An Upper Cretaceous chert nodule, apparently marine ballast, from Princess Royal Harbour, Western Australia

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Abstract

A stone nodule recovered in the excavation of a silo foundation in the Port Authority area of Princess Royal Harbour, Western Australia, is composed of Upper Cretaceous chert, a lithological type anomalous to the region. The chert in this nodule closely resembles black English flint, and contains algal microfossils (dinoflagellates) that are more likely to be European than Australian. The specimen is, almost certainly, a nineteenth century ballast stone from northwestern Europe, and may have come from Thames River gravels or similar deposits in southern England. The investigation shows the danger of making uncritical assumptions about the origin and provenance of chert objects in southwestern Australia.

Introduction

In 1968, Mr Brian Ayre of Rockingham, W.A., picked a nodule of flint (generally classified by geologists as chert) from the lower part of a six metre-deep silo foundation in the Port Authority area of Princess Royal Harbour, at Albany (35° 03' S 117° 54' E) on the southern coast of Western Australia (see Fig 1). He observed that the foundation walls consisted of layers of beach sand, marine shell grit, a 60 cm-thick zone of black mud, and two or more layers of whole marine shells (*pers. comm.*). The stone came from the disturbed floor of the foundation. Mr Ayre passed the specimen to the Western Australian Museum in 1993 for identification. On the basis of superficial examination, the stone was tentatively identified as a naturally flaked chert or flint nodule from England or elsewhere in northwestern Europe. The occurrence of a putative ballast stone at a depth of about six metres can be explained by the massive dredging and earth-filling operations done in the Albany Port Authority area around the turn of the century (Garden 1978), several decades after sailing ships first could have dumped loads of English or European chert ballast in Princess Royal Harbour. Although we have not been able to verify the dumping of flint ballast in Princess Royal Harbour, it is reasonable to assume that the practice took place during the half century or more (ending about 1900) when sailing ships arriving from England were loading cargos (Garden 1978). It is also possible that the nodule came from a nearby wreck.

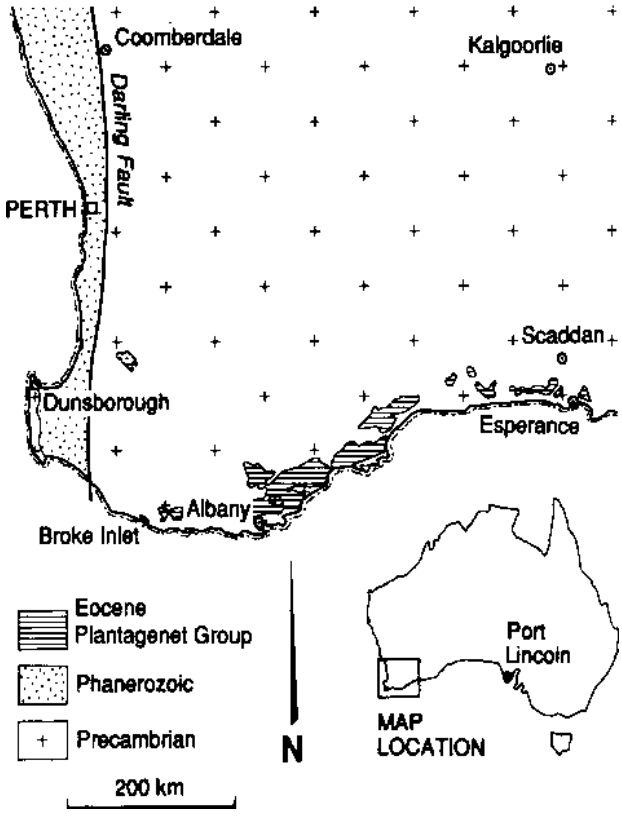

Figure 1. Map of southwestern Australia showing the distribution of the Plantagenet Group, and localities mentioned in the text.

Results

General description

The object is irregularly shaped and measured roughly 11.5 X 7 X 6 cm (Fig 2) and weighed 461.8 gm before the removal of cores in the laboratory. It is a flint (or chert) nodule that is randomly flaked and rolled on several parts. The angles between some of the large flake scars and adjacent striking platforms are much more obtuse than normally associated with, or even possible by, knapping (*i.e.* artificial flaking), but are like those seen on pebbles flaked by wave action. Consistent with this is the rolled condition of the piece, *i.e.* it has heavy abrasion and multiple chipping (tiny negative flake scars) extending along the ridges formed between the various flake scars. The flaking appears to have been done by wave action in which the nodule would have been flung and dragged against other nodules, as on a pebble beach (*cf.* Shackley 1974).

