Resolution Revolution: Advances in Palynostratigraphy Over Three Decades

Dennis R. Braman, Royal Tyrrell Museum of Palaeontology, Box 7500, Drumheller, Alberta, T0J 0Y0, dennis.braman@gov.ab.ca

Significant improvements in the ability of palynology to solve stratigraphic problems in the Upper Cretaceous-Paleocene strata of the southern part of the Alberta Basin have been made over the last three decades. This progress has developed in conjunction with similar improvements in other correlation tools including radiometric dating, strontium isotope dating, magnetostratigraphy, lithostratigraphy, and ammonite biostratigraphy. It is the purpose of this presentation to select a few representative examples which illustrate some of these advances with emphasis on the palynostratigraphy.

Much of the material used in this research comes from surface exposures with the oldest significant exposures on the plains area being those of the Milk River Formation. Based on comparisons of the paleomagnetostratigraphic results of Leahy and Lerbekmo (1995) compared to those of Europe, Braman (2002) concluded that nearly the entire formation was Santonian in age in Alberta and there was a significant time gap of 2 to 3 million years between the Milk River and overlying Pakowki Formation in southern Alberta. A portion of this missing time interval is accounted for in the upper unnamed member of the Eagle Formation in the vicinity of the Missouri River in Montana between Eagle Creek and the Bearpaw Mountains (Payenberg et al., 2002). This member is entirely marine and represents a transgressive event that is entirely missing from exposures in southern plains area of Alberta. The Telegraph Creek, Virgelle, and Deadhorse Coulee members of the Milk River Formation can be directly correlated with the Telegraph Creek Formation and Virgelle and unnamed middle members of the Eagle Formation in that they have similar palynomorph assemblages. In Alberta, the Virgelle Member has been divided into lower and upper sandstones. Based on palynological studies, the lower sandstone is entirely marine and the upper sandstone is nonmarine as is the entire Deadhorse Coulee Member (Meyer et al., 1998).

Sweet and Braman (1989) described the palynomorphs from a supposed Chungo Member locality of the Wapiabi Formation on the Highwood River in the foothills of Alberta, but it turned out to have an assemblage that is closely comparable to that seen in the Milk River Formation whereas the Chungo Member has an assemblage representing a much younger age. The recognition of two sandstone units in the foothills, with the lower being correlated with the Milk River Formation, has some interesting implications for exploration targets within the basin. Most workers have correlated the Chungo and Nomad members of the foothills with the Milk River and Pakowki formations on the plains to the east. It is now apparent that the Chungo Member is equivalent to a portion of the Pakowki Formation based on palynological studies.

Thirty years ago the only comprehensive palynological studies undertaken on the Belly River-Judith River groups were studies by Tschudy (1973) in Montana and Jarzen (1982) in Alberta. Since the time of these reports, much has been learned about the palynology of the upper part of the groups. Eberth and Hamblin (1993) subdivided the Oldman Formation into the Oldman Formation and Dinosaur Park Formation establishing the contact at a sedimentologically defined disconformity. It is now known that a distinct palynological change occurs in the uppermost Oldman Formation strata and the assemblage in this thin organic-rich unit most closely compares to that seen in the overlying Dinosaur Park Formation. This situation where the changes in palynological assemblages occurs in fine-grained, organic-rich sediments that precedes the arrival of coarser-grained sediments that are used by lithostratigraphers to mark sequence boundaries has been documented from other localities by Sweet et al. (2005) and (Koppelhus and Braman, in press).

Jarzen (1982) reported 85 palynomorph species based on a study of 35 samples from Dinosaur Provincial Park while Braman and Koppelhus (2005) have found 511 species based on a study of 271 samples from the same area, significantly increasing the known diversity. Braman and Koppelhus (2005) also provided information on the ranges of key species across the interval of Oldman Formation to Bearpaw formations that are exposed in Dinosaur Provincial Park. They showed that during Dinosaur Park Formation time there was a great deal of innovation in palynomorph assemblages with a large number of first appearances. This allows a fine-scale biostratigraphic subdivision of the studied interval not available previously. An interval in the lower half of the Dinosaur Park Formation also has an abundance spike of *Translucentipollis plicatilis* Chlonova 1961. This abundance spike has been found at sections in the Battle River, Dinosaur Provincial Park, and Sandy Point areas of Alberta and at Birch Creek near Judith Landing, Montana. Preliminary results suggest that the species is more abundant in the north. Although there is no suggestion of a direct relationship, the position of the spike coincides with the rich bone beds noted in the lower Dinosaur Park Formation in the Dinosaur Provincial Park area. At present, it is uncertain if the spike is exactly the same age in all areas.

