Extract from:
THE GEOLOGY AND MINERALOGY OF BRICK CLAYS
P S Keeling (Brick Development Association Limited 1963)

7 : British Clays

The preceding chapters have dealt with the geology, mineralogy and properties of brick clays. This final chapter is an attempt to summarize what has been said in a brief review of British brick clays. They cover a very wide stratigraphical range and have a wide variety of mineralogy and properties that are the outcome of the extremely varied geological history of Britain.[23,24]

The majority of British brick clays are from formations extending from the Upper Carboniferous to Recent times. Older formations are used, however, notably the Lower Devonian shale in S.W. England. But, in general, the clay rocks of the older formations have become indurated and hardened by the great pressures that have acted on them at different periods of their history so that they not sufficiently plastic to be used. Fig. 47 shows the positions in the geological time scale and relative importance as regards production of the more important British brick clays.

For most of the time covering the formation of brick clays, the British area has been in the foreland region of a large stable continental mass occupying the N. Atlantic region. This land mass which has now disappeared under the waters of the N. Atlantic ocean supplied most of the sediment from which our clays were formed. Although the continental area was stable for something like 250 million years, the foreland area was subject to up and down movements largely determined by pressures acting from the south. This has given rise to a number of marine invasions separated by periods when the area was above sea-level. For this reason the British area offers a geological succession with only a few major gaps in a comparatively small area.

It is proposed to discuss the nature of some of the British clays with reference to their mineralogy and probable environment of deposition. Unfortunately the evidence is far from complete and much more mineralogical information involving the examination of many samples is required. More information is also needed from the brickmaker about the behaviour of his clays so that this can be correlated with the mineralogy. The ensuing discussion therefore may omit some important formations due to lack of knowledge about them. However, it is hoped that it will demonstrate the fundamental dependence of the brick industry on geological history.

1. Lower Devonian Shale: The material used for brickmaking consists of a hard slaty shale with numerous small mica flakes giving a silky sheen along the bedding planes. The general colour is a deep red. It is believed to have been laid down in marine conditions in a desert environment. There appears to be a considerable proportion of clay mineral but on account of its high degree of consolidation the clay is relatively poorly plastic. Only in the weathered zone near the surface is a high degree of

Ref. 23. Wills, L. J., Palaeogeographical Atlas. Blackie & Son, Ltd., London, 1951.

Ref. 24. Keeling, P. S., Trans. Brit. Ceram. Soc., **52**, 465, 1953.

Geological Period	Main Building Clays	Percentage of 1938 Brick Output
Recent & Pleistocene	Alluvium Brickearth Glacial Clays	17
Pliocene & Miocene 24 MILLION YEARS	MILLIONS OF YEARS 25	–
Oligocene & Eocene 35 MILLION YEARS	LC RB 60	4
Cretaceous 60 MILLION YEARS	WC 120	3
Jurassic 25 MILLION YEARS	OC 145	32
Triassic 25 MILLION YEARS	KM 170	6
Permian 40 MILLION YEARS	210	1
Carboniferous 75 MILLION YEARS	EM CM 280	33
Devonian 40 MILLION YEARS	325	2
Silurian 25 MILLION YEARS	350	
Ordovician 60 MILLION YEARS	410	
Cambrian 90 MILLION YEARS	500	–
		Unknown 2
		100

LC = London Clay RB = Reading Beds WC = Weald Clay OC = Oxford Clay
KM = Keuper Marl EM = Etruria Marl CM = Coal Measures

Fig. 47 The positions of some British Brick Clays in Geological Time.

plasticity obtainable. The formation is veined with quartz and calcite, and limestone reefs occur. The veins are mostly thin and their contents break into small fragments. The quartz causes no trouble but the calcite and limestone are strictly excluded as they are liable to cause lime-bursting.

2. Culm Measures: These are rocks of Carboniferous age and are worked for brickmaking on the outskirts of Exeter where they consist of hard, variegated shales with a dominantly reddish-brown colour. They are similar in appearance to the Lower Devonian shale but appear to contain rather more fine-grained siliceous material. The formation also contains thin bands of quartzite and is thinly veined with quartz. It was laid down under marine conditions and is probably dominantly illitic in character.

