<u>Granite types related to magma-crust interaction</u>

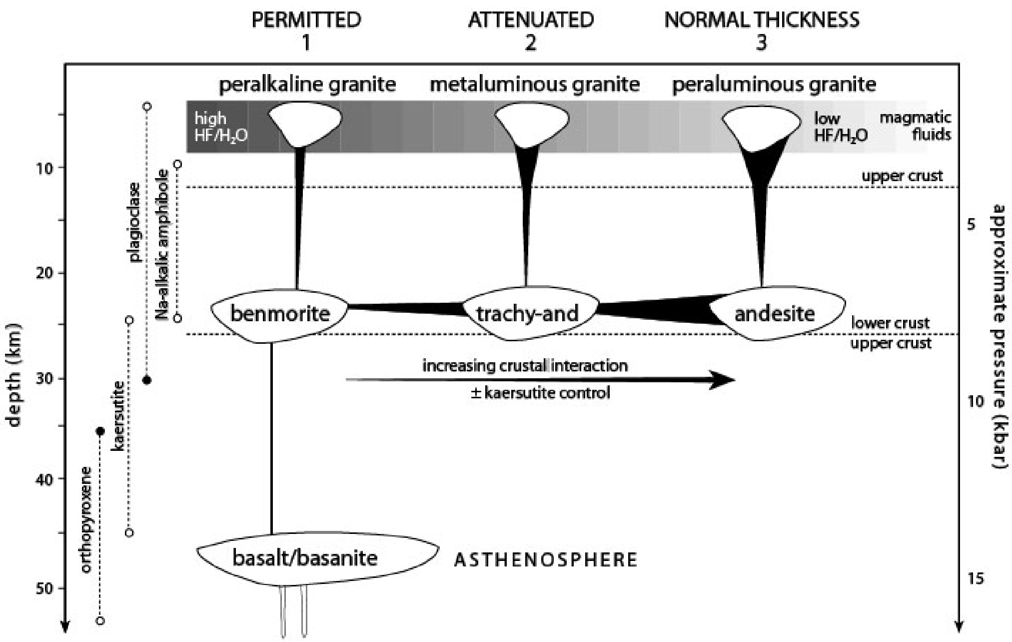

Figure DR1. Possible fractionation pathways for anorogenic granite derived from an initial alkali basalt magma. Peralkaline refers to granites with molar (Na+K)/Al > 1; metaluminous to Al/(Na + K + Ca) ≈ 1; peraluminous to Al/(Na + K + Ca) > 1. Permitted refers to the situation when a granite can traverse the crust without significant interaction with the crust (*sensu* Pitcher, 1979). 'Attenuated' refers to granite emplaced into attenuated lithosphere (e.g. Skaergaard, Mull); normal thickness to granite that must traverse lithosphere that is not attenuated and is thus likely to undergo significant interaction with crustal rocks (including S-type *sensu* Chappel & White, 1974, 2001). The fractionating phases on the left of the diagram are those largely responsible for the generation of peralkaline derivatives (LeMasurier et al., 2004). Fractionation of kaersutite is known to result in Si-saturation in the anorogenic volcanic rocks and associated intrusions of Marie Byrd Land, Antarctica (LeMasurier et al., 2004). The first derivative of the alkali basalt is likely to be of the alkali hawaiite-mugearite-benmorite series, and here it is assumed that benmorite will pond at the base of the lower crust. Interaction of a Si-undersaturated benmorite with lower crust will result in more Si-saturated derivatives, as will kaersutite fractionation. Increasing interaction with the upper crust from left to right in the diagram will result in progressively more aluminous magma (shown by black triangles). At the crystallization depth of the granite, magmatic fluids associated with the peralkaline granite will have a high HF/H_2O ratio often resulting in the crystallization of primary fluorite. With increasing input of crustal material the fluids will have progressively lower HF/H_2O ratios.

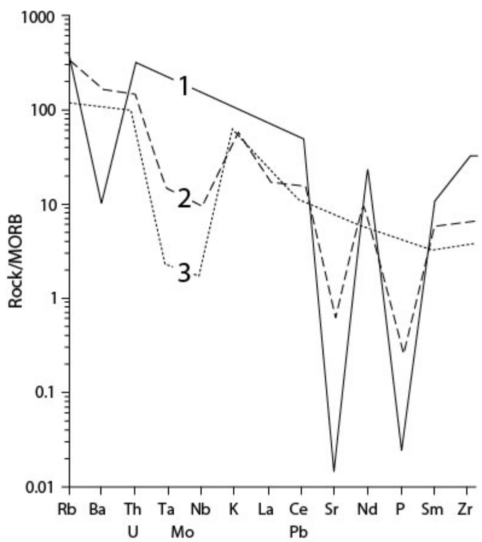

Figure DR2. Average element abundances for 1) peralkaline melts (LeMasurier et al., 2004), 2) metaluminous granite in attenuated lithosphere (e.g. Palaeocene of Mull; Pearce et al., 1984) 3) peraluminous granite (Chile; Pearce et al., 1984). Isotopic data confirms that the crustal input into these magmas increases in the order 1, 2 and 3, i.e. the abundances of elements, including many metals, is substantially higher in peralkaline melts, without crustal input. The position of Mo, Pb and U is taken from Sun and McDonough (1989), such that they have similar compatibility to Th, Ta and Pb respectively. The behaviour of the transition elements such as Zn and Cu during fractional crystallization is poorly understood, and they are more likely to be modified during fluid circulation at high levels. Normalizing values from Sun and McDonough (1989).

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Data sources

1. Torridon Group
   Age: 1.0 Ga (Stewart 2002)
   Copper sulfides: chalcopyrite-pyrite intermixtures (authors' unpublished data)
   $\delta^{34}S$ values: -35 to -39 per mil (authors' unpublished data)
   Interpretation of microbial sulfate reduction: Parnell et al. 2010

Precompactional/early diagenetic origin: authors' unpublished data
Lacustrine environment: Stewart 2002

2. Midcontinent Rift
   Age: 1.1 Ga (Mauk et al. 1992)
   Copper sulfides: chalcocite (Burnie et al. 1972)
   $\delta^{34}S$ values: -15.8 to +29.2 per mil (Burnie et al. 1972)
   Interpretation of microbial sulfate reduction: Burnie et al. 1972
   Precompactional/early diagenetic origin: Mauk et al. 1992
   Lacustrine or restricted marine environment: Elmore et al. 1989
3. Stoer Group
   Age: 1.18 Ga (Parnell et al. 2010)
   Copper sulfides: chalcocite (Parnell et al. 2010)
   $\delta^{34}S$ values: -35.5 to -18.4 per mil (Parnell et al. 2010)
   Interpretation of microbial sulfate reduction: Parnell et al. 2010
   Precompactional/early diagenetic origin: Parnell et al. (2010)
   Lacustrine environment: Stewart 2002
4. Lower Belt Supergroup
   Age: 1.46 Ga (Sears et al. 1998)
   Copper sulfides: unspecified (Strauss and Schieber 1990)
   $\delta^{34}S$ values: -17 to +12 per mil (Strauss and Schieber 1990)
   Interpretation of microbial sulfate reduction: Lange and Sherry 1983, Strauss and Schieber 1990
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