High-Resolution, Cretaceous Biostratigraphic Record from the Kennecott Crooked River and Leather River Kimberlite Cores, East-central Saskatchewan – Preliminary Report

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1. Introduction

Kimberlite exploration in east-central Saskatchewan has resulted in the collection of numerous cores from Cretaceous sedimentary rocks and associated kimberlites (e.g. Gilboy, 1997; Jellicoe *et al.*, 1998; Leckie *et al.*, 1997). Two of the cores, referred to here as the Kennecott Crooked River SK-16B-93-1 (1-4-45-10W2) and the Kennecott Leather River I-09-01 (4-23-46-16W2), although lacking in kimberlite facies, are nonetheless remarkable in that they contain essentially continuous Cretaceous strata from the Albian to the Campanian (Figure 1). Sampling of these cores for microfossils (mainly foraminifera) was completed during 1998 at the Subsurface Geological Laboratory in Regina where the cores are stored. Analysis of the samples is currently in progress, but some preliminary results are presented in this paper. The overall objectives of the study are two-fold, first to obtain a detailed biostratigraphic/lithostratigraphic record for the Cretaceous rocks of east-central Saskatchewan and second, to establish biostratigraphic correlations to nearby kimberlite-bearing cores so that kimberlitic events can be accurately related to Cretaceous depositional history.

2. Previous Work

Leckie *et al.* (1997) and McNeil *et al.* (in press) documented kimberlite crater facies interbedded with Lower Cretaceous sediments. Radiometric (Pb/perovskite) and biostratigraphic methods were used to date the kimberlite volcanism as middle Albian to early late Albian. Stratigraphically, the kimberlites occur within and above the Mannville Group and below the Westgate Formation.

Jellicoe *et al.* (1998), in their summary of the Fort à la Corne diamond exploration project, indicated that kimberlitic activity took place as early as the early Albian and as late as the early Turonian. Additional radiometric (Kjarsgaard *et al.*, in progress) and biostratigraphic studies (McNeil *et al.*, in progress) will provide more information about the age and stratigraphic distribution of the kimberlite events.

The basic biostratigraphic framework for the Cretaceous of Saskatchewan has been established by Caldwell *et al.* (1978) and McNeil and Caldwell (1981). Their zonal scheme is followed here. Recent studies by McNeil *et al.* (in press) on the upper Albian Westgate Formation in the Smeaton core from the Fort à la Corne area show that a finer biostratigraphic resolution is attainable from detailed sampling and quantitative analysis. Foraminiferal data are providing insight into sequence stratigraphic trends that were not previously apparent.

3. Methods

The Kennecott Crooked River (Gilboy, 1997) and Kennecott Leather River cores were lithologically logged and sampled at intervals of 1 m or less. A tentative stratigraphic interpretation has been determined (Figure 1), but resolution of some of the stratigraphic units await more input from the biostratigraphic studies.

A total of 326 samples were collected and are being processed primarily for foraminifera, but also for radiolarians, pyritized diatoms, plant microfossils, and vertebrate teeth and bone fragments. Future studies should include nannoplankton, pollen, spores, and dinoflagellates. Analyses on the organic geochemistry and organic petrology of the samples will also be carried out at the Geological Survey of Canada, Calgary. Mechanical logs were not run on either of the two cores.

Data processing for the Westgate Formation in the Crooked River core has been completed and a preliminary interpretation of the stratigraphic relationships between the Crooked River core and the previously studied Smeaton core (Leckie *et al.*, 1997; McNeil *et al.*, in press) is presented in this paper.

4. Preliminary Results

a) Lithostratigraphy

A preliminary lithostratigraphic correlation between the Crooked River and Leather River cores is presented

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in Figure 1. Stratigraphic nomenclature is adapted from McNeil and Caldwell (1981), Simpson (1982), and Bloch *et al.* (1993).