The proportion of clay mineral appears to be rather less than in the Lower Devonian shale.

Both the Culm Measures and the Lower Devonian shale were acted upon by very strong earth pressures towards the end of Carboniferous times that threw up mountain chains similar to the Alps and Himalayas across the northern part of central Europe and in other parts of the world. The mountains have long since been denuded but their stumps remain and the nature of the movements that took place can be deduced. The movements strongly affected southern England and caused a hardening of all clay rocks of Carboniferous and earlier age.

3. Coal Measures Shales and Clays: The shales and clays of the Coal Measures are used extensively for brickmaking in all the coalfield areas. This material accounts for about one-third of all the bricks made in this country and is equal in importance to the Oxford Clay, although the industry based on the Coal Measures is far more scattered and consists of much smaller units.

The Coal Measures were laid down in deltas and swamps that were obviously fed by very large rivers. There is a sequence of sedimentation that took place over and over again and that can be interpreted in terms of movements of the basin of deposition with corresponding movements of the continental area from which the sediments were derived. The sequence is as follows; the six phases being numbered in the order in which they were deposited:

1. Coal seam	Top
6. Fireclay or ganister	
5. Shale/mudstone	
4. Grit, gritty shale, sandstone	
3. Mudstone and shale	
2. Marine shale	
1. Coal seam	Bottom

The basin of deposition silted up to such an extent that in time vegetation spread over the greater part of the area. The probably conditions were vegetation growing on swampy land with numerous lagoons. Only very fine grained material was sedimented in the lagoon and this eventually gave rise to fireclay or, in some cases, ganister. In the meantime silting up of the lagoons allowed the spread of vegetation which grew and died, the dead material forming a humic deposit on which more vegetation grew. This period gave rise to a coal seam and associated fireclay, the thicknesses depending on the length of time that conditions persisted for their respective accumulation. A fairly rapid subsidence followed, probably amounting to something between 100 and 200 feet, in which the swamp deposits were inundated by the sea. The period saw the deposition of black muds which later consolidated to black shales containing marine fossils, known as marine bands. The conditions leading to the formation of marine bands appear to have been contemporaneous over large sections of the area of deposition and it has been possible to trace some of these bands over very wide areas from one coalfield to another and from Britain to the Continent. For this reason marine bands form valuable marker horizons in the Coal Measure rocks.

At this particular period in the earths' history the crust appears to have been in a condition of delicate balance. Subsidence in the basin of deposition was accompanied by corresponding elevation of the land areas from which the sediments were derived. After the marine phase, the sediments once more became deltaic starting with shales and mudstones followed by coarser deposits (sands and grit) due to the increased elevation of the land. As the land areas became worn down the sediments became finer and the basin of deposition became sufficiently silted up for vegetation to begin once more its prolific growth. With the exception of the marine bands which form only a tiny fraction of the total formation, the Coal Measure sediments were laid down in brackish or fresh water associated with humic acids from the decomposition of vegetable debris. Under these conditions disordered kaolinite was formed and this mineral appears to be the principal clay mineral of both the shales and the clays. Both shales and clays contain visible mica probably decomposed muscovite of the type separated from a Yorkshire fireclay.[25] The difference appears to be that in the shales, the flakes sedimented with their flat surfaces parallel to the basin of deposition giving a laminated structure, whereas in the fireclays the flakes do not appear to have achieved any definite orientation and as a result the material shows no distinct bedding planes. The proportion of visible mica is higher for the shales than for the clays. The clays consist of essentially finer-grained material than the shales and on average contain a greater proportion of clay mineral. The iron in the clays is concentrated in nodules which may occupy only a limited part of the seam and can be rejected whereas the iron in the shales is distributed more evenly in a fine-grained form and may be in the clay mineral. As a result, bricks made from Coal Measure shales generally give brown and red colours, while those made from fireclay type of material give yellows and buffs often with brown spots. The clays are generally more refractory than the shales and have a higher proportion of kaolinite and rather less alkali. As a result they require a higher firing temperature than the shales which are fired to a maximum of about 1,050 degrees C. Carbonaceous matter is usually present but is normally removed by ignition before any vitrification takes place. The problem of black-coring is much less acute than with more vitrifiable material.

