CLAY MINERALOGY IN BUILDING RESEARCH*

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EXTENDED ABSTRACT

Clay is important in the construction industry both as a building material and as a foundation for structures. Buildings and utensils made of clay date back to the earliest periods of man's civilized development, and the use of clay is intimately associated with his history. Sun-baked clay structures were built during the pre-European period of American history. In the southwest of the United States by about 500 B.C. pottery was made from sun-dried clay. Bricks were made from the same material, which is durable under semi-arid conditions, and great community houses were built. Bricks were commonly used in Europe at the time of the early European settlement of North America and fired bricks were produced at an early date. The widely scattered and rather sparse population of this period favoured small-scale production designed to meet local demand.

As a result of the increase in the density of population and concomitant exploitation of resources, extensive scientific surveys were carried out and available raw materials catalogued. With the development of understanding of the true nature of clay it became possible to correlate composition with the behaviour of clay on firing. By comparing the effect of different brick-making processes on one type of clay it was shown that the effect of manufacturing methods may be less than had been supposed (Butterworth, 1949). Semi-dry pressed bricks were found to be only slightly more porous than wirecut or stiff-plastic pressed bricks when the same clay was used.

Differential thermal analysis was employed as a guide not only to the mineralogical composition of the material but also to indicate its ceramic properties. This was possible as sufficient experience had been gained in trial runs in which the clay was examined on the thermal analysis equipment and the curve then correlated with its ceramic behaviour. Certain general principles emerged from this work. It was found that montmorillonite or illite confer high plasticity and high shrinkage and tend to be non-refractory, with a short vitrification range, while aluminum hydroxide or kaolinite confer refractory properties and have a long vitrification range (Grim and Rowland, 1944).

An alternative approach to taking a naturally occurring clay and attempting to correlate its behaviour on firing with its mineralogy is to study the effects of heat treatment on artificial mixtures. For example, studies have been made on co-precipitated gels of silica and alumina. Of considerable practical importance to the building industry has been the production of lightweight aggregate. It was found that certain clays on firing have the property of swelling or "bloating", becoming light in weight yet strong and durable. Much work has been done to produce commercially feasible lightweight aggregate in areas where the clays are of the non-bloating variety. The addition to such clays of compounds of iron, alkalies, alkaline earths, carbon, and flowers of sulphur often induces bloating. The essentials for success are that a viscous melt must form during evolution of gas.

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Great progress in materials research has been possible since the crystallography of clay minerals became understood but the properties of clay at normal temperatures are determined to a great extent by the interaction of clay minerals with water. This system is of considerable commercial importance particularly in the ceramics field, but from the viewpoint of research oriented toward the building industry the major importance of clay–water interaction concerns the behaviour of foundations and is closely linked to soil mechanics. Distortion of foundations results from uptake or loss of water from the soil and the magnitude of the volume change is largely determined by the clay minerals.

Geological factors such as conditions at the time of deposition and post-depositional changes have an important influence on the properties of a sediment. The high electrolyte concentration of the marine environment favours the more open type of packing produced by flocculation, whereas clays deposited in fresh-water lakes are more closely packed due to the parallel orientation of the flaky minerals (Mitchell, 1956, and Rosenqvist 1959). Since texture of sediments has as important an influence on properties as mineralogy, a knowledge of local geology is of the utmost importance in understanding the engineering behaviour of a clay. Canada contains a greater area of glacial deposits than any other country in the world (Prest, 1961). The mineralogy of the soils is in large measure controlled by the nature of the rocks eroded by the glaciers and clay minerals are often mixed with rock flour. The conditions of deposition, however, differed as the end of the Pleistocene was marked by marine transgression in the St. Lawrence lowland, whereas much of the west was occupied by ice-dammed lakes. Isostatic uplift in the St. Lawrence has led to leaching of the clays with removal of salt. As in the case of similar Norwegian deposits the flocculated fabric ceases to be stable and the clays show high sensitivity (Bjerrum, 1954) and are subject to slides (Crawford, 1961). Less dramatic, but still important from the viewpoint of the construction industry, is the large non-reversible shrinkage which these Leda clays show on drying or being disturbed.

Chemists, physicists and mineralogists tend to interest themselves in the units of which a clay is composed, geologists are primarily concerned with the history and conditions of the formation of a deposit, and engineers consider quantitative properties such as strength and compressibility of materials. It is to this almost instinctive approach on the part of engineers that soil mechanics owes its character. Various simple yet ingenious tests have been devised by which the engineering properties of a sediment can be expressed in numerical terms. The present status and success achieved by soil mechanics is in itself a justification for such tests, which indeed are the only ones possible in many laboratories where the analytical equipment and background training of mineralogy are not available. There is, however, an inherent danger that the more fundamental mineralogical approach may become neglected since it may be thought that a determination of "activity" or "sensitivity" takes account of the nature of the fundamental building units to the extent, at any rate, which is required in engineering practice. This is not necessarily the case and a knowledge of the mineralogy of a deposit is essential if one wishes in some way to predict or modify the properties of a sediment.

The study of clays as colloids is of fundamental importance to soil mechanics while knowledge of the crystal chemical and structural properties of clay minerals is fundamental to materials research.

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