35. FUSED CLUSTERS OF THE CONODONT GENUS *BELODINA* ETHINGTON FROM THE THUMB MOUNTAIN FORMATION (ORDOVICIAN), ELLESMERE ISLAND, DISTRICT OF FRANKLIN

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Abstract

Two fused clusters of the Ordovician conodont species **Belodina compressa** *(Branson and Mehl) are described from the Thumb Mountain Formation on Ellesmere Island. The specimens each consist of two elements, but differ in elemental composition. A previous report of the species as a fused cluster shows profound differences in arrangement and size distribution of the fused elements. Comparison with this and other known fused clusters suggests that the examples from the Thumb Mountain Formation are not representative of the geometry of the species' apparatus, despite being composed of elements belonging to the species. It is suggested that the fusion may be of diagenetic origin.*

Introduction

Upon death of a conodont animal, the skeletal apparatus usually became disaggregated, and most collections of conodonts are of these disassociated, discrete elements. Hinde (1879) proposed the multielement concept of a conodont species. He suggested that an individual conodont animal contained one or more different element morphotypes, but it was not until the discovery of natural conodont assemblages from Carboniferous black shales in Germany and the United States (Schmidt, 1934; Scott, 1934) that the proposal gained widespread approval. In recent years, major advances have been made in the recognition of natural conodont species from disaggregated samples. These reconstructions are based on several lines of evidence including stratigraphic co-occurrence of elements, symmetry transitions between generally similar elements, and upon similarity of size, colour, denticulation, surface ornamentation, basal cavity and white matter distribution (for a review see Sweet and Bergström, 1972). Gradually, basic templates and concepts of genera and species have developed from both empirical and numerical studies of large collections (e.g. Bergström and Sweet, 1966; Kohut, 1969). Despite considerable success with apparatus reconstruction from discrete elements, perhaps the only unequivocal evidence is available through natural assemblages.

Assemblages of conodont elements occurring on shale surfaces may represent individual conodont animals; others may be coprolitic associations. In addition to the Carboniferous occurrences, assemblages are also known from the Cambrian (Miller and Rushton, 1973; Müller and Andres, 1976) and Devonian (Lange, 1968; Mashkova, 1972; Nicoll, 1977). Using the pattern of arrangement and numerical ratios of elements in the assemblages, it has been possible to reconstruct the apparatus of several conodont species. The number of taxa known from these assemblages is rather few, however, and none is recorded from the Ordovician.

The rarest type of natural association is the so-called fused cluster that may be found in residues of acidized samples. The preservation potential of this type of natural association is poor, considering the number of processes, both laboratory and taphonomic, to which the sample may have been subjected. Fused clusters have been reported from the Cambrian (Landing, 1977), Ordovician (Barnes, 1967), Silurian (Rexroad and Nicoll, 1964; Pollock, 1969), Carboniferous (Austin and Rhodes, 1969) and Triassic (Ramovs, 1978). With the exception of Landing (1977), Pollock (1969) and Ramovs (1978) these studies dealt with only one or two specimens. This report is concerned with two fused clusters of the species **Belodina compressa** (Branson and Mehl). The specimens are described and compared with the fused cluster of the same species described by Barnes (1967) from the Cobourg Formation, at Ottawa. The Cobourg is now considered Edenian (Sweet and Bergström, 1971) and so the locality is of Upper Ordovician age.

Locality and Age of Sample

The sample that yielded both specimens is from the Thumb Mountain Formation (Kerr, 1967a) in a section measured near the head of Svarte Fiord, Ellesmere Island (77°17'N; 84°24'W). The section is described by Kerr (1967b, p. 90) as section 45, and further description is available in Nowlan (1976) wherein the sample is described as #152. The Thumb Mountain Formation is characterized by massive, rusty weathering, locally grey-brown, calcisiltites and fine calcarenites. Sample 152 was taken of dark grey, massive, rubbly weathering calcisiltite, 55 m below the contact of the Thumb Mountain Formation with the overlying Irene Bay Formation.

