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ScienceDirect
Palaeogeography, Palaeoclimatology, Palaeoecology 260 (2008) 342–346
PALAEO
www.elsevier.com/locate/palaeo

# A *Bathysiphon* (Foraminifera) 'shell bed' from the Cretaceous of northern California, USA: Example of a parautochthonous macro-skeletal deposit in deep-ocean turbidites

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Received 20 April 2007; received in revised form 19 November 2007; accepted 26 November 2007

**Abstract**

Shell beds consisting of concentrations of minimally transported, slightly damaged skeletal remains of indigenous organisms—comparable to bedded shelly accumulations of certain shallow-marine environments—have rarely been reported from truly deep-ocean turbidites. The general expectation is that shelly accumulations, when they do occur, ought to be derived from upslope sources and many kilometers away from the site of deposition. A Cretaceous thin-bedded turbidite in the Franciscan Complex of northern California, however, hosts a concentration of large specimens of the giant foraminiferan, *Bathysiphon aaltoi*, reflecting localized transportation and deposition in the original life habitat. The tests were derived from a densely populated thicket of the bathysiphonid probably located only a few metres/10s-of-metres away, decimated by a turbidity current that either overflowed an active submarine fan channel or spread outward from a suprafan lobe. As such, this unusual bathysiphonid-rich deposit can be viewed as a kind of deep-ocean level bottom 'shell bed'.


*Keywords:* Foraminifera; *Bathysiphon*; Macro-skeletal accumulation; Turbidite; Deep-ocean; Cretaceous

## 1. Introduction

Shell beds of varied geometry, lateral extent and thickness are typical features of shallow-marine deposits of all kinds. Skeletal accumulations consisting of allochthonous material derived from shallow water are also common features of deep-marine turbidites, especially calciturbidites (reviewed by Meischner, 1964; Rupke, 1976; Cook and Mullins, 1983; Eberli, 1991; Einsele, 1991; Kidwell, 1991; Flügel, 2004). In fact, skeletons derived from different kinds of shallow-marine and even estuarine environments can be transported laterally up to hundreds of kilometers into deep-ocean settings in water depths of thousands of metres. Perhaps the most spectacular example of this kind of reworking of shells is the well-known Pleistocene 'Black Shell Turbidite' of the Hatteras Abyssal Plain, documented by Orrin Pilkey and coworkers (Elmore et al., 1979; Pilkey and Curran, 1986; Prince et al., 1987). In this instance, blackened estuarine mollusc shells were displaced >500 km from the continental margin of North America to water depths of >5000 m.

The turbidite literature is vast and contains many less dramatic examples of displaced shallow-marine skeletons, usually only mentioned in passing or simply plotted on stratigraphic columns without much explanation. We assume that deep-sea shell beds, when they do occur in turbidite successions, resulted from redeposition of material derived from shallow water, upslope settings via sediment gravity flows. This assumption may not always hold true. A review of all such concentrations of macro-skeletal material in deep-ocean deposits, especially for siliciclastic deposits, would be a valuable contribution to taphonomy.

In modern deep-ocean environments, skeletal or 'shelly' deposits consisting of the indigenous benthos may be produced in several special—and often localized and ephemeral—settings, including lithoherms and other localized organic buildups,

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doi:10.1016/j.palaeo.2007.11.009

hardground patches, associated with wood and deadfalls of large vertebrates, and in the vicinity of cold/chemical seeps and hydrothermal vents (Gage and Tyler, 1991). Although shells made of $CaCO_3$ have limited preservation potential below the carbonate compensation depth (CCD), other kinds of skeletal material could occur as concentrated deposits owing to reworking by normal bottom currents and by episodic sediment gravity flows. I know of few published examples, however, of level bottom deep-ocean deposits containing laterally extensive (bedded) concentrations of indigenous macroscopic skeletons—comparable to the shell beds of shallow-marine deposits made of minimally reworked skeletons. Uncommon occurrences of the skeletal fossil accumulations associated with special settings and conditions, like those mentioned above, have been documented in the fossil record (e.g., Sheehan, 1977; Haymon et al., 1984; Hickman, 1984; Goedert and Squires, 1990; Hogler, 1994; Walker and Voight, 1994; Walker, 2001; Amano, 2006; Campbell, 2006; and references therein). But with respect to one of the most common forms of deep-ocean sediments, siliciclastic turbidites of abyssal and hadal environments, fossil occurrence of skeletal beds (not merely stringers or pavements the thickness of a single skeleton or skeletal fragment) consisting exclusively of the *indigenous benthic macrobiota* has rarely been documented (e.g., Simpson, 1969).

In this paper I describe a blanket-shaped concentration of giant bathysiphonid foraminiferans in a fine-grained, thin-bedded turbidite. Although concentrations such as this are not exactly like the shell beds of more familiar shallow-marine successions (in terms of organisms involved, shell composition, depositional setting, etc.), they may be considered as deep-sea counterpart of such deposits—the closest thing to level bottom, laterally extensive shell beds occurring at the deep-ocean floor below the CCD. And considering the great abundance and broad distribution of bathysiphonids in deep-marine settings (Gooday, 1983, 1988; Gage and Tyler, 1991; Levin, 1991; Gooday et al., 1992, 1997), and the enormous amount of turbidite sediment deposited in deep-ocean basins, the kind of fossil deposit that I describe may not be uncommon.