In the past, the Bearpaw transgression across Alberta has been thought as a unidirectional and relatively rapid event. Data from the Dinosaur Park area now indicates that this was not a simple event, but rather complicated by a number of short marine pulses. Brinkman et al. (2005) document some of these events from a section at the east end of the park. Marine palynomorphs indicate that the last major coal of the Lethbridge Coal Zone is sharply overlain by a thin marine unit. This thin unit is in turn overlain by a zone of interbedded, plant-rich nonmarine sandstones and mudstones. A second marine interval bearing a marine vertebrate assemblage overlies this zone. At one locality, a marine-filled channel cuts down through these three units. These three units are in turn overlain by a thin nonmarine package of strata which is plant rich and has a minor coal associated with it. Finally, the whole package has been transgressed by a major marine sea that initiates Bearpaw Formation deposition proper. Overall, it is a complex sequence of events that terminated terrestrial deposition in the park area.

The Whitemud and Battle formations are known to provide very poor or no recovery of palynomorphs. From evidence of rooting structures and depositional features, it is known that the contact is erosional although it is not known how much time is involved in this unconformity. Recently, studies along the Red Deer River have revealed that, where the Battle has cut down into the Whitemud, there is a very thin laminated unit that is rich in organic materials. This thin unit appear to infill an irregular surface and well-preserved palynomorph assemblages have been recovered from this unit as documented by Koppelhus and Braman (in press). Hopefully, these assemblages along with radiometric dating studies currently underway will help to constrain the timing issues associated with the Whitemud-Battle contact.

Over time, our understanding of the Cretaceous-Paleocene boundary has changed markedly. Thirty years ago the working definition for the boundary consisted of locating it at the base of the first coal overlying the last dinosaur bone (Brown, 1952). It turns out that this was a relatively accurate way of estimating the boundary. The recognition of a boundary claystone brought about a renaissance in boundary research and in the placement of the boundary. Palynological sampling intervals across the boundary were at first rather coarse measured in metres. Eventually, sampling intervals were reduced to the millimeter scale as attempts were made to improve the resolution of the palynological changes associated with the end of Cretaceous events. At this resolution, it was shown that the 1 to 2 cm-thick boundary claystone could be subdivided into three layers, each with distinct characteristics (Sweet et al., 1999). A series of events appear to mark the boundary interval including an impoverishment of assemblages over a short interval before the boundary, an extinction event within the boundary claystone, a remarkable decrease in the gymnosperms in upper part of the boundary claystone, the presence of a *Cyathidites* fern spike within the upper part of the boundary claystone, the occurrence of a *Laevigatosporites* fern spike above the boundary claystone, and a gradual recovery of the floras through the coal overlying the boundary claystone (Sweet et al., 1990, 1999; Sweet and Braman, 1992, 2001; Braman and Sweet, 1999).

Currently, studies are underway with the goal of defining the palynomorph biostratigraphy for an interval spanning the Turonian to Eocene. This should result in better resolution for utilizing palynology as a biostratigraphic tool in the basin. Potential details of biostratigraphic occurrence are just now being realized. Studies of the Triprojectate pollen group have shown large numbers of first and last appearances in the basin that may one day provide a basis for an even finer resolution level. Initial data shows that first appearances were not gradual, but occur in clusters and extinctions were not uniform and again occur in pulses. One example of this is on data across the Cretaceous-Paleocene boundary in the Northwest Territories (Sweet and Braman, 2001). This data has now been duplicated from a composite section in southern Alberta and a similar pattern emerges where the rates of extinctions increased before the boundary and following the boundary returned to a slower rate again.

There has been an effort to coordinate the palynological data with a number of disciplines. Over the last 30 years, a large number of new radiometric dates have been published by numerous authors and the magnetostratigraphy of the Campanian through Paleocene has also been established. The combination of these data along with the established ammonite zonation and lithostratigraphy, has provided a solid framework for building a unified view for the Upper Cretaceous.

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