Table S7: Non-modal batch melting calculation

**1. Definition**

Equation (Shaw, 1970)：

Cl/C0 = 1/[D*i*+F(1-P*i*)]

Where F = the melting degree i.e. fraction of melted solid

Di = Bulk distribution coefficient of element *i* between crystals and liquid

P*i* = Bulk distribution coefficient of element *i* in the melt assemblage (weight proportion of mineral phases in the melt)

Cl = concentration of element *i* in the melt

C0= concentration of element *i* in the initial source

**2. Calculation for La/Sm and Sm/Yb in Spinel lherzolite with 2% spinel.**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Ol | Opx | Cpx | Sp | Reference |
| Composition in the source(volume %) | 58% | 16% | 22% | 4% | Yangtze SCLM xenolith from Huang et al., 2011 |
| Melting mode(weight %) | 11% | 20% | 57% | 12% | From our CIPW normalization results |
| Partitioning coefficient in mineral phases relative to melt (K*i*mineral/melt): |
| La | 0.0004 | 0.002 | 0.054 | 0.01 | McKenzie & O'Nions 1991 |
| Sm | 0.0013 | 0.01 | 0.26 | 0.01 | McKenzie & O'Nions 1991 |
| Yb | 0.0015 | 0.049 | 0.28 | 0.01 | McKenzie & O'Nions 1991 |

Presumed concentration in the source: La = 1.1 ppm; Sm= 0.67 ppm; Yb= 0.55 ppm. From Jourdan et al., 2007

**Calculation results:**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| F (%) | LaN in melt (ppm) | SmN in melt (ppm) | YbN in melt (ppm) | LaN/SmN | SmN/YbN |
| 0.1 | 336.34 | 72.02 | 28.78 | 4.67 | 2.50 |
| 0.5 | 262.67 | 68.21 | 27.50 | 3.85 | 2.48 |
| 1 | 206.21 | 63.99 | 26.06 | 3.22 | 2.46 |
| 2 | 144.22 | 56.93 | 23.58 | 2.53 | 2.41 |
| 3 | 99.39 | 48.85 | 20.64 | 2.03 | 2.37 |
| 5 | 75.83 | 42.77 | 18.35 | 1.77 | 2.33 |
| 10 | 42.35 | 30.24 | 13.40 | 1.40 | 2.26 |
| 20 | 22.49 | 19.07 | 8.70 | 1.18 | 2.19 |

LaN, SmN, YbN: chondrite-normalized (Sun and McDonough, 1989).

**3. Calculation for La/Sm and Sm/Yb in Spinel lherzolite with 2%, 4% and 8% garnet.**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Ol | Opx | Cpx | Gt | Reference |
| Modal composition(volume %) | 69%-63% | 20% | 9% | 2%-8% | Jourdan et al., 2007 |
| Melting mode(weight %) | 16% | -12% | 81% | 15% | Walter, 1998; Jourdan et al., 2007 |
| Partitioning coefficient in mineral phases relative to melt (K*i*mineral/melt): |
| La | 0.0004 | 0.002 | 0.054 | 0.01 | McKenzie & O'Nions 1991 |
| Sm | 0.0013 | 0.01 | 0.26 | 0.217 | McKenzie & O'Nions 1991 |
| Yb | 0.0015 | 0.049 | 0.28 | 4.03 | McKenzie & O'Nions 1991 |

Concentration in the source: La = 1.35 ppm; Sm= 0.62 ppm; Yb= 0.45 ppm. From Jourdan et al., 2007