4. Carboniferous Clays above the Productive Coal Measures: These include the Etruria Marl and similar types of formation such as the Coalport Beds of Shropshire and the 'Barren Red Group' of the Bristol and Somerset coalfield. The cyclical deposition of Coal Measure times was caused by a rhythmic sinking of the basin of deposition and was evidently connected with the mountain building movements further south. Eventually, as the mountain building movements reached their culmination a positive effect was produced on parts of the Coal Measure basin causing elevation of some of the land that had previously been swamp. Coal formation ceased and the sediments that were mainly derived from the now exposed Coal Measures changed to red-beds. The essential difference from the Coal Measure period appears to be that sediments formerly under reducing conditions were now exposed to oxidizing conditions. Indeed, the conditions during Etruria Marl times would appear to have been similar to the conditions that produce the red lateritic soils found on elevated land in monsoon climates. It is thought that the Etruria Marl may have been derived from this type of soil by the normal processes of erosion and sedimentation in mainly fresh water conditions.

Ref. 25. Carr, K., Grimshaw, R. W. and Roberts, A. L., Trans. Brit. Ceram. Soc. **51**, 334, 1952.

Coming from a dominantly kaolinitic formation and being sedimented in mainly fresh water conditions, the clay mineral of these red-beds is also mainly kaolinitic. But in the Etruria Marl there are zones in the upper part of the formation in which a fair proportion of calcium carbonate is present, and the clay mineral here appears to be more illitic. These horizons may represent periods when the water had become more saline due to arid conditions and the accumulation of dissolved salts by evaporation. A recurrence of the Coal Measure type of deposition is represented by the Newcastle Beds that overlie the Etruria Marl but the interlude was comparatively short-lived and the red-bed type of deposition represented by the Keele Beds, took over again. The Keele Beds were probably laid down in a desert environment since the clay mineral appears to be illitic, and the formation contains a proportion of fine-grained calcareous material similar to the Keuper Marl. Eventually the mountain building movements raised the British area above sea-level. Large-scale sedimentation ceased and the Carboniferous period came to a close.

The material used for brickmaking is a dominantly kaolinitic material with a high proprtion of Fe_2O_3, generally in the range seven to ten per cent, much of which is in the form of finely divided red oxide. The clays are moderately refractory and firing temperatures in the region of 1,100 degrees C. are employed for making ordinary bricks. In oxidizing atmospheres good red and brown colours are usually obtained due to the high proportion and fine-grained nature of the Fe_2O_3. In the case of the Etruria Marl extremely strong engineering bricks are obtained by causing the iron oxide to combine with other minerals present and fuse in a reducing atmosphere; maximum temperatures employed are about 1,150 to 1,200 degrees C.

The Permian period succeeded the Carboniferous. By this time the mountain ranges and much of the high ground formed at the close of the Carboniferous had been largely worn down by the forces of denudation. Sedimentation took place in enclosed basins in a hot desert environment. Although the Permian achieved a moderate development in Britain, it is of little importance to the brickmaker; it consists mainly of sands, breccias, magnesian limestone, and some evaporite deposits.

5. Keuper Marl: Desert conditions still prevailed in the Triassic period. In the first half the sediments consisted of pebble beds and sands, which represent the detritus from a rugged elevated land, probably the so-called Hercynian continent to the south. During the second half of the period which saw the deposition of the Keuper Marl, the central part of Britain was an enclosed desert basin surrounded by a base-levelled land. As there was little relief, the deposits were fine-grained and may have been largely wind-borne, settling in lakes which covered the central depression. Gypsum and salt deposits indicate the sites of dessicated lakes which existed at various periods during Keuper times. The fact that these lakes dried up and gave rise to evaporite deposits testifies to the arid conditions of the period. The Keuper Marl in places is more than 2500 feet thick, and to explain this great thickness it is necessary to posulate considerable subsidence of parts of the area of deposition. This subsidence appears to have taken place by normal faulting with the crust in tension, certain sections sinking more than others. By the end of Keuper times the general picture is that of a peneplained land with practically no relief. The close of the period was marked by the transgression of a sea, which spread

rapidly from the south over the greater part of England.

