

Experimental data on major and trace element partitioning in partially molten carbonated peridotites

I.D. Ryabchikov

Institute of Ore-Deposit Geology, Moscow 109017, Russia.

Introduction

The pioneering experimental works of Wyllie and Eggler on melting relations in carbonated peridotites mainly on an example of simplified system CMS-CO₂ demonstrated that at sufficiently high pressures near-solidus melts are represented in them by silicate-poor carbonate-rich liquids (Wyllie and Huang, 1975; Eggler, 1978). Wallace and Green (1988) demonstrated that carbonate melts equilibrated with fertile lherzolites contain substantial amounts of sodium carbonate, which expands field of their existence to much lower P and T as compared with simplified CMAS-CO₂ system. In order to conduct quantitative analysis of trace-element behaviour during the metasomatic enrichment of mantle rocks we need to know partition coefficients for coexisting minerals and carbonate-rich melts. Several authors reported experimental results of this kind (Brenan and Watson, 1991; Sweeney, Green and Sie, 1992). I have extended these studies by investigating the behaviour of major and some trace elements in near solidus melts produced in apatite-saturated carbonated peridotites.

Experimental method

Conventional piston-cylinder apparatus with cells made of compressed NaCl was used for these experiments. Starting materials were sealed in Ag-Pd capsules. Sandwich-type assemblies were employed. Glass and newly formed minerals were analyzed by electron microprobe near liquid-solid interface. Starting materials were prepared by mixing natural lherzolite + apatite + dolomite + magnesite + reagent sodium carbonate. Ca/Mg ratio in carbonate or carbonate-phosphate mixture were varied to reach equilibrium with lherzolitic phase assemblage. Systems with excess of carbonates are characterized by very low solidus temperatures, because low-melting alkali carbonates are accumulated in residual melts. In contrast, in peridotite-dominated situation Na₂CO₃ content is buffered by Cpx and solidus temperature is much higher. I

therefore deduced the position of solidus for excess of peridotite from the composition of equilibrium clinopyroxene (when Na₂O in it exceeds 1.5–2% I concluded that the system is below solidus).

Some experiments were doped with Ce and Yb at levels sufficient for electron microprobe analysis. Some runs were performed with the excess of UO₂.

Results

Apatite solubility in carbonate-rich melts is quite substantial (around 20% P₂O₅, which is higher than Baker and Wyllie's (1992) measurements, which may be due to higher CaO contents in the melts from the experiments of these authors). In fact, considering similar abundances of C and P in mantle, we may expect that near solidus interstitial peridotitic magmas may be represented by carbonate-phosphate melts.

Ca/(Mg+Fe) ratios in the melts equilibrated with lherzolite rise with T and drop with increasing P. In near solidus melts it is close to dolomitic value (*c.* 1). As in the case of P-free system carbonate-phosphate melts contain substantial level of Na₂O. In fact, cation proportions in apatite-saturated and P-free melts coexisting with lherzolites are very similar. Solidus temperature are only slightly lower than for P-free carbonated lherzolite.

Kd between apatite and carbonate-rich melt are high for REE (> 1) and U (*c.* 0.3). These values are similar for carbonate-rich and silicate melts. For Cpx and other silicates KJ are low and also similar to both P-free carbonate liquids and C-free silicate systems. Therefore, the specific complexing of the investigated incompatible elements in P-bearing melts is not confirmed.

On the other hand the observed Kd for Ti in Cpx-melt equilibrium is much higher by comparison with basaltic systems. This confirms that high P/Ti ratio is diagnostic feature of carbonate metasomatism as has been suggested by Baker and Wyllie (1992).

Discussion

The available experimental data indicate that both P-rich and P-free carbonate melts are capable of extracting *REE* and U from rock-forming minerals of mantle rocks, and therefore they are appropriate agents of some types of mantle metasomatism.

The immobilization of incompatible components dissolved in primary carbonatitic magmas may take place when such melts intersect the boundary between mantle rocks with diverse lithology. Solidus of carbonated harzburgite lies at much higher temperatures than the solidus of carbonated lherzolite. This implies, that interstitial carbonatitic melts which may be formed under given PT conditions in the blocks of lherzolitic mantle and later migrate into more refractory harzburgitic rocks should solidify there and precipitate all dissolved incompatible elements. Many of these incompatible components enter apatite on solidification of carbonate-rich magmas which agrees with the fact that microscopic grains of apatite in metasomatized mantle rocks is the main repository of U and *REE*.

Conclusions

1. Carbonate-phosphate melts are useful tools for experimental modelling of carbonate-bearing systems because they are easily quenched into glasses.

2. Proportions of major cations in carbonate-rich melts coexisting with lherzolitic mineral assemblage and Kd for *REE* and U are similar for P-free and apatite-saturated compositions.

3. Carbonate-phosphate melts intensely extract many incompatible elements from lherzolites and precipitate them in harzburgites in the form of apatite.

References

- Baker, M.B. and Wyllie, P.J. (1992) *Geochim. Cosmochim. Acta*, **56**, 3409–22.
 Brenan, J.M. and Watson, E.B. (1991) *Geochim. Cosmochim. Acta*, **55**, 2203–14.
 Egglar, D.H. (1978) *Amer. J. Sci.*, **278**, 305–43.
 Sweeney, R.J., Green, D.H. and Sie, S.H. (1992) *Earth Planet. Sci. Lett.*, **113**, 1–14.
 Wallace, M.E., and Green, D.H. (1988) *Nature*, **335**, 343–6.
 Wyllie, P.J., and Huang, W.L. (1975) *Geology*, **3**, 621–4.