

**The volcanic record of the upper 600 m of the ANDRILL AND-1 drill cores:  
Evidence of ice-free conditions and local volcanic activity over the  
past 6 million years**

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The upper 600 m of the ANDRILL McMurdo Ice Shelf (MIS) AND-1 drill cores contain numerous volcanic-rich intervals. These intervals provide samples for radiometric dating and give insights into the location and nature of volcanic activity in McMurdo Sound. The occurrence and nature of the volcanic layers also has implications to ice local conditions, sediment provenance and magmatic evolution. We examined the volcanic material in over 80 core samples by electron microprobe to characterize their morphology, mineralogy and chemical compositions. Volcanic glass was examined in samples from the upper 185 m and the 430 to 600 m intervals of the core.

Volcanic materials in the core consist of reworked volcanogenic sediments, volcanic clasts and reworked or primary pyroclastic materials. Pyroclastic materials consist of volcanic glass fragments and shards, pumice and cinders. The glass shards are vesicular with low crystal contents and often have delicate bubble-wall textures. Many such layers are well-sorted and show no evidence of reworking. These are interpreted as primary pyroclastic fall deposits which have settled through the water column which resulted in deposition of graded beds. Angular and blocky glass occurs in the sediment cores and this is likely reworked materials, but may, where chemically uniform, be derived from hyaloclastite subaqueous eruptions. Some volcanic-rich parts of the cores are characterized by rounded volcanic fragments of heterogeneous compositions and morphology. These layers may contain some fragments that appear pyroclastic and others that are more characteristic of lava flows and represent reworked material erupted from multiple volcanic events.

The identification of primary pyroclastic deposits based on morphology is reinforced using microprobe analyses of chemical compositions of individual glass shards and fragments. Primary deposits typically have uniform glass compositions and are likely to be derived from individual volcanic events and have not been significantly reworked. The compositions of the homogeneous layers tend to be basanitic, although examples of phonotephrite, trachyte and phonolite are also present in the core. In contrast, some volcanic-rich horizons are heterogeneous and contain glass shards ranging from basanite to trachyte and phonolite suggesting that reworking has occurred. Several layers in the 420-500 m depth range have bimodal populations of basanite and trachyandesite perhaps from reworking from two distinct sources.

Interpretation of the morphology of glass shards and their uniform chemical compositions as primary pyroclastic deposits implies open-water conditions at the site at the time of volcanic deposition. A thick primary ash (tephra) fall interval from 134 to 146 m depth is a chemically homogeneous basanite and was likely deposited over a short interval of days or weeks during a time when there was open water in McMurdo Sound. Primary and slightly reworked pyroclastic deposits at 427-459 m and more commonly at 577-584 m depth correspond with long intervals of open water conditions inferred from other core properties (Naish et al., in review).

Hut Point Peninsula has a known eruptive history extending from 0.4 to over 1.6 Ma. Its close proximity to the MIS drill site makes it a likely source for many of the volcanic intervals examined in the upper 160 m of drill core. The thick tephra at 134-146 m is dated at ~ 1.67 Ma (Ross et al., 2007) and we suggest it correlates with the early eruptive phase of the polygenetic