The Keuper Marl was deposited in waters containing a high proportion of dissolved salts, that at times reached saturation point to give rise to evaporite deposits. Under such conditions the usual clay mineral to form is illite and the Keuper Marls that have been examined in the British Ceramic Research Association's laboratories contain this clay mineral. There was evidently considerable Ca and Mg in solution since many Keuper Marls contain fine-grained dolomite. At a locality near Birming-conditions were favourable for the formation of the clay mineral sepiolite ($2MgO.3SiO_2.2H_2O$) and in these clays the calcium combined to form aggregates of calcite crystals. In the vicinity of this locality, an illitic type of clay mineral has been found with a high proportion of Mg. Unusual clay minerals that are said to have a mixed chlorite and montmorillonite lattice have also been discovered.[26,27] The combination of illitic types of clay with fine-grained calcium and magnesium carbonates makes for a very vitrifiable mixture. Fusion takes place at comparatively low temperatures over a short range. Firing temperatures are therefore usually not above 950 degrees C. Iron in these clays occurs as the fine-grained red oxide although not in such high proportions as in some of the Upper Carboniferous clays. Reds and paler colours are obtained on firing and it is possible that the calcite and dolomite cause a paler colour than otherwise might be expected. Owing to the tendency to underfire, the bricks are not usually outstanding for their crushing strength, but high strengths are obtainable if vitrification is allowed to take place.

6. Jurassic Clays: Deposition of Jurassic sediments took place mainly in interconnected marine basins. The main brick clays occur in the Lower Lias and the Oxford Clay, the latter formation accounting for one-third or more of the total brick production in the country.

(a) *Lower Lias.* The Lower Lias consists mainly of blue shales that were laid down in reducing conditions. Being marine, the clay mineral is dominantly illitic. The sulphides, marcasite and pyrites, are fairly common in nodules and fine-grained form. The sea supported numerous organisms whose calcareous remains are now found as fossils, often well preserved and sometimes with their calcite replaced by pyrites. There is a comparatively high proportion of altered mica including much that is of a green, chloritic type. The quartz-grains in the clay are comparatively small. Glauconite occurs in small proportion and there are also small amounts of carbonaceous material. On exposure to the atmosphere the clay oxidizes to a buff colour. The blue clays obviously contain a fair proportion of iron mineral, probably the sulphide, in finely divided form and on firing this gives light brown and red colours. The fossil remains can be troublesome and may cause lime-bursting. Moderate firing temperatures are used and vitrification is not unduly rapid unless fine-grained lime is present. A good deal of sulphur trioxide from oxidation of the sulphides is evolved on firing which attacks flue and stack structures. Maximum firing temperatures are around 950 to 1,000 degrees C.

(b) *Oxford Clay.* The Oxford Clay is a bluish or lead-coloured clay that oxidizes to a brown colour on weathering. It was laid down in a marine environment and appears to be similar in clay mineral content to the Lower Lias. It has many fossil-bearing horizons and also contains a

Ref. 26. Honeybourne, D. B., Clay Min. Bull. **1**, 150, 1951.
Ref. 27. Stephen, I. and MacEwan, D. M. C., ibid, **157**, 1951.

comparatively high proportion of iron sulphide. Some of this has been broken down and oxidized to form sulphuric acid which has reacted with the calcite to form gypsum (selenite). The clay contains a comparatively high proportion of finely-dispersed carbonaceous matter that is a valuable source of indigenous fuel, largely eliminating the need for conventional fuels.

7. Cretaceous Clays: The Jurassic period was brought to a close by uplift along a N.W. to S.E. axis through central England, which converted most of the British area to dry land. However, the distribution of deposits shows that a large delta of a river flowing from the N.W. covered southern England and the Weald. The Lower Cretaceous clays, which are all used in varying extent for brickmaking, were deposited in this delta. The formations include the Fairlight Clay, Ashdown Sand, Wadhurst Clay, Grinstead Clay, Weald Clay, and Atherfield Clay. Of these, the Weald Clay is the most extensive and important.

