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PRELIMINARY OBSERVATIONS ON THE ORIGIN AND SEDIMENTOLOGICAL NATURE OF SARSEN STONES

W.B. WHALLEY[1] & C.J. CHARTRES[2]

ABSTRACT

The type of orthoquartzite known as sarsen stone is found over wide areas above the Chalk of south-east England. Scanning electron microscope and thin section studies indicate that sarsens are composed of quartz grains with syntaxial overgrowths of secondary quartz. They contain relatively little inter-particle siliceous cement. Their strength appears to be derived from the interlocking structure of the quartz grains produced by the syntaxial overgrowths.

1. INTRODUCTION

Sarsen stones (or just sarsens)[3] are the large blocks of orthoquartzite (K r y n i n e, 1948) found in a belt from near Portsmouth to central East Anglia towards the southern edge of the Chalk outcrop (Fig. 1). Perhaps the most famous examples are those of the large outer circle of the early Bronze Age Megolith at Stonehenge. There has long been interest in these large blocks of hard and resistant stone and their geomorphological importance in helping to explain the Tertiary and Post-Tertiary evolution of southern England has been discussed by C l a r k et al (1967). More recently, H o d g s o n et al (1974), have re-examined the long held views of W o o l d r i d g e and L i n t o n (1955) about the denudation chronology of this area. It therefore seems necessary to investigate the sedimentological nature of these deposits more thoroughly with a view to help explain the paleo-geomorphological conditions. Except for a brief examination of the Hertfordshire Puddingstone (a siliceous conglomerate composed of flints set in a fine-grained matrix presumed to be related to the sandier sarsens) by K e r r (1955), no sedimentological work appears to have been carried out. Determination of the environmental factors, both geological and climatic, is important in solving the general problem of the formation of siliceous duricrusts (silcretes), to which it is suggested that sarsens belong (G o u d i e, 1973), as well as in helping to elucidate the problem of silica cementation in both Tertiary (R i e z b o s, 1974) and very recent (W h a l l e y, 1974) sediments. Here we present some preliminary findings as part of an examination of these questions. We hope to present more detailed and extensive results at a later date.

The samples examined in this study were collected from sarsen stones found on the Nature Conservancy Reserves at Aston Rowant, Oxfordshire and Fyfield Down, Wiltshire. In all, approximately 30 samples representing 10 sarsens have been examined to date.

RESULTS

The term "sarsen" is here restricted to an orthoquartzite which has 95% of sand size particles. In the sarsens examined, this sand is usually fine (50-300μm) with some silt-sized material down to 20μm. Though sarsens may contain flint within them (J o n e s, 1901), this is rather rare; however, puddingstones are common and widespread (K e r r, 1955; B e n n i s o n and W r i g h t, 1969), but are not discussed here. Silcretes are usually considered to result from near-surface cementation of unconsolidated materials by the precipitation of silica from percolating waters in a seasonal-rainfall, arid or semi-arid climatic regime (see G o u d i e, 1973 for discussion). C l a r k et al (1967) mention the presence of silicified roots in several sarsens and this tends to corroborate a near-surface origin. It is generally assumed that both sarsens and puddingstones are derived from Tertiary deposits which have otherwise been stripped away. The usual contenders for provenance are from the Eocene: Reading Beds (B a r r o w, 1919; S h e r l o c k, 1960), Bagshot Sands (B a r r o w, 1919) and Blackheath Beds (S h e r l o c k, 1960) though K e r r (1955) points out that because S h e r l o c k (1960) found silicified "penny-stones" in the Blackheath Beds, at least some sarsen formation must predate these times. C l a r k et al (1967) consider separate formation of silcretes in the lower Eocene (Sparnacian and Thanetian), Bagshot period (Cuisian) and Bartonian, as well as development during a single phase of formation when an erosion surface cut across several Eocene beds. Stratigraphic evidence tends to support the latter view.

The Reading Beds, however, do contain some quartz sands which might have provided material for sarsens. Such sands

[1] Department of Geography, Queen's University, Belfast.

[2] Department of Geography, The University, Reading.

[3] The name sarsen is thought to be derived from the Saxon words *sar* meaning 'troublesome' and *stan*, 'a stone' because of the difficulties they caused to early clearers of the land (Chatwin, 1960). It is now accepted as a geological term.

