Problem Solving Applications of Palynology in Cretaceous and Paleogene Basins, Western Canada

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Introduction

Nichols and Sweet (1993) published the first comprehensive review of a pollen and spore-based Late Cretaceous biostratigraphy for mid-continental North America, including western and northern Canada. The ultimate goals of this and subsequent Albian to Paleogene palynological studies have been to gain an enhanced understanding of biochronologies, paleoclimates and the timing of tectonic and eustatic events. Over the past 30 years data has been accumulated from the Alberta Foreland, Nechako, Sustut, Bonnet Plume and Brackett basins. Of these, three basins are dominantly non-marine; Nechako and Sustut of central and north-central British Columbia, respectively and the Bonnet Plume of east-central Yukon Territories. Central and southern Alberta, and the Brackett Basin of the Northwest Territories have interfingering marine and non-marine strata and the Smoky River/Clear Hills and Buffalo Head Hills areas, in north-central Alberta, are dominantly marine. In this presentation the focus will be on north-central Alberta sections and the Bonnet Plume and Nechako basins. Studies in these areas have supported kimberlite, stratigraphic, sedimentological and mapping activities. Inevitably these applied studies have contributed to increasing the reliability of other palynological applications.

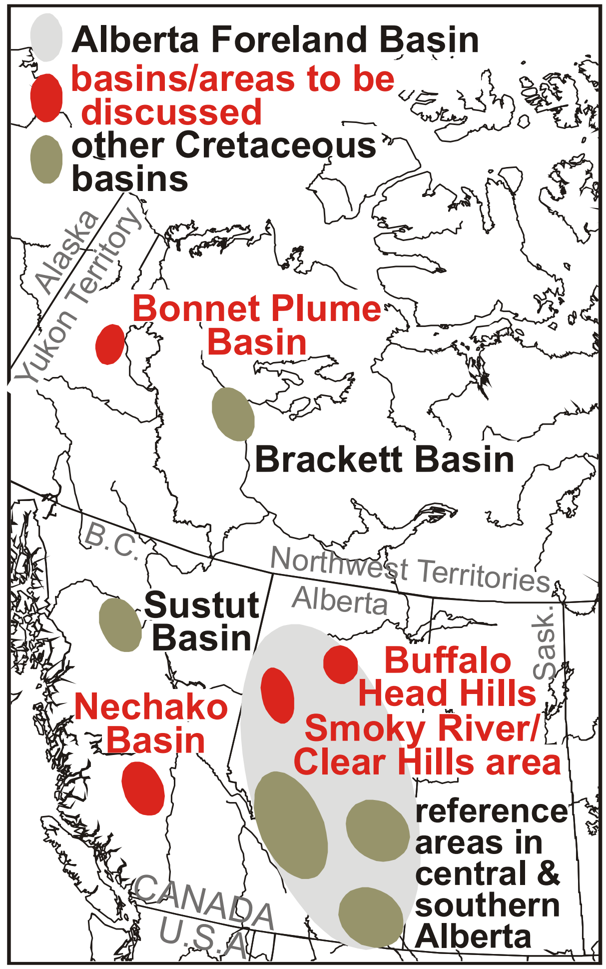

Figure 1. Late Cretaceous and Paleogene basins.

Method

The Upper Cretaceous and Paleogene of Alberta are key to calibrating the ranges of spores, pollen and dinoflagellates. Only here are magnetostratigraphy, radiochronology, and macrofossils available to provide a chronological framework for biostratigraphically significant taxa (Braman, 2010; Braman and Sweet, in preparation; Eberth and Deino, 2005; Lerbekmo and Braman, 2002). This allows the age range of taxa determined in Alberta to be applied to other areas.

Examples of geological applications of palynology in four different regions follow.

