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Reuse of Granite Quarry Waste for REEs Recovery Along the Industrial Production Chain: Results from Preconcentration Tests

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Granite quarry waste from the “Graniti dei Laghi” plutons in Piedmont, Italy, underwent several lab-scale beneficiation tests to enhance the recovery of critical raw materials (CRMs) in the context of circular economy and sustainable mining. Preliminary analyses by ICP-MS, XRPD, SEM-EDS, and automated mineralogy highlighted that the magnetic waste from granite industrial reprocessing for feldspar production is notably enriched in rare earth elements (REEs), paving the way for simulating and refining a lab-scale treatment to optimize the concentration of REE-bearing minerals. Monazite-(Ce) was identified as the primary target mineral, predominantly locked within Fe-rich biotite (siderophyllite). The feed material was milled to various grain sizes and subjected to multiple magnetic separation stages to identify the optimal conditions for REE mineral beneficiation. Results indicate that approximately 90% of REEs are associated with paramagnetic fractions of 75-150 µm and 150-250 µm grain sizes. The 75-150 µm paramagnetic concentrate recovered at 1 A of current intensity shows the highest enrichment to ~1800 ppm REEs + Y and Sc compared to ~200 ppm in the raw granite. However, significant REE amounts remaining in the paramagnetic material at 0.4 A suggest possible incomplete liberation of monazite. Although grinding below 600 µm favours the rejection of diamagnetic gangue minerals from the monazite-bearing siderophyllite, SEM-EDS observations reveal liberation issues for monazite particles above 100 µm due to their smaller size compared to siderophyllite. Consequently, additional grinding below 100 µm is required to isolate monazite. However, dry electromagnetic separation on fine material demonstrated poor monazite recovery, indicating the need for wet magnetic separation and flotation for effective recovery from the fine-grained preconcentrate. This work underscores the potential of improving beneficiation techniques to maximise the recovery of CRMs as by-products along the industrial production chain, advocating the valorisation and sustainable management of mineral processing waste through its reuse.