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Deformation-driven differentiation during in-situ crystallization of the Iguilid mafic intrusion (West African craton)

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The 2.7 Ga Iguilid mafic body is a small (9x2 km) magmatic intrusion with preserved igneous textures and not affected by metamorphism and deformation. It intrudes the metamorphic Archean basement of the Amsaga domain in the West African craton in Mauritania. The dominant lithology is a gabbronorite with subordinate gabbros and norites. We investigated 45 oriented samples for fabric analysis, anisotropy of magnetic susceptibility and geochemical analyses to explore the link between chemical differentiation and emplacement of the plutonic body. According to the limited variations in modal proportions and in major element compositions within the intrusion, the Iguilid pluton crystallized via an in-situ mechanism where solidification fronts progressively thickens from the rim to the core of the cooling intrusion and where the trace-element composition is controlled by the amount of interstitial liquid (containing most incompatible trace-elements) preserved between cumulus minerals before total solidification. An in-situ crystallization process alone normally does not produce chemical differentiation but the mafic cumulates at Iguilid have been deformed during their crystallization (i.e. when melt was still present). The vertical foliations and the randomly oriented lineations argue for horizontal flattening as the main deformation mechanism. We estimated the amount of trapped interstitial liquid preserved between the network of cumulate minerals with geochemical modelling in 12 samples and found that it is negatively correlated to the anisotropy degree determined by fabric analysis. The rocks located close to the margins of the intrusion were not deformed, probably because the degree of crystallization and, hence, the viscosity of the mush was too high. The most deformed rocks with the lowest trapped interstitial liquid content are found in the center of the intrusion where the crystal mushes were rich enough in melt to record significant strain. Deformation leaded to expulsion of the differentiated interstitial liquid and, consequently, the most deformed rocks are those with the lowest trace-element content. We interpret the deformation process as a filter-press mechanism: (1) the crystal-free magma emplaced in a relay between two strike-slip faults and (2) when the magmatic pressure decreased due to crystallization, the magma chamber closed partially and induced deformation of the partially solidified crystal mushes. The expulsed liquid can feed superficial volcanic systems in differentiated silicic melt. This process can also explain the frequently observed Daly Gap in volcanic series where volcanic rocks with an intermediate composition are missing or scarce.