Classification and Geological Significance of Biostromes

Stephen Kershaw, London

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SUMMARY

Biostrome and bioherm were described as terms by CUMINGS (1932), and bioherm has become synonymous with reef because of the discrete mound or lens shape in vertical section. The phrase “reefs and biostromes” is common in the literature and emphasises that biostromes are normally regarded explicitly as not reefal structures, because of the lack of topographic relief and common absence of a framework. However, the position adopted here is that bioherm and biostrome are most usefully applied to simply describe the outline shape of an organic accumulation, and not to denote any particular inherent internal structural organisation. Furthermore, the view here is that biostromes are most usefully considered as single organic layers (i.e. beds). Observations of biostromes of numerous ages and settings indicate that a considerable variety of internal structure exists within the outline which defines biostrome. Often, the structure comprises frameworks and dense clusters of in-place organisms and is just as much “reefal” as similar constructions with a biothermal shape. In other cases biostromes consist of beds of skeletal debris consistent with the concept of biostrome used by many workers. These differences demonstrate that classification of biostromes is needed in order to allow comprehensive palaeoenvironmental analysis, and highlight the long-standing problem of using ‘reef’ to describe organic buildups. For biostromes, autobiostrome, autoparabiostrome, and parabiostrome are introduced to describe a continuum from structures where the constructing organisms are mostly in place (autobiostromes), to mostly debris of the structure (parabiostromes), with autoparabiostrome as intermediate. Allobiostrome describes biostromes formed of material derived from allochthonous sources, for example skeletal plankton sedimented onto the sea bed. Most biostromes are of calcareous construction and their composition is most adequately described by existing limestone classification terminology.

Other descriptive terms include: a) for biostrome geometry - ribbon and sheet; b) for internal layering - internally unbedded and internally bedded, because some biostromes show lateral facies changes resulting in single layers becoming internally divided by bedding; c) for internal packing variation of constructors, using terminology introduced by R. Riding - dense (where constructors are closer together than one unit distance), and sparse (where constructors are more distantly spaced). Biostromes are further categorised to account for thickness variations. Adaptation of terminology used for bed thickness descriptions is applied; standard bed thickness categories are not appropriate to biostromes, which are often thicker than 1m. Instead: Very thin biostromes - up to 0.1m, thin biostromes - 0.1-0.5m, medium biostromes - 0.5-2.0m, thick biostromes - 2.0-5.0m, very thick biostromes - >5.0m. Autobiostromes which form significant features in sedimentary successions may be regarded as the peak of in place benthic organic skeletal buildup (= reef sensu lato) development, and their recognition is required to permit full palaeoenvironmental analysis of facies containing them. Particular emphasis may be placed on their role in identifying sea level change in shallow water carbonate sequences, and thence their utility in models to explain such change.

Address: Dr. S. Kershaw, Palaeobiology Research Unit, West London Institute, Borough Road, Isleworth, Middlesex, TW7 5DU, U.K., Fax: 081-569-9198
1 INTRODUCTION

The term bioherm was introduced in a footnote by Cumings & Serock (1928: 599) and later, Cumings (1932) fully defined bioherm, and introduced biostrome to describe bedded organic accumulations which do not have a lens or mound morphology, therefore distinct from bioherns (Fig.1). Cumings (1932: 334) emphasised that 'biostrome means literally an organic layer' (his italics). As a result of the detailed discussion by Cumings (1932), which focused on problems of reef terminology, a generally agreed synonymy between bioherm and reef as terms has since developed, which usually excludes biostrome from anything reefal in the minds of most workers. Biostrome has become chiefly a description of debris beds of skeletons; see examples in the reef review of Fagerstrom (1987).

