

Supplementary information

From Volcanic Ashes to Magnetic Zeolites: Unrevealing the Iron Oxides Phase Transitions by Magnetic and Advanced Structural Characterization

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XRD analysis

Figure S1 and **S2** show the XRD patterns of the samples. In particular, the *VA1H₆₀* sample exhibited the formation of X-type zeolite, zeolite P, and sodalite, along with detectable peaks corresponding to hematite. A predominance of sodalite was observed in *VA1HM₆₀*. The hydrothermal processing of *VA2H₆₀* and *VA2HM₆₀* yielded similar patterns; however, *VA2H₆₀* displayed a higher content of hematite compared to other samples. Notably, the synthetic products derived from VA0 featured a higher proportion of X-type zeolite than the other samples. Additionally, samples incubated with seawater (*HM*) consistently exhibited halite precipitation.

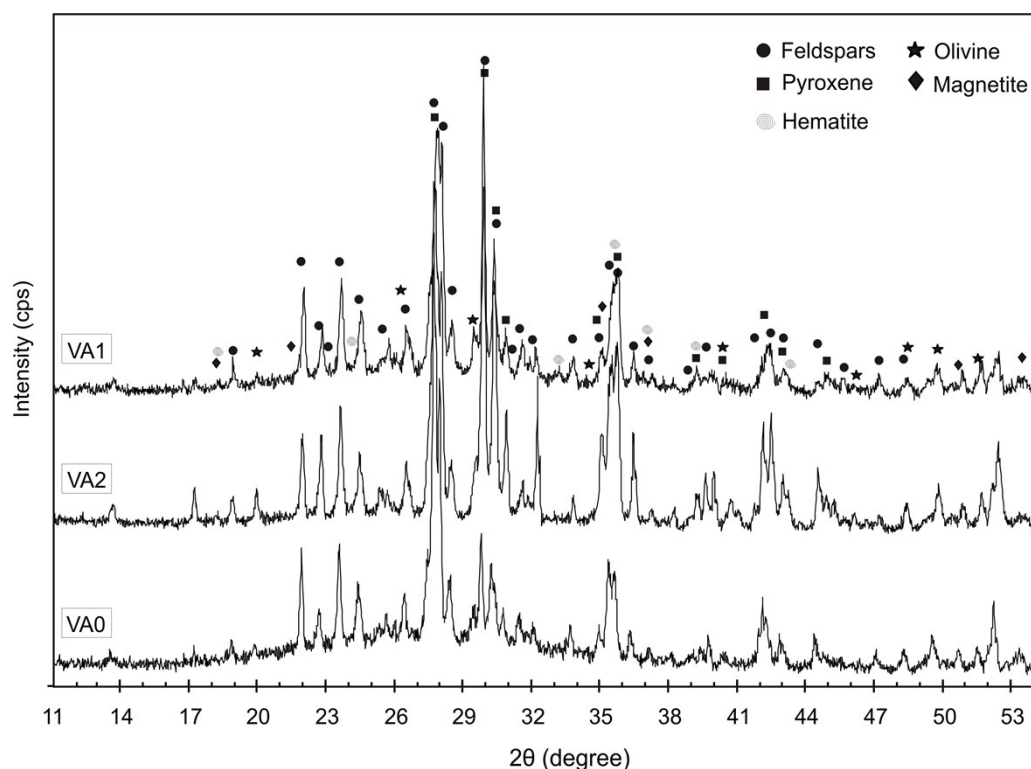


Figure S1. X-ray patterns of VA1 (volcanic ashes collected from Catania roads); VA2 (volcanic ash from the area of Chalet Sapienza) and VA0 (unpolluted volcanic ash sample) samples.

