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# Challenging the 'offshore hypothesis' for fossiliferous chert artefacts in southwestern Australia and consideration of inland trade routes

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ABSTRACT

Surface scatters containing Eocene chert artefacts are a widespread cultural site type along the Swan Coastal Plain; however, no source rock for the chert is known to exist locally. In the absence of chert outcrops onshore, archaeologists have argued for an offshore source that was subsequently flooded during post-glacial sea level rise. Support for this theory has been the decline or absence of Eocene chert artefacts in deposits younger than 6000 years BP, and the apparent decrease in chert assemblage inland from the contemporary coastline, which may call into question a distal eastern source.

This paper presents an alternative theory whereby chert was sourced from the Nullarbor Plain (~1000 km to the east) and traded east as well as west across southern Australia. Evidence to support this theory includes (1) absence of Eocene age sedimentary strata outcropping on the continental shelf, (2) faunal evidence showing bryozoans imbedded in the Swan Coastal Plain chert, with similar environmental affinities to bryozoans embedded in chert outcropping along the Nullarbor Plain sea cliffs, and (3) geochemical evidence showing a similar geochemical fingerprint between artefacts from the Nullarbor Plain and Swan Coastal Plain.

With a peak in fossiliferous chert use around the Last Glacial Maximum, these findings have significant ethnographic implications supporting long distance trade to the east rather than local sourcing of lithic resources by isolated Aboriginal groups. These findings also have chronological implications relating to the use of Eocene fossiliferous chert as a chronological marker for Late Pleistocene to early-Holocene age deposits in southwest Western Australia, albeit with source accessibility following post-glacial sea-level rise still a main factor in the decline in chert use.



## 1. Introduction

The southwest of Western Australia has a rich record of human occupation extending back to 48,000 years B.P. (Turney et al., 2001), with evidence of resource exploitation documented in the rich faunal remains recovered from limestone rock shelters (Dortch et al., 2012) and mid to late Holocene coastal midden sites (Smith, 1999). Surface artefact scatters comprise the main archaeological site type in the region, and are usually present in the form of concentrated primary- and secondary-flaked and unflaked material in dune depressions created by sand deflation. Raw material types typically include locally-sourced quartzite, mylonite, amygdaloidal basalt and Proterozoic chert (Glover, 1984). Another widespread but more distinctive raw material type is fossiliferous (bryozoan) chert (Hallam, 1972). This cryptocrystalline raw material would have been sought after for tool-making because it breaks with a smooth conchoidal fracture that produces durable, sharp, non-jagged edges.

Faunal analysis of fossiliferous chert artefacts by Glover and Cockbain (1971) was able to identify 15 bryozoan species, as well as the diagnostic foraminifera species (*Maslinella chapmani*) embedded in the chert, indicating a Middle to Late Eocene age for the geological material. Despite the relative abundance of fossiliferous chert artefacts in southwestern Western Australia (Glover,

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1975b) extensive geological surveys within both the Perth and Carnarvon Basins have yet to reveal any Eocene age outcrop or formation that might potentially hosts fossiliferous chert rock (Glover and Cockbain, 1971; Quilty, 1974; Cockbain, 2014). Glover and Cockbain (1971) initially proposed that the chert may have been derived from Eocene sedimentary rock units, either from the Plantagenet Group and Norseman Limestone located over 500 km to the east of Perth, or from the Wilson Bluff Limestone. The latter is exposed in caves of the Nullarbor Plain and along the 60–120 m high Baxter and Bunda sea cliffs that stretch for over 380 km along the Great Australian Bight starting from Point Culver (830 km east of Perth) and ending at Head of the Bight (1500 km east of Perth). However several archaeological peculiarities of the fossiliferous chert artefacts led Glover (1975a) and Quilty (1978) to propose that fossiliferous chert flakes of the Swan Coastal Plain were locally sourced. They argued that chert sediments were exposed along the inner continental shelf during glacial lowstands (i.e. west of the present coastline) but that access was subsequently cut off when the sediments were submerged during post-glacial sea level rise – this was the so-called “offshore hypothesis”.

Several arguments have been put forward in support of the offshore hypothesis. Firstly, Glover (1975a, b) argued that an increase in the abundance of fossiliferous chert westward towards the present coastline would counter Glover and Cockbain's (1971) proposed easterly source, and instead favour a westerly “offshore” source. Secondly the absence of chert artefacts in strata younger than 4500 years BP was attributed to an elimination of source following post-glacial flooding of the continental shelf (see also Quilty, 1978; Glover, 1984). Thirdly, spatial trends in geochemical analysis (primarily Mg/Ca and Na/K ratios) of fossiliferous chert flakes was argued to represent multiple offshore chert sources and highly localised resource-use patterns (Glover and Lee, 1984). Finally, the presence of chert nodules Eocene sediment horizons recovered from a petroleum well drill core from the Rottnest shelf (west of Perth) led Quilty (1978) to suggest the possibility of surface exposures of Eocene chert in Quaternary depressions, now submerged on the continental shelf.

