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Understanding the emplacement of magma bodies: why is it so crucial?

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Field observations and geophysical data indicate that many igneous bodies grow by amalgamation of successive magma sheets. Geochronological data suggest that some plutons may be emplaced over millions years. The emplacement style and emplacement rate of magma bodies have fundamental implications on differentiation, country rock metamorphism and assimilation, and for the formation of large magma chambers.

When a magma body begins to grow by slow accretion of sills, each successive intrusion solidifies before the injection of the next one during an incubation period, which duration depends on the magma injection rate. When the system is thermally mature, sill temperatures equilibrate above the solidus, melts accumulate and older sills can re-melt. The time needed for each magma injection to cool down and equilibrate with its surrounding is short relatively to the total emplacement time of the body, so that, if the sills are mafic, the differentiation of the mafic magma is fast, whereas the resulting evolved residual melt can reside in the crust for protracted periods. Thus the extraction of intermediate melt is unlikely, which may explain the bi-modal character and the absence of intermediate compositions in many volcanic and granitic provinces.

The level of emplacement of successive magma pulses controls the shape of the thermal anomaly associated with the magma body growth. The metamorphism, partial melting and assimilation of the country rock is favoured if the successive magma sheets are emplaced at or close to the country rock-magma body boundary. Moreover, if the magma emplacement rate is low, the size of the thermal aureole is controlled by the size of one pulse and not by the size of the entire igneous body.

In the upper crust, emplacement rates of meters per year are required for an intrusive body to stay largely molten during its emplacement. If magma sheets are accreting at an average rate of a few centimetres to decimetres per year, less than 20% of the total intruded volume is molten enough to be mobile and eruptible.