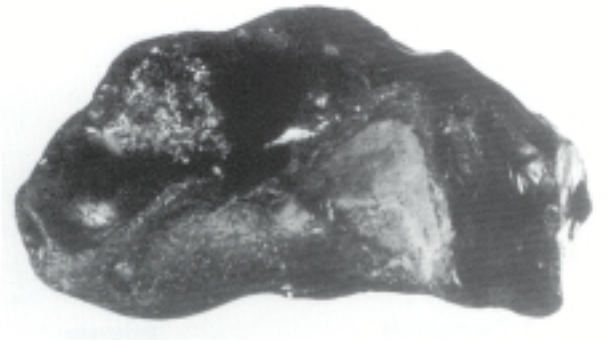

Figure 2. The Princess Royal Harbour chert nodule. Note the smooth, slightly patinated surface (bottom centre and bottom left) and the shiny black conchoidal fracture (right and top centre). Length of specimen = 11.5 cm.

Petrology

The surface of the nodule is mostly rounded, but where flaked it has well-developed conchoidal fracture. The fresh rock is generally shiny black (N1) but in places it is irregularly mottled and ranges to medium light grey (N6) and greyish orange (10YR 7/4). Locally, there is a surface patination about 0.75 mm thick ranging from greyish orange (10 YR 7/4) to pale yellowish brown (10 YR 6/2) (colours based on Rock-Color Chart Committee, 1963). There is no effervescence in cold dilute hydrochloric acid, indicating the absence of calcite.

For determinative purposes, two solid cylindrical cores, one 2 x 1.5 cm and one 2 x 2.5 cm, were drilled from the specimen. The chert fractured easily and irregularly, and the objective of retaining the slightly patinated tops of the cores to restore the original appearance was only partly realised. Portions of the cores were used for thin sections, and for the extraction of palynomorphs.

The rock is composed mainly of cryptocrystalline quartz (Fig 3). In thin section, there are various dark grey-brown patches ranging from partly to highly silicified argillaceous material, which are up to three mm long.

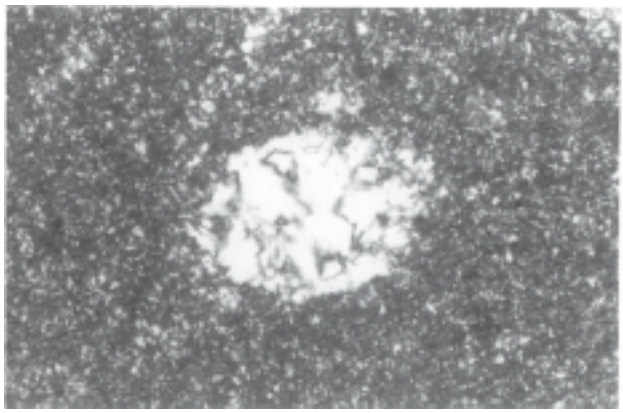

Figure 3. Typical thin-section field of Princess Royal Harbour chert nodule under crossed polarisers. The central chalcedonic mass, 0.25 mm long, may represent an in-filled fossil cavity. Remainder of field is cryptocrystalline silica.

The argillaceous areas grade fairly sharply into surrounding chert. There are also rare minute granules of hematite, possibly from the oxidation of pyrite.

Fossils are abundant. Most of the fossils are siliceous palimpsests, indeterminate except at broad taxonomic levels; they consist of foraminiferal tests, curved elongate shards that were probably shell fragments, and other debris. Spicules are abundant and may have been siliceous originally. There are some black carbonaceous flakes. The chambers of fossils are filled with cryptocrystalline quartz, radiating chalcedony, or argillaceous matter. Test walls are commonly converted to cross-fibre silica, apparently chalcedony. A remarkable feature is the presence of sparse but excellently preserved uncompressed dinoflagellate cysts that are clearly visible in thin section.

The rock is evidently a secondary chert originally consisting of a foraminiferal and spicular sediment. The excellent preservation of the dinoflagellate cysts is consistent with early post-depositional solidification caused by silicification at shallow depth. The argillaceous patches may represent intraclasts but, if so, other clasts are conspicuously absent. Alternatively, the patches may represent areas disturbed by animals burrowing in poorly consolidated calcareous ooze.