(a) *Weald Clay*. Fossil footprints and other amphibious remains indicate that the Weald Clay was laid down in shallow water, probably in a series of interconnected shallow lakes and lagoons such as would be found in a large delta. This is confirmed by the cyclical nature of the sediments and the variation in the clay mineral from disordered kaolinite to a more illitic type strongly suggestive of deltaic conditions alternating from brackish water to marine. The clays are mostly grey but red and chocolate seams occur and there is a weathered zone of buff-brown clay extending down to 20 feet from the surface. The quartz is mostly fine-grained and is very variable in proportion. The main impurities are siderite, iron sulphides, gypsum and calcite, the last often in the form of small fossil remains.

Some very fine-grained clays occur at the top of the formation and these appear to vitrify rather more rapidly than the coarser grained clays. Moderate firing temperatures up to 1,050 degrees C. are used and the clays give red-brown colours in an oxidizing atmosphere. Limestone and highly calcareous bands in the formation can give trouble due to lime-bursting but the trouble is controlled by selection of the raw material in the quarry, salt addition, control of grinding and firing, fine-grinding and hard firing being desirable, and inspection and testing of the bricks. Some of the clays contain a small proportion of carbonaceous material in the form of lignite but this burns off at a low temperature and there is no trouble on this score.

(b) *Gault*. The next stage in the geological history of Britain was a regional submergence which commenced in the east and spread westward, allowing a transgression of the sea into eastern and southern England, and perhaps beyond. The initial deposits under these new conditions consisted of muds which now constitute the inky-blue clays of the Lower Gault. Changing conditions led next to a series of calcareous grey muds, the Upper Gault, that gave place in a westerly direction to the silt and sand deposits of the Upper Greensand. In the few samples examined, gypsum is a prolific impurity and glauconite occurs. The clay mineral appears to be dominantly illitic. The Lower Gault clays produce a red brick. The calcareous Upper Gault under suitable conditions produces bricks of a creamy white colour; reducing conditions are required during the main firing period otherwise an undesirable red tinge is said to be produced.

The relatively local downward movement of the land that commenced during Lower Gault times was the precursor of a remarkable subsidence

which affected much of central and western Europe, including practically the whole of England and Scotland and parts of Wales and Ireland. Over the whole of the gradually submerged region, a great thickness of white, calcareous mud, now chalk, was laid down. The close of the Cretaceous period was marked by regional elevation which converted most of the British area to dry land.

8. Eocene Clays: The Eocene period was inaugurated by a gradual marine transgression over S.E. England which formed part of a depositional basin covering parts of England, France and Belgium. This was a relatively shallow sea connected at intervals to a much larger ocean to the south. Intermittent subsidence and periods of quiescence led to large-scale interdigitation of marine and estuarine sediments. At the end of the period the basin was largely silted up. The Reading Beds and London Clay are the most important building clay formations of this period.

(a) *Reading Beds*. The Reading Beds consist of mottled clays that appear to have been laid down in oxidizing conditions. They are generally regarded as estuarine and this is supported by the grading figures and contents of the coarse and medium fractions that suggest wholesale dumping of coarse and fine material carried by rivers when they met the salt water of the sea. Unusual clay mineral assemblages have been found including montmorillonite.

(b) *London Clay*. The London Clay also shows a great variety in grain size ranging from sands to fine-grained clays. Generally speaking, however, the proportion of quartz grains is high, but the grains themselves are of small size. The clays are mostly blue and grey, and weather brown at the surface. Certain seams contain a comparatively high proportion of carbonaceous material in the form of lignite. The clays were obviously laid down under reducing conditions and often contain iron sulphides. Other common impurities are gypsum and fossil calcite. The latter can cause lime-bursting. Glauconite is common in small proportion and indicates that the clays were deposited in a marine environment. The clay mineral appears to be dominantly illitic. The clays contain a comparatively high proportion of mica with much green, chloritic alteration. Mineralogically, they are rather similar to the Lower Lias clays and may have been deposited in similar conditions.

From Carboniferous to Eocene times the bulk of the sediments that are now found in Britain were derived from the North Atlantic continent. At the end of this time the continent began to break up and at the same time the Alpine mountain building movements to the south began to gather strength. The axis of these movements was based on great thicknesses of sediment that had accumulated in Jurassic and Cretaceous times in a rapidly sinking basin of deposition known as a geosyncline. Geographical conditions in the central European and Mediterranean regions after the close of the Eocene period were probably something like those that exist today in the island archipeligoes of Indonesia.

