# Chlorine stable isotopes in two subduction zones: Nankai Trough and Mariana, and implication for fluid-sediment interactions and fluid flow

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Pore fluids at Nankai Trough and Mariana subduction zones were analyzed for chlorine stable isotope ratios ($^{37}Cl/^{35}Cl$). At Nankai subduction zone (ODP Sites 808, 1174, and 1173) pore fluids exhibit the largest range in $\delta^{37}Cl$, from seawater value of 0‰ to -7.8‰; the latter is the most negative value of all the ODP pore fluids analyzed so far; at the Mariana subduction zone (Site 1200) $\delta^{37}Cl$ ranges from 0‰ to +1.8‰.

Chlorine isotopes fractionate when they are incorporated into diagenetic or metamorphic hydrous minerals where Cl substitutes for OH group. At Nankai, because of the low Cl concentration in smectite (~30 ppm), even if a maximum $\delta^{37}Cl$ value in smectite of 8‰ is assumed (Magenheim et al., 1995), a 100% I/S transformation would not account for the very negative $\delta^{37}Cl$ values observed in the pore fluids (−7.8‰), at the chloride minimum (450-480 mM) depth interval at Site 808 and 1174 (Spivack et al., 2002). Arcward, at greater depths, the formation of high temperature (>250° C) hydrous minerals could preferentially consume $^{37}Cl$ (Schauble et al., 2003), thus enriching the residual fresher fluid in $^{35}Cl$ (negative $\delta^{37}Cl$). Accordingly, the negative $\delta^{37}Cl$ observed could be explained by mixing with a laterally advecting deep-sourced fluid carrying the negative $\delta^{37}Cl$ signal.

In contrast, the pore fluids at Mariana subduction zone (ODP Site 1200) are enriched in $^{37}Cl$. $\delta^{37}Cl$ increases from seawater value at the seafloor to ~+1.8 ‰ at 71 meter below sea floor. Chloride concentration is also diluted as compared to bottom seawater by ~8-9%. The pore fluids at this site originate at greater depths, where serpentine dehydration occurs (Mottl et al., 2003). The serpentines in Mariana contain hundreds of ppm Cl. When they dehydrate, Cl with enriched $^{37}Cl$, as well as $H_2O$, are released to the pore fluid. As a result, the upwelling fluid exhibits the positive $\delta^{37}Cl$ but lower Cl concentration.

Cl concentration and isotope systematics can thus supply critical information, not available from other measurements, about the source of fluids, flow paths, and reaction conditions. Here they are shown to distinguish different mechanisms of deep-sourced fluids at two subduction zones, i.e., between dehydration concurrent with the formation of high temperature hydrous minerals at Nankai Trough, and serpentine dehydration in Mariana.

# Environmental change recorded in mid-latitude ice cores from southern North America and Central Asia: Comparison of chlorine-36 and iodine-129 profiles and the implications for stewardship of the environment

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The U.S. Geological Survey (USGS) is conducting a collaborative global research program in mid-latitude glacial environments to study the effects of increased loading of anthropogenic radionuclides and rapid climate change on alpine ecosystems. This global research program includes the collection of isotopic and geochemical data from the Upper Fremont Glacier, located in the Wind River Mountain Range, Wyoming, U.S.A., and the Inilchek Glacier, located in the Tien Shan Mountains, Republic of Kyrghyzstan, in central Asia. Mid-latitude glacial sites also are being studied in China, New Zealand, Nepal, and Russia. Geochemical records preserved in ice and snow collected from these mid-latitude sites include significant anthropogenic radioactive fallout such as plutonium, tritium, chlorine-36 ($^{36}Cl$), and iodine-129 ($^{129}I$), and signals from global and regional events such as volcanic eruptions, droughts, and forest fires. Organic matter preserved in the ice also provides a means to age-date sections of ice cores by using the carbon-14 inventory. Concentrations of the cosmogenic isotopes $^{36}Cl$ and $^{129}I$ in ice cores from the Upper Fremont Glacier and the Inilchek Glacier were significant. The $^{129}I$ concentrations in ice from the Upper Fremont Glacier were orders of magnitude greater than $^{129}I$ concentrations predicted by global fallout modeling and greater than the $^{129}I$ concentrations in ice from the Inilchek Glacier. The $^{36}Cl$ concentrations in ice cores from these two sites were similar. The largest $^{129}I$ concentration in the Upper Fremont Glacier could be a result of elevated atmospheric releases of $^{129}I$ from the U.S. Department of Energy's Hanford facility in the western United States in the late 1940s and early 1950s.

The isotopic and geochemical data gained from analyses of these glacial records has lead to a reevaluation of the timing of climate and environmental changes. For example, by better defining the glacial chronology at the Upper Fremont site using the $^{36}Cl$ and $^{129}I$ nuclear weapons-testing peaks in conjunction with other isotopic data, it was determined that, from the mid-1800s to the present, there have been relatively rapid changes in the regional climate of southern North America. These rapid changes in the mid-1800s are interpreted as an abrupt end of the Little Ice Age; these changes occurred within a period of less than 10 years and possibly within as few as 2 to 3 years. The environmental implications of these records will be discussed.