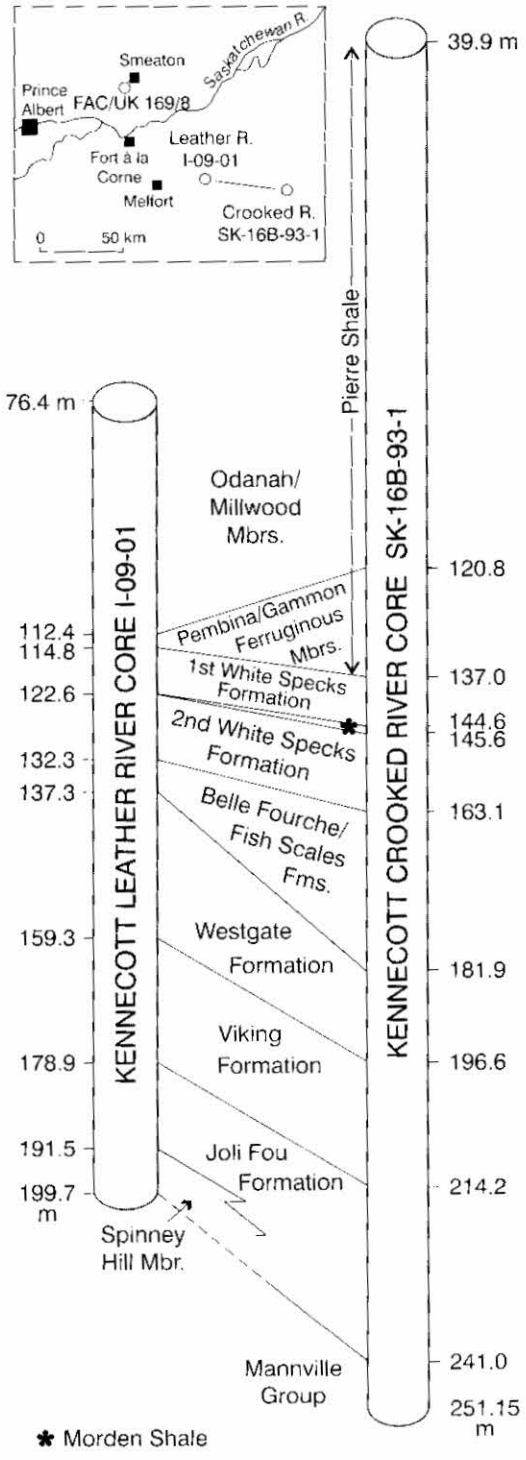

Figure 1 - Stratigraphy and location of the Kennecott Leather River I-09-01 and Crooked River SK-16B-93-1 kimberlite cores.

The stratigraphic units in the Crooked River core correspond generally to those described by Gilboy (1997). An exception is the boundary between the Westgate Formation and the overlying Fish Scales Formation that has been tentatively moved downward from 172.5 m to 181.9 m based on the occurrence of the *Verneuilinoides perplexus* Zone at 181 m.

Several units could not be differentiated with assurance and therefore are grouped. These include the combined Fish Scales and Belle Fourche formations, the Pembina and Gammon Ferruginous members of the Pierre Shale, and the Millwood and Odanah members of the Pierre Shale (Figure 1).

Unconformities appear to be significant in the stratigraphy of the Leather River core. The section from the top of the Westgate Formation to the top of Pembina/Gammon Ferruginous members is 24.9 m thinner than in the Crooked River core (Figure 1). There are three or four apparent unconformities between 112.4 and 137.3 m, but only one is documented by the preliminary biostratigraphic data - that between the First and Second Whites Specks formations.

