In-situ isotopic analysis of volatile fluids from subsurface carbon reservoirs

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Technological advances are moving analytical laboratory sensors into the field. This transition eliminates sample collection and transport requirements for offsite analysis, improving spatial and temporal resolution of data, while decreasing operations costs and latency. We present a miniaturized isotope ratio mass spectrometer (IRMS) for in-situ analysis of gases and volatile hydrocarbons from subsurface carbon reservoirs.

This new instrument, which uses a compact double-focusing mass analyzer is capable of rapid spectrum scans across a 2-200AMU range for quantitative characterization of a broad range of volatile compounds including hydrocarbons and reduced gases at concentrations to less than one part-per-billion. Its multiple fixed-cup collectors enable simultaneous isotopic ratio precision to better than one per-mil. This fully self contained IRMS requires less than 20W of power and displaces a volume of approximately 10 liters.

We present an overview of the IRMS design in two differing embodiements, a TETHYS configuration for marine operation on subsea robotic vehicles, and a configuration with integrated gas chromatograph (GC) for field applications such as logging-while-drilling. Results from laboratory testing of GC-IRMS confguration indicate isotopic precision of better than δ0.25‰ analysis of mixed natural gas with total cycle times of less than five minutes. Marine operations using the TETHYS configuration for real-time analysis of dissolved water column hydrocarbons and gases indicate sensitivities better than 1 part-per-billion and isotopic precision to better than δ1‰ with measurement cycle times of seconds. This provides an efficient method for locating and classifying biogenic and thermogenic seafloor seeps from subsurface carbon reservoirs.

A rheological and textural characterization of the fall-out phase of the large volume Pozzolane Nere mafic ignimbrite (Colli Albani Volcano, Rome)

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The Pozzolane Nere ignimbrite (PNR) represents one of the largest explosive events in the history of the Colli Albani volcano (407 ka, Vulcano Laziale period). The PNR is tephri-phonolitic in composition and is characterized by a basal scoria fallout deposit with an east-trending axis of dispersion overlain by a low aspect ratio ignimbrite, estimated at 30km^3 as bulk volume. Despite extensive studies on the deposits of the volcano, the mechanisms governing the explosive activity of these very undersaturated magmas are still poorly known. In order to improve our understanding on the origin of these high-energy eruptions (VEI 6), petrological and minero-chemical analyses of the five PNR fallout sub-layers were performed. Results from the VSD of the selected scoriae suggest an uneven distribution of nucleation events with VNDs (on the order of 10^8-10^9 cm^{-3}) higher than those observed in literature for mafic explosive eruptions and more comparable to VNDs pertaining to explosive eruptions of evolved composition. Textural and minero-chemical investigations of the samples have been combined with their rheological characterization. Low T measurements (690°C<T<800°C) were performed by micropenetration technique, while the high T viscosities of fully molten (1250°C<T<1569°C) and partially crystallized specimens (1100°C <T<1225°C) were measured at 1 bar in air with a concentric cylinder viscometer. Above the liquidus temperature, viscosity ranges from $10^{1.04}$ to $10^{3.64}$ in good agreement with the viscosity model by Giordano *et al.*[1]. In the subliquidus region, isothermal crystallization experiments allowed to quantify the role of crystals on the rheology of PNR magmas. The increase of apparent viscosity together with the onset of strain rate- and strain-dependent behavior could play a critical role during PNR degassing history, governing the elevated explosivity of these very undersatured magmas.

[1] Giordano et al. (2008) Earth and Planetary Science Letters **271,** 123-134

DOI: 10.1180/minmag.2013.077.5.3