

Deciphering the Origin of the North-Sardinia Bentonite Basin: An Integrated Sr-Nd Isotope and Geochemical Approach

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This study presents an integrated isotopic and geochemical investigation aimed at defining the genetic model of bentonite deposits in northwestern Sardinia, Italy. Bentonites from the NW Sardinia Basin are economically important industrial minerals, widely used in foundry sands and paper production, and are mainly derived from the alteration of rhyolitic to rhyodacitic pyroclastic rocks emplaced during Oligo-Miocene calc-alkaline volcanism. The research focused on two representative deposits, S'Aliderru and Sa Pigada Bianca, in order to link precursor magmatic compositions to final bentonite quality and to quantify the role of fluid-rock interaction in deposit evolution. A total of 32 samples were analyzed through SEM-EDS, major- and trace-element geochemistry, and Sr-Nd isotopes. Major-element data indicate a broadly common felsic parental magmatism, although Sa Pigada Bianca shows slightly higher Fe₂O₃ and TiO₂ contents, suggesting some heterogeneity in the volcanic source rocks. Trace-element systematics, including the Co/(Ti/Zr) differentiation index and REE patterns, confirm variable magmatic differentiation, with S'Aliderru North representing the most evolved products. Nd isotopic ratios ($^{143}\text{Nd}/^{144}\text{Nd} = 0.512288\text{--}0.512498$) define two distinct groups, supporting a heterogeneous volcanic source related to alternating felsic Oligo-Miocene units. In contrast, Sr isotopes clearly record the intensity and nature of post-depositional alteration. S'Aliderru shows the highest $^{87}\text{Sr}/^{86}\text{Sr}$ ratios, interpreted as the result of strong hydrothermal leaching by deep crustal, Rb-rich radiogenic fluids channeled along major faults. This process enhanced depletion of mobile elements (Na₂O + K₂O) and enrichment in Al₂O₃, producing a highly mature bentonite deposit. Sa Pigada Bianca, by comparison, displays lower $^{87}\text{Sr}/^{86}\text{Sr}$ ratios, consistent with weaker interaction with mixed deep fluids and groundwater, resulting in only partial leaching. These results demonstrate that fluid circulation, more than primary magmatic zoning alone, ultimately controlled bentonite maturation and industrial quality. Proximity to deep-seated faults is therefore proposed as a key exploration criterion for identifying high-quality bentonite resources in the region.