

Geochemical characterization of an accessible extreme environment analogue: Nirano Mud Volcanoes Field (Northern Apennines, Italy)

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Mud Volcanoes (MVs) are unique geomorphological formations where deep fluids rise carrying sediment. These are well-known structures, although rare on land, and can often be found on the seafloor where the geochemical imprint generates peculiar ambient. The Regional Park of “Salse di Nirano” is located in the Modena province on the Northern Apennines foothills (Italy). The Park is characterized by several active mud volcanoes, called "Salse" by locals, and in 2004 was recognized as Site of Community Importance by the European Commission. This area is one of the most important in Italy and among the most complex in Europe. For years, geochemical data has been published in bits and pieces and used as marginal information, accompanying geophysical, fluid dynamic and structural studies. The last fully geochemical paper dates back to the 2000s and focused on water chemistry. In turn, this project, approved by the Natural Park authorities and Regional Institution, aims to characterize sediments, mud, and water composition of MVs field to understand the deep fluids system in the frame of climate and ecosystem imprint of these areas that are considered full-fledged extreme environments. Analysis has been portrayed mostly by Ferrara University Labs in the Physics and Earth Sciences Department. Preliminary analyses on MVs waters are, on average, in agreement with previous results [1], but evidenced small variability between the gryphons never reported before. Preliminary geochemical and isotopic analyses together with general mineralogical composition describe the possible switching from marine to terrestrial sedimentary contribution of the area. Furthermore, these preliminary results hint at the potential of using MVs to study fluid seepage and dehydration processes in extreme environments like deep-sea MVs [2] and potentially applicable to planetary analogues on Solar System bodies [3].

[1] Minissale, Magro, Martinelli, Vaselli & Tassi (2000), *Tectonophysics* 319,199–222.

[2] Panieri, Argentino, Savini, *et al.*(2025), *Nature Communication* 16 ,504.

[3] Dapremont & Wray (2021), *Journal of Geophysical Research: Planets*,126, e2020JE006390.