Fossils Recovered from Kimberlite Pipes in the Lac de Gras Field, Slave Province, Northwest Canada; Geological Implications

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The presence of abundant Cretaceous and Tertiary fossils in kimberlite mudstone and shale xenoclasts within many pipes in the Lac de Gras kimberlite field has important implications regarding age constraints on pipe emplacement and the paleogeography of the region. Palynomorphs (pollen, spores, and dinoflagellates) are particularly common and widespread within crater sediments and xenoclasts. Rare fossilized leaves, turtle bones and fish parts have also been recovered from a few of the pipes. Most fossils occur in xenoclasts within crater facies kimberlite and represent fragments within Cretaceous and/or Tertiary strata that were penetrated by and incorporated into rising kimberlites.

In most cases, the youngest fossils within the xenoclasts are of late Paleocene age implying post-Paleocene kimberlite emplacement. The youngest palynomorphs recovered to date from xenoclasts and epiclastic sediments in the Lac de Gras pipes are pollen and spores of late Paleocene age. Typical assemblages include representatives of *Betula, Carya, Cercidiphyllum, Momipites* as well as *Paraalnipollenites alterniporus* and *Triporopollenites mullensis*.

Nearly 100 species of palynomorphs have been recovered from Lower to uppermost Cretaceous (Albian-Mastrician) shale xenoclasts in Lac de Gras pipes. Most samples contain dinoflagellates which are restricted to marine environments. Parts of skull bones, fin rays, and scales from telost (ichthyodectid) fish of probable Turonian age have been recovered from the Point Lake Pipe. Fish scales and other parts of fish were recovered from a depth of approximately 100 m in the Nancy pipe. This particular fish scale horizon is recognized as an important marker of the Albian–Cenomanian boundary through the Interior Plains and Arctic regions of North America. Fossil evidence reveals that prior to emplacement of the Lac de Gras pipes, Archean rocks in the area were overlain by a veneer of mainly marine Cretaceous strata and lacustrine Paleocene strata. All of these units were subsequently completely eroded.

Fossils have also been recovered from Crater facies epiclastic mudstones that were deposited following kimberlite emplacement. For example, fossil pollen grains, leaves and a turtle bone of late Paleocene age were recovered from a thick (>100 m) succession of aeolian, organic-rich and thermally immature mudstones that overlie the Sue kimberlite. In this case, kimberlite preceded late Paleocene time. Emplacement of kimberlites at Lac de Gras therefore occurred during at least two intervals: pre-late Paleocene (e.g. Sue pipe) and post-late Paleocene. Rb-Sr dating of the phlogopite megacrysts from some of the pipes have yielded ages of 53.2 $\pm$ 3.8 Ma (Collerson, K.D., 1995, pers. comm.) and 47.5 $\pm$ 2 Ma (Davis,W.J., 1996, pers. comm.)

The presence of wood, leaves, pollen grains, and turtle bones suggest that large conifer trees and reptiles thrived in the area during early Tertiary time. Climatic conditions throughout northern Canada were remarkably warm and humid during the Paleocene–Eocene interval. Rich assemblages of pollen from a variety of plants and trees have been recovered from strata in this interval throughout the Arctic. Redwood forests containing *Metasequoia* as well as crocodile and turtle remains are known from

Paleocene and Eocene strata nearly 1000 km north of Lac de Gras in the northern Canadian Archipelago at about 77° north latitude (Estes and Hutchinson, 1980; Basinger, 1991). The Lac de Gras Paleocene forest may represent a southern extension of that same high Arctic forest complex.