b) Biostratigraphy

Quantitative biostratigraphic data are currently available only for the Westgate Formation in the Crooked River core. The total abundance of foraminifera in 50 g samples is shown in Figure 2. The section through the Westgate Formation includes the *Miliammina manitobensis* Zone of late Albian age. McNeil *et al.* (in press) recognized three assemblages within the *M. manitobensis* Zone in the Smeaton core, 75 km to the north: a lower *Ammobaculites* assemblage, a middle *Portatrochammina* assemblage, and an upper *Haplophragmoides* assemblage. In succession, these assemblages represent an initial marine transgression, a maximum marine transgression, and a marine regression. The point of maximum marine transgression within the Westgate Formation is interpreted to coincide with the peak abundance of *Portatrochammina* sp. In the Crooked River core, this point occurs at 194 m (Figure 2). This also corresponds to the peak abundance of pyritized diatoms. Radiolarians (*Spongodiscus*?) are abundant in the upper part of the Westgate Formation and are associated with the *Haplophragmoides* assemblage, but their significance is undetermined at this time.

5. Sequence Stratigraphy and Regional Correlation – Westgate Formation

Biostratigraphic data from the Westgate Formation in the Crooked River core show a pattern nearly identical to that in the Smeaton core. A synthesis of the data from the two locations is shown in Figure 3. The succession of lithotypes and biozones is interpreted in terms of a nearly complete transgressive-regressive depositional sequence.

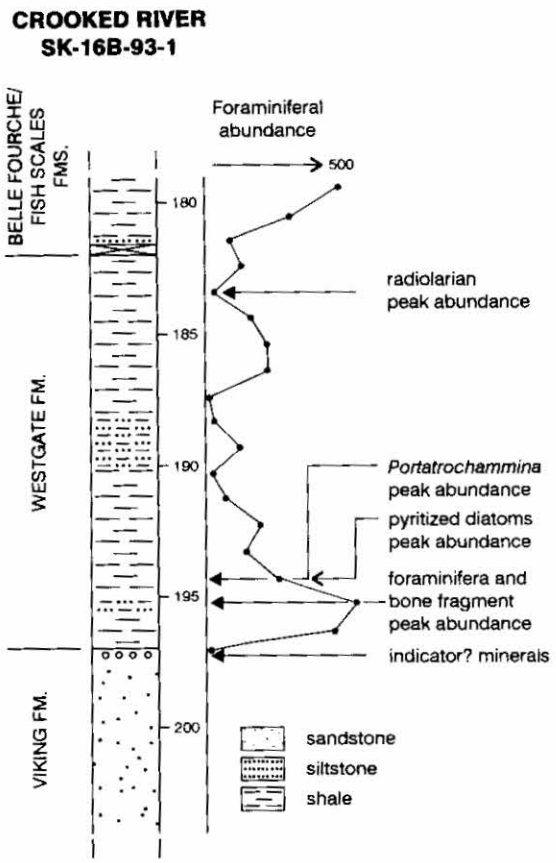

Figure 2 - Foraminiferal abundance (specimens/50 g sediment) and peak occurrences of other microfossils in the Westgate Formation, Crooked River SK-16B-93-1 core, east-central Saskatchewan.

