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Mineral chemistry and thermobarometry of a southern Appalachian amphibolite
with epidote + quartz symplectite

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For deposit: Tables 2,3,5

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Table 2. Representative electron-microprobe analyses of plagioclase

| | HRA-1 | | HRA-3 | | HRA-4 | | HRA-5 | | HRA-7 | | DMA-5 | DMA-6 | DMA-11 | DMA-12 | DMA-13 | DMA-16 | LC-1 | | LC-2 | | | |
|--------------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|-------|--------|--------|--------|-------------|-------------|-------------|-------------|-------------|-------------|--------|------------|-------------|
| | Core | Rim | Core | Rim | Core | Inter. | Rim | Core | Inter. | Rim | Avg(4) | Avg(6) | Avg(3) | Avg(7) | Avg(4) | Avg(8) | Core | Rim | Avg(2) | | | |
| SiO ₂ | 57.59 | 56.50 | 61.58 | 57.11 | 48.84 | 50.28 | 47.38 | 59.56 | 57.39 | 54.06 | 47.77 | 47.39 | 46.93 | 61.68(0.50) | 59.94(0.73) | 60.37(1.40) | 60.31(0.61) | 60.57(0.72) | 49.79(2.18) | 54.69 | 58.42 | 52.77(0.72) |
| Al ₂ O ₃ | 26.98 | 27.83 | 24.65 | 27.18 | 33.06 | 32.53 | 34.11 | 26.11 | 27.49 | 28.30 | 33.79 | 34.19 | 34.47 | 24.05(0.47) | 24.96(0.57) | 23.72(0.45) | 24.42(0.30) | 25.14(0.51) | 31.54(1.30) | 28.73 | 26.62 | 29.89(0.55) |
| FeO | 0.23 | 0.20 | 0.30 | 0.64 | 0.28 | 0.30 | 0.38 | 0.22 | 0.41 | 0.51 | 0.29 | 0.47 | 0.29 | 0.45(0.05) | 0.28(0.18) | 0.27(0.12) | 0.39(0.12) | 0.40(0.17) | 0.40(0.20) | 0.39 | 0.35 | 0.35(0.03) |
| MnO | n.d. | n.d. | n.d. | n.d. | n.d. | 0.17 | 0.22 | n.d. | 0.16 | n.d. | 0.27 | n.d. | n.d. | 0.13(0.01) | 0.14(0.03) | 0.14(0.05) | 0.14(0.10) | 0.16(0.03) | 0.21(0.09) | 0.18 | 0.16 | 0.14(0.01) |
| MgO | n.d. | n.d. | n.d. | n.d. | 0.13 | 0.22 | 0.15 | n.d. | n.d. | n.d. | 0.19 | 0.15 | n.d. | n.d. | n.d. | n.d. | n.d. | 0.12(0.05) | n.d. | n.d. | 0.07(0.01) | |
| CaO | 9.52 | 10.45 | 6.83 | 9.57 | 16.58 | 15.78 | 17.75 | 7.83 | 9.52 | 11.03 | 17.74 | 17.75 | 18.22 | 5.62(0.58) | 6.81(0.61) | 5.80(0.16) | 7.29(0.42) | 6.89(0.33) | 15.40(1.70) | 11.47 | 8.67 | 13.15(0.54) |
| Na ₂ O | 6.07 | 5.74 | 7.53 | 6.26 | 2.32 | 2.88 | 1.65 | 6.65 | 5.86 | 5.45 | 1.74 | 1.67 | 1.34 | 8.54(0.30) | 7.77(0.51) | 7.63(0.44) | 7.79(0.39) | 7.87(0.26) | 2.86(0.98) | 5.07 | 6.49 | 4.06(0.44) |