Palynology

After digestion of the silica from the core sample to concentrate the organic debris, a sparse but diverse and well-preserved assemblage of dinoflagellate cysts was recovered. The identified taxa are listed in Table 1.

Provenance and age

Dr N G Marshall and Dr A N Bint, who initially examined the palynoflora, concluded (*pers. comm.*) that it was of Late Cretaceous age and not typically Australian. They could not rule out a Northern Hemisphere origin. Detailed examination of the material has confirmed and extended these observations of Marshall and Bint. The most abundant taxon is *Spiniferites ramosus*, a long-ranging dinoflagellate cyst. The dinoflagellate association is completely consistent with a provenance in western Europe, including the United Kingdom. It should be added that

Table 1

Abundance of taxa in the palynoflora of the chert object from Princess Royal Harbour

Taxon	Proportion of palynoflora
Marine Microplankton	
Acanthaulax wilsonii Yun 1981	6%
acanthomorph acritarchs	1%
?*Actinotheca aphroditae* Cookson & Eisenack 1980	3%
Apteodinium deflandrei (Clarke & Verdier 1967) Lucas-Clark 1987	Present
Atopodinium perforatum (Clarke & Verdier 1967) Masure 1991	1%
Cleistosphaeridium spp	2%
Coronifera oceanica Cookson & Eisenack 1958	Present
Coronifera striolata (Deflandre 1937) Stover & Evitt 1978	Present
? *Cribroperidinium* sp	Present
Dinopterygium cladoides Deflandre 1935	1%
Elytrocysta circulata (Clarke & Verdier 1967) Stover & Helby 1987	4%
Endoscrinium campanula (Gocht 1959) Vozzhennikova 1967	1%
Exochosphaeridium spp	2%
Florentinia buspina (Davey & Verdier 1976) Duxbury 1980	4%
Florentinia ferox (Deflandre 1937) Duxbury 1980	1%
Florentinia tenera (Davey & Verdier 1976) Duxbury 1980	1%
Heterosphaeridium sp	3%
Histiocysta palla Davey 1969	1%
Hystrichodinium pulchrum Deflandre 1935	2%
Hystrichosphaeridium recurvatum (White 1842) Lejeune-Carpentier 1940	1%
Isabelidinium cooksoniae (Alberti 1959) Lentin & Williams 1977	1%
Laciniadinium sp	1%
Odontochitina costata Alberti 1961	Present
Oligosphaeridium complex (White 1842) Davey & Williams 1966	1%
Palaeohystrichophora infusorioides Deflandre 1935	1%
Palambages sp	Present
Pterodinium cingulatum (O Wetzel 1933) Below 1981	1%
Sentusidinium sp	6%
Spinidinium echinoideum (Cookson & Eisenack 1960) Lentin & Williams 1976	1%
Spiniferites ramosus group (Ehrenberg 1838) Mantell 1854	41%
Surculosphaeridium longifurcatum (Firtion 1952) Davey *et al.* 1966	1%
Tanyosphaeridium sp	1%
Trithyrodinium spp	1%
Valensiella reticulata (Davey 1969) Courtinat 1989	1%
Valensiella sp	4%
Xenascus ceratioides (Deflandre 1937) Lentin & Williams 1973	1%
Terrigenous pollen grains	
angiosperm pollen indeterminate	1%
bisaccate pollen undifferentiated	1%

palynological species were widely distributed during the Late Cretaceous (Costa & Davey 1992), and most of those listed here have also been recorded from Western Australia (Marshall 1975, Helby *et al.* 1987), which had comparable latitudes with western Europe during the epoch. However, there are several forms, including *Balteocysta perforata* and species of *Conosphaeridium* which occurred in the Australian region at the time but have not been observed in this assemblage. The composition of the palynoflora is therefore more European than Australian, but species variation in the Chalk Sea assemblages is too slight to show where the chert is likely to come from in western Europe.

The flint is Late Cretaceous in age, probably late Turonian to Coniacian, on the basis of significant occurrences of *Acanthaulax wilsonii* (Fig 4), *Florentinia buspina*, *F. tenera*, *Surculosphaeridium longifurcatum* and *Isabelidinium cooksoniae* (single specimen).

