In our paper, the thermometer and Oxygen fugacity are estimated using the trace element concentrations in zircon and melt composition (represented by whole-rock). The detail methods are descripted as following.

Blundy and Wood [1] showed a model to predict the mineral melt partition coefficient for a cation (i) by the lattice strain energy, which created by substituting a cation whose ionic radius (*r*i) differs from the optimal value for that site (*r*0) according the equation:

$$\ln D_{\mathrm{i}} = \ln D_0 - \frac{4\pi E N_{\mathrm{A}}}{RT}\left(\frac{r_{\mathrm{i}}}{3} + \frac{r_0}{6}\right)(r_{\mathrm{i}} - r_0)^2 \tag{1}$$

Where $D_i$ is partition coefficient of element i, $D_0$ is the strain compensated partition coefficient, $N_A$ is Avogdro's number, $R$ is the gas constant, and $T$ is the temperature (K). When $D0$, $N_A$, $R$ and $T$ are treated as constants, the ln$D$i versus ($r$i/3 + $r$0/6)($r$i − $r$0)2 yields a linear relation.

Based on the lattice strain model, the zircon $Ce^{4+}/Ce^{3+}$ ratios could use following formula [2].

$$\left(\frac{\mathrm{Ce}^{4+}}{\mathrm{Ce}^{3+}}\right)_{\mathrm{zircon}} = \frac{\mathrm{Ce}_{\mathrm{melt}} - \dfrac{\mathrm{Ce}_{\mathrm{zircon}}}{D_{\mathrm{Ce}^{3+}}^{\mathrm{zircon/melt}}}}{\dfrac{\mathrm{Ce}_{\mathrm{zircon}}}{D_{\mathrm{Ce}^{4+}}^{\mathrm{zircon/melt}}} - \mathrm{Ce}_{\mathrm{melt}}} \tag{2}$$

Where Ce melt and Ce zircon are the concentrations of Ce in melt and zircon, respectively. $DCe^{3+}$ and $DCe^{4+}$ are partial coefficients calculated from the linear fit of trivalent cations ($REE^{3+}$), and tetravalent cations (such as, $Th^{4+}$, $U^{4+}$and $Hf^{4+}$), respectively (Figure S1).

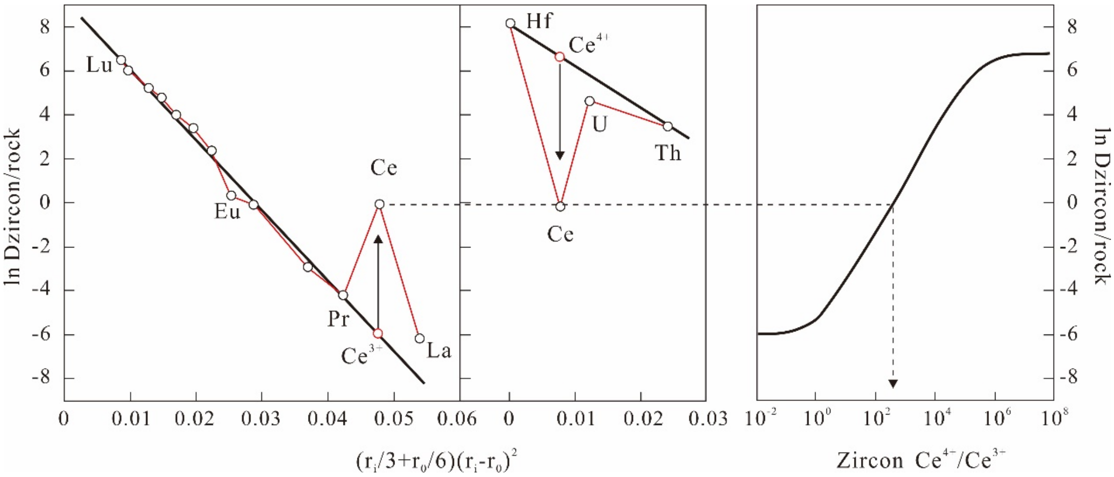


**Figure S1.** Diagrammatic representation of zircon/rock distribution coefficients by a lattice-strain parameter for trivalent and tetravalent cations[2]. The $r_i$ represent ionic radius of a cation *i*, and $r_0$ is ionic radius of the optimal cation.