| K ₂ O | 0.08 | 0.09 | 0.12 | n.d. | 0.07 | 0.08 | n.d. | n.d. | 0.10 | 0.09 | n.d. | n.d. | 0.07 | 0.05(0.01) | 0.07(0.004) | 0.04(0.01) | 0.06(0.04) | 0.07(0.02) | 0.05(0.02) | 0.08 | 0.08 | 0.09(0.01) |
| Total | 100.47 | 100.81 | 101.01 | 100.76 | 101.28 | 102.24 | 101.64 | 100.37 | 100.93 | 99.44 | 101.79 | 101.62 | 101.32 | 100.52 | 99.97 | 97.97 | 100.40 | 101.10 | 100.37 | 100.63 | 100.79 | 100.52 |
| Cations per 8 oxygens | | | | | | | | | | | | | | | | | | | | | | |
| Si | 2.571 | 2.522 | 2.711 | 2.550 | 2.212 | 2.253 | 2.148 | 2.642 | 2.553 | 2.461 | 2.162 | 2.148 | 2.130 | 2.730 | 2.675 | 2.734 | 2.686 | 2.675 | 2.271 | 2.459 | 2.565 | 2.385 |
| Al | 1.421 | 1.466 | 1.280 | 1.432 | 1.766 | 1.719 | 1.825 | 1.367 | 1.443 | 1.520 | 1.804 | 1.828 | 1.853 | 1.256 | 1.314 | 1.267 | 1.283 | 1.310 | 1.697 | 1.524 | 1.428 | 1.594 |
| Fe | 0.008 | 0.008 | 0.011 | 0.024 | 0.011 | 0.011 | 0.014 | 0.008 | 0.015 | 0.019 | 0.010 | 0.018 | 0.011 | 0.017 | 0.012 | 0.010 | 0.015 | 0.015 | 0.015 | 0.013 | 0.013 | 0.013 |
| Mn | n.d. | n.d. | n.d. | n.d. | n.d. | 0.007 | 0.009 | n.d. | 0.06 | n.d. | 0.010 | n.d. | n.d. | 0.005 | 0.005 | 0.005 | 0.005 | 0.006 | 0.008 | 0.007 | 0.006 | 0.005 |
| Mg | n.d. | n.d. | n.d. | n.d. | 0.009 | 0.015 | 0.010 | n.d. | n.d. | n.d. | 0.013 | 0.010 | n.d. | n.d. | n.d. | n.d. | n.d. | 0.008 | n.d. | n.d. | 0.005 | |
| Ca | 0.455 | 0.449 | 0.322 | 0.458 | 0.805 | 0.758 | 0.863 | 0.372 | 0.454 | 0.538 | 0.861 | 0.862 | 0.890 | 0.267 | 0.326 | 0.282 | 0.348 | 0.326 | 0.753 | 0.553 | 0.422 | 0.637 |
| Na | 0.525 | 0.497 | 0.643 | 0.542 | 0.204 | 0.250 | 0.145 | 0.572 | 0.506 | 0.481 | 0.153 | 0.147 | 0.118 | 0.733 | 0.673 | 0.670 | 0.673 | 0.674 | 0.253 | 0.442 | 0.572 | 0.356 |
| K | 0.005 | 0.005 | 0.007 | n.d. | 0.004 | 0.005 | n.d. | n.d. | 0.006 | 0.005 | n.d. | n.d. | 0.004 | 0.003 | 0.004 | 0.002 | 0.003 | 0.004 | 0.003 | 0.005 | 0.005 | 0.005 |
| Sum | 4.985 | 4.997 | 4.974 | 5.006 | 5.011 | 5.018 | 5.041 | 4.961 | 4.983 | 5.024 | 5.013 | 5.013 | 5.006 | 5.011 | 5.009 | 4.970 | 5.013 | 5.010 | 5.008 | 5.005 | 5.011 | 5.000 |
| X _{An} | 0.46 | 0.50 | 0.33 | 0.46 | 0.79 | 0.75 | 0.86 | 0.39 | 0.47 | 0.53 | 0.85 | 0.86 | 0.88 | 0.27 | 0.33 | 0.30 | 0.34 | 0.32 | 0.75 | 0.55 | 0.42 | 0.64 |

