certain chemical characteristics which can be defined according to the criteria of mineralogy which are chemical and spatial arrangement of the constituent atoms. Of course, clay-sized material is not totally made up of clay minerals, but most of it is. Some other minerals are reduced to this small grain size, by natural or anthropogenic means, and they are found along with clay minerals in the clay size fraction.

Hence there are two terms, one, clays, which are all minerals in the less than 2-Jlm fraction and the other, clay minerals, which are minerals in this size fraction with a specific mineral structure. The structure common to most clay minerals is that of a thin, sheet-like form. Clay particles are somewhat like the pages of paper in a book. As is the case with minerals, the external structure reflects the arrangement of the atoms within the crystal. Clay structures are large two-dimensional linked networks which have strong chemical bonds in two directions and weaker ones in the third direction. Within the crystal, cations are linked to oxygen ions, and in fact cross-linked, i.e. an oxygen ion is shared between two or more cations which creates the tightly bound, linked network (Fig. 3.1A). Linked networks can be formed from two or three layers of cations. Always one outer cation layer is made up dominantly of silicon ions. This layer is called the tetrahedral ion layer because the silicon ions are surrounded by four oxygen ions which form a tetrahedron figure. The next cross-linked layer of cations is surrounded by six oxygen anions. These ions form an octahedron around the cations present. These are octahedral ion sites in the structure. The oxygens between the cation layers are cross-linked, that is, they are shared by electronic attraction to more than one cation (oxygen ion). They can also form part of both the tetrahedral and octahedral configuration (Fig. 3.1 labelled Band C, respectively). The number of cross-linked cation layers can be either two or three. In the language of clay mineralogists the first is a 1: 1 layer structure where two cation layers are present and the second is a 2: 1 layer structure where three cation layers are present, one tetrahedral and the other octahedrally coordinated. The first number gives the silicon, tetrahedrally coordinated layer count and the second that of the octahedrally coordinated ion layers. These cross-linked cation and anion networks (2:1 or 1:1) are stacked one on the other to form a clay crystal (Fig. 3.2a). The structural arrangement of atoms in layers gives the name of layer silicate to clay minerals. The internal arrangement of the atoms in the layer silicates is expressed in the exterior shape of clay minerals. As the crystals grow, they follow their internal structure, forming tabular crystallites. Clay minerals are also called sheet silicates because of their sheet -like crystal shapes. As can be seen in the schematic diagram of Fig. 3.1, there are about as many oxygens as cations in clay structures. This is true of most silicates. In the Figure the oxygen ions are linked by electronic covalent bonding to cations on the inside of the unit layers, the surface oxygen have little or no electronic charge on them. They are most often without an electrostatic charge or neutral charge.

THE GEOLOGY OF NIGERIA

The geology of Nigeria formed beginning in the Archean and Proterozoic eons of the Precambrian. The country forms the Nigerian Province and more than half of its surface is igneous and metamorphic crystalline basement rock from the Precambrian. Between 2.9 billion and 500 million years ago, Nigeria was affected by three major orogeny mountain-building events and related igneous intrusions. Following the Pan-African orogeny, in the Cambrian at the time that multi-cellular life proliferated, Nigeria began to experience regional sedimentation and witnessed new igneous intrusions. By the Cretaceous period of the late Mesozoic, massive sedimentation was underway in different basins, due to a large marine transgression. By the Eocene, in the Cenozoic, the region returned to terrestrial conditions.

Nigeria has tremendous oil and natural gas resources housed in its thick sedimentary basins, as well as reserves of gold, lead, zinc, tantalite, columbite, coal and tin.

THE BASEMENT COMPLEX

The basement complex is one of the three major litho-petrological components that make up the geology of Nigeria (Fig. 1.1). The Nigerian basement complex forms a part of the Pan-African mobile belt and lies between the West African and Congo Cratons and south of the Tuareg Shield. It is intruded by the Mesozoic calc-alkaline ring complexes (Younger Granites) of the Jos Plateau and is unconformably overlain by Cretaceous and younger sediments. The Nigerian basement was affected by the 600 Ma Pan-African orogeny and it occupies the reactivated region which resulted from plate collision between the passive continental margin of the West African craton and the active Pharusian continental margin . The basement rocks are believed to be the results of at least four major orogenic cycles of deformation, metamorphism and remobilization corresponding to the Liberian (2,700 Ma), the Eburnean (2,000 Ma), the Kibaran (1,100 Ma), and the Pan-African cycles (600 Ma).