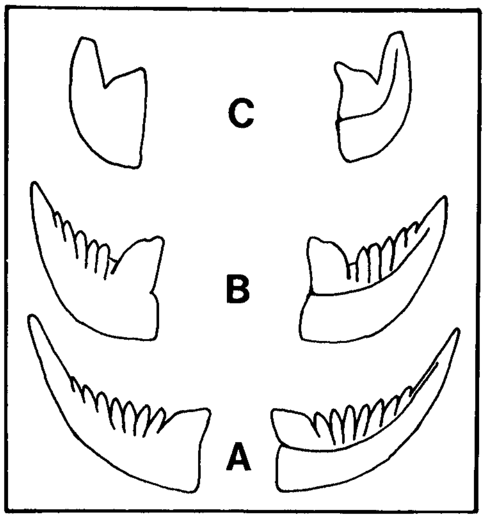

Figure 35.1. *Sketches of the component morphotypes of* **Belodina compressa** *(Branson and Mehl) as suggested by collections of disjunct elements. Outer and inner lateral views of: A., grandiform element (* **B. grandis** *Stauffer s.f.); B., compressiform element (* **B. compressa** *(Branson and Mehl) s.f.); C., eobelodiniform element (* **Eobelodina fornicala** *(Stauffer) s.f.).*

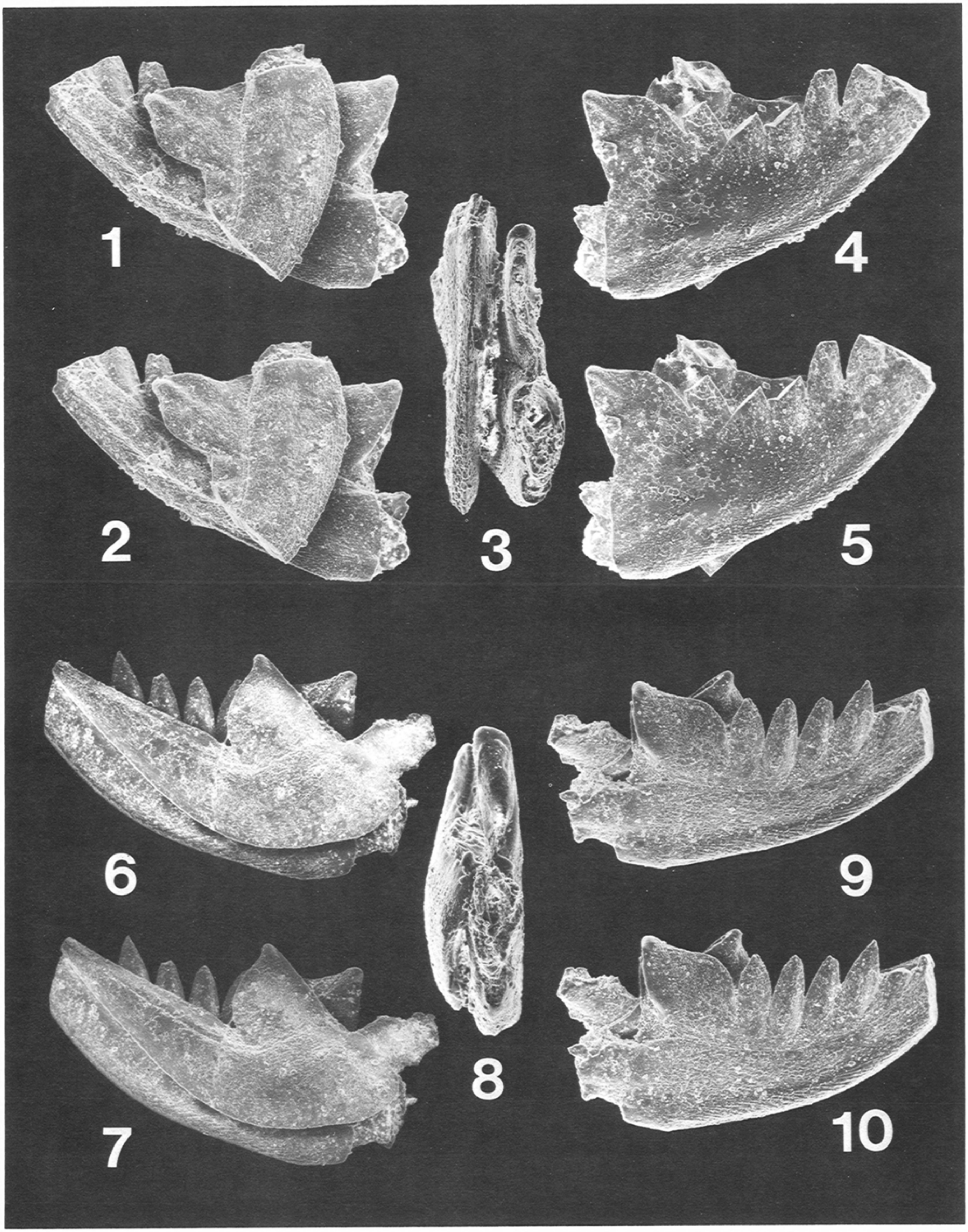
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Plate 35.1. *(facing page)*