Note: Analyses in weight percent. n.d. = not detected. Avg = average composition for unzoned crystals from non-symplectite domains with number of analyses next to Avg. 1 S.D. in parentheses. Inter. = intermediate between core and rim.

Table 3. Representative electron-microprobe analyses and structural formulae of amphiboles

| | SRA-1 N | HPA-3 7 | HPA-4 6 | HRA-5 9 | HRA-7 7 | HRA-8 7 | HRA-9 6 | HRA-10 5 | DMA-1 8 | DMA-1X 7 | DMA-2 6 | DMA-3 6 | DMA-4 7 | DMA-5 6 | DMA-6 6 | DMA-11 4 |
|--------------------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| SiO ₂ | 40.90(0.49) | 41.82(0.60) | 42.20(0.30) | 40.82(0.39) | 42.05(1.25) | 41.40(0.24) | 41.09(0.31) | 41.46(0.24) | 42.21(0.59) | 42.54(0.65) | 42.39(0.58) | 42.07(0.63) | 42.52(1.49) | 43.13(1.53) | 41.75(0.23) | 42.10(0.42) |
| Al ₂ O ₃ | 15.17(0.75) | 14.70(1.00) | 14.70(0.40) | 14.42(0.15) | 14.62(0.27) | 15.09(0.60) | 14.40(0.05) | 14.70(0.22) | 12.35(0.52) | 11.48(0.87) | 12.39(0.10) | 12.55(0.62) | 11.46(1.46) | 11.38(1.14) | 12.14(0.35) | 12.45(0.59) |
| FeO | 18.55(0.51) | 17.81(0.34) | 17.22(0.48) | 17.65(0.54) | 17.52(0.27) | 18.04(0.30) | 17.48(0.25) | 17.18(0.23) | 16.21(0.49) | 17.35(0.25) | 17.93(0.46) | 16.40(0.27) | 17.17(0.46) | 15.81(0.22) | 17.40(0.32) | 18.03(0.57) |
| MnO | N.A. | N.A. | 0.29(0.05) | 0.33(0.05) | 0.33(0.04) | 0.42(0.08) | 0.38(0.04) | 0.33(0.06) | 0.31(0.09) | 0.51(0.11) | 0.54(0.03) | 0.36(0.03) | 0.45(0.07) | 0.42(0.08) | 0.47(0.06) | 0.64(0.10) |
| MgO | 8.02(0.24) | 8.82(0.12) | 9.13(0.20) | 8.38(0.37) | 8.91(0.16) | 8.93(0.25) | 8.39(0.31) | 8.91(0.17) | 10.30(0.26) | 9.11(0.25) | 9.49(0.29) | 9.98(0.45) | 10.09(1.04) | 11.20(0.74) | 9.61(0.15) | 9.36(0.59) |
| TiO ₂ | 0.62(0.21) | 1.08(0.11) | 0.62(0.10) | 0.86(0.14) | 0.78(0.13) | 0.54(0.10) | 0.75(0.11) | 0.91(0.11) | 0.71(0.07) | 0.7(0.19) | 1.01(0.12) | 0.80(0.09) | 0.51(0.16) | 0.83(0.34) | 0.82(0.20) | 0.75(0.16) |
| CaO | 11.44(0.21) | 11.62(0.54) | 11.65(1.20) | 11.33(0.15) | 11.62(0.11) | 11.23(0.10) | 11.38(0.10) | 11.22(0.18) | 11.95(0.16) | 11.81(0.24) | 11.48(0.15) | 11.63(0.22) | 12.00(0.12) | 11.67(0.22) | 11.61(0.11) | 11.23(0.23) |
| Na ₂ O | 1.40(0.11) | 1.40(0.18) | 1.32(0.10) | 1.40(0.04) | 1.36(0.14) | 1.41(0.11) | 1.31(0.14) | 1.39(0.14) | 1.57(0.11) | 1.1(0.20) | 1.54(0.06) | 1.08(0.07) | 1.32(0.17) | 1.41(0.15) | 1.37(0.17) | 1.59(0.13) |