The Alpine movement now began to affect Britain and from the end of the Eocene period to the present, the greater part of Britain has remained dry land.

9. Glacial and Recent Clays: The clays in this group are sometimes referred to as 'surface' clays since they are of such comparatively recent geological age (less than one million years old) that they have not been covered by younger deposits. Inspite of the short period of time represented by these clays they are third in importance as a source of brick and tile clays. The main feature of the period was the Ice Age, which affected a large part of the northern hemisphere. Britain had its own ice sheets that were distinct from those covering northern Europe. The ice sheets in Britain centred on high ground and spread over the lower parts of the country as far south as the Thames valley. The movement of the ice sheets was directed by their mutual interference and by the barrier of the Scandinavian ice sheet that stood off the east coast for most of the period. The general directions of flow are indicated by the arrows (Fig. 48). When the ice sheets melted they left behind the boulder clay.

(a) *Boulder Clay.* Boulder clay consists of material obtained from the rocks over which the ice passed. In N.E. England, the rocks were mainly of Carboniferous age and the boulder clay contains Coal Measure material and limestone fragments from the Lower Carboniferous. In Lincolnshire the boulder clay contains Coal Measure material and fragments of chalk; there is also a high proportion of quartz grains. In the Manchester area, the boulder clays contain Carboniferous material and much quartz derived from Triassic rocks.

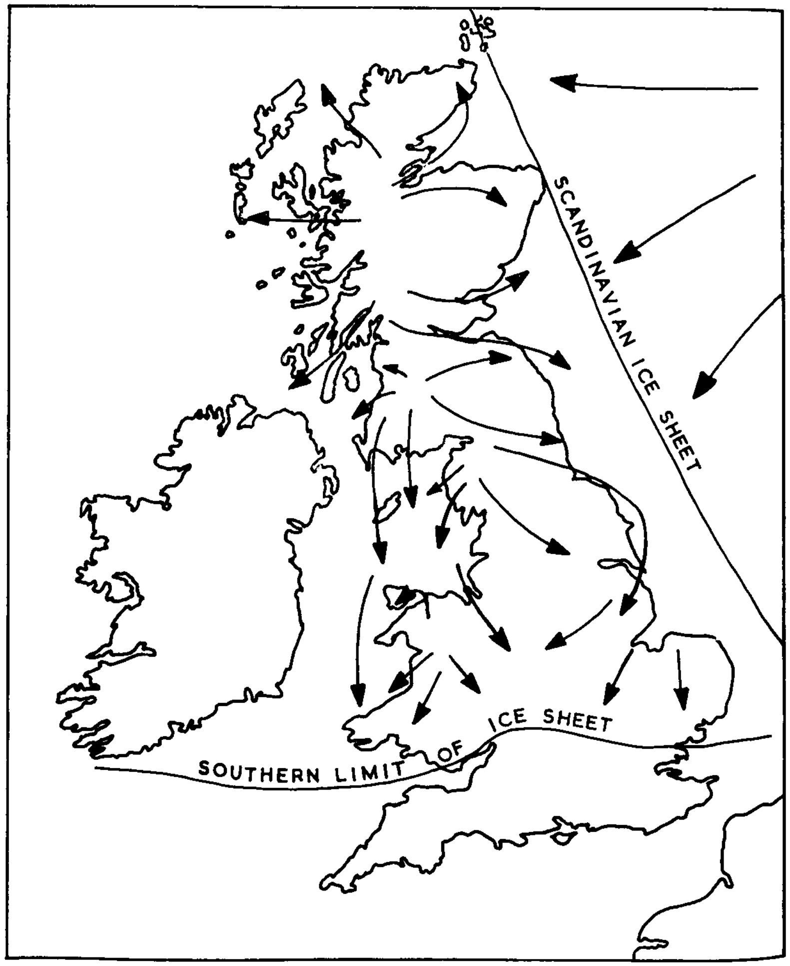

Fig. 48 Ice movement in Britain during the Ice Age.

