

# Integrated melts from melting regimes of different shapes

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*Melting regimes have a 'shape'.* It is most improbable that the mass fraction of melt formation and extraction from different parts of a melting regime should be constant. Intuitively one might expect these parameters to increase from zero to some central maximum within a linear plan (ridge segment), circular plan (plume) or spherical (blob) region. Any convenient relationship might be used to model this variation or 'shape' of the melting region, a simple power law being chosen here (following O'Hara, 1985).

*Assumption of constant distribution coefficients.* Constant distribution coefficient for each element is also assumed throughout the process at this stage - i.e. melting is assumed to be modal and all effects due to pressure-temperature dependency of the source rock mineralogy (O'Hara and Mathews 1981, Figs. 11–15) are ignored.

*Relative concentrations of trace elements in some integrated melting regimes.* The relative concentrations of ideal trace elements in the liquid products of integrated melts derived by perfect equilibrium or accumulated fractional melting of selected linear and circular plan melting regimes are to a first approximation quite similar to those of a simple equilibrium partial melt of the same source material using a single weighted average mass fraction of partial melt. Results are, therefore, presented in Fig. 1 as plots of the difference between the logarithms of relative concentration in the equilibrium partial melting (EPM) process with average mass fraction of melt and that yielded by the integrating process under consideration, as a function of the distribution coefficient and the average mass fraction of melt - i.e. plotting values effectively normalised against those of the equilibrium process operating under the same parameters of

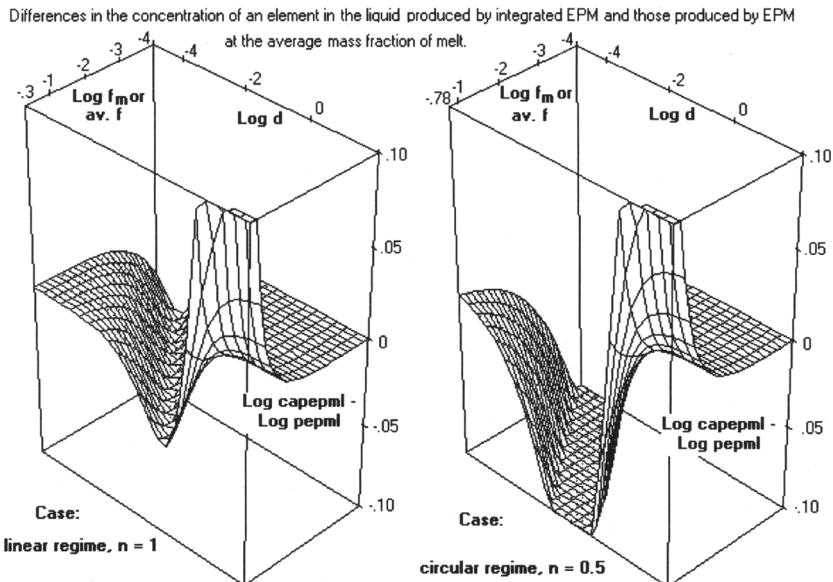


FIG. 1.

distribution coefficient and average melt fraction developed. The diagrams display the effects previously identified by an analytical treatment (O'Hara, 1985) and provide more quantification of the scale and positioning of the effects. Similar figures may be developed to display the differences relative to a simple accumulated perfect fractional melt with a single average melt fraction if this is felt to offer a better model.

*Is the average melt fraction extracted 'good enough' for modelling purposes?* Some have argued that the approximation of modelling results using the EPM model and the average mass fraction of melt is sufficient. Figs. 1 and 2 show that this is only true provided that one is not modelling elements for which the distribution coefficient was numerically approximately equal to the average mass fraction of melt extracted (i.e. not using elements for which  $d \sim 0.001-0.1$ , which covers most of the popular incompatible elements!) or that no petrogenetic significance should be read into observed departures from the expected concentrations of up to 30% (the base of the 'box' in the figures represents a deficiency of 20%), far exceeding the aspired-for accuracy and precision of the sampling and analytical procedures.

*Implications of 'shape' for subdued and reversed discrimination.* At any given average mass fraction of melt extraction of integrated melt extraction there is a range of elements, the numerical values of whose distribution coefficients are equal to or a little greater than the numerical value of the average mass fraction of melt, within which the relative concentration of the more incompatible element will be less than expected from the simple EPM model (i.e. discrimination appears to be subdued in the integrated melt). The extent to which the discrimination is subdued is controlled by the chosen 'shape' and increases as the planform changes from linear to circular to spherical and as the shape factor,  $n$ , used to describe that shape increases (i.e. as the ratio of low mass fraction melts to high mass fraction melts in the integration increases). No combination of parameters yet explored leads to reversed discrimination in the integrated melts relative to their immediate source region; but if that source region were already depleted, integrated melting will extend the range of parameters within which reversed discrimination combined with high relative concentration might be produced (see preceding abstract).

*Reconciliation of apparently conflicting field evidence and trace element data.* The discrepancy between field observations in the peridotite section of ophiolites, apparently requiring large mass fractions of partial melt extraction, and the desirability of keeping melt fractions small in order to generate reversed discrimination, may to some extent be reduced by adoption of integrated melting models. When the shape factor,  $n$ , is large the incompatible trace element signature is increasingly dominated by contributions from the periphery where the melt fraction extracted is indeed small - but the immediate sub-Moho residual mantle is dominated by material which has passed through the centre of the melting regime.

*Possible misinterpretations of 'real' data if the 'shape' effects are ignored.* Suppose that a set of high accuracy and high precision data for liquids, which were in reality the product of integrated melting, were coerced into an interpretation assuming a simple EPM model at the average mass fraction of melting - how will the deficiency among the incompatible trace elements be (mis)interpreted? The geochemical effects of melt integration are inevitably ascribed to the characteristics of the source region. The decline in relative concentration as the distribution coefficient declines towards the numerical value of the average mass fraction of melt extracted, when this value is compared with that expected in simple EPM, mirrors that seen in melts produced by fractional melting - the temptation is to postulate a prior episode of fractional melt extraction from the source. The recovery of relative concentration values in the still more incompatible elements then requires explanation - what else but an episode of mantle metasomatism by LILE! Exploration shows that the discrepancy to be explained, and the imperative to explain it, increases as the factor  $n$  decreases (i.e. as the ratio of peripheral melts to central melts increases) and as the planform of the melting regime changes from linear through circular to spherical.

## References

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