| K ₂ O | 0.52(0.05) | 0.91(0.04) | 0.27(0.05) | 0.70(0.05) | 0.30(0.05) | 0.23(0.04) | 0.42(0.02) | 0.53(0.05) | 0.93(0.07) | 0.94(0.06) | 0.58(0.07) | 0.65(0.09) | 1.17(0.18) | 0.72(0.29) | 0.90(0.10) | 0.50(0.05) |
| Total | 96.62 | 98.16 | 97.40 | 95.89 | 97.50 | 96.47 | 95.60 | 96.60 | 96.60 | 96.57 | 97.25 | 95.92 | 96.72 | 96.97 | 96.08 | 96.65 |
| Cations per 20 oxygens | | | | | | | | | | | | | | | | |
| Si | 6.101 | 6.177 | 6.216 | 6.170 | 6.206 | 6.187 | 6.205 | 6.178 | 6.470 | 6.308 | 6.300 | 6.332 | 6.413 | 6.442 | 6.314 | 6.297 |
| ²⁶ Al | 1.869 | 1.823 | 1.784 | 1.830 | 1.794 | 1.812 | 1.795 | 1.822 | 1.810 | 1.802 | 1.700 | 1.668 | 1.587 | 1.588 | 1.636 | 1.703 |
| ²⁷ Al | 0.813 | 0.738 | 0.770 | 0.741 | 0.751 | 0.846 | 0.770 | 0.762 | 0.408 | 0.528 | 0.478 | 0.560 | 0.451 | 0.428 | 0.479 | 0.430 |
| Fe ³⁺ | 0.735 | 0.594 | 0.772 | 0.678 | 0.750 | 0.790 | 0.707 | 0.733 | 0.47 | 0.474 | 0.775 | 0.647 | 0.521 | 0.704 | 0.681 | 0.523 |
| Ti | 0.070 | 0.120 | 0.069 | 0.098 | 0.087 | 0.061 | 0.085 | 0.102 | 0.080 | 0.06 | 0.113 | 0.091 | 0.058 | 0.092 | 0.094 | 0.059 |
| Mg | 1.729 | 1.942 | 2.004 | 1.888 | 1.959 | 1.787 | 1.888 | 1.957 | 2.101 | 2.305 | 2.107 | 2.239 | 2.268 | 2.470 | 2.166 | 2.682 |
| Fe ²⁺ | 1.590 | 1.606 | 1.249 | 1.553 | 1.412 | 1.404 | 1.501 | 1.400 | 1.716 | 1.865 | 1.459 | 1.417 | 1.644 | 1.262 | 1.520 | 1.267 |
| Mn | - | - | 0.036 | 0.042 | 0.041 | 0.053 | 0.049 | 0.042 | 0.08 | 0.042 | 0.068 | 0.046 | 0.057 | 0.063 | 0.06 | 0.039 |
| Ca | 1.837 | 1.839 | 1.839 | 1.835 | 1.837 | 1.797 | 1.841 | 1.808 | 1.914 | 1.914 | 1.833 | 1.876 | 1.944 | 1.630 | 1.881 | 1.800 |
| ²⁶ Na | 0.163 | 0.161 | 0.161 | 0.165 | 0.163 | 0.203 | 0.159 | 0.192 | 0.076 | 0.076 | 0.157 | 0.124 | 0.056 | 0.150 | 0.199 | 0.200 |
| A _{Na} | 0.244 | 0.240 | 0.215 | 0.245 | 0.226 | 0.205 | 0.225 | 0.209 | 0.200 | 0.302 | 0.277 | 0.278 | 0.330 | 0.235 | 0.283 | 0.261 |
| K | 0.099 | 0.171 | 0.051 | 0.135 | 0.056 | 0.053 | 0.081 | 0.101 | 0.181 | 0.182 | 0.110 | 0.125 | 0.225 | 0.136 | 0.174 | 0.095 |
| A sum | 0.343 | 0.411 | 0.267 | 0.280 | 0.282 | 0.263 | 0.306 | 0.310 | 0.501 | 0.504 | 0.387 | 0.403 | 0.555 | 0.301 | 0.457 | 0.356 |
| Total | 15.343 | 15.411 | 15.267 | 15.380 | 15.282 | 15.150 | 15.306 | 15.311 | 15.501 | 15.564 | 15.387 | 15.403 | 15.554 | 15.201 | 15.457 | 15.355 |

