

THE ORIGIN OF THE CLAY-WITH-FLINTS: THE MISSING LINK

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The Clay-with-flints has a patchy, but extensive, outcrop in southern England south of the limit of the Anglian ice sheets, and in northern France where it is referred to as the Argiles à silex. Since early Victorian times, when it was recognised that its principal components were clay and unworn flints, the deposit has been presumed to have been derived from the dissolution of large volumes of chalk. It was also recognised, however, that the clay contents of typical chalks were too low to have produced the clay-flint ratios of much of the Clay-with-flints. The additional clay, together with sand that could not have been derived from the Chalk Group, was therefore presumed to be of later origin. The solution hypothesis remained largely undisputed until the 20th Century, even though there is no published example of an intermediate stage in the process in the form of a layer of partially dissolved chalk. The age of formation of the Clay-with-flints has long been the subject of dispute, partly because of the absence of palaeontological evidence, and partly because the name has been applied to a wide variety of lithologies including reworked and remobilised materials. Suggested ages range from Palaeocene in parts of northern France to Pleistocene in the London Basin. In east Devon and west Dorset, beds of partially dissolved *in situ* Upper Greensand and Chalk tens of metres thick are overlain by Clay-with-flints. They confirm the importance of large-scale solution as a contributing factor in the formation of the deposit in south-west England. The partially dissolved layers and the Clay-with-flints were folded and faulted in the Miocene, and they can be seen to pre-date Pleistocene erosional features including hanging dry valleys and frost-wedge pipes. The principal phase of dissolution is presumed to have been in warm moist climates during the Palaeocene-Eocene Thermal Maximum.

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INTRODUCTION

The deposition of the Chalk Group in the Anglo-Paris Basin was followed in the latest Cretaceous and earliest Tertiary by a period of folding and regional uplift related to renewed pulses in the opening of the Atlantic Ocean, North Sea and Bay of Biscay (Ziegler, 1990). The Cretaceous phase was characterised by the reactivation of narrow fault zones: in contrast, the Palaeocene movements involved plate-wide, domal uplift with little faulting (Hansen and Clausen, 2005). In south-west England, a continuous sheet of Chalk Group sediments up to about 500 m thick was reduced by a combination of fluvial erosion and dissolution to a few outliers in east Devon in which up to 75 m of Chalk is preserved. The youngest Chalk preserved onshore in the region is of early Coniacian (*Micraster coranguinum* Zone) age (Woods, 2002), but the former presence of chalks as young as Campanian (*Belemnitella mucronata* Zone) age is indicated by the presence of well preserved echinoids and belemnites in flints in the residual drift deposits that cap the Haldon Hills (Wood in Selwood *et al.*, 1984). Some of the most complete Chalk successions in the UK, up to 1200 m thick, have been recorded in boreholes in the Celtic Sea where chalks as young as Maastrichtian in age are preserved (Tappin *et al.*, 1994).

The sedimentology of the Turonian and younger chalks exposed in east Devon and west Dorset suggests that they were deposited in moderately deep (50 to 100 m depth) water on a stable marine shelf that occupied most of south-west England. The absence of near-shore or shallow-water deposits suggests

that a complete Chalk succession was originally present over much of the region, although thinner than that preserved in the Celtic Sea Basin. In the Hampshire Basin, where a Chalk succession up to 500 m thick is preserved, Senonian and Campanian chalks are overlain by fluvial and brackish-marine Palaeocene and Eocene sediments. There is no proven correlative of these Tertiary deposits in south-west England, but the local presence of laminated, stoneless clays, quartz sands and well rounded quartzitic pebbles in the Clay-with-flints suggests that a widespread veneer of Tertiary deposits was formerly present. Woodward (1902) recorded sands and stony clays with chert, flint and quartz pebbles at Combyne [SY 302 922] that Woodward and Ussher (1911) correlated with the Eocene 'Bagshot Series' of Dorset.

The deposits shown as *Clay-with-flints* on geological maps of southern England and as *Argiles à silex* on those of northern France, include a wide range of lithologies. Their distribution and stratigraphical relationships to the underlying rocks show that they were not all formed by the same process (or processes) and that they are not all of the same age. In south-west England, the Clay-with-flints shown on the most recent geological maps can be divided into two types which are here described as Clay-with-flints *sensu stricto* (*s.s.*) and Clay-with-flints *sensu lato* (*s.l.*). The first of these locally rests on thick beds of partially decalcified Upper Greensand and/or Chalk, the missing link in the process by which these Cretaceous deposits give rise to the Clay-with-flints *s.s.*