Carbon dioxide degassing and estimation of thermal energy release from White Island volcano , New Zealand

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Accurate quantification and mapping of the total carbon dioxide (CO_2) emitted from a variably permeable volcano still remains a challenge. We used high resolution measurements of CO_2 flux and heat flow within the crater floor of White Island to characterise the mass (CO_2 and steam) and heat released. White Island is an andesite stratocone and New Zealand's most active volcano. Frequent phreatic, phreatomagmatic and magmatic eruptions have occurred throughout the 19th and 20th century. White Island's most recent magmatic explosive eruption occurred in 2000. Currently, the hydrothermal system is manifested by localised vigorous fumarolic activity, mud pools and mounds, and an acidic (pH ≈–0.4) 200 m diameter crater lake, and diffuse degassing through the crater floor.

CO_2 flux degassing and thermal budget

In 2011, we performed 691 measurements of CO_2 flux using the accumulation chamber method. CO_2 flux values measured were ranged between of 0.1 – 29,896 g m^{-2} d^{-1}. Total CO_2 emission rate estimated by stochastic simulation was 116 ± 2 td^{-1} within the crater floor (0.31 km^2). The $\delta^{13}C$ range (-10 and -2‰) reflects the spatial variance in magmatic CO_2 contribution. Based on CO_2 flux data and a mean H_2O/CO_2 wt ratio of 15.3, the flux of thermal energy released from the crater floor totals 54 ± 1MW. The associated rate of steam condensation is 1760 ± 25td^{-1}. The spatial distribution of surface heat flow, soil gas $\delta^{13}C$, surface hydrothermal features and CO_2 flux indicates high gas and thermal permeability at old crater margins, and breaks in slope (crater floor/wall, crater floor/mound). We suggest that areas of high degassing are associated with advective gas transport adjacent to persistent fumarole pathways. Areas of low permeability are associated with sulphur/anhydrite and iron oxide-silica precipitation crusts which limit gas diffusion to the surface. In addition, we explore the influence of sea water and meteoric water influx into the hydrothermal system.

Evidence of paleo sulfate methane transition zone in marine sediments

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The sulfate methane transition zone (SMTZ) denotes a redox interface within the anoxic sediment column where pore water sulfate and methane concentration profiles intersect and are depleted to non detectable concentrations. This depletion in sulfate and methane concentrations are attributed to the anaerobic oxidation of methane (AOM) performed by a syntrophic consortium of CH_4-oxidizing archaea and sulfate-reducing bacteria [1]. AOM causes marked enrichment in H_2S and HCO_3^- ion concentrations in the porewaters within the SMTZ, resulting in precipitation of Fe-sulfides, Ca-Mg-carbonates. Sulfate concentration profile, depth to SMTZ and thickness of SMTZ depend on the methane flux. High methane flux results in linear sulfate concentration gradient and shallow SMTZ and vice versa. In the Krishna-Godavari (K-G) basin, Bay of Bengal, seismic data [2] show regional presence of gas hydrates manifested in the form of a bottom simulating reflector (BSR). Sediment cores for the study were collected on-board Marion Dufresne and JOIDES Resolution as part of the gas hydrate exploration program in the K-G basin offshoe. Our results show multiple carbonate bearing zones in the sediment with pronounced carbon isotopic depletion typical of AOM. Biogenic methane with $\delta^{13}C$ ranging from -80 to -100‰ (VPDB) have earlier been reported [3] from K-G basin. In contrast, we have not recorded any appreciable barium front in any of the cores. The barium front possibly diappeared whenever the SMTZ moved up across an existing Ba front. However carbonate layers are not subject to such dissolution. The zones with deplted carbon isotope ratios are enriched in pyrite with heavy sulfur isotope ratios suggesting Rayleigh fractionation in a closed system. The sharp rise in $^{34}S_{CRS}$ indicate focussed sulfate reduction in SMTZ. In the long core NGHP-01-10D several such zones with heavy sulfur isotope ratios have been noted indicating paleo SMTZ transition zones We propose that content and stable isotope ratios of authigenic carbonate and pyrite in marine sediments may serves as an ideal tool to detect fossil sulfate methane transition zone in the absence of barium front.

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