Pyroclastic Quartz Grains from the Late Cretaceous Battle Formation of Southwestern Saskatchewan

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Unabraded quartz crystals and "rounded" grains, isolated from the Late Cretaceous Battle Formation of southwestern Saskatchewan, have been studied by scanning electron microscopy and fluid inclusion thermometry in order to determine their mode of formation and occurrence in a lacustrine mudstone.

1. Geological Setting

The Battle Formation is a 10 to 12 m thick, brown claystone that occurs 50 to 60 m below the Cretaceous-Tertiary boundary (Lerbekmo *et al.*, 1979) and outcrops in river cuts and badlands of southern Alberta and in the Cypress Hills of Alberta and Saskatchewan. It has also been traced over a large area in the subsurface of Alberta (Elliott, 1960). East of the Cypress Hills, the unit is cut by a major regional disconformity (Furnival, 1946).

In outcrop, the Battle Formation can be easily recognized by its chocolate-brown colour in stark contrast with the underlying white beds of the Whitemud Formation (Figure 1). It is a blocky, massive-bedded mudstone with typical popcorn weathering; however, in thin section, it displays a fine, but irregular, layering of clayey laminae, generally less than 0.1 mm thick, and silty-sandy laminae, commonly less than 1.0 mm thick (Binda, 1992). The clay is predominantly smectite with minor kaolinite (Binda, 1970). The microfossil content of the Battle Formation is quite unusual, consisting of silicified spores and pollen grains, chrysomonad cysts, and siliceous sponge gemmoscleres (Binda and Srivastava, 1968; Srivastava and Binda, 1984), indicating a lacustrine to paludal depositional environment.

In the Cypress Hills, a tuffaceous bed (Kneehills Tuff), occurring near the top of the unit, yielded a K-Ar date of 65 Ma from sanidine and biotite (Folinsbee *et al.*, 1965). The Kneehills Tuff is a crystal-vitric tuff composed of fresh fragments of quartz and feldspar in a groundmass of devitrified glass and fibers of chalcedonic silica. A few volcanic glass shards have been identified by Binda (1970). Zircons separated from the tuff suggested a derivation from explosive phases of the Butte rhyolite (Ritchie, 1957). A southern provenance for the ash is also indicated by the northerly decrease in grain size of the coarse fraction of the tuff (Binda, 1969).

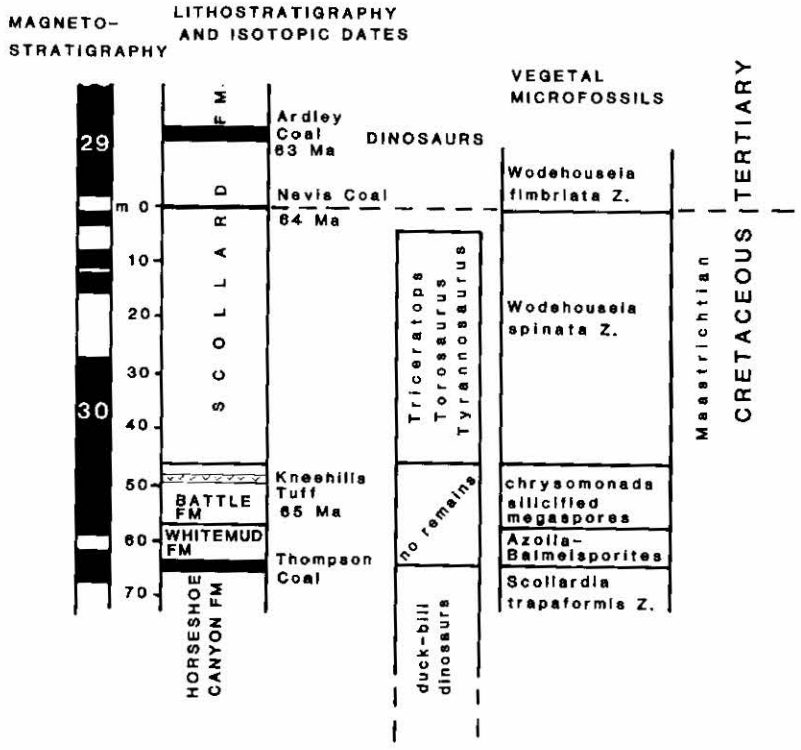

Figure 1 - Stratigraphic column and palynomorph zonation of the late Maastrichtian sequence in Alberta and Saskatchewan (from Nambudiri and Binda, 1991).

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2. Field and Laboratory Methods

Samples were collected west of the town of Ravenscrag, in the northeastern corner of Section 22, Township 6, Range 24, west of the third meridian. A 12 m vertical section was sampled at 1 m intervals. The mudstone was disaggregated in water and detergent and wet sieved at 100 and 200 mesh. The quartz grains, which were found in all samples, were hand picked from the residue under a binocular microscope. Further random sampling in abandoned kaolin quarries in the Cypress Hills of Alberta revealed similar quartz grains. The grains range in size from approximately 80 to 200 μm.

