

## Garnet-biotite geothermometry revised: New Margules parameters and a natural specimen data set from Maine

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### ABSTRACT

The garnet-biotite geothermometer has been recalibrated using recently obtained Margules parameters for iron-magnesium-calcium garnet, Mn interactions in garnet, and Al interactions in biotite, as well as the Fe oxidation state of both minerals. Fe-Mg and  $\Delta W_{Al}$  Margules parameters for biotite have been retrieved by combining experimental results on <sup>61</sup>Al-free and <sup>61</sup>Al-bearing biotite using statistical methods. Margules parameters, per mole of biotite are

$$W_{MgFe}^{Bt} = 40719 - 30T \text{ J/mole,}$$

$$\Delta W_{Al}^{Bt} = W_{FeAl}^{Bt} - W_{MgAl}^{Bt} = 210190 - 245.40T \text{ J/mole,}$$

$$\Delta W_{Ti}^{Bt} = W_{FeTi}^{Bt} - W_{MgTi}^{Bt} = 310990 - 370.39T \text{ J/mole.}$$

Based on this model, the exchange reaction  $\Delta H$  is 41952 J/mol and  $\Delta S$  is 10.35 J/(K mol). Estimated uncertainty for this geothermometer is 25 °C.

This geothermometer was tested on two data sets. The first consisted of 98 specimens containing garnet and biotite from west-central Maine, which formed under reducing  $f_{O_2}$  with graphite, a limited range of  $P$  (~3 to 4.5 kbar), and a moderate range in  $T$  (~550–650 °C), and which were all analyzed on a single microprobe using the same standards. Results indicate that the Maine staurolite zone averages 574 °C compared with 530 °C previously calculated and that the muscovite-breakdown  $T$  is consistent with experimental data. The second set consisted of cordierite-garnet granulites without hypersthene from Ontario. Results here suggest an average  $T$  of 662 °C, compared with significantly lower or higher  $T$ s calculated from other geothermometers.

This model reproduces the Perchuk and Lavrent'eva (1983) experimental  $T$ s with a standard deviation of 12 °C and discriminates the assemblages in the Maine data set better than other models.