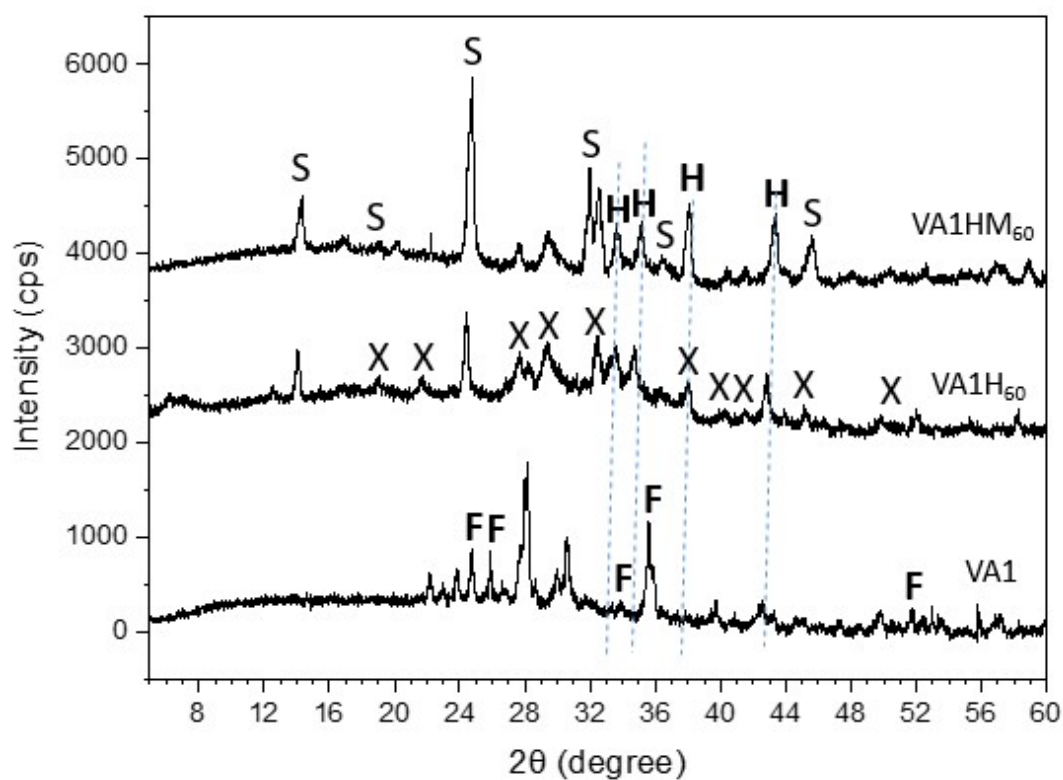


Figure S2. XRD patterns of volcanic ashes incubated with distilled water (H) and seawater (HM) at 60 °C. F = fayalite; H = hematite; S = sodalite; X = X-type zeolite.

TEM analysis

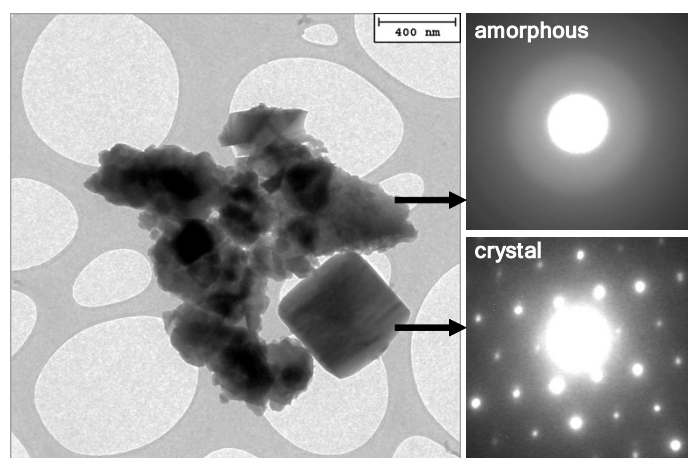


Figure S3. TEM bright-field image of the $VA0HM_{60}$ sample showing both crystalline regions—characterized by a SAED pattern with regularly distributed diffraction spots—and amorphous areas, which display a SAED pattern with diffuse intensity.

Additional Magnetic Characterizations

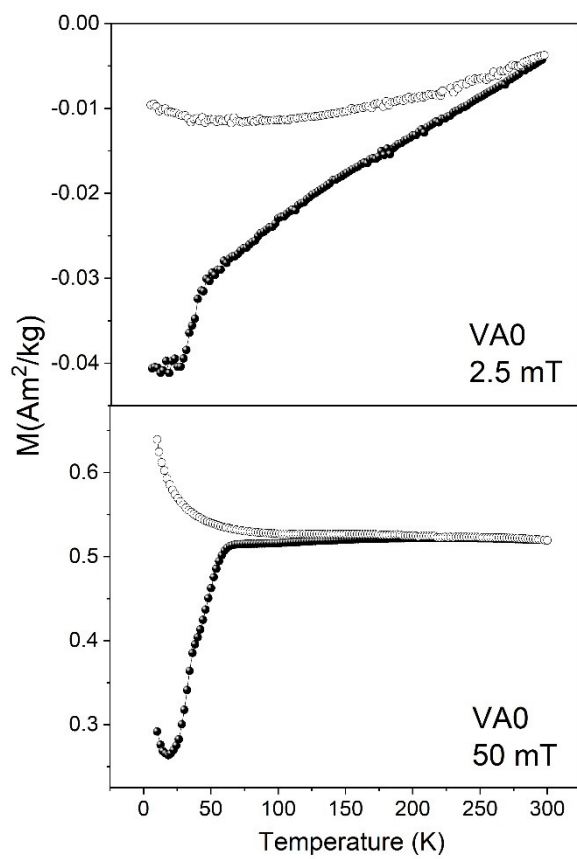


Figure S4. ZFC-FC curves of VA0 sample under the different applied magnetic fields.

