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Geochemical characterization of the Nirano Mud Volcano Field

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Mud volcanoes, among fluid venting structures, are the most important phenomena related to natural seepage from the Earth's surface. The occurrence of mud volcanoes is controlled by several factors, such as tectonic activity and continuous hydrocarbon accumulation in a reservoir. Mud volcanoes in Italy occur along the external compressive margin of the Apennine chain. These mud volcanoes are usually small and unspectacular, when compared to other world examples. They rarely exhibit the periodic explosions, which is often related to important seismic activity.
The Nirano Mud Volcano Field (NMVF) is located in the western sector of the Modena Apennine margin (Italy), which belongs to the Northern Apennines. The NMVF occurs over the crest of a thrust anticline associated with the main Pede-Apennine thrust and represents a good example of an onshore relationship between a mud volcano caldera structure and active thrust deformation, even if the fluid pathways are still not well understood at depth.
The mud volcanoes are distributed along an area of about 10 ha, inside of the wider Natural Reserve, and are situated at the bottom of a wide sub-circular depression. The NMVF is currently formed by four main vents composed of a number of individual active cones (or gryphons) defining structural alignments trending ENE-WSW.
A geochemical soil gas survey of 230 CO_2 and CH4 fluxes and 150 CO_2, CH4, Rn, He, H2 concentration measurements has been carried out inside the NMVF. Moreover, the fluid emissions from 4 active cones located in different sectors of NMVF have been sampled for chemical and isotopical analysis of water and free gas.
The distribution of pathfinder elements as 222Rn, He e H2 has been studied in order to identify potential faults and/or fractures related to preferential migration pathways and the possible interactions between reservoir and surface.
Soil gas data highlight two zones characterized by higher values, localized in the WSW and ENE of the NMVF area. In fact, Rn is around 28800 Bq/m3 (southern part), CO_2 up to 5.5 %, CH4 about 6000 ppm, He and H2 are 18 ppm and 39 ppm, respectively.
CO_2 flux measurements show high values (up to 91 g/m2day) along a natural slope, at the central sector of the NMVF, suggesting the presence of fracturation zone. CH4 fluxes show a spotty distribution and low values (mean 65,95 mg/m2day), similar to average values measured in adjacent areas (67 mg/m2day), in the Modena province.
The mud volcanoes of Nirano are characterized by mud, gas bubbles, and muddy water, which may also contain a small fraction of liquid hydrocarbons. Water analysis highlights connate origin of fluids dominated by sodium-chloride component. Extruded gas is chemically composed essentially by methane and in minor measure by nitrogen, oxygen, carbon dioxide, and ethane. Isotopic analyses highlight the thermogenic origin of emitted methane.