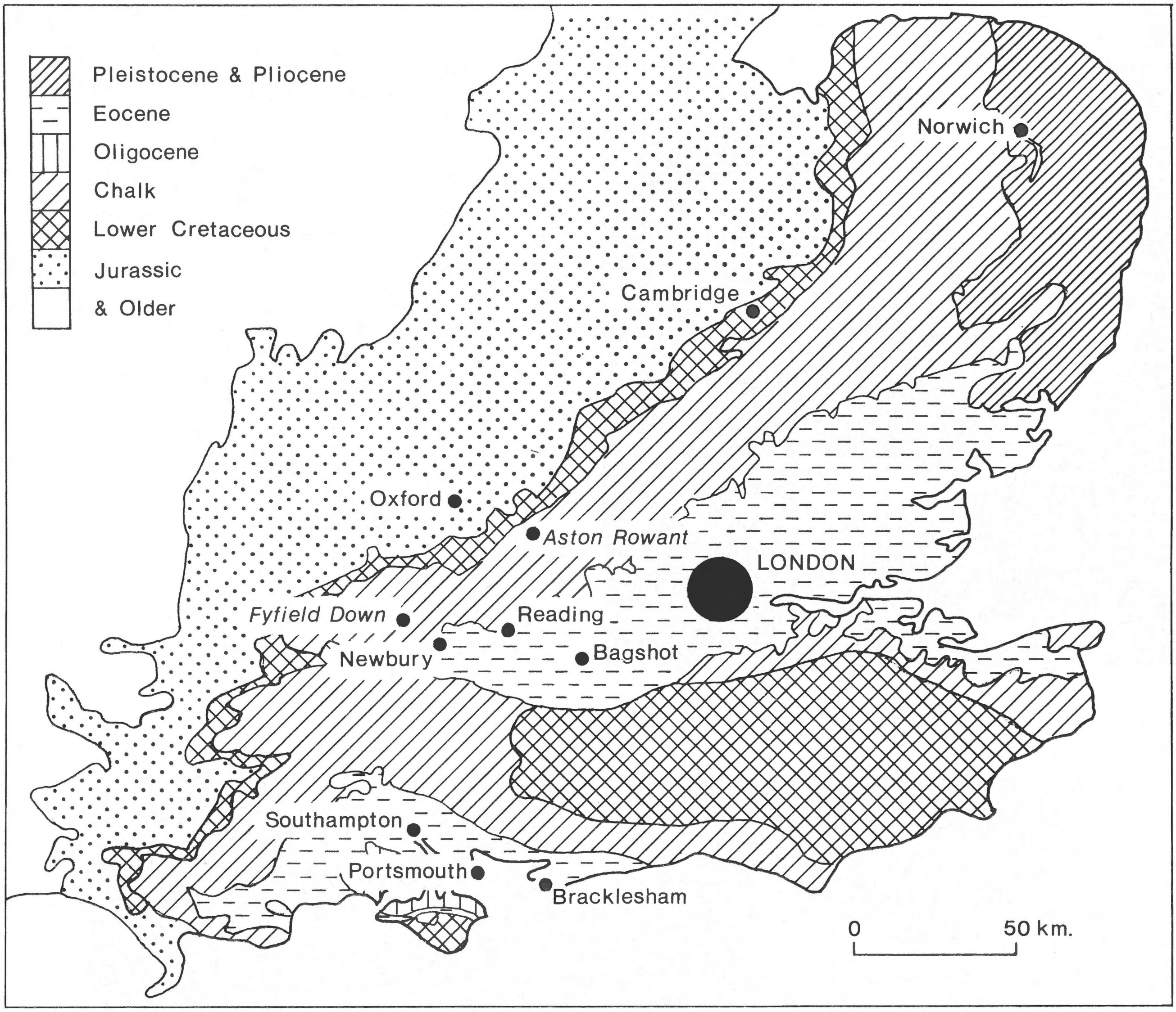


Fig. 1
Map of the generalized geology of southern England, showing the sites of sarsens sampled and other important localities.

do not occur everywhere in the rather variable Reading Beds and the fact that sarsens are apparently surface formations might explain their occasional occurrence and might answer the objections of Osborne White (1925) that deposits in which sarsens are found do not seem to provide suitable source material – the latter presumably having otherwise been removed by denudational processes. Furthermore, this source variability may preclude the formation of sheets of sarsen as suggested by Clark et al (1967) by analogy with Australian examples of silicretes. However, in the supposition that such Reading Beds sands could provide the source for at least some sarsens, samples were taken from sites at Hermitage (SU 501 700), Hamstead Marshall (SU 417 662) and Wickham (SU 407 711) in the neighbourhood of Newbury (Fig. 1) and examined with a scanning electron microscope.