Examples

The first set of examples includes developing a stratigraphic framework for the Buffalo Head Hills kimberlite field (Fig. 1) and evaluating kimberlite emplacement models. This was a collaborative study with R. Eccles of (Alberta Geological Survey) and K. Boyce (GSC-Calgary). The combination of radiogenic kimberlite ages (Eccles et al., 2008, b) and palynologically-based ages for the kimberlite host rocks and clastic xenoliths (Sweet et al. 2006) were applied to refining kimberlite emplacement models. The K1A/K1B complex on the southwest corner of Buffalo Head Hills was found to bear characteristics of eruptive volcanoclastic kimberlites. Middle Paleocene, Maastrichtian and Campanian clastic xenoliths were recovered from the Middle Paleocene, 59.6±2.8 Ma kimberlite emplaced in Albian/Cenomanian and Santonian/Campanian host rocks. Post-Campanian host rocks, are represented only by the clastic xenoliths having otherwise been removed by post-emplacement erosion. Four kimberlite intersections in the K252-1 core hole had also been interpreted as a succession of extrusive kimberlites (Boyer, 2005). The finding of a Campanian, 81.3±2.3 Ma radiogenic age for the K252 kimberlite combined with a palynologically-based Albian/Cenomanian host rock age forced the alternate conclusion that the DDHK252-12 kimberlites are intrusive. A second example of intrusive kimberlite layers was confirmed for five hypabyssal kimberlite intersections in the BH2-01 core hole. Here, Albian/Cenomanian host rocks were found inter-layered with 64.1± 3.6 Ma Early Paleocene kimberlites. In this instance, the thermal maturity of the host rock was elevated adjacent to the kimberlite intersections. Campanian strata occur in the upper part of the BH2-1 core. The pattern of Campanian and sometimes upper Santonian host rocks overlying lower Turonian but usually Cenomanian/Albian host rocks was repeated in many cores from the Buffalo Head Hills, which identified the presence of a major unconformity within the area.

The second set of examples comes from a study of the iron-bearing Bad Heart Formation southwest of the Buffalo Head Hills. This study is based on samples collected by Reg Olson and Basant Kafle (under the auspices of the Alberta Geological Survey). Collom (2001) had established an ammonite zonation for a reference section on the Smoky River, spanning Turonian to Santonian strata, which gave an age framework for the palynology. The open marine to restricted marine Bad Heart interval yields abundant dinoflagellates (studied by K. Boyce) but only small numbers of pollen and spores (Núñez-Betelu et. al., 1999; this study). The palynological study: 1) established that the Bad Heart of the Smoky River and Clear Hills areas is coeval; 2) identified one relatively short unconformity at the base of the Bad Heart; 3) recognized, by changes in the composition of dinoflagellate assemblages, open to restricted marine depositional sequences; and 4) provided an ammonite-based age calibration for the ranges of biostratigraphically significant terrestrial spores and pollen. The combined palynological results from the Bad Heart and contiguous strata and the Buffalo Head Hills also confirmed an inverse relationship of uplift and subsidence between the two areas.

The third set of examples is from the Bonnet Plume Basin (Fig. 1). The initial stratigraphic and sedimentological study of the over 1500m-thick, mostly non-marine, Bonnet Plume Formation (Long,1978) was followed by a palynological study to provide an age framework. Nine Albian through Late Maastrichtian palynofloral assemblages were initially recognized (Nichols and Sweet 1993) based on the presence of a unique and diverse array of angiosperm pollen and spores. Nichols and Sweet (1993, fig. 3) concluded a Santonian/Coniacian? to Late Campanian age for the main coal-bearing interval in the southern portion of the basin. This age range can now be updated to Middle Coniacian to early Late Campanian based on the Bad Heart study's calibrations of the age ranges of biostratigraphically significant spores and pollen. The partly coal-bearing Little Bear Formation in the Brackett Basin, NWT falls within a similar age range based on the presence of closely comparable pollen and spore assemblages (Sweet et. al., 1989, Nichols and Sweet, 1993) implying that the Coniacian-Campanian in these northern basins was a time of regionally extensive and probably interconnected coal swamps.