The clay mineral of boulder clays appears to be a mixture of illite and kaolinite. Those derived largely from Coal Measure rocks, such as in N.E. England, contain a high proportion of disordered kaolinite. Limestone fragments may be sufficiently large to cause lime-bursting. Fine-grained lime gives a short vitrification range and if this is accompanied by carbonaceous material, black coring and bloating will be likely problems.

(b) *Lacustrine Clays.* Clays deposited in glacial lakes are often associated with other deposits of glacial clay and are recognized by their fine stratification and sandy alternations. They are used for brick and tile making in N.E. England.

(c) *Brick earth.* The origin of this deposit has already been discussed. Samples examined contained a fair proportion of quartz grains, including grains upto 1 mm. diameter. There are also flint chippings, and limestone nodules that appear to be the result of deposition from solution around suitable nuclei. The limestone fragments may cause trouble due to lime bursting. The clay mineral appears to be a mixture of illite and kaolinite with the former predominating. The formation is important in the area to the south and south-east of London.

(d) *Alluvium.* Alluvial clays are river deposits of recent origin that are of considerable importance in the Bridgwater and Humber areas. The clays are fine-grained and fairly siliceous. They contain calcite in the form of nodules and small fossils, iron sulphides, and detrital carbonaceous material. The fine-grained, yet siliceous, nature of the material makes them suitable for tile manufacture. Occasional lime bursting due to calcareous nodules may occur.

10. General Conclusions: British brick clays can be divided into four main groups depending on the environment in which they were deposited:

(1) Fresh to brackish water
(2) Marine
(3) Salt lake
(4) Glacial

(1) The first group which is typified by Coal Measure shales and clays is characterized by a disordered kaolinite clay mineral and a comparatively low mica content which makes for a refractory material. Depositional conditions were acidic and iron tended to be segregated as nodules of siderite and sulphide. At the close of Coal Measure times, possibly due to a less acidic environment, the iron was deposited as fine-grained oxide as in the Etruria Marl giving a refractory material capable of being vitrified at comparatively high temperature under reducing conditions.

resisting the action of heat - difficult to fuse Shorter O.E.D.

Clays in this first group tend to be less plastic than in the other groups. They are more refractory and require higher firing temperatures, but they have a wider firing range and can be fired harder with less risk of loss.

(2) Marine clays are typified by the Lower Lias, Oxford Clay, Gault and London Clay. The clay mineral is dominantly illitic and is associated with a fairly high proportion of fine-grained mica. Iron tends to be incorporated in the clay mineral which gives a brown or reddish-brown fired colour. The reducing conditions in the environment of deposition have preserved carbonaceous material and have given rise to iron sulphides that have produced gypsum crystals in the weathered zone. These clays tend to be more plastic and less refractory than the clays in the first group.

3 Salt lake clays are typified by the Keuper Marl which is generally characterized by an illitic clay mineral with much fine-grained mica. Evapo-

ration in the basin of deposition caused the precipitation of calcite and dolomite which act as additional fluxes and reduce the refractoriness and permissible firing range of this material.

(4) Glacial clays are mixtures of the other three types depending on their location. They have sometimes resulted in the association of different types of material that would not normally be found together in a sedimentary clay. This generally adds to the problems of the brickmaker as, for example, when a boulder clay consisting of Coal Measure material also contains limestone fragments capable of lime bursting that would not normally be found in a Coal Measure clay.

Some of the characteristics of the clays in Groups (1), (2) and (3) can vary according to the degree of pressure that has been exerted on the formations either by the weight of overlying material or by earth movements. Pressure tends to aggregate the clay mineral crystals, and clays that have been under pressure are usually less plastic and disperse in water with difficulty compared with relatively unconsolidated clays. In Britain clays younger than the Carboniferous generally mix readily with water, but some Coal Measure clays and clays from older formations tend to be rather intractable except in the weathered zone where they may be very plastic.

In general, it can be said that the wide variety of geological conditions in Britain has resulted in a wide variety of brick clays which have their own characteristic properties and problems. The key to the understanding of clays lies in their mineralogy and this has been determined by their geological history. Further progress depends on developing more sensitive ways of examining the clay mineral. This will not only lead to a better understanding of ceramic properties but it may also suggest palaeogeographical interpretations for the elucidation of geological problems.