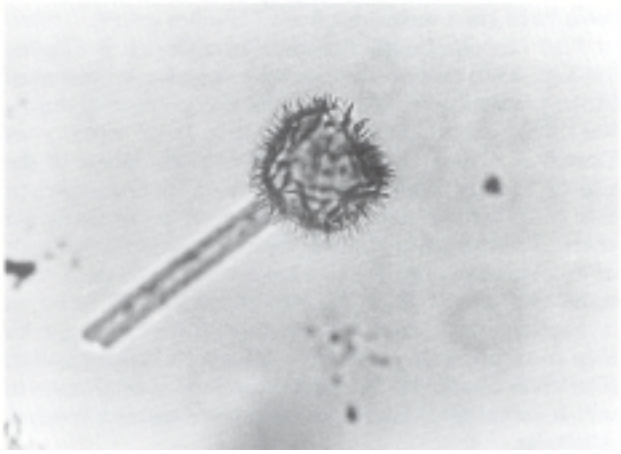

Figure 4. The resistant resting cyst of the dinoflagellate *Acanthaulax wilsonii*, which composes 6% of the total palynoflora. Width of field 0.23 mm.

Discussion

Many chert objects, overwhelmingly of Aboriginal origin, have been found on or near the surface in southwestern Australia (Glover 1984). Most are flakes, but a few larger artifacts have been found: for example the Broke Inlet biface from about 150 km west of Albany (Glover *et al.* 1993), weighed 1797 grams. The artifacts are composed of both non-fossiliferous and fossiliferous chert. Non-fossiliferous artifacts were derived from the Proterozoic Coomberdale Chert or other Precambrian units. Fossiliferous chert, on the other hand, came either from silicified Eocene rocks along west coast areas now submerged by the sea, or from silicified Eocene Plantagenet Group rocks cropping out in the south coastal region, or from silicified Plantagenet rocks now submerged off the south coast. The estimated age of the silicified rock ranges from Early to Late Eocene. No potential source of chert containing Late Cretaceous fossils in southwestern Australia is known to us.

The significance of the fossils in secondary chert should be considered briefly. Fossils give the age of the original sediment, which may be substantially greater

than that of the chert. McGowran (1989) stated that a world-wide Eocene process of silicification reached its peak in early Middle Eocene. Fortunately, the time of silicification in some cherts can be inferred from their texture. Delicate uncrushed palynomorphs in the Dunsborough biface (Glover *et al*. 1978) indicate early solidification of the rock by silicification (B Balme, *pers. comm.*). Similarly, the presence of uncompressed Late Cretaceous dinoflagellate cysts in the Upper Cretaceous chert of western Europe is consistent with a silicification depth of 5-10 metres or less, according to Clayton (1986). The excellent preservation of dinoflagellate cysts in the Princess Royal Harbour object accords with shallow silicification. In each of these examples, therefore, the fossils represent the age of the chert as well as the age of the original sediment.

Not all chert objects found in southwestern Australia are necessarily local. McCarthy (1958) implies that flint implements have more than once been dumped with ballast in Australia, and Tindale has stated that flint tools have been recovered from "Thames gravel" ballast at Port Lincoln, South Australia (see Dortch & Glover, 1983, p. 330). English flint pebbles may have been used in the processing of gold ore in the Kalgoorlie area during the 1890s according to Hutchinson (*pers. comm.*, see Dortch & Glover 1983). Charleton (1903) refers to the use of "quartz pebbles from Norway" in the Hannans Star Mill, but the term may have been a misnomer for chert. Finally, an implement of chert containing fossils of indeterminate age found near Scaddan, Western Australia (400 km ENE of Albany) is considered to be an Acheulian (*i.e*. Lower Palaeolithic) biface brought by ship from England, either as a collector's item or ballast (Dortch & Glover 1983). There were thus several ways in which exotic siliceous stone could have entered Western Australia.

What is a likely Northern Hemisphere source for the nodule from Princess Royal Harbour? According to Scott (1993), many Quaternary and Recent sand and gravel deposits in southern England are characterised by more than 80% flint of Late Cretaceous age. The chances of flint ballast in Australia having been derived from those areas are obviously significant.

The Princess Royal Harbour stone resembles black flint from western Europe. The macroscopic appearance, Late Cretaceous age and well-preserved palynomorphs, combined with the heavily rolled condition, suggest that the Princess Royal Harbour object is a naturally flaked nodule deriving from a pebble or shingle beach (or other gravel deposit) in western Europe, and more specifically from southern England. It is probably a 19th century ballast stone that was inadvertently deeply buried within the highly disturbed, made ground in the Port Authority area. It adds to evidence that untested assumptions of Eocene age for fossiliferous chert objects in southwestern Australia should not be accepted uncritically.

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