Figure 2 shows a typical grain from a sandy deposit in the Reading Beds; its "rounded" form with some re-deposition of quartz on the surface can be seen. These grains contrast strongly with fresh fracture surfaces of sarsens which almost always have a clean angular appearance (Fig. 3). Close inspection shows, however, that the "angularity" is not an original feature of the constituent grains, but is due to syntaxial growths of quartz. The overgrowths can be clearly seen in thin section (Fig. 4). Such grains form the bulk of the sarsen specimens examined. This secondary silica has not completely filled the pore spaces, and it is through such spaces that near-surface waters charged with silica are presumed to have moved up and down to give the precipitation. No trace of

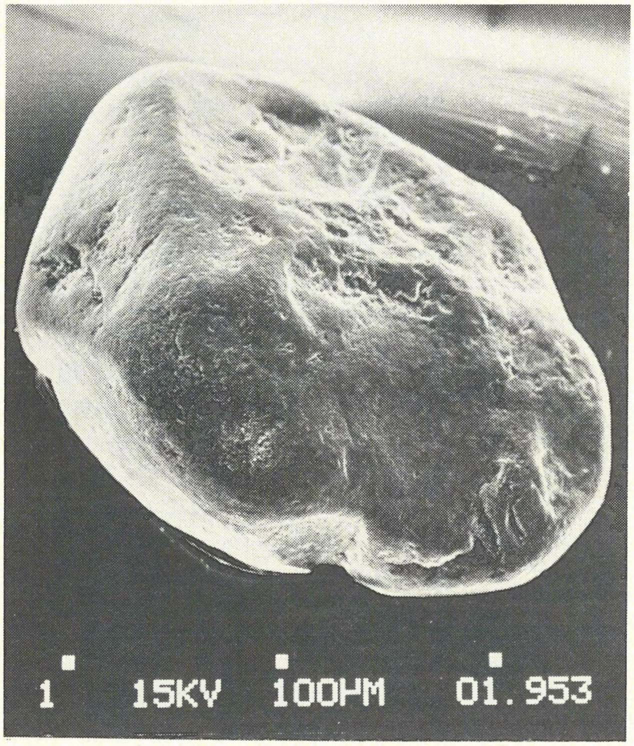
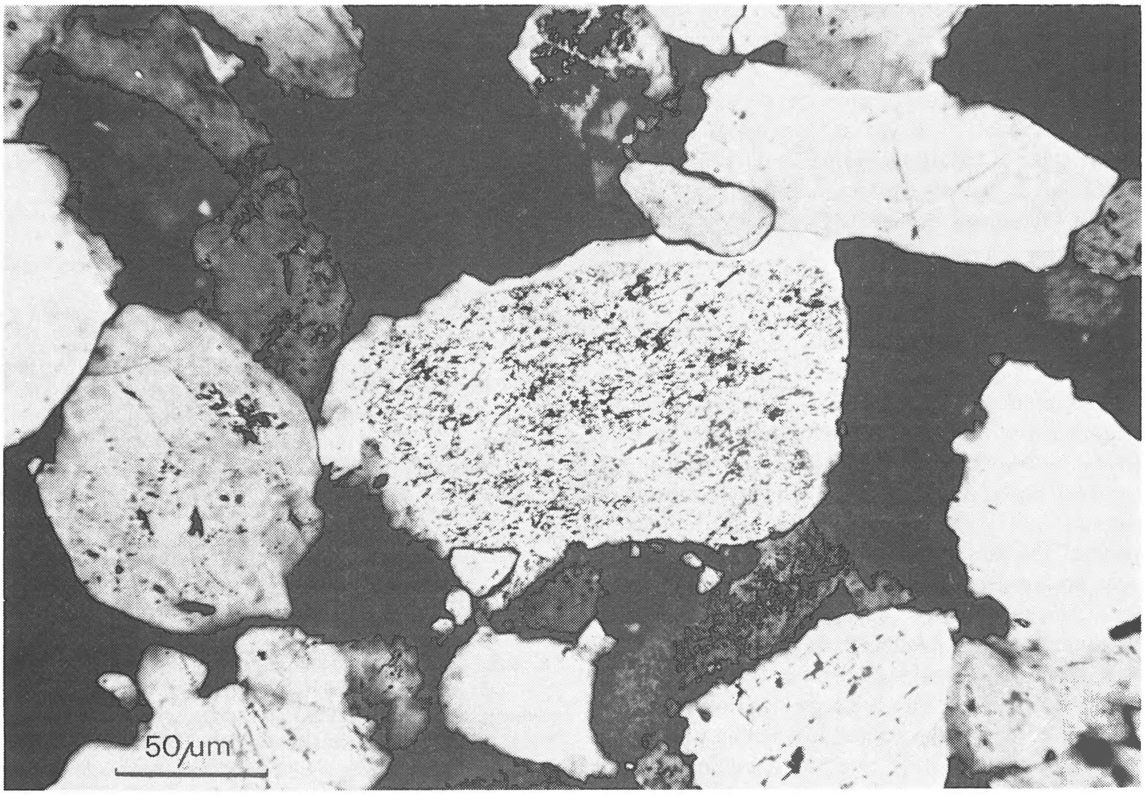


Fig. 2
Scanning electron micrograph of a single sand grain from the Reading Beds, near Hermitage, Berkshire. (Scale indicated from leading edge to leading edge of the white bars at the base of the photograph = 100μm. Electronic mag. x 269 (Cambridge Instruments Stereoscan 180).

pressure solution (T h o m s o n, 1959) has been found. This finding is similar to that of R i e z e b o s (1974) on the weakly-cemented sands from the Miocene of South Limburg (Netherlands). In the latter case, the secondary growths give less well-formed authigenic grains than found in the examined sarsens. As Riezebos also suggests that a rising and falling water table gives rise to these secondary growths it may be that the Miocene deposits are less well-cemented just because they are younger than the Eocene sarsens. How well this observation fits with a single phase of sarsen formation is not known as the Miocene is absent from Britain.

