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3D relationships between sills and their feeders: evidence from the Golden Valley Sill Complex (Karoo Basin) and experimental modelling

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Saucer shaped sills are tabular intrusions observed worldwide on volcanic margins and in sedimentary basins (e.g., offshore Norway, Karoo Basin). Although they are common, their feeding mechanisms are still poorly known mainly because the relationships between sills and their feeders are (1) rarely exposed, and (2) difficult to image on seismic data. The present study address sill emplacement mechanisms through an integrated approach: i) we use field observations and geochemistry in order to assess the three-dimensional relationships between sills and their potential feeders (dykes or sills) in the well-exposed Golden Valley Sill Complex (GVSC), Karoo Basin, South Africa; ii) the results were then compared with scaled laboratory experiments of saucer-shaped sill emplacement.

Field observations in the GVSC show that sills present some physical contacts between them, suggesting sill-feeding-sill relationships. Systematic chemical analyses, however, show that their compositions were different, implying that these sills were not connected when they were emplaced. There are, however, close associations between one elliptical sill (the GVS) and a small dyke (d4): the dyke crops out underneath the southern tip of the sill, is parallel and superimposed on the long axis of the GVS sill, and they both exhibit identical geochemical compositions. Such relationships suggest that GVS is fed by d4 and that the linear shape of the dyke may have controlled the elliptical development of the GVS.

To test this hypothesis, we present results of experimental modelling of sill emplacement, in which we vary the shape of the feeder. In the experiment with a punctual feeder (E1), the sill develops a sub-circular geometry, whereas in the experiment with a linear feeder (E2), the sill develops an elliptical geometry. The geometrical relationships between the sill and its feeder in E2 show that the elliptical shape of the sill is controlled by the linear shape and the length of the linear feeder. The experiment E2 presents strong similarities with the GVS-d4 relationships and thus supports the proposition that the d4-dyke is the feeder of the GVS. Our experimental results also indicate that the feeders of the other elliptical sills of the GVSC may be dykes. These results show that sills in contact do not necessarily imply feeding relationships. This finding suggests that the model of interconnected sill networks based on the observation of contacts between sills on seismic profiles should be revisited.