Neutron fluence measurements on the lunar surface

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Thermalized neutrons arise from the interaction of cosmic rays with planetary materials. Because ^{149}Sm, ^{155}Gd and ^{157}Gd have very large neutron capture cross sections, isotopic shifts of ^{150}Sm/^{149}Sm, ^{156}Gd/^{155}Gd and ^{158}Gd/^{157}Gd can be used as a monitor of neutron dose. Estimation of the neutron fluence and energy spectrum provides useful information on shielding location and irradiation history of planetary materials. In the 1970s, Sm and Gd isotopic analyses were established to study neutron capture effects on the lunar surface, which were effectively used to discuss the lunar gardening processes (Russ et al., 1972; Russ, 1973; Curtis and Wasserburg, 1977). More than a quarter century later, instrumental developments in mass spectrometry and improvments in chemical separation offer better analytical precision of the isotopic data than before (Hidaka et al., 2000). The purpose of this study is to find new understanding of the cosmic-ray irradiation history of the planetary materials from the lunar data.

In this study, we used twenty two samples from three deep drill-stems at the Apollo-15, 16 and 17 landing sites for Sm and Gd isotopic measurements. The three drill-core samples are considered to be suitable to study depth dependence of cosmic-rays interactions.

Neutron fluences estimated from the Sm and Gd isotopic shifts are (5.16-7.49)x10^{16} ncm^{-2} for A-15, (9.71-14.8)x10^{16} ncm^{-2} for A-16, and (2.90-8.70)x10^{16} ncm^{-2} for A-17. Depth-profiles of the neutron fluences suggest the existence of thick slabs which were well-mixed in a short time after the deposition. Furthermore, isotopic enrichments of ^{152}Gd and ^{154}Gd due to neutron capture for ^{151}Eu and ^{153}Eu, respectively, were also observed. The combination of Sm and Gd isotopic shifts, defined as a parameter εSm/εGd, can be used to determine energy of thermal neutron. The ~6% and ~10% variations observed in εSm/εGd values of A-15 and A-17 cores, respectively, suggest the depth dependence of neutron energy spectrum, although there are slight variations of the chemical components in the cores.

References

Curtis D.B. and Wasserburg G.J., (1977) *Proc. Lunar Sci. Conf. 8th*, 3575-3593.

Hidaka H., Ebihara M. and Yoneda S., (2000) *MAPS* **35**, 581-589.

Russ G.P., Burnett D.S. and Wasserburg G.J., (1972) *EPSL* **15**, 172-186.

Russ G.P., (1973) *EPSL* **17**, 275-289.

Early deglacial rise in Peru Margin denitrification: Oceanic trigger for transition to interglacial conditions?

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Denitrification is the predominant global loss term for combined nitrogen and can exert a major control on its oceanic inventory, global productivity and atmospheric CO_2. Our prior work demonstrates that proxy records for changing denitrification, oxygenation and productivity in the recent geological past in the Arabian Sea exhibit unprecedented similarity with abrupt climate fluctuations recorded in high-latitude ice-cores (Altabet *et al*., 2002). Since the Peru Margin and Arabian Sea together constitute almost two-thirds of global marine water-column denitrification, changes in concert in these regions could have effected rapid global climate changes through an oceanic mechanism.

The Peru Margin is intimately coupled to the Equatorial Pacific, source of El Niño-La Niña SST, productivity and precipitation anomalies. Here, biogeochemical cycles are especially sensitive to abrupt climatic changes on decadal time-scales by virtue of this ENSO coupling. Results from several ^{14}C-dated Peru Margin cores reveal a strikingly consistent pattern of low glacial denitrification (low sedimentary δ^{15}N), a dramatic and early rise between 18 and 16 Ka, a gradual decline in denitrification until the mid-Holocene, and then a marked increase, and enlarged amplitude through to the present. Moderate core-top values are consistent with these cores' modern position within the along-margin gradient in denitrification (11 to 13°S). Data from the Nazca Rise in the center of the denitrification zone at 16°S show approximately the same amplitude and timing of the early deglacial rise in δ^{15}N but are 2 - 4 ‰ higher than the mid-Peru Margin during the LGM and mid-Holocene.

These initial observations are consistent with a southward contraction of the suboxic zone (and increased δ^{15}N gradient between our sites) during periods of overall diminished suboxia and denitrification. The uniquely early deglacial peak in Peru denitrification leads (by several or more kyr) both the N. Hemisphere denitrification zones (Arabian Sea and Mexican margin) as well as ice-volume and atmospheric CO_2. We extrapolate these new nitrogen isotopic results in the context of global marine denitrification. Considering its timing, the corresponding reduction in marine fixed N inventory may have had an important role in the initial deglacial rise in atmospheric CO_2 and ultimate transition to interglacial conditions. We suspect forcing via remote ventilation of intermediate waters either in the Tropical Pacific or the Southern Ocean.