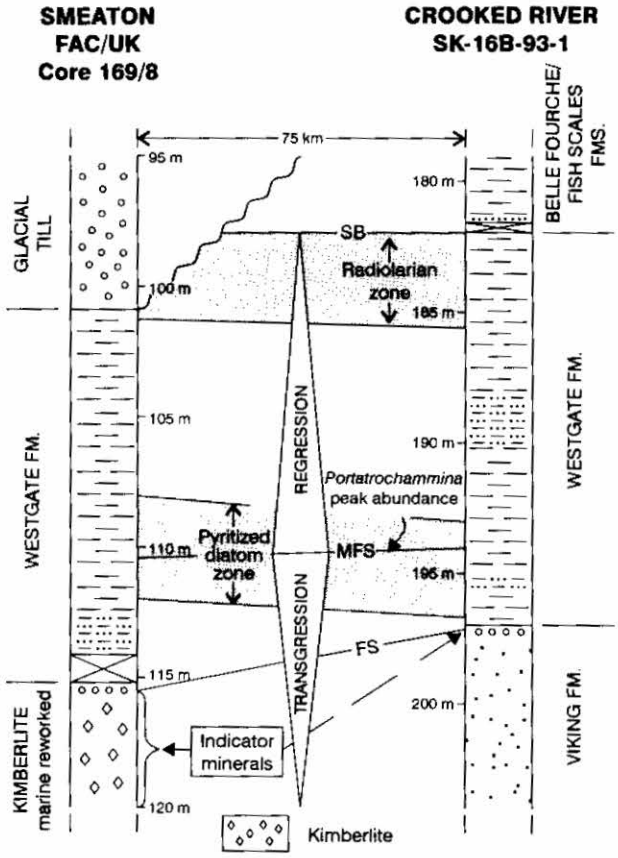

Figure 3 - Sequence stratigraphic interpretation and correlation of the Crooked River SK-16B-93-1 and Smeaton FAC/UK 169/8cores of east-central Saskatchewan. Legend symbols as in Figure 2; FS, flooding surface; MFS, maximum flooding surface; and SB, sequence boundary.

The sedimentary record begins in contrasting marginal marine facies; kimberlites at Smeaton and sandstones at Crooked River. At Smeaton, kimberlitic rocks were reworked in shallow marine depositional environments (Leckie *et al.*, 1997). Indicator minerals are conspicuous and include garnets, Cr-diopside, Mg-ilmenite, and Cr-spinel from mantle peridotite and eclogite. At Crooked River, the initial marine sediments are fine sands of the Viking Formation. A possible indicator mineral, ilmenite, has been found in processed microfossil residues at the top of the formation. It is associated with a pebble sand that is interpreted as a transgressive lag, and correlated with a similar bed in the Smeaton core. On Figure 3, this bed is indicated as a flooding surface (**FS**). Above this surface, the Westgate consists entirely of uniform shaly to silty mudstone. Foraminiferal and other microfossil distributions within the Westgate Formation are utilized to recognize the transgressive-regressive patterns in sedimentation.

In both the Crooked River and the Smeaton cores, shallow marine sediments (*Ammobaculites* assemblage) form the lowermost part of the Westgate Formation (McNeil *et al.*, in press). The point of maximum marine transgression is interpreted to coincide with the maximum abundance of the benthic foraminifera, *Portatrochammina* sp. Correlation of this point in the Smeaton and Crooked River cores establishes a datum that represents the maximum flooding surface (**MFS**) during Westgate sedimentation. Quantitative foraminiferal distribution data allow a maximum flooding surface to be defined, probably as more of a "zone" than a "surface." For example, there are several indicators of maximum marine sedimentation occurring over a three- or four-metre section in both the Smeaton and the Crooked River cores. They include high abundances of all microfossils, such as foraminifera, pyritized diatoms, and bone fragments. In sequence stratigraphic terminology, these three or four metres probably represent a condensed section.

The upper two-thirds of the Westgate Formation, in both the Crooked River and Smeaton cores, contain a reduced number of foraminifera (*Haplophragmoides* assemblage) and are here interpreted to represent a marine regression. Radiolarians are abundant in the uppermost Westgate Formation. Their significance is not known, but they may represent an increase in dissolved silica associated with an increase of terrigenous clastic sediments during regression.

In the Smeaton core, the Westgate Formation is erosionally truncated under glacial till. However, in the Crooked River core, the uppermost beds of the Westgate Formation appear to be terminated by an unconformable sequence boundary (**SB**) at 181.9 m. Core recovery here was incomplete, and consists of a 50 cm thick section (181.4 to 181.9 m) exhibiting only shale rubble with very fine-grained sandstone and bentonite (Gilboy, 1997). The overlying strata are assigned tentatively to the Belle Fourche/Fish Scales formations on the basis of lithological characteristics and the appearance of the *Verneuilinoides perplexus* Zone at 181 m.

6. References

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