EGU2020-3281
https://doi.org/10.5194/egusphere-egu2020-3281
EGU General Assembly 2020
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Emplacement of Jurassic dolerite sills in Tasmania: Implications for Australia-Antarctica connections and Gondwana breakup

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The ca. 182 Ma Jurassic dolerite sills of Tasmania, SE Australia, overlap in age with dolerite sills and basaltic lavas in the Ferrar province, Antarctica, and the Karoo, South Africa. Hence, the Tasmanian dolerites have long been considered to be part of a major Large Igneous Province that extended parallel to the Jurassic margin of Gondwana from what is now southern Africa, the Transantarctic Mountains, to Tasmania and South Australia. Two hypotheses have been proposed for the Ferrar and Tasmanian dolerites. 1) They are related to a mantle plume emplaced in the present-day Wedell Sea region, implying long-range, shallow-crustal transport of magmas in sills and dykes over distances of up to 4,000 km. 2) They are sourced from the mantle below Tasmania and Antarctica, implying only short-range lateral transport at the level of emplacement. We report results from a combined structural and anisotropy of magnetic susceptibility (AMS) study of the Tasmanian dolerites conducted to evaluate these hypotheses by differentiating between flow patterns and structural architectures in sills that are indicative of local versus distal sources.

Detailed structural mapping and 3D modelling indicate that no more than a few individual large sub-horizontal dolerite sheets were emplaced parallel to bedding in Permian sedimentary host rocks. They are offset by map and outcrop scale steps that we interpret to be NW-SE-trending, steeply dipping broken bridges.

The AMS of dolerite was measured in oriented samples collected from 126 sites across Tasmania. Their mean bulk magnetic susceptibility is ~0.01 SI units, which together with high-temperature susceptibility measurements indicate that the AMS is carried by magnetite, which occurs as skeletal grains with morphologies controlled by the petrofabric of plagioclase and pyroxene. These observations, and scant microstructural evidence for solid-state deformation, indicate that the AMS records a magmatic fabric that formed during emplacement and crystallization of the dolerite sheets. Magnetic lineations are dominantly subhorizontal, trending mostly NW-SE. Steeply-moderately inclined magnetic lineations are rare and mostly plunge SE. Subsets of shallow N-S and NE-SW lineations are associated with sites with subvertical E-W and NW-SE striking magnetic foliations. Magnetic foliations are dominantly subhorizontal, parallel to bedding in the surrounding sedimentary rocks, and the upper and lower contacts of subhorizontal dolerite sheets. Anomalous subvertical E-W and NW-SE striking magnetic foliations are associated with steps or broken bridges observed in the field and cross sections.

The AMS results are consistent with dominantly NW-SE magma flow within subhorizontal sheets,

which is supported by the NW-SE orientation of steps and broken bridges. The architecture of segmented sheet fronts indicates that the polarity of sill propagation was from SE to NW. This finding is inconsistent with a magma source immediately below Tasmania and implies lateral transport from another location. However, the magma flow vector does not point back to the Ferrar dolerites in Antarctica, and therefore does not support the long-range Ferrar-Tasmania LIP hypothesis. Rather fabrics in the Tasmania dolerite are consistent with lateral flow from the present SE, perpendicular to the Gondwana margin with a source in the back-arc of the associated subduction zone