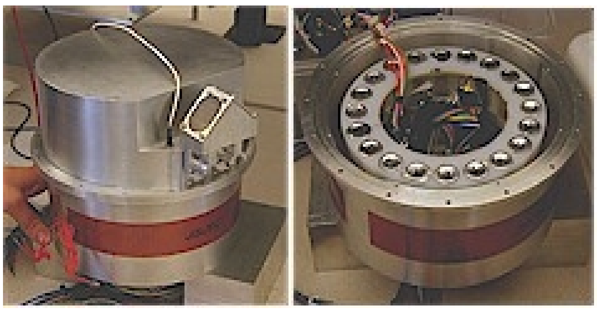
Geochemical Analysis on Mars

S. P. KOUNAVES[1] AND M. H. HECHT[2]

[1] Department of Chemistry, Tufts University, Medford, MA USA (samuel.kounaves@tufts.edu)
[2] Jet Propulsion Laboratory, 4800 Oak Grove Drive, Pasadena, CA USA (michael.h.hecht@jpl.nasa.gov)

A rigorous chemical analysis of the surface and subsurface material in a remote hostile environment such as Mars presents a truly daunting and unique challenge. To undertake such a mission, with the slightest hope of obtaining meaningful analytical data, requires instrumentation that can withstand rigors far beyond those encountered on Earth. In addition to mass, volume, and power constraints, the device must withstand temperature fluctuations that may range from -120 to 60ºC, and anticipate any unexpected chemistry such an environment might present. We report here the initial development and evaluation of a prototype *Robotic Chemical Analysis Laboratory* (RCAL) equipped with an array of electrochemical sensors for measuring in-situ a variety of ionic species and parameters in the Martian regolith.

The RCAL instrument, shown below, is based on the *Mars Environmental Compatibility Assessment* (MECA) wet chemistry lab (WCL), a payload developed and flight qualified for the now-cancelled Mars'01 Lander. Similar to the MECA, RCAL will contain an array of sensors which will allow for determination of a wide variety of inorganic ions and electrochemical parameters, including, Ag^{2+}, Br^{-}, Ca^{2+}, Cd^{2+}, Cl^{-}, ClO_4^{-}, Cu^{2+}, HCO_3^{-} , Hg^{2+}, I^{-}, K^{+}, Li^{+}, Mg^{2+}, Na^{+}, NH_4^{+}, NO_3^{-}, SO_4^{2-}, Pb^{2+}, pH, oxidants, reductants, redox potential, conductivity, dissolved O_2 and CO_2 .



The RCAL expands on the MECA concept by providing twenty individual sealed sample chambers mounted on a rotating carousel. The soil, after delivery by an external mechanism such as a robotic arm or sub-surface drill, is loaded into a dual soil hopper. Multiple small samples can then be taken from the hopper and delivered to the test chambers. After the chamber is punctured, one of a set of four electrodes mounted over the carousel can be inserted into the selected chamber.

The RCAL will enable bench-top wet chemistry analyses of the Martian regolith, assessing its interaction with water, and ultimately providing unique scientific information about the geochemical history of Mars.

El Niño-La Niña pattern of glacial-interglacial transitions: Evidence from geochemical proxies in foraminifera

A. KOUTAVAS, J. LYNCH-STIEGLITZ AND T. M. MARCHITTO

Lamont-Doherty Earth Observatory of Columbia University, Palisades, NY 10964, USA (athan@ldeo.columbia.edu, jean@ldeo.columbia.edu, tmarchit@ldeo.columbia.edu)

The role of tropical Pacific ocean-atmosphere dynamics in glacial-interglacial and millennial scale climate fluctuations is believed important but remains controversial and little understood. By analogy with modern ENSO it has been argued that glacial/stadial climate stages may correlate or even be causally linked to La Niña-like conditions with intensified upwelling in the eastern equatorial Pacific (EEP). In order to test this theory we use Mg/Ca ratios and $\delta^{8}O$ in planktonic foraminifera from 9 cores in the EEP to reconstruct sea surface temperature (SST) gradients in the tropical Pacific during the last glacial-interglacial transition (termination I).

Mg/Ca-based SST estimates indicate reduced zonal and meridional low-latitude gradients during the Last Glacial Maximum (LGM). $\delta^{18}O$ records from sites straddling the equator in the EEP similarly show reduced hydrographic (temperature and salinity driven) cross-equatorial gradient during the LGM. These conditions are analogous to prevailing conditions during modern El Niño episodes, but with a cooler background level. By contrast Holocene climate is marked by strong tropical SST gradients as occurs presently during La Niña episodes, a pattern especially accentuated during the middle Holocene. ^{14}C dating of a high-resolution record near the Galapagos Islands documents early deglacial warming in phase with Antarctica. Abrupt cooling and a La Niña-like increase of the zonal SST gradient in the tropical Pacific is recorded at the time of the Bølling warming, while a relapse toward El Niño-like conditions is seen during the Younger Dryas.

Our data show that a prevailing long-term El Niño pattern with weakened Walker and Hadley circulation is a dominant feature of glacial/stadial climate. Glacial-interglacial transitions and millennial scale rapid warming shifts are related to onset of a La Niña pattern in the tropical Pacific, with reestablishment of strong SST gradients and intensified winds. While precession appears to modulate the orbital scale variations, the cause of the millennial scale variability remains enigmatic.