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A technique for conodont histology

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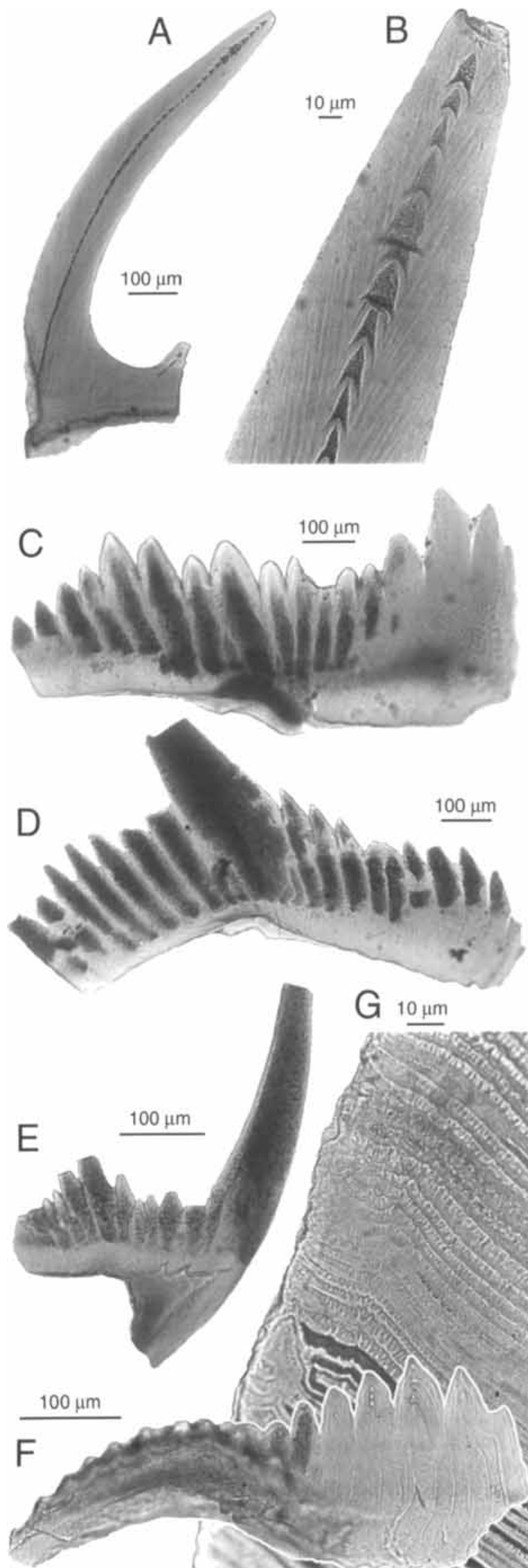
More than thirty years have passed since Lindström (1964) suggested that the internal structure of conodont elements was potentially of greater taxonomic significance than external morphology. However, although this sparked new interest in the study of conodont hard tissues, leading to the seminal works of Müller & Nogami (1971) and Bengston (1976), Lindström's expectations were never tested. The reason for this surely lies with the difficulty in studying the microstructure of conodont elements, which requires that thin sections are manufactured. This process is both laborious and fraught with technical difficulties that can only be overcome with experience.

The recent renaissance in conodont hard-tissue histology has demonstrated not only the homology of conodont hard tissues with those of vertebrates (Sansom *et al.* 1992, 1994; Sansom 1996; Smith *et al.* 1996; Donoghue, in press) but also the potential utility of distinguishing growth patterns in conodont elements (Donoghue, in press). However, Lindström's expectations will only really be tested if a quick and cheap technique for the study of conodont hard tissues can be developed. One such technique has been utilized for many years to great success in the histology of scales and teeth of vertebrates less contentious than conodonts (e.g., Karatajūtė-Talimaa 1978; Karatajūtė-Talimaa & Predtechenskyj 1995), and a similar technique was proposed for studying conodont microstructure by Branson & Mehl (1933, p. 16). The technique requires immersion of the study material in a liquid of similar refractive index, thus rendering the material transparent and allowing the internal structure to be readily viewed in transmitted light. Conodont elements are composed of apatite, which has a refractive index (RI) of about 1.63–1.66. Standard immersion oils used in microscopy have a RI close to the ideal, and practice has shown that there is little gain in going to the great expense of obtaining an immersion oil with a specific RI. Suitable oils include Agar Fractoil, clove oil, and oil of anise (used by Karataj té-Talimaa 1978), and anise oil in conjunction with xylol (in a proportion of one-to-four), a medium used by Branson & Mehl (1933). However, the immersion oil must be of high viscosity or surface tension, so that it does not flow away from the specimen during study.

Specimens should be mounted on a glass slide and bonded to the surface using a water-soluble glue such as gum tragacanth, thus preventing a specimen from moving around while under study. The mount should then be allowed to dry before being immersed in a small droplet of immersion oil. It is often preferable to spread the oil so that the meniscus just overlies the highest point of the specimen – this prevents oiling the lenses. The specimen can then be studied using a standard transmitted-light microscope for high magnification (Fig. 1A–G) and a reflected-light microscope for lower magnification; differential interference contrast optics are particularly recommended because they increase apparent relief in microstructural features such as growth increments. After study, specimens can be recovered undamaged by cleaning with a picking brush in a small bath of solvent such as ethanol or acetone.

This technique is particularly useful for the study of elements which do not have plane of symmetry and are thus very difficult to thin section (e.g., Fig. 1C). Similarly, where some elements are extremely thin and



the angle at which a thin section is cut is critical, the problem is obviated by oil-immersion study (e.g., Fig. 1E). Furthermore, because complete elements can be studied in this way, problems such as cut-effect are avoided. This technique is also preferable to others in instances where the material is rare or important for reference, such as with type or figured specimens. However, this technique should not replace study of conodont hard tissues by thin-section, as both techniques have advantages and disadvantages. For instance, in some taxa tissue types cannot be distinguished unless elements are sectioned, etched and examined in a scanning electron microscope. Nevertheless, the simplicity of this technique should encourage others to enter into the fray of conodont hard tissue histology with the hope of fulfilling Lindström's prophecy.

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Fig. 1. □A. Cusp of an S element of '*Ligonodina*' in oil; the albid core of pseudo-white matter is rendered transparent in transmitted light. BU 2678. □B. Detail of the cusp tip in A; the hollow growth cavities and orientation of the crystallites can clearly be discerned. □C, D. Pa and Pb elements, respectively, of *Ozarkodina confluens* in oil, showing the distribution of white matter and internal discontinuities. BU 2679 and BU 2680. □E. Sc element of *Carniodus* showing the distribution of white matter and the multiple basal cavities, each underlying separate structural units of the crown. BU 2629. □F. Juvenile Pa element of *Idiognathodus* in oil, exhibiting internal growth increments in the lamellar crown tissue of both the platform and blade. BU 2681. □G. Detail of the blade of a gerontic Pa element of *Idiognathodus* in which individual crystallites can be discerned. BU 2682.