Fused clusters assignable to **Belodina compressa** *(Branson and Mehl). Stereopairs photographed at tilts of 10° and 20°.*

Figures 1-5. *1,2. Inner lateral view, stereopair, X120; probable compressiform element fused on a grandiform element. Note 90° rotation of compressiform relative to grandiform element.*
3, basal view, X200; shows basal opening of grandiform element and anterior margin of compressiform element.
4,5, outer lateral view, stereopair, X120; shows outer lateral side of grandiform element largely obscuring the underlying compressiform element. Specimen deposited as: GSC 59981; from the Thumb Mountain Formation, Ellesmere Island.

Figures 6-10. *6,7. Inner lateral view, stereopair, X120; eobelodiniform element fused on a grandiform element. Note that the cusps are subparallel.*
8, basal view, X200, shows basal opening of grandiform element; basal filling of eobelodiniform element obscures most of the basal opening of that element.
9,10, outer lateral view, stereopair, X120; shows grandiform element on eobelodiniform element. Specimen deposited as GSC 59982; from the Thumb Mountain Formation, Ellesmere Island.

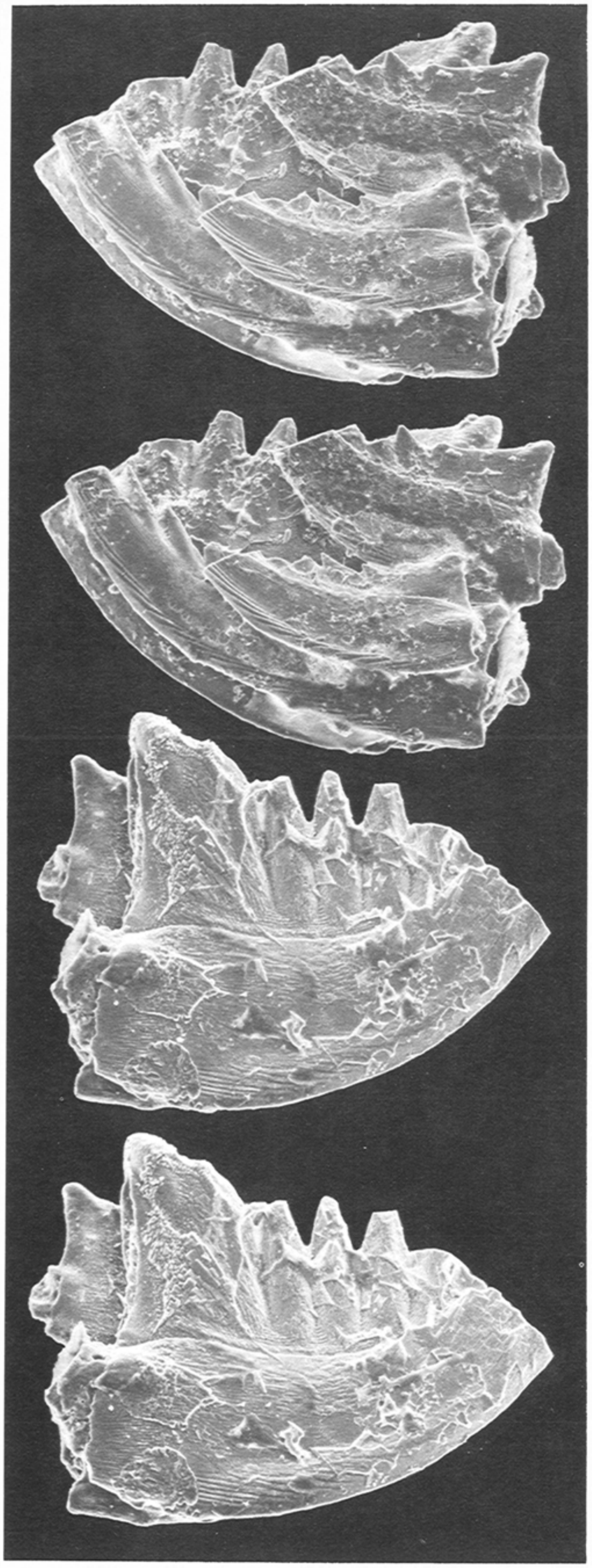

Figure 35.2.

