

Origin of Brines in Neogene Sediments of the Ross Sea, Antarctica: AND-2A Core, ANDRILL Southern McMurdo Sound Project

Z. Gui and T. D. Frank

Department of Geosciences, University of Nebraska-Lincoln, Lincoln, NE 68588-0340 USA

Brines with salinities that approach six times seawater that of were encountered in Neogene sediments of the Ross Sea during the ANDRILL Southern McMurdo Sound Project. This study integrates geochemical and isotopic data from pore waters with petrographic, C-O isotopic, and clay mineralogical data from sediment samples to investigate the origin of these unusual pore waters. During drilling, 35 pore water samples were extracted from whole-round sections of core collected from 9.67 to 545.01 meters below sea floor (mbsf) and subjected to the following analyses: alkalinity, pH, $\delta^{18}\text{O}$ and $\delta^{13}\text{C}_{\text{DIC}}$ values, and major ion concentrations (Cl^- , Br^- , SO_4^{2-} , Na^+ , K^+ , Mg^{2+} , and Ca^{2+}). Sediment samples were collected every 10 to 20 m for petrographic examination, XRD determination of clay mineralogy, and stable isotopic analysis of carbonate phases. Alkalinity, salinity and the concentrations of most major ions increase from near-seawater values near the top of the core to values that are several fold higher near the base. With the exception of SO_4^{2-} , all ions that behave conservatively in seawater maintain a constant relationship with Cl^- . These patterns suggest that the brines evolved from seawater via a process that removes H_2O while leaving salts behind. Petrographic observations suggest that the most plausible explanation involves chemical exchange between pore fluids and reactive volcanogenic particles, which make up a significant proportion of the sediment. The major processes include uptake of H_2O during hydration of volcanic glass and the formation of hydrous secondary minerals such as zeolite. A relatively high geothermal gradient ($\sim 50^\circ\text{C}/\text{km}$) may be enhancing reaction rates in the AND-2A core. Petrographic observations and XRD analyses confirm that these secondary phases are present throughout much of the section. Chemical exchange between pore water and silicate minerals is reflected in $\delta^{18}\text{O}$ values of pore waters, which decrease with increasing depth. Carbon isotope values of pore water as low as -24‰ suggest that organic matter degradation is also occurring. Carbon and oxygen isotope compositions of matrix carbonate and the pore water lack correlation. It suggests that matrix cement may have precipitated before pore water evolved to its present composition. Results indicate that seawater-rock exchange in volcanic-rich marine sediments can produce brines at relatively low temperatures and over geologically short time intervals. 38