**Calculation results:**

**2% garnet:**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| F (%) | LaN in melt (ppm) | SmN in melt (ppm) | YbN in melt (ppm) | LaN/SmN | SmN/YbN |
| 0.1 | 851.33 | 129.07 | 22.66 | 6.60 | 5.70 |
| 0.5 | 541.94 | 117.71 | 22.53 | 4.60 | 5.23 |
| 1 | 372.66 | 106.04 | 22.36 | 3.51 | 4.74 |
| 2 | 229.36 | 88.49 | 22.04 | 2.59 | 4.02 |
| 3 | 145.46 | 70.89 | 21.57 | 2.05 | 3.29 |
| 5 | 106.51 | 59.13 | 21.12 | 1.80 | 2.80 |
| 10 | 56.27 | 38.08 | 19.74 | 1.48 | 1.93 |
| 20 | 28.96 | 22.24 | 17.47 | 1.30 | 1.27 |

**4% garnet:**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| F (%) | LaN in melt (ppm) | SmN in melt (ppm) | YbN in melt (ppm) | LaN/SmN | SmN/YbN |
| 0.1 | 827.58 | 113.48 | 13.41 | 7.29 | 8.46 |
| 0.5 | 532.22 | 104.60 | 13.36 | 5.09 | 7.83 |
| 1 | 368.03 | 95.28 | 13.31 | 3.86 | 7.16 |
| 2 | 227.60 | 80.87 | 13.19 | 2.81 | 6.13 |
| 3 | 144.75 | 65.92 | 13.02 | 2.20 | 5.06 |
| 5 | 106.12 | 55.63 | 12.85 | 1.91 | 4.33 |
| 10 | 56.16 | 36.59 | 12.33 | 1.53 | 2.97 |
| 20 | 28.93 | 21.73 | 11.41 | 1.33 | 1.90 |

**8% garnet:**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| F (%) | LaN in melt (ppm) | SmN in melt (ppm) | YbN in melt (ppm) | LaN/SmN | SmN/YbN |
| 0.1 | 783.85 | 91.40 | 7.38 | 8.58 | 12.38 |
| 0.5 | 513.79 | 85.55 | 7.37 | 6.01 | 11.61 |
| 1 | 359.12 | 79.21 | 7.35 | 4.53 | 10.78 |
| 2 | 224.17 | 68.99 | 7.32 | 3.25 | 9.43 |
| 3 | 143.36 | 57.80 | 7.26 | 2.48 | 7.96 |
| 5 | 105.37 | 49.74 | 7.21 | 2.12 | 6.90 |
| 10 | 55.95 | 33.95 | 7.04 | 1.65 | 4.82 |
| 20 | 28.87 | 20.77 | 6.73 | 1.39 | 3.08 |

LaN, SmN, YbN: chondrite-normalized (Sun and McDonough, 1989).

**References:**

Huang X., Mo X.,Yu X., Li Y., He W., Li X., 2011. The composition and age of subcontinental lithospheric mantle beneath Maguan, Yunnan Province: Constraints from Re-Os isotopes of mantle-derived peridotitic xenoliths. Acta Petrologica Sinica, 27(9), 2646-2654

Jourdan, F., Bertrand, H., Schärer, U., Blichert-Toft, J., Féraud, G., Kampunzu, A.B., 2007. Major and Trace Element and Sr, Nd, Hf, and Pb Isotope Compositions of the Karoo Large Igneous

Province, Botswana–Zimbabwe: Lithosphere vs Mantle Plume Contribution. Journal of Petrology, 48, 1043-1077.

McKenzie, D. and O’Nions, R. K. 1991. Partial melt distribution from inversion of rare earth element concentrations. Journal of Petrology, 32, 1021-1091.

Shaw, D.M., 1970. Trace element fractionation during anatexis. Geochimica Cosmochimica Acta 34, 237-243

Sun, S. and McDonough, W. F., 1989. Chemical and Isotopic Systematics of Oceanic Basalts: Implications for Mantle Composition and Processes. In: Saunders, A.D. and Norry M.J., Eds., Magmatism in the Ocean Basins, vol. 42, Geological Society, London, Special Publications, 313-345.

Walter, M. J., 1998. Melting of garnet peridotite and the origin of komatiite and depleted lithosphere. Journal of Petrology, 39, 29-60.