Stereopair lateral views of the **Belodina** *assemblage reported by Barnes (1967, Text-fig. 2), from the Cobourg Formation (Upper Ordovician) at Ottawa; GSC 21396, X200; pairs photographed at tilts of 10° and 20°. Compare this specimen with the two illustrated on Plate 35.1.*

Regionally, the Thumb Mountain Formation ranges in age from Blackriveran at the base to late Edenian or early Maysvillian at the top, and is about 350-400 m thick. Species recovered from the sample, in addition to the fused cluster, include: **Belodina compressa** (Branson and Mehl), as disjunct elements, **Drepanoistodus suberectus** (Branson and Mehl), **Panderodus gracilis** (Branson and Mehl), **Paroistodus? mutatus** (Branson and Mehl) and **Plectodina tenuis** (Branson and Mehl). The fauna is largely undiagnostic although the presence of **P. tenuis** suggests an age younger than Kirkfieldian. Based on the high stratigraphic level of the sample, and on conodont data from elsewhere (Barnes, 1974; Nowlan, 1976), the upper Thumb Mountain Formation is probably late Shermanian to early Edenian in age. Fossils, other than conodonts, were absent from the sample locality and enclosing strata.

Nature of the genus *Belodina* Ethington

Ethington (1959) proposed the genus **Belodina** as a form genus to include elements with crowded, blade-like denticles on the posterior margin, a deep basal cavity and an expanded basal portion termed the heel. Bergström and Sweet (1966) revised the genus to multielement status and showed that the apparatus of the type species (**Belodina compressa**) consisted of belodiniform and eobelodiniform elements. This reconstruction has been followed by most authors (e.g. Sweet et al. 1975; Barnes, 1977). The apparatus of the type species consists of three types of elements: an elongate, broadly curved, slender, denticulate element (grandiform); a more tightly recurved, broad, denticulate element (compressiform), and a sharply recurved element, lacking denticles between cusp and heel (eobelodiniform) (Fig. 35.1). These elements can be viewed as a symmetry transition series with progressively increased recurvature. Other species of **Belodina** do not seem to follow this apparatus plan. Several lack an eobelodiniform element (e.g. **B. dispansa** Glenister), and others show a more complex group of morphotypes (e.g. **B. profunda** (Branson and Mehl)). A more detailed discussion of the variability within the genus **Belodina** is available in Nowlan and Barnes (in press).

Description and Interpretation of the Material

The fused assemblages reported here, show two different associations. The first (GSC 59981, Pl. 35.1, figs. 1-5) consists of a probable compressiform element fused to a grandiform element, and the second (GSC 59982, Pl. 35.1, figs. 6-10) consists of an eobelodiniform element fused to a grandiform element. The compressiform element of specimen 59981 is broken close to the heel and could possibly be a second grandiform element, but seems to possess a tight curvature of the anterior margin.

The two specimens differ not only in composition but also in the relative orientation of the elements. In the eobelodiniform-grandiform association, the elements lie with cusps virtually parallel; the difference in the angle of their basal openings being equivalent to the degree of recurvature of the specimens (Pl. 35.1, figs. 6, 7). In the compressiform-grandiform association, the compressiform element is rotated, so that its basal opening is at about 90° to that of the grandiform element (Pl. 35.1, figs. 4, 5).

Despite differences in composition and orientation of the two specimens, some similarities may be noted. Both specimens have elements of similar relative size; the eobelodiniform of one and compressiform of the other are slightly smaller than the grandiform elements to which they adhere. In addition, the inner lateral grooves of both elements in each specimen are similarly oriented, so that the inner lateral face of each grandiform element is fused to the outer lateral face of the associated element.

These clusters of **B. compressa** recovered from the Thumb Mountain Formation, differ radically from the fused cluster of the same species described by Barnes (1967) and reillustrated in this paper (Fig. 35.2) using SEM techniques. In Barnes' material, four specimens are stacked in an orderly fashion, with basal openings approximately parallel. The elements decrease in size from one side of the cluster to the other. Only grandiform and compressiform elements are fused together and no eobelodiniform elements are present either in the fused cluster, or among the discrete elements recovered in the same sample (Barnes, 1967, Table 1). Thus Barnes' (1967) specimen differs from the Thumb Mountain specimens in the following aspects: (a) composition: Barnes' (1967) specimen lacks any eobelodiniform elements; (b) size: the size differential from one side of the apparatus noted for Barnes' specimen is not exhibited by the Thumb Mountain specimens. These profound differences between the two reports of **B. compressa** clusters, bring into question the reliability of this type of association as a basis for apparatus reconstruction and interpretation. In both cases the elements fused together are elements that independent evidence has suggested belong together in the apparatus. However, the orientation, size and proportions are markedly different, which is surprising considering the two samples are of about the same age.

