Regional stress field interaction with magma intrusion : the case of wedge-shaped granitic plutons

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Combined structural and geophysical data allow two main types of granite intrusion to be defined. Flat-floored plutons, mainly leucogranitic, are rather thin ($\leq$ 3 km) and contrast with the thick ($\geq$ 10 km) wedge-shaped plutons, preferentially granodioritic.

We propose that this two fold discrimination is the result of a switch in the stress pattern induced by the magma emplacement. Stress reorientation occurs when the magma reachs the rigidity state (50% crystals) during its cooling and crystallisation. Computer modelling of water saturated magmas shows that the rate at which rigidity is achieved (100-200 mm/y) is faster than tectonic rates (10-50 mm/y) meaning that magmas are able to sustain the ambient stress pattern. Intrusion along a plane (σ_1-σ_2 often vertical except for compressional conditions) leads to an increase in magnitude of the two lesser principal stress components to values greater than the lithostatic load. This results in flipping of the orientation of the principal stress axes, which induces a switch from a vertical (dyke-shaped) to a horizontal (laccolith-shape) plane of intrusion.

During magma ascent, the point at which the switch in the stress pattern occurs can be not attained. This can be explained by : (i) the existence of crustal anisotropies which can modify the shape of intrusions and (ii) the time delay between magma intrusion, as a liquid, and its response to stress, as a consolidated framework of crystals. This time delay is longer for granodioritic than leucogranitic magmas. This explains the formation of wedge-shaped intrusions (granodioritic), as the magmas are unable to sustain stress leading to stress reorientation.

In conclusion, we suggest that the feedback between magma intrusion and the local stress pattern controls the geometry of magma emplacement rather than the neutral buoyancy hypothesis.