**Effect of crustal contamination/assimilation on potential temperature calculation**

During the Archean period, the assimilation of continental crust by basaltic magma is a common occurrence, and it can significantly impact the calculation of potential temperature. Assimilating a substantial amount of continental crust can lead to changes in the concentration of major oxides, thereby influencing the estimation of potential temperature.

To illustrate the effect of crustal contamination, we have utilized the FCA (Decoupled Fractional Crystallization and Assimilation) model (Ersoy and Helvaci 2010). This model considers the fractionation of olivine in the input basalts and the subsequent assimilation of the upper continental crust by the fractionated basalt. The model explores various "r" values, which represent the relative ratio of assimilated material to crystallized material. The initial experimental melt composition used in this study is sourced from Davis and Hirschmann (2013) (Table R3T1). The MgO vs. CaO relationship suggests no clinopyroxene-related fractionation history for the melt composition. In this context, we explore the impact of olivine fractionation and subsequent melt assimilation on the calculation of mantle potential temperature (Tp).

Initially, the melt undergoes a 9% fractionation process involving only olivine, excluding assimilation (Table R3T2). Following this, the same melt undergoes olivine fractionation alongside the assimilation of crustal material. The composition of the assimilant is sourced from Rudnick et al. (2003). The change in melt composition with increasing “r” value are shown from Table R3T3 to R3T5. The subsequent change in MgO and CaO values are shown in figure R3S1.

**Table R2T1.** Starting melt composition.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| SiO2 | TiO2 | Al2O3 | FeO | MnO | MgO | CaO | Na2O | K2O | Tp (℃) at Fo= 0.92 and Fe+3/FeT=0.1 |
| 44.1 | 2.86 | 13.42 | 9.08 | 0.13 | 15.68 | 9.20 | 2.67 | 1.39 | 1485.97 |

**Table R2T2.** Olivine Fractionation only.

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  Percentage of melt remaining | **SiO2** | **TiO2** | **Al2O3** | **FeO (t)** | **MnO** | **MgO** | **CaO** | **Na2O** |  | **K2O** | Tp (℃) @ Fo= 0.92 and Fe+3/FeT=0.1 |
| **100.00%** | 44.1 | 2.86 | 13.42 | 9.08 | 0.13 | 15.68 | 9.2 | 2.67 |  | 1.39 | 1485.975439 |
| **99.00%** | 44.2 | 2.89 | 13.55 | 9.13 | 0.13 | 15.15 | 9.29 | 2.7 |  | 1.4 | 1484.875292 |
| **98.00%** | 44.31 | 2.92 | 13.69 | 9.17 | 0.13 | 14.63 | 9.38 | 2.72 |  | 1.42 | 1484.235192 |
| **97.00%** | 44.41 | 2.95 | 13.83 | 9.21 | 0.13 | 14.12 | 9.47 | 2.75 |  | 1.43 | 1484.037978 |
| **96.00%** | 44.52 | 2.98 | 13.97 | 9.26 | 0.13 | 13.63 | 9.56 | 2.78 |  | 1.45 | 1480.000663 |
| **95.00%** | 44.62 | 3.01 | 14.12 | 9.3 | 0.13 | 13.14 | 9.66 | 2.81 |  | 1.46 | 1480.646141 |
| **94.00%** | 44.73 | 3.04 | 14.27 | 9.35 | 0.13 | 12.67 | 9.76 | 2.84 |  | 1.48 | 1481.689659 |
| **93.00%** | 44.84 | 3.07 | 14.42 | 9.39 | 0.13 | 12.22 | 9.86 | 2.87 |  | 1.49 | 1483.117816 |
| **92.00%** | 44.95 | 3.1 | 14.57 | 9.44 | 0.14 | 11.77 | 9.96 | 2.9 |  | 1.51 | 1480.659296 |
| **91.00%** | 45.07 | 3.14 | 14.73 | 9.48 | 0.14 | 11.34 | 10.06 | 2.93 |  | 1.53 | 1482.824866 |

**Table R2T3.** Olivine fractionation and assimilation by upper continental crust at r = 0.1.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Percentage of melt remaining at r=0.1 | **SiO2** | **TiO2** | **Al2O3** | **FeO (t)** | **MnO** | **MgO** | **CaO** | **Na2O** | **K2O** | Tp (℃) @ Fo= 0.92 and Fe+3/FeT=0.1 |
| **100.00%** | 44.1 | 2.86 | 13.42 | 9.08 | 0.13 | 15.68 | 9.2 | 2.67 | 1.39 | 1485.975439 |
| **99.00%** | 44.23 | 2.89 | 13.56 | 9.13 | 0.13 | 15.13 | 9.28 | 2.7 | 1.41 | 1484.250944 |
| **98.00%** | 44.36 | 2.91 | 13.69 | 9.16 | 0.13 | 14.6 | 9.37 | 2.73 | 1.42 | 1483.027486 |
| **97.00%** | 44.49 | 2.94 | 13.84 | 9.2 | 0.13 | 14.08 | 9.45 | 2.75 | 1.44 | 1482.284742 |
| **96.00%** | 44.62 | 2.97 | 13.98 | 9.24 | 0.13 | 13.57 | 9.54 | 2.78 | 1.45 | 1477.736617 |
| **95.00%** | 44.75 | 2.99 | 14.13 | 9.28 | 0.13 | 13.08 | 9.62 | 2.81 | 1.47 | 1477.903828 |
| **94.00%** | 44.89 | 3.02 | 14.28 | 9.32 | 0.13 | 12.6 | 9.71 | 2.84 | 1.49 | 1478.498908 |
| **93.00%** | 45.02 | 3.05 | 14.43 | 9.35 | 0.13 | 12.13 | 9.8 | 2.87 | 1.5 | 1475.242435 |
| **92.00%** | 45.16 | 3.08 | 14.58 | 9.39 | 0.14 | 11.68 | 9.9 | 2.9 | 1.52 | 1476.652364 |
| **91.00%** | 45.3 | 3.11 | 14.74 | 9.43 | 0.14 | 11.24 | 9.99 | 2.93 | 1.54 | 1478.445812 |