Partition coefficients for $D_{Ce^{3+}}$ and $D_{Ce^{4+}}$ can be determined by interpolation. Due to La and Pr are present very low concentration levels in natural zircons, and Eu, U are multivalent elements, these elements should be excluded in the calculation procedure [3]. Values of $r_0$ used for 3+ and 4+ cations were 0.93 Å (determined by regression) and 0.84 Å (8-fold coordinated $Zr^{4+}$), and ionic radii for $r_i$ were from Shannon [4]. Smythe and Brenan [3] descripted a following equality for estimating $Ce^{4+}/Ce^{3+}$ in melt:

$$\left(\frac{\mathrm{Ce}^{4+}}{\mathrm{Ce}^{3+}}\right)_{\mathrm{melt}} = 1.04877 * \left[\frac{\mathrm{Ce}_{\mathrm{zircon}} - \left(\mathrm{Ce}_{\mathrm{melt}} * D_{\mathrm{Ce}^{3+}}^{\mathrm{zircon\,/melt}}\right)}{\left(\mathrm{Ce}_{\mathrm{melt}} * \mathrm{D}_{\mathrm{Ce}^{4+}}^{\mathrm{zircon\,/melt}}\right) - \mathrm{Ce}_{\mathrm{zircon}}}\right] \tag{3}$$

Where $D_{Ce^{3+}}$ and $D_{Ce^{4+}}$ can be obtained from Equation (2). The proportions of $Ce^{3+}$ and $Ce^{4+}$ are related to $fO_2$ of melt which can be obtain through the following equation by Smythe and Brenan [3]:

$$\ln\left(\frac{Ce^{4+}}{Ce^{3+}}\right)_{melt} = \frac{1}{4}\ln fO_2 + \frac{13136(\pm 591)}{T} - 2.064(\pm 0.011)\frac{NBO}{T} - 8.878(\pm 0.112) * xH_2O - 8.955(\pm 0.091) \quad (4)$$

Where NBO/T is the proportion of non-bridging oxygens to tetrahedrally coordinated cations calculated on an anhydrous basis that can be calculated by the bulk element composition [5], and $xH_2O$ is the mole fraction of water dissolved in the melt. $Ce^{4+}/Ce^{3+}$ in melt can be obtained from Equation (2) and T is temperature degrees in K determined using the Ti-in-zircon thermometer as described below.

The Ti-in-zircon thermometer has been widely used to identify magma forming or metamorphism temperatures. The experimentally calibrated thermometer is provided using the expression [6]:

$$\log(Ti_{zircon}) = (6.01 \pm 0.03) - \frac{5080 \pm 30}{T(\mathrm{K})} \quad (5)$$

Where $Ti_{zircon}$ denote the concentration of Ti in zircon in ppm, and T is temperature degrees in K.

The concentration of trace elements for melts are represented by average values of two samples from Guojialiang monzonites in Huyanshan complex by Ying et al. [7] presented in Table S1.

**Table S1**. Major and trace element data for the Guojialiang monzonites from Huyanshan complex.

| **Trace Element (ppm)** | **La** | **Ce** | **Pr** | **Nd** | **Sm** | **Eu** | **Gd** | **Tb** | **Dy** | **Ho** | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| XML08-2 | 36.5 | 64.1 | 7.74 | 28.6 | 4.98 | 1.66 | 4.45 | 0.67 | 3.95 | 0.8 | |
| XMl08-3 | 22.1 | 52.8 | 6.84 | 25.2 | 4.69 | 1.32 | 4 | 0.6 | 3.57 | 0.69 | |
| Average | 29.30 | 58.45 | 7.29 | 26.90 | 4.84 | 1.49 | 4.23 | 0.64 | 3.76 | 0.75 | |
| Trace element (ppm) | Er | Tm | Yb | Lu | Hf | Th | U | Ta | Zr | Y | |
| XML08-2 | 2.27 | 0.35 | 2.28 | 0.35 | 4.3 | 4.2 | 0.9 | 0.45 | 156 | 23 | |
| XMl08-3 | 1.95 | 0.3 | 1.92 | 0.29 | 4.2 | 3.2 | 0.6 | 0.43 | 149 | 19 | |
| Average | 2.11 | 0.33 | 2.10 | 0.32 | 4.25 | 3.70 | 0.75 | 0.44 | 152.50 | 21.00 | |
| Major element (wt. %) | $SiO_2$ | $TiO_2$ | $Al_2O_3$ | $TFe_2O_3$ | MnO | MgO | CaO | $Na_2O$ | $K_2O$ | $P_2O_5$ | LOI |
| XML08-2 | 62 | 0.29 | 19 | 3.29 | 0.1 | 0.69 | 1.86 | 5.22 | 5.32 | 0.11 | 2.07 |
| XMl08-3 | 61.5 | 0.26 | 18.4 | 3.13 | 0.13 | 0.31 | 2.65 | 6.74 | 4.76 | 0.11 | 1.98 |
| Average | 61.75 | 0.28 | 18.70 | 3.21 | 0.12 | 0.50 | 2.26 | 5.98 | 5.04 | 0.11 | 2.03 |

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