Wood occurs in various states of preservation, from "fresh" to deeply carbonized in several of the pipes and vitrinite reflectance values have been employed to determine approximate thermal variations between the crater and diatreme facies (Stasiuk et al., 1998). Unusually well preserved wood was recovered at a depth of 30 to 40 m, within the crater of the Panda pipe. Several hundred pieces of wood, including some parts of logs up to 1-2 metres long as well as tree stumps have been recovered. A moderate amount of mineral matter occurs within the cell lumens, but for the most part the organic material of the cell walls is intact and has not been affected by mineralization such that the anatomical features of wood cell walls are well preserved. Annual rings are distinct, with an abrupt change from early to late wood. The thickness of the late wood is moderate, and the rings are relatively narrow. These features are typical of wood growing under mesic seasonal conditions. Narrow rings and general lack of curvature of the rings are consistent with peripheral wood in large (>1 m diameter) trees. Wood of this general type is consistent with the Taxodiaceae (redwood family) and Cupressaceae (cedars). The presence of smooth crosswalls of the wood parenchyma and ray parenchyma exclude such forms as *Glyptostrobus* and *Taxodium*. The wood is most similar to the redwoods *Sequoia* and *Metasequoia* which are generally indistinguishable from one another on the basis of wood morphology. *Metasequoia* is one of the most common swamp plants of the Eocene in mid to high latitudes, and is ubiquitous within northern Paleogene (Paleocene–Oligocene) deposits (Basinger, 1991).

Carbonized leaf fragments have been noted in xenoclasts within the crater and diatreme facies of several pipes. A whole leaf was recovered from a succession of epiclastic kimberlite in the Sue pipe. The leaf is *Trochodendroides* cf. *T. speciosa* (Berry) often referred to in the literature as the extant *Cercidiphyllum arcticum*. The species is common in Paleocene but less common in Eocene sediments throughout the Interior Plains and Arctic regions of North America. Very often it is associated with pollen and wood of the Taxodiaceae, including *Metasequoia* (Brown, 1962). In addition, late Paleocene mudstones in the same kimberlite crater have yielded fragments of unidentified insects, snails and, the proximal (upper) part of a femur bone from a fresh-water turtle (Fig. 1). Turtles are widely distributed in Paleocene and Eocene continental deposits throughout the Interior Plains but are also known from high latitudes. Several species from lower Eocene strata on Ellesmere Island in the Canadian Arctic Archipelago appear to be endemic to Arctic regions (Estes and Hutchinson,1980).

The discovery of Cretaceous and Tertiary fossils within kimberlite pipes in the Lac de Gras area has helped resolve some long standing regional geological problems in the mainland of northern Canada. Previously, it was not known that Cretaceous and Tertiary strata were deposited in the Slave Structural Province, a segment of the stable North American Craton in which all trace of these strata have been removed by erosive mechanisms since Tertiary time. It has to be concluded that the Cretaceous Western Interior Seaway, which extends in a north-south direction east of the Cordillera must have extended several hundred kilometres farther to the east than previously thought.

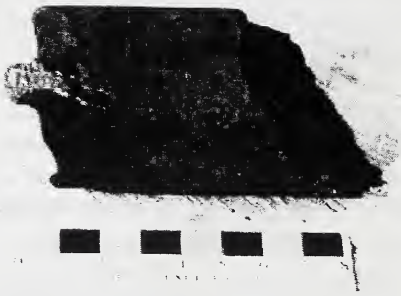

Figure 1 – The proximal (upper) part of a femur bone of a fresh-water turtle within organic-rich mudstone. Recovered from the Sue pipe. Scale bars are in centimetres.

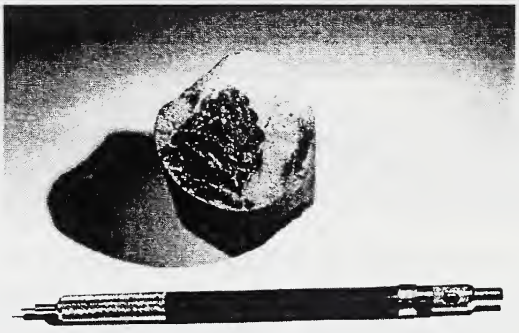

Figure 2 – A whole leaf from *Trochodendroides* cf. *T. speciosa* (Berry) within epiclastic mudstone is often referred to in the literature as the extant *Cercidiphyllum arcticum.* The pencil is 14 cm. in length.

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