3. Results and Discussion

The quartz grains represent single crystals, the external form of which varies from well-preserved with flat crystal faces and angular or slightly smoothed face intersections (Figures 2A and 2B) to rounded with remnant crystal faces (Figure 2C), or no crystal faces at all (Figure 2D). All crystals display a short prismatic bipyramidal habit which typically have six identical pyramid faces capping each end of the crystal (Figure 2B). These crystal forms are typical of high-quartz that forms at temperatures above 573°C and are commonly found in acidic volcanic rocks (Fisher and Schmincke, 1984).

The "rounded" surfaces on the crystals do not show the pitted character typical of particles abraded by sedimentary processes, rather the rounding is believed to represent resorption or magmatic corrosion (Figure 2), and provides further evidence for a magmatic origin. As such, the quartz crystals would have developed as phenocrysts in an acidic magma and suffered varying degrees of resorption prior to being erupted as volcaniclastic components.

Many of the quartz crystals contain fluid inclusions which were subjected to heating experiments using a U.S.G.S.-type gas-flow heating/freezing system. Instrumental limitations did not allow the crystals to be heated to temperatures above 500°C but at that temperature the fluid inclusions were still unchanged. These results, while inconclusive on their own, support

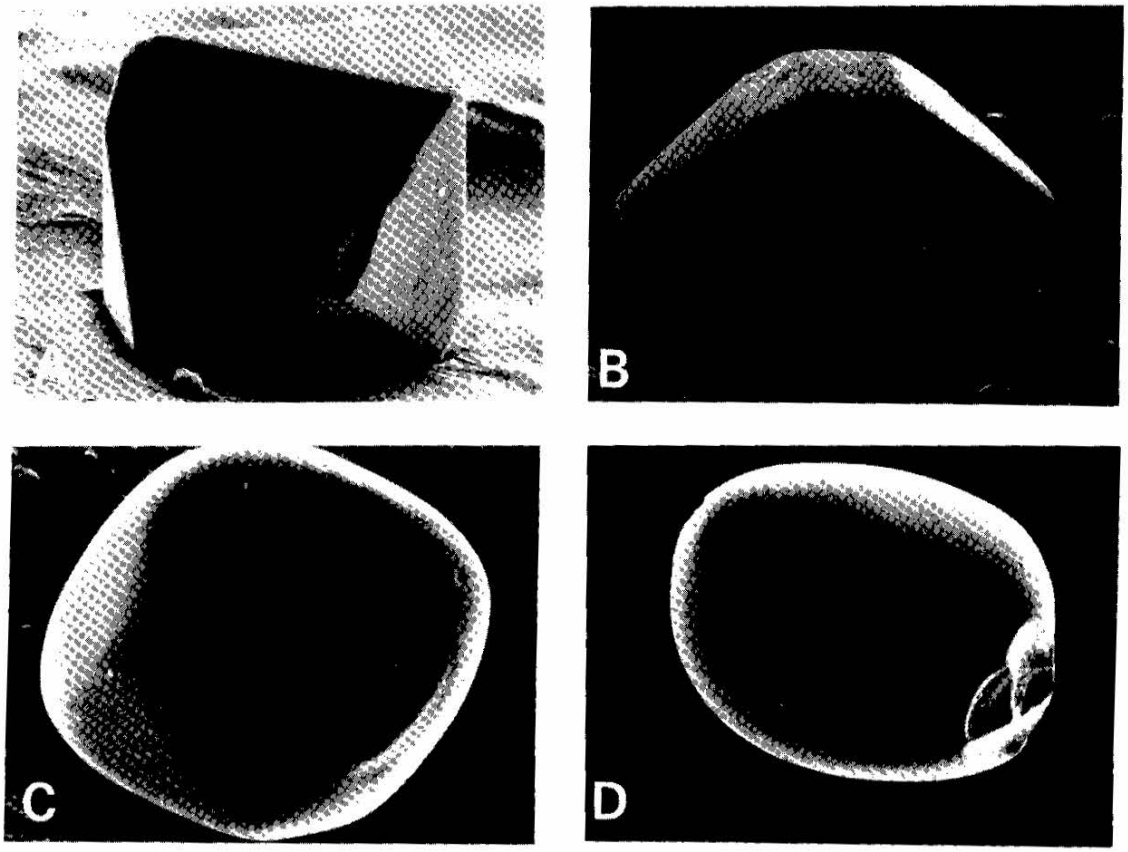

Figure 2 - SEM photographs of pyroclastic quartz grains from the Battle Formation of southwestern Saskatchewan. A) bipyramidal crystal with well-defined crystal habit, long axis=130 μm; B) bipyramidal quartz crystal with limited prismatic development and incipient resorption, long axis=150 μm; C) bipyramidal quartz crystal with limited prismatic development and advanced resorption, long axis=160 μm; D) egg-shaped quartz grain in which the crystal faces have been completely obliterated by resorption, conchoidal fractures at one end of the grain may be due to impact, long axis=110 μm.

the interpretation that the quartz grains represent crystals formed at high (magmatic) temperatures.

4. Conclusions

Unabraded bipyramidal, short prismatic, and "rounded" quartz grains of the late Maastrichtian Battle Formation are recognized as magmatic in origin and represent a pyroclastic component of the lacustrine mudstone. Their occurrence throughout the vertical extent of the unit shows that volcanic ash was falling into the "Battle Lake" from its inception and not just during the time of deposition of the Kneehills Tuff.

5. References

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