**Table R2T4.** Olivine fractionation and assimilation by upper continental crust at r = 0.2.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Percentage of melt remaining at r=0.2 | **SiO2** | **TiO2** | **Al2O3** | **FeO (t)** | **MnO** | **MgO** | **CaO** | **Na2O** | **K2O** | Tp (℃) @ Fo= 0.92 and Fe+3/FeT=0.1 |
| **100.00%** | 44.1 | 2.86 | 13.42 | 9.08 | 0.13 | 15.68 | 9.2 | 2.67 | 1.39 | 1485.975439 |
| **99.00%** | 44.26 | 2.88 | 13.56 | 9.12 | 0.13 | 15.12 | 9.27 | 2.7 | 1.41 | 1483.472081 |
| **98.00%** | 44.42 | 2.91 | 13.7 | 9.15 | 0.13 | 14.57 | 9.35 | 2.73 | 1.43 | 1481.523839 |
| **97.00%** | 44.58 | 2.93 | 13.84 | 9.18 | 0.13 | 14.03 | 9.42 | 2.76 | 1.44 | 1480.106062 |
| **96.00%** | 44.75 | 2.95 | 13.99 | 9.21 | 0.13 | 13.51 | 9.5 | 2.78 | 1.46 | 1474.928424 |
| **95.00%** | 44.91 | 2.98 | 14.14 | 9.25 | 0.13 | 13 | 9.58 | 2.81 | 1.48 | 1474.508749 |
| **94.00%** | 45.08 | 3 | 14.29 | 9.28 | 0.13 | 12.51 | 9.66 | 2.85 | 1.5 | 1474.555977 |
| **93.00%** | 45.25 | 3.03 | 14.44 | 9.31 | 0.13 | 12.03 | 9.74 | 2.88 | 1.52 | 1470.787704 |
| **92.00%** | 45.42 | 3.05 | 14.59 | 9.34 | 0.13 | 11.57 | 9.82 | 2.91 | 1.54 | 1471.719163 |
| **91.00%** | 45.6 | 3.08 | 14.75 | 9.37 | 0.14 | 11.12 | 9.9 | 2.94 | 1.56 | 1468.802841 |

**Table R2T5.** Olivine fractionation and assimilation by upper continental crust at r = 0.3.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Percentage of melt remaining at r=0.3 | **SiO2** | **TiO2** | **Al2O3** | **FeO (t)** | **MnO** | **MgO** | **CaO** | **Na2O** | **K2O** | Tp (℃) @ Fo= 0.92 and Fe+3/FeT=0.1 |
| **100.00%** | 44.1 | 2.86 | 13.42 | 9.08 | 0.13 | 15.68 | 9.2 | 2.67 | 1.39 | 1485.975439 |
| **99.00%** | 44.3 | 2.88 | 13.56 | 9.11 | 0.13 | 15.09 | 9.26 | 2.7 | 1.41 | 1482.473234 |
| **98.00%** | 44.5 | 2.9 | 13.71 | 9.14 | 0.13 | 14.52 | 9.33 | 2.73 | 1.43 | 1479.60023 |
| **97.00%** | 44.7 | 2.92 | 13.85 | 9.16 | 0.13 | 13.97 | 9.39 | 2.76 | 1.45 | 1477.325522 |
| **96.00%** | 44.91 | 2.94 | 14 | 9.18 | 0.13 | 13.43 | 9.46 | 2.79 | 1.47 | 1471.352734 |
| **95.00%** | 45.12 | 2.95 | 14.15 | 9.21 | 0.13 | 12.9 | 9.52 | 2.82 | 1.49 | 1470.195653 |
| **94.00%** | 45.33 | 2.97 | 14.3 | 9.23 | 0.13 | 12.39 | 9.59 | 2.85 | 1.51 | 1469.558231 |
| **93.00%** | 45.54 | 2.99 | 14.45 | 9.25 | 0.13 | 11.9 | 9.65 | 2.88 | 1.54 | 1465.153775 |
| **92.00%** | 45.76 | 3.01 | 14.61 | 9.27 | 0.13 | 11.42 | 9.72 | 2.91 | 1.56 | 1465.494199 |
| **91.00%** | 45.98 | 3.03 | 14.76 | 9.29 | 0.13 | 10.96 | 9.79 | 2.95 | 1.58 | 1462.028622 |



**Repository Fig. R2S1.** Change in MgO vs. CaO values due to Olivine fractionation and subsequent assimilation at different “r” values, where “r” represents relative ratio of assimilated material to crystallized material. The starting composition indicates the experimental melt composition from Davis and Hirschmann (2013).

The example illustrates that Tp values can be influenced when a substantial amount of crustal assimilation occurs. Negligible amount of crustal assimilation at lower olivine fractionation results in minimal change in Tp values.

**References**

Davis FA, Hirschmann MM (2013) The effects of K 2 O on the compositions of near-solidus melts of garnet peridotite at 3 GPa and the origin of basalts from enriched mantle. Contributions to Mineralogy and Petrology 166:1029–1046

Ersoy Y, Helvaci C (2010) FC–AFC–FCA and mixing modeler: a Microsoft® Excel© spreadsheet program for modeling geochemical differentiation of magma by crystal fractionation, crustal assimilation and mixing. 36:383–390

Rudnick RL, Gao S, Holland HD, Turekian KK (2003) Composition of the continental crust. The crust 3:1–64