Examination of discrete elements of **B. compressa** in prolific samples, suggests a ratio of eobelodiniform elements to belodiniform elements of about 2:8 for the species (see Barnes, 1967, p. 1559 for discussion). As noted above, Barnes' (1967) specimen lacks an eobelodiniform element leading him to conclude (p. 1559) that "four pairs of **B. compressa** lie behind a single pair of **E. fornicala**", in the species. In the Thumb Mountain sample, additional discrete specimens of eobelodiniform and belodiniform elements of **B. compressa** are present in a 2:8 ratio (4 eobelodiniform, 16 belodiniform).

As there is little similarity between the two occurrences of fused clusters of **Belodina**, they do not clarify the nature and geometry of the apparatus. Examination of the discrete elements which belong to **B. compressa** indicates a symmetry transition from the grandiform element through the compressiform element to the eobelodiniform element. One might expect this transition series to be reflected in the geometry of the apparatus. The Cobourg specimen does show two grandiform elements stacked upon two compressiform elements which may be natural, but in one specimen from the Thumb Mountain Formation (GSC 59981), the two end members are juxtaposed; the latter situation suggests that the cluster may not be a natural one.

Comparison of the Thumb Mountain fused clusters with those of other ages, indicates some other dissimilarities. In the Cambrian examples of **Prooneotodus tenuis** (Müller), a definite size increase of elements suggests a progressive addition of new elements with growth (Landing, 1977). The **B. compressa** apparatus of Barnes (1967) also shows marked size gradation of elements, and the same is true for the Carboniferous cluster described by Austin and Rhodes (1969). Carls (1977) has recently advocated that conodont elements could be lost and replaced through life. This juxtaposition of elements of divergent sizes may be support for such a hypothesis.

It seems likely that the fused clusters recovered here do not represent the true geometry of the **B. compressa** apparatus. The question arises as to the mode and location of fusion. To have survived the sample preparation process (dissolution in 15% acetic acid, sieving, and separation with tetrabromoethane and a magnetic separator) the specimens must have been securely cemented together. Attempts to determine the nature of the cement by using an X-ray energy spectrometer in conjunction with a scanning electron microscope were inconclusive. Emissions from the deep groove between the specimens were erratic, probably because they were effectively shielded by emissions from the specimens themselves. Certainly, no excess cementing material is visible and it may be that the fusion was effected through the soft tissue of the animal, or by diagenesis.

The preservation of the fused clusters and the discrete elements associated in the sample is the same. All specimens are reasonably well preserved, with only minor denticle breakage and a conodont colour alteration index of 1.5 (Epstein et al., 1977). This similarity of preservation eliminates the possibility of any special origin for the fusion as a result of heat or compression.

The question arises as to when and why fusion takes place. Rexroad and Nicoll (1964), Barnes (1967), Pollock (1969) and Austin and Rhodes (1969) have all suggested that fusion might be the result of a pathologic condition. It is to be expected that a disease would affect all individuals in a similar manner resulting in similar fused clusters. Although a pathologic origin is possible for some fused clusters, it is viewed as unlikely in the case of the Thumb Mountain specimens, for the following reasons. Firstly the composition of the two clusters is different, suggesting some element movement, and secondly they are different from the other report of the species suggesting a different origin. The fusion is more likely to be a result of some diagenetic process involving local phosphate mineralization, such as Landing (1977) has suggested for Cambrian examples. Even a diagenetic process favours fusion of elements related in the same apparatus, but the time lapse between death of an animal and fusion of elements will influence the natural appearance of the cluster. Those elements fused early in diagenesis, prior to disturbance, may resemble the original geometry of an apparatus in whole or in part, whereas those fused later may become rearranged in 'unnatural associations'. The diagenetic origin is not advocated for all fused clusters, but it is suggested that a pathologic condition resulting in some genetic defect would affect all individuals in the same manner and therefore produce similar clusters.

Conclusions

The fused clusters of **B. compressa** recovered from the Thumb Mountain Formation differ considerably from a fused cluster of the same species described by Barnes (1967). They are probably a result of diagenetic fusion, and as such, may not reflect the geometry of a **B. compressa** apparatus. The specimens contribute little to the understanding of Ordovician conodont apparatus geometry, but provide a caution to the interpretation of future occurrences of fused clusters as necessarily natural associations.

Acknowledgments

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The figured specimens were photographed in stereoscopic pairs on an Etec Autoscan SEM, at 10° and 20°.

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