Note: Fe³⁺ calculated; see text for method. N = no. of analyses. N = number of analyses for unjoined crystals from non-symplectite chains. Value in parentheses represents one standard deviation from the mean.

Table 5. Representative electron-microprobe analyses of garnet

| | HRA-5 | HRA-8c | HRA-8r | HRA-10c | HRA-10r | HRA-9c | HRA-9r | HRA-16c | HRA-16r | DMA-1x | DMA-2c | DMA-2r | DMA-11 |
|--------------------------------|--------|--------|--------|---------|---------|--------|--------|---------|---------|--------|--------|--------|--------|
| SiO ₂ | 38.49 | 38.09 | 38.01 | 38.64 | 38.62 | 37.87 | 37.76 | 38.02 | 38.23 | 37.25 | 37.67 | 37.74 | 37.27 |
| Al ₂ O ₃ | 20.58 | 20.54 | 20.33 | 20.63 | 20.99 | 20.07 | 20.51 | 20.33 | 20.57 | 20.40 | 20.81 | 20.33 | 20.11 |
| FeO | 27.47 | 26.95 | 27.52 | 27.60 | 28.12 | 26.41 | 27.09 | 26.62 | 26.95 | 23.25 | 25.57 | 23.52 | 23.11 |
| MnO | 1.91 | 3.58 | 5.05 | 2.22 | 2.33 | 4.72 | 4.72 | 3.98 | 2.08 | 1.31 | 3.86 | 5.98 | 8.42 |
| MgO | 4.25 | 3.22 | 2.90 | 3.74 | 4.58 | 2.71 | 3.32 | 2.92 | 4.14 | 2.47 | 2.94 | 2.33 | 1.92 |
| TiO ₂ | 0.07 | 0.00 | 0.00 | 0.18 | 0.00 | 0.00 | 0.12 | 0.00 | 0.00 | 0.00 | 0.17 | 0.00 | 0.44 |
| CaO | 7.86 | 8.56 | 7.34 | 8.46 | 6.57 | 7.35 | 6.34 | 8.31 | 8.14 | 14.03 | 9.46 | 10.41 | 8.94 |
| Total | 100.63 | 100.94 | 101.15 | 101.47 | 101.21 | 99.13 | 99.86 | 100.18 | 100.11 | 98.71 | 100.48 | 100.31 | 100.21 |
| Cations per 12 oxygen | | | | | | | | | | | | | |
| Si | 3.022 | 3.006 | 3.011 | 3.018 | 3.015 | 3.045 | 3.091 | 3.024 | 3.017 | 2.983 | 2.982 | 3.002 | 2.989 |
| Al | 1.906 | 1.912 | 1.900 | 1.901 | 1.933 | 1.904 | 1.881 | 1.907 | 1.915 | 1.927 | 1.944 | 1.908 | 1.902 |
| Fe | 1.804 | 1.779 | 1.824 | 1.803 | 1.836 | 1.776 | 1.761 | 1.771 | 1.779 | 1.557 | 1.693 | 1.565 | 1.550 |
| Mn | 0.127 | 0.239 | 0.339 | 0.147 | 0.154 | 0.322 | 0.311 | 0.268 | 0.139 | 0.089 | 0.259 | 0.403 | 0.572 |
| Mg | 0.479 | 0.379 | 0.342 | 0.435 | 0.533 | 0.325 | 0.385 | 0.346 | 0.487 | 0.295 | 0.347 | 0.276 | 0.229 |
| Ti | 0.004 | 0.00 | 0.00 | 0.011 | 0.00 | 0.00 | 0.007 | 0.00 | 0.00 | 0.00 | 0.010 | 0.00 | 0.027 |
| Ca | 0.661 | 0.724 | 0.623 | 0.708 | 0.550 | 0.633 | 0.528 | 0.708 | 0.689 | 1.204 | 0.803 | 0.888 | 0.767 |
| X _{Mg} | 0.422 | 0.176 | 0.158 | 0.194 | 0.225 | 0.155 | 0.179 | 0.163 | 0.215 | 0.159 | 0.170 | 0.150 | 0.129 |
| a _{Alm} | 0.19 | 0.17 | 0.19 | 0.18 | 0.20 | 0.19 | 0.19 | 0.18 | 0.17 | 0.11 | 0.15 | 0.12 | 0.12 |

Note: c = core; r = rim; a_{Alm} calculated using Hodges and Spear (1982) solution model.