Fig. 3
Scanning electron micrograph of the interior surface of a sarsen removed from the cutting of the M. 40 motorway, near Watlington, Oxfordshire. Scale bar = 50μm. Electronic mag. x 150 (Bausch & Lomb S.M.II).



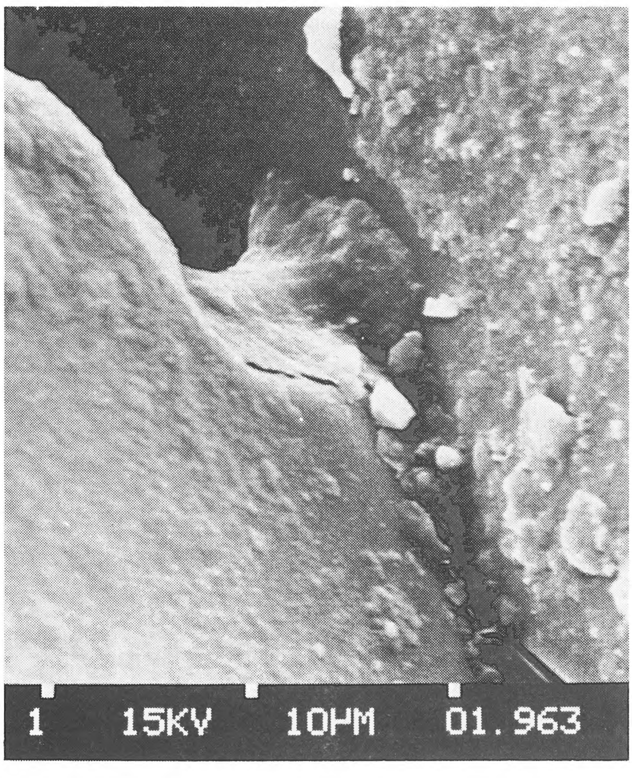


Fig. 4
Thin section micrograph (crossed polars) from different sarsen but same site as Fig. 3. Quartz overgrowth clearly visible on central grain. Scale bar = 50μm.

It is rather misleading to call the sarsens "cemented" because, in fact, in many of them very little cement is seen (Fig. 3). Interlocking of crystals provides a high coëfficient of friction which apparently gives most of the strength. The lack of cement is shown by the small number of fracture surfaces across crystals (as would be evidenced by conchoidal fracture marks). Separation takes place *round* rather than *through* grains. There is some evidence of secondary quartz growth as can be seen in Figure 5 where grains are linked together. However, despite the apparent paucity of such cemented contacts, sarsens are very tough rocks and the reason for this appears to lie in the high frictional strength

Fig. 5
Scanning electron micrograph of secondary quartz precipitation from same sarsen as Fig. 3. Scale indicated from leading edge to leading edge of white bars at the base of the photo = 10μm. Electronic mag. × 800. (Cambridge Instruments Stereoscan 180).

from interlocking crystals. The slight cohesion necessary is supplied by occasional intergranular cementation. Individual grains can be prised off the mass with surprisingly little difficulty even though the rock as a whole is strong. The cement appears to be microcrystalline quartz – though chalcedonic quartz (which may act as cement) is sometimes found on the sides of authigenic grains. Very rarely are there any clay minerals in the pore spaces, and then only near the outer parts of the sarsens, where they could have infiltrated after cementation.

3. CONCLUSIONS

The micrographs and thin sections, therefore, suggest a two-stage formation, first of authigenic quartz, and a second of additional interparticle cement. However, whether this represents two different types of environment for quartz precipitation is not known. Some quartz sand found in a small "pocket" in one sarsen was only very lightly cemented but became progressively more so towards the main mass of the sarsen. The morphology of grains from this pocket is similar to those from the Reading Beds, with about the same amount of secondary quartz deposition (very rarely syntaxial). As it seems likely that these grains are those of the material which comprise the sarsen, but without the pronounced syntaxial growth, some localized conditions may be necessary for the formation of the sarsen silcrete. Not only does a particular climate appear to be required but specific geochemical conditions may be needed in even a suitable quartz sand.

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