Cumings (1932: 347) primarily regarded biostromes as comprising sedimentary organisms, and included features such as crinoidal debris beds, shell beds and even coal seams, but extended the usage to encompass layered accumulations of pelagic microfossils. Unfortunately, the definition provided by Cumings is so broad that it is possible to include all layered organic deposits under this term, so that it is therefore open to interpretation. For example, James (1983: 379), in contrast to the use of the term by other authors to denote debris bands, illustrates a stromatolite biostrome, composed principally of in situ sheets and domes of stromatolites. Furthermore, in James' (1983: 372, Fig. 57) illustration of the concept of bioherm and biostrome, biostromes are described as made of 'generally in-place carbonate skeletons'. Thus, the conclusion that can be drawn is that biostrome has been applied both to structures with in-place skeletal growth, and with debris. However, this broadness allows an opportunity to classify and highlight the potential importance of some biostromes in palaeoenvironmental analysis. Thus some biostromes are composed of largely in situ organisms as a sheet-like buildup, sometimes with a frame. Examples are: Proterozoic stromatolite biostromes illustrated by James (1983), Silurian biostromes of Gotland (e.g. halystitids-Nield 1981, stromatoporoids and algae- Riding & Watts 1991), Carboniferous biostromes of Britain and America (e.g. chaetetids-Johnson 1958, Connolly et al. 1989, Vosgei 1992), and Cretaceous biostromes (e.g. rudist bivalves-Kaufman & Sohl, 1979, Skelton 1979). Other biostromes are clearly debris (e.g. phylloid algae, Toomey 1976), while still others are a mixture of in place and broken skeletal material (e.g. stromatoporoids, Kano 1990, Kershaw 1990), see PI. 9. Thus, biostromes composed of in situ skeletons could be regarded as reefal, but the purpose of this paper is not to re-examine the problem of defining reef as a term in relation to biostromes (see Flegel & Flegel-Kahler 1992 for database of the great variety of reefs through time, in which biostromes are included, also Bratkhwatte 1967, Heckel 1974). Instead, the aim is to appraise Cumings' definition of biostrome as a descriptive term, and discuss its utility, a topic which has received little attention in the literature. A classification of biostromes is presented, for international discussion, to sharpen the practical value of the term biostrome, and to aid interpretation of biostromes in facies analyses. Several terms which emphasise various attributes of biostromes are introduced to highlight crucial variations. The geological importance of biostromes is emphasised; this paper contends that some biostromes played a significant role in shallow water facies development, and may be of value in formulation of models of even global magnitude where they occur at critical stratigraphic levels. For example, the potential relevance of biostromes to a recent model of oceanographic processes applied to the Silurian is highlighted. The overall conclusion is that exclusion of some biostromes from such models may lead to incomplete analysis.

Although biostromes are common features in modern environments in that shell beds are commonplace, modern reefs with a biostome shape are not recognised so easily, probably partly due to the paucity of vertical sections of modern reefs. The result is that there are no satisfactory analogues amongst Recent reefs and reef-associated deposits for fossil biostromes, the interpretations of which therefore rely on sedimentological study.

2 BIOSTROME VS BIOHERM

Cumings (1932: 333) used bioherm to describe '... reeflike, moundlike, lenslike or otherwise circumscribed structures of strictly organic origin, embedded in rocks of different lithology, and biostromes as organic features which are ... purely bedded structures. ... not swelling into moundlike or lenslike forms' (Cumings 1932: 334), a point noted by other authors, e.g. Johnson (1958). In situations where the structures developed by in situ organic growth across a surface, it is the way in which the surface aggrades in relation to various environmental controls, which leads to either form. Cumings did not provide detailed criteria for the morphological boundary between bioherm and biostrome, but in a review, Fagerstrom (1987: 15) emphasised that biostromes have essentially flat and parallel upper and lower surfaces. There is a problem of scale here, because biostromes rarely have flat surfaces when seen in detail, and the upper and lower surfaces may be parallel (in strict geometric sense) in only certain parts of the structure. When viewed from a sufficient distance, however, biostromes normally have approximately flat basal and top surfaces, which are usually approximately parallel, and usually interbedded with other rocks. Therefore most biostromes are conformable with beds above and below, do not display sediment

Fig. 1. Stylistical vertical sections of outline shapes of bioherm and biostrome, following Cumings' (1932) definition. Note the general conformity of biostrome form with subjacent and superjacent sediment, in contrast to the bioherm.