Over the last 40 years the offshore hypothesis has become an accepted central concept within the West Australian archaeological community. It has been used extensively by researchers and archaeological consultants to provide a relative chronology for dating archaeological sites, based on presence of fossiliferous chert to >6500 BP or alternatively its absence to <4500 BP (Hallam, 1972, 1986; Marwick, 2002; Dortch, 1991, 2002). It has also provided a template for ethnographic investigations of Aboriginal culture in southwestern Western Australia, i.e. limited trade or movement between Aboriginal groups across southern Australia. For the first time in 40 years, this study revisits the offshore hypothesis and challenges the notion that chert was sourced from quarries on the continental shelf that were subsequently drowned during post-glacial sea level rise. Instead we use a range of methodologies, including geochemical and faunal fingerprinting, to argue for an eastern source for fossiliferous chert with material being traded over many hundreds to over a thousand kilometers - a theory first proposed by Glover and Cockbain (1971) and subsequently abandoned. This finding has significant implications for our current understanding of Aboriginal ethnographies and may require a revision of the long accepted chronological sequences of archaeological sites in Australia's southwestern regions.

## 2. The occurrence of fossiliferous chert in the Perth Basin

Fossiliferous chert is a sedimentary rock formed through the deposition and diagenesis of siliceous marine organisms, including (1) diatoms - unicellular phytoplankton, (2) radiolarians - zooplankton, both of which produce a siliceous (opaline) skeleton, and (3) sponges that have an endoskeleton of silica spicules. Once on the sea floor, these siliceous sediments undergo diagenesis from opal-A (siliceous ooze) to opal-CT (porcelanite) through to chalcedony (chert) (Stein and Kirkpatrick, 1976). The maturation process is influenced by solution chemistry and mineralogy of the host sediments but are most strongly affected by temperature (as a function of burial depth) and time, the latter on the order of 25–50 Myr under typical oceanic heat flow conditions (Kastner et al., 1977).

In a global survey of Deep Sea Drilling Project (DSDP) and International Ocean Drilling Program (IODP) sediment cores, Muttoni and Kent (2007) found that cherts are most frequently and geographically widespread in Paleocene to Early Eocene marine sedimentary strata with peak occurrences at 50 Ma. An investigation of 38 DSDP/IODP wells drilled around the Australian continental margin found a peak frequency of biogenic chert beds in the early Eocene, which is also the geological age of the fossiliferious chert artefacts on the Swan Coastal Plain (Glover and Cockbain, 1971). A secondary chert peak is also observed in the Middle Miocene (Muttoni and Kent, 2007). If Glover (1975a; 1984) and Quilty (1978) are correct that the fossiliferous chert was sourced from now submerged outcrops on the continental shelf, then Eocene age sedimentary strata should be observed at or near the present seabed and at a water depth not deeper than ~130 m so as to be accessible during the previous sea level lowstand. However, a detailed geological study of the Perth Basin using onshore hydrological bore holes (Davidson, 1995) and offshore petroleum wells (Marshal et al., 1993), seismic data (Borissova et al., 2015) and seabed surveys (Nicholas et al., 2014) found no evidence of Eocene or Miocene strata outcropping on the continental shelf, or buried onshore by Holocene sediments.

The north-south orientated Swan Coastal Plain (Fig. 1) represents onshore surface expression of the Perth Basin; it is bounded to the east by the Darling Scarp and the Neoproterozoic Yilgarn Craton, and to the west by the present shoreline (Cockbain, 2014). The Kwinana Group sediments cover the coastal plain and include Holocene to Pleistocene marine and coastal sedimentary strata up to 30 m thick. Kwinana Group sediments continue onto the continental shelf with recent geophysical surveys (Nicholas et al., 2014) revealing submerged coastal strandlines, and parabolic dune systems, which would have formed during lower than present sea levels. Underlying the Kwinana Group is the Pliocene mineral-sand-bearing Yoganup Formation representing a former coastal and shallow marine depositional environment. Extensive onshore hydrogeological drilling (Davidson, 1995) reveals these Plio-Pleistocene units to be many tens of metres thick and unconformably overlying Cretaceous age sediments. This indicates there has either been non-deposition or erosion of Paleogene sediments within the onshore Perth Basin. An exception is the Late Paleocene to Early Eocene Kings Park Formation, which was encountered in the Kings Park 2 well. The unit occupies a deep channel incised through the Cretaceous sediments. The top of the section is at a depth of −23 m and is characterized by grey, calcareous, glauconitic siltstone and shale of shallow-marine to estuarine origin. Fossiliferous chert has not been reported from this formation and it is stratigraphically too old to be the source of the chert artefacts. The Kings Park Formation was also encountered in the offshore Quinns Rock 1 well, which reached the Mullaloo Sandstone Member of the Eocene Kings Park Formation at −37 m below the seabed (77 m below sea level) but no chert was found.

Both Miocene and Eocene strata are known from petroleum wells drilled on the continental shelf and shelf slope west of Perth. These are the Miocene Stark Bay Formation, the Late Eocene Challenger and Middle Eocene Porpoise Bay Formations. The Stark