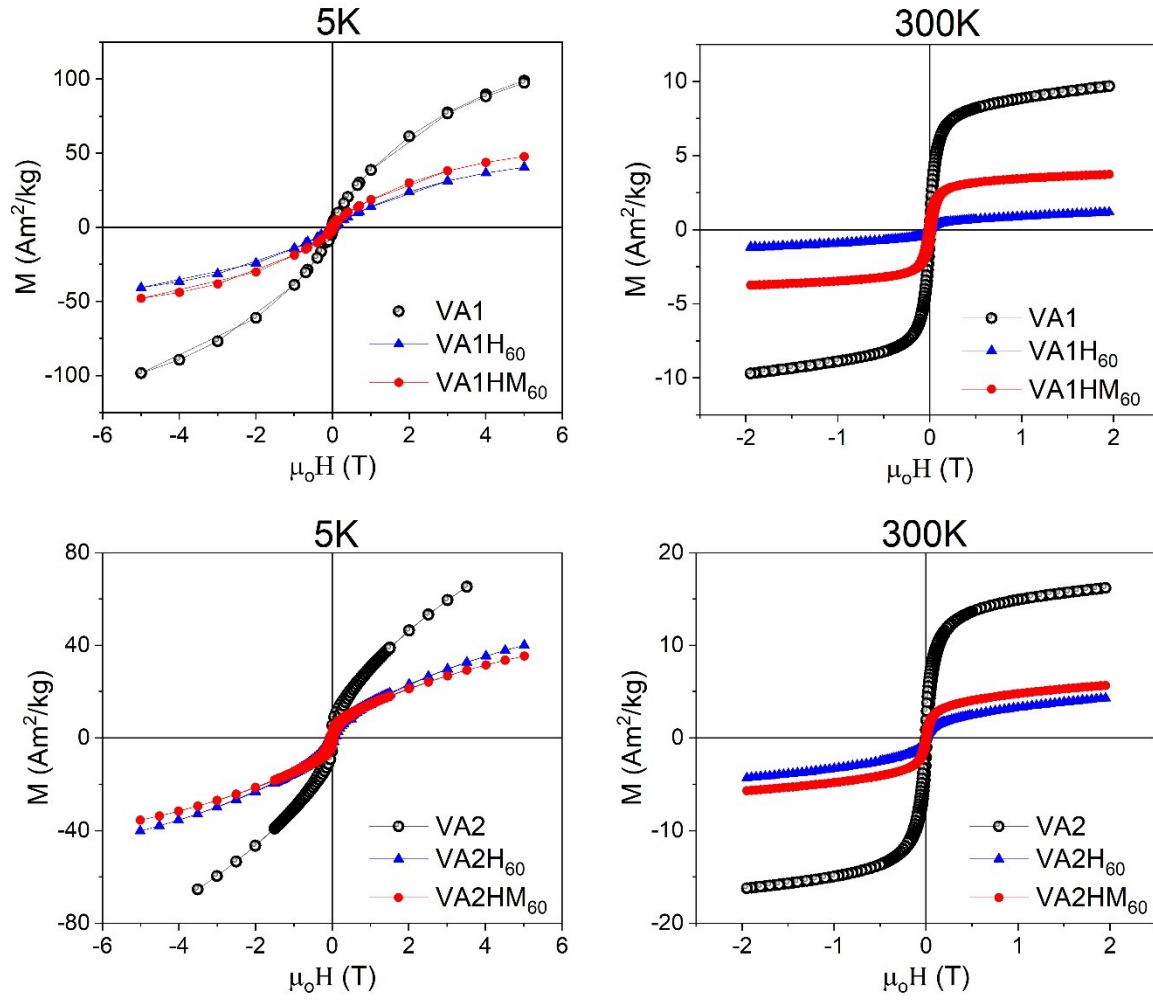


Figure S5. Field dependence magnetization curves at 5 K and 300 K of VA2 and VA0 series.