A higher resolution study was subsequently undertaken to palynologically identify individual Coniacian-Campanian coals. This was accomplished using several different rapidly evolving pollen lineages. In doing this, steps in the composition of palynological assemblages, reflecting horizons of concentrated range origins and terminations, were recorded. These steps were interpreted to result from intra-formational unconformities. The stratigraphic position of breaks between successive assemblages occurs within the mudrocks below conglomerates, making this the lithostratigraphic position of the interpreted unconformities in each mudrock, , sandstone, conglomerate, mudrock, coal sequence. This implies the processes involved in the deposition of the conglomerates were non-erosive. Starting with about 10 m of coal and mudstone below the conglomerate, the palynofloral assemblage was found to be correlative with that documented by Braman and Koppelhaus (2005) from the Dinosaur Park Formation of south-central Alberta whose base is dated at about 76.4 Ma (Eberth, 2005). This means that the total age span of the main coal-bearing interval was about 11 m.y. (87 Ma, base of Middle Coniacian to 76.4 Ma, base of correlative Dinosaur Park Formation). Given this, each of the 6 identified sequences, including the unconformites, must have been less than 2 m.y. long. A 100m-thick conglomerate, marking the base of the upper Bonnet Plume Formation, overlies the main coal-bearing interval followed by an extended interval of interbedded mudrock, sandstone, siltstone, thin coaly shale and coal. It is also likely that the post-Dinosaur Park Formation radiogenic ages determined for rocks in central Alberta (Eberth and Deino, 2005) will allow the calibration of upper Bonnet Pl;ume Cretaceous assemblages. This Upper Campanian part of the Bonnet Plume Formation is being studied by Kimberly Ball (Ball, 2010, poster presentation, this session).

The last examples of applied palynology are from the Nechako Basin, west-central British Columbia. The palynological analysis of Nechako Basin rocks was initiated to support a basin analysis project undertaken by the BC Ministry of Energy and Mines starting in 2005 (Riddell et. al., 2007). This study is now being carried forward in collaboration with Janet Riddell but under the auspices of the GEM Energy Mountain Pine Beetle Project. The analyses of cutting and some core samples from seven exploration wells produced the following results. In the CanHunter et. al. Redstone b-82-C/92-O-14 well Albian/Cenomanian strata directly underlies Late Campanian strata providing evidence for an extended unconformity of about the same magnitude as in the Buffalo Head Hills. This has yet to be seen in other Nechako basin wells. Most of the rocks are non-marine but there are Cenomanian exceptions. An about 20m-meter thick marine facies was identified by the presence of a diverse suite of dinoflagellates near the top of the Hudson's Bay Redstone c-75-A well. Possible lateral correlatives of this marine facies are lacustrine to brackish facies, indicated by *Botrycoccus* and *Januasporites*, grading upwards to marine facies with common dinoflagellates in the Honolulu Nazko a-04-L/93-B-11 and CanHunter et. al. Redstone b-82-C/92-O-14 wells. Finally, Albian/Cenomanian strata is identified as thrust over Late Campanian strata in the Honolulu Nazko a-04-L/93-B-11 and CanHunter et. al. Nazko d-96-E/93-B-11 wells at a depth of 2100 and 2700 m, respectively. The Late Campanian age is based on the presence of *Aquilapollenites attenuatus*, *A. augustus*, *A. quadrilobus*, *A. sentus*, *A. vinosus* and *Azonia pulchella.* Presumed Tertiary rocks were usually barren or yielded very limited assemblages in the CanHunter et al Chilcotin b-22-K/93-C-9 and CanHunterEsso Nazko b-16-J/93-B-11 wells.

Conclusions

A unified palynological framework is emerging permitting correlations between widely-spaced basins in Western Canada. As demonstrated, stratigraphic studies of individual basins cannot be undertaken in isolation as each study builds on and utilizes knowledge from past studies.

Looking forward, calibrated ages of spore and pollen assemblages derived from Alberta and Bonnet Plume Basin will be applicable to: 1) developing a biostratigraphy for the upper part of the Eagle Plains Group; 2) refining the existing biochronology of the Brackett Basin (Slater River through Summit Creek formations; 3) and providing an underlying age framework for spore and pollen studies of the Kanguk and Eureka Sound formations of the high Arctic.

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