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Growth mechanisms of the bimodal Matorello calc-alkaline pluton, Central Swiss Alps

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The Matorello pluton is a 297 Ma-old, 3 x 4 km, calc-alkaline intrusion located in the Sambuco unit of the Maggia nappe s.l. (lower Penninic domain, Central Lepontine Alps). The dominant facies are granodiorites and quartz-diorites, crosscut by acid-basic composite sills, aplitic and pegmatitic dykes and lamprophyres. Alpine orogeny induced complete overturning and polyphase folding of the pluton, as well as amphibolite-facies metamorphic recrystallization. Despite this overprint, the pluton still preserves spectacular features of successive injection of magma batches with flow and deposition structures reminiscent of sedimentary environments.

The Matorello pluton was originally a tabular intrusion, built up by the accumulation of multiple, several meter-thick, subhorizontal sheet-like injections of magma. Individual magma batches are sometimes easily identifiable by their contrasting composition compared to their host (e.g. granodiorite against quartz-diorite) or by their contrasting rheological behaviour. Depending on their emplacement rate, the successive magma injections either rapidly solidified with sharp and rather well-defined boundaries (like the composite sills) or mingled with previous ones to the point of generating a thick molten layer up to several tens to hundred meters thick, like in the main granodioritic facies. These coalesced injections are hardly distinguishable by subtle contrasts in granulometry, mineral mode or mineral sorting (cross-bedded biotite-rich schlieren), or by erosional features and/or crystal entrapment along contact surfaces. Two exceptional meter-thick layers with sinuous boundaries with the host granodiorite

consist of a densely packed accumulation of mafic enclaves of variable size (2-40 cm), shape (mostly rounded, but also angular), grain size and composition (mostly quartz-dioritic), in a granodioritic to monzogranitic matrix. Gravitational sorting of the enclaves with load cast features at the base of the layers and sinuous biotite schlieren point to injection of low viscosity (fluid-rich?), turbulent composite magma flows in the still largely molten granodiorite host.

Magma mingling is ubiquitous, not only at the emplacement level where it is best illustrated in the contact zone between the comagmatic quartz-diorite and granodiorite masses, but also at deeper levels, as revealed by the enclave-rich injections and the late composite sills. Quartz ocelli and plagioclase xenocrysts in the quartz-diorite also evidence more thorough magma mixing processes. The magmas involved are mantle-derived mafic liquids and crust-derived partial melts as evidenced by a range in initial Sr isotopic ratios and Nd epsilon values (0.704 to 0.709 and -2.1 to -4.7, respectively). These data also show that the crustal contribution was dominant, in agreement with Pb isotopes. Hybridization processes presumably took place at the mantle-crust boundary (MASH processes).

Reconstruction of the original geometry and sequence of intrusion of the Matorello pluton is the following: (a) multi-pulse sill-like intrusion of the quartz-diorite facies, which hosts mafic enclaves; (b) repeated injection above and below this quartz-diorite body of essentially granodioritic magma carrying variable amounts of mafic material as microgranular enclaves. Mingling occurs between the quartz-diorite and the granodiorite; (c) episodic injection of layers made of a highly mobile mush of mafic enclaves in a granodioritic matrix; (d) later emplacement in a more consolidated and brittle environment of aplitic dykes, acid-mafic composite sills with some gravity-driven sorting of the mafic material and lamprophyric dykes.