## 2. Geologic setting

The bathysiphonid 'shell bed' occurs in Early Cretaceous turbidites of the Franciscan Complex, exposed in a roadcut 500 m south of the abandoned Coast Guard Station at Point Saint George, northernmost coastal California (Fig. 1). The rocks in this area are part of the Yolla Bolly terrane, consisting here of mostly thick-bedded turbidite sandstones (Aalto and Murphy, 1984; Aalto, 1989a,b). Although the sedimentary rocks at Point Saint George are texturally unreconstituted, lateral continuity of beds and sequence thickness are limited by complex faulting, producing a broken formation structural pattern visible in the roadcut exposure. The bathysiphonid bed occurs in a block of dark-gray, thin-bedded turbidites (mostly Facies D in the traditional classification of Mutti and Ricci Lucchi, 1978; Facies C2.3 in the more recent scheme of Stow, 1986; Pickering et al., 1989), structurally enclosed in light gray, thick-bedded sandstone turbidites (mostly Facies B).

Miller (1993, p. 13–15) interpreted the thin-bedded turbidites as an interchannel or interlobe deposit associated with a large sand fan located in a trench slope or possibly trench floor setting. The thin-bedded deposits probably represent a muddy bottom area on a dominantly sandy submarine fan that was occasionally blanketed by sandy turbidity currents spilling over channel margins or spreading outward from a suprafan lobe. Thickness of the sandstone–mudstone couplets ranges from 2.6 to 20.0 cm (averaging 10.4 cm); beds are generally flat-bottomed, laterally continuous, and consist of $T_{cde}$ and $T_{de}$ Bouma divisions. The sandstone:mudstone ratio is about 1:3. Miller (1993, fig. 8 and table 1) identified 17 pre-turbidite and 9 post-turbidite ichnotaxa from the Facies D deposits. These included the deepwater graphoglyptids *Belorhaphe zickzack*, ? *Cosmorhaphe* isp., *Glockerichnus* cf. *glockeri*, *Lorenzenia apenninica*, *Lorenzinia* cf. *moreae*, *Megagrapton irregulare*, *Squamodictyon squamosum* and *Strobilorhaphe* cf. *clavata*.

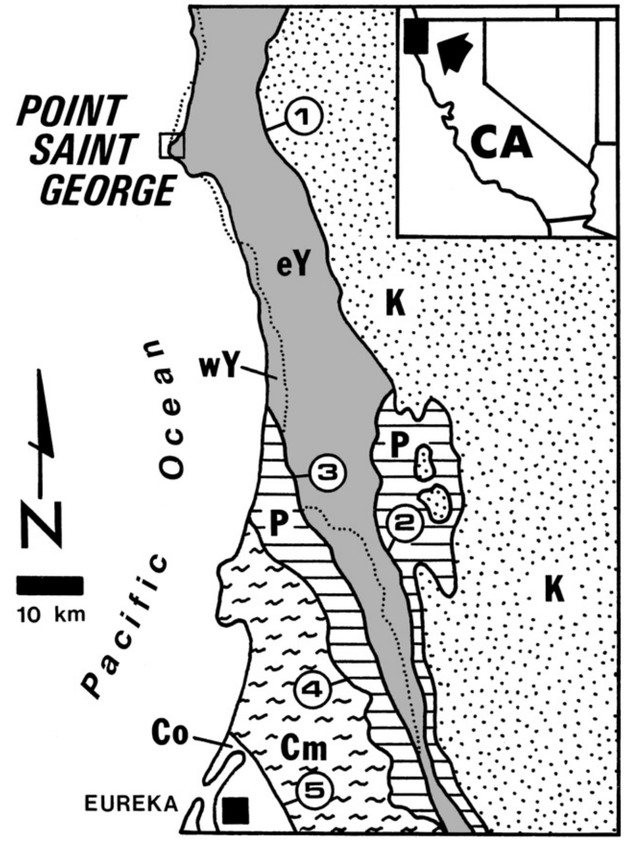

Fig. 1. Map showing location of Point Saint George and major geologic features of the region. Tectonostratigraphic terranes include (K) Klamath Province undifferentiated, (P) Pickett Peak, (eY and wY) eastern and western belts of the Yolla Bolly, (Cm) Central mélange, and (Co) Coastal. Major bounding faults are (1) Coast Range, (2) Redwood Mountain, (3) Grogan, (4) Bald Mountain, and (5) Coastal belt. (Based on Aalto, 1989a.)

The only body fossils found in these beds are the tests of the giant astrorhizacean foraminiferan, *Bathysiphon aaltoi* Miller, 1986. These huge foraminiferans occur as scattered, barrel-shaped fragments a few mm in length in the sandstone layers and as nearly complete tests over 100 mm long in the mudstone divisions (taphonomy and ecology described in Miller, 1988, 1991, 1993, 1995a, 2005b). In one bed within the block of Facies