THE YOUNGER GRANITES

The Mesozoic Younger Granite ring complexes of Nigeria form part of a wider province of alkaline anorogenic magmatism. They occur in a zone 200km wide and 1,600km long extending from northern Niger to south central Nigeria. Rb/Sr whole rock dating indicates that the oldest complex of Adrar Bous in the north of Niger is Ordovician in age, with progressively younger ages southwards. The most southerly ring complex of Afu is Late Jurassic in age . Aeromagnetic anomalies suggest that a series of buried NE–SW lineaments of incipient rifts controlled the disposition of the individual complexes.

THE BENUE TROUGH

The Benue Trough of Nigeria is a rift basin in central West Africa that extends NNE–SSW for about 800 km in length and 150 km in width. The southern limit is the northern boundary of the Niger Delta, while the northern limit is the southern boundary of the Chad Basin. The trough contains up to 6,000 m of Cretaceous – Tertiary sediments of which those predating the mid-Santonian have been compressionally folded, faulted, and uplifted in several places. Compressional folding during the mid-Santonian tectonic episode affected the whole of the Benue Trough and was quite intense, producing over 100 anticlines and synclines. Major such deformational structures include the Abakaliki anticlinorium and the Afikpo syncline in the Lower Benue, the Giza anticline and the Obi syncline in the Middle Benue, and the Lamurde anticline and the Dadiya syncline in the Upper Benue Trough.

THE BORNU BASIN

The Nigerian sector of the Chad Basin, known locally as the Bornu Basin, is one of Nigeria's inland basins occupying the northeastern part of the country. It represents about one-tenth of the total area extent of the Chad Basin, which is a regional large structural depression common to five countries, namely, Cameroon, Central African Republic, Niger, Chad, and Nigeria. The Bornu Basin falls between latitudes 11°N and 14°N and longitudes 9°E and 14°E, covering Borno State and parts of Yobe and Jigawa States of Nigeria.

THE SOKOTO BASIN

The hullemmeden Basin in north-western Nigeria is known locally as the "Sokoto Basin". It consists predominantly of a gently undulating plain with an average elevation varying from 250 to 400 m above sea-level. This plain is occasionally interrupted by low mesas. A low escarpment, known as the "Dange Scarp" is the most prominent feature in the basin and it is closely related to the geology.

THE DAHOMEY BASIN

The Dahomey Basin is a combination of inland / coastal / offshore basin that stretches from southeastern Ghana through Togo and the Republic of Benin to southwestern Nigeria. It is separated from the Niger Delta by a subsurface basement high referred to as the Okitipupa Ridge. Its offshore extent is poorly defined. Sediment deposition follows an east-west trend. In the Republic of Benin, the geology is fairly well known . In the onshore, Cretaceous strata are about 200 m thick . A non-fossiliferous basal sequence rests on the Precambrian basement. This is succeeded by coal cycles, clays and marls which contain fossiliferous horizons. Offshore, a 1,000 m thick sequence consisting of sandstones followed by black fossiliferous shales towards the top has been reported. This was dated by Billman (1976) as being pre-Albian to Maastrichtian. The Cretaceous is divisible into two geographic zones, north and south. The sequence in the northern zone consists of a basal sand that progressively grades into clay beds with intercalations of lignite and shales. The uppermost beds of the Maastrichtian are almost entirely argillaceous. The southern zone has a more complicated stratigraphy with limestone and marl beds constituting the major facies.

THE NIGER DELTA BASIN

The Cenozoic Niger Delta is situated at the intersection of the Benue Trough and the South Atlantic Ocean where a triple junction developed during the separation of the continents of South America and Africa in the late Jurassic .Subsidence of the African continental margin and cooling of the newly created oceanic lithosphere followed this separation in early Cretaceous times. Marine sedimentation took place in the Benue Trough and the Anambra Basin from mid-Cretaceous onwards. The Niger Delta started to evolve in early Tertiary times when clastic river input increased. Generally the delta prograded over the subsidizing continental-oceanic lithospheric transition zone, and during the Oligocene spread onto oceanic crust of the Gulf of Guinea. The weathering flanks of out-cropping continental basement sourced the sediments through the Benue-Niger drainage basin. The delta has since Paleocene times pro-graded a distance of more than 250 km from the Benin and Calabar flanks to the present delta front .Thickness of sediments in the Niger Delta averages 12 km covering a total area of about 140,000 km2.

The above sections detail amongst others the sectors that make up Nigeria’s geology.