

# A REVIEW OF CLAY MINERAL RESEARCH IN THE UNIVERSITY OF LEEDS

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Investigations of clay minerals are being actively pursued in the Fuel and Physics Departments of the University; while the investigations are being carried on independently of each other, a close liaison is maintained between the two laboratories and the special techniques developed in each are at the service of the other.

## *Fuel Department.*

In the Fuel Department work has been in progress for some years on the mineralogical constitution of a range of refractory and other clays employed in the ceramic industries. The object is ultimately to establish the nature and proportions of the constituent minerals and to assess the bearing of each on the plastic and firing properties of the clays.

Thermal analysis has been most successfully used for the identification, and for the estimation in some cases, of the clay minerals present in kaolinitic fireclays and foundry-sand bond-clays. The Leeds technique differs somewhat from American practice (Heaton, Grimshaw and Roberts, 1945). A special method "double differential analysis" has been developed for identifying the individual components in mixtures of minerals whose thermal characteristics are so similar as to cause mutual interference (*e.g.*, in mixtures of kaolinite and illite). The method is based on the addition to the *reference* material of one of the minerals known or believed to be present in the mixture. For example, in dealing with a mixture of A and B, repeated thermal analyses are made in which successively increasing amounts of A are added to the inert reference material until the thermal effect due to A disappears. The resultant curve then shows only the thermal characteristics of B.

Tests on a number of fireclays and bond clays showed that the maximum or "peak" of the endothermal effect at approximately 550-600° was considerably lower than that for pure kaolinite. The "peak" temperature varied somewhat for different fireclays but was always at least 25° lower than for kaolinite; this difference was well outside experimental error. The thermal characteristics of the fire-clay minerals resembled those of halloysite, although they were not identical.

Thermal analysis evidence thus suggested that the minerals were new members of the kaolinitic group, and confirmation was obtained by Dr Brindley's X-ray examination of these minerals, as described later. The fireclay minerals appear to occupy intermediate positions in a series of which kaolinite and halloysite are the respective end-members.

The present work in the Fuel Department is directed towards isolating pure samples of the clay minerals from the various fireclays, in order to examine their properties both from the fundamental and industrial standpoints.

Experience has established thermal analysis as a valuable tool in mineralogy. A modified method has been successfully used for the estimation of quartz in siliceous materials, (Grimshaw and Roberts, 1945), and has also provided new information regarding the variable nature of the  $\alpha \rightleftharpoons \beta$  inversion temperature of cristobalite. (Grimshaw and Roberts, 1946). The modern techniques should find wide application in identifying or estimating minerals which undergo physical or chemical changes when heated.

### References.

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### *Physics Department.*

In the Physics Department, X-ray studies of clays and related minerals are in progress both for mineralogical analysis and for crystal structure analysis. For the last two years interest has been largely concentrated on the relation between the minerals kaolinite, halloysite (dehydrated) and the kaolin mineral found in many Coal Measure fireclays. This problem arose out of the thermal researches of Professor A. L. Roberts described above. Preliminary study showed that the fireclay mineral occupied an intermediate position between kaolinite and dehydrated halloysite, kaolinite being the best crystallized and halloysite the least well crystallized of these minerals. Further progress necessitated detailed crystallographic study. The structure of kaolinite given by Gruner (1932), with a monoclinic cell containing two layers of atoms per unit cell was found to be incorrect and an alternative structure has been proposed (Brindley and Robinson, 1946), with a triclinic cell containing one layer of atoms per cell. In hydrated halloysite there is a highly random stacking of the kaolin layers, giving characteristic two-dimensional X-ray diffraction spectra of type ( $hk$ ) together with crystalline (001) reflections. A preliminary statement by Brindley, Robinson and MacEwan (1946) will be followed by a more detailed analysis of the diffraction effects from this type of structure. The character of the bands, which may be diffuse, or sharp, or may even show secondary structure within the bands, is found to be related to the structure of the two-dimensional

sheets of atoms forming the mineral. The kaolin-type mineral found in many fireclays also shows random structural features, mainly random displacements of the atomic layers parallel to the *b*-axis of the structure. An analysis of this type of structure is in course of publication (Brindley and Robinson, 1947).

While the main problem of the relation of the fireclay mineral to kaolinite and halloysite can now be regarded as largely solved, we are still interested in this group of minerals, for there remain many problems connected with their occurrence and formation. We are therefore always interested in examining clays of these types from different localities.

More recently we have undertaken the investigation of some bauxitic clays in collaboration with Mr V. A. Eyles of the Geological Survey; in particular, we are examining specimens which have been subjected to various degrees of baking by igneous formations. The main points of interest lie in the nature of the clay minerals present in these rocks, and in the state of hydration of the iron and aluminium oxides. Mr J. Goodyear is carrying out the X-ray studies of these minerals.

Single crystal and powder studies of the chlorite group of minerals have recently been started. While the main structural scheme of these minerals, suggested first by Pauling (1930), has been confirmed in some cases by McMurchy (1934), more detailed studies are likely to yield further information. The results so far obtained are too rudimentary to justify more than this preliminary announcement.

### References.

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