Supplementary Information to Albers et al.: ‘Fluid–rock interactions in the shallow Mariana forearc: carbon cycling and redox conditions’

# Figures

Figure S: Carbonate phases in serpentinite clasts. Thin section scans of (a) a serpentinized dunite from Asùt Tesoru with calcite and aragonite veins (sample U1495B-5G-CC, 1–3 cm) and (b) a serpentinized harzburgite from Yinazao crosscut by a narrow calcite–iowaite vein (sample U1492C-1H-2, 18–20cm). Red rectangles mark positions of close-ups shown in lower panels. (c) SEM image of blocky aragonite. (d,e) Photomicrograph of calcite and SEM image of acicular iowaite occurring within the same vein. Abbreviations: Arg, aragonite; Bst, bastite; Cal, calcite; Iow, iowaite; Mt, magnetite.

Figure S2: Chrondrite-normalized (McDonough and Sun, 1995) REE+Y compositions of deep carbonates depicted for the individual clasts.

# Tables

Table S1: Representative geochemistry of metamorphic phases.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Sample | U1498B-8R-1, 32–34 cm | U1495B-5G-CC, 1–3 cm | U1497A-12F-1, 93–95 cm | U1498B-8R-1, 32–34 cm | U1496B-8X-CC, 33–41 cm | U1496B-10F-2, 10–12 cm | U1496B-8X-CC, 33–41 cm | U1496B-8X-CC, 33–41 cm | U1498B-8R-1, 32–34 cm | U1496A-10G-CC, 23–26 cm | U1497A-12F-1, 93–95 cm | U1496B-8X-CC, 33–41 cm | U1498B-8R-1, 10–15 cm | U1496A-10G-CC, 23–26 cm | U1498B-8R-1, 0–4 cm | U1498B-8R-1, 32–34 cm |
| Seamount | Fantang-isña | Asùt Tesoru | Fantang-isña | Fantang-isña | Asùt Tesoru | Asùt Tesoru | Asùt Tesoru | Asùt Tesoru | Fantang-isña | Asùt Tesoru | Fantang-isña | Asùt Tesoru | Fantang-isña | Asùt Tesoru | Fantang-isña | Fantang-isña |
| Phase | Chl | Chl | Cpx | Cpx | Gln | Gln | Lws | Lws | Pct | Pct | Ph | Ph | Pmp | Pmp | Prh | Prh |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| wt.% |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| SiO2 | 30.68 | 32.90 | 46.49 | 45.83 | 53.30 | 52.54 | 38.10 | 38.27 | 53.07 | 53.36 | 52.27 | 54.42 | 34.10 | 35.91 | 42.32 | 42.61 |
| TiO2 | 0.01 | 0.04 | 2.66 | 1.98 | 0.08 | 0.43 | 0.14 | 0.20 | 0.05 | <0.01 | 0.53 | 0.06 | 0.44 | 0.15 | 0.01 | 0.21 |
| Al2O3 | 14.88 | 15.06 | 6.73 | 4.91 | 4.86 | 4.89 | 32.14 | 31.97 | <0.01 | 0.06 | 17.02 | 20.61 | 21.51 | 22.49 | 24.36 | 24.49 |
| Cr2O3 | 0.25 | 0.62 | 0.05 | 0.10 | 0.02 | 0.01 | 0.03 | 0.03 | <0.01 | 0.02 | <0.01 | 0.01 | 0.08 | 0.05 | 0.02 | 0.03 |
| MgO | 19.82 | 34.23 | 13.33 | 9.84 | 1.41 | 2.94 | 0.02 | 0.03 | 0.02 | 0.01 | 6.25 | 5.14 | 2.63 | 7.49 | 0.00 | 0.10 |
| FeO | 19.80 | 3.62 | 8.22 | 16.00 | 22.58 | 17.98 | 1.11 | 1.54 | 0.33 | 0.07 | 10.07 | 3.87 | 6.39 | 6.30 | 0.08 | 0.38 |
| MnO | 0.17 | <0.01 | 0.11 | 0.25 | 0.15 | 1.35 | 0.04 | 0.01 | 1.10 | 0.08 | 0.11 | 0.07 | 0.10 | 0.03 | 0.00 | 0.03 |
| CaO | 0.92 | 0.06 | 22.13 | 19.18 | 2.91 | 5.07 | 16.52 | 16.61 | 32.36 | 33.41 | 0.69 | 0.12 | 20.76 | 17.39 | 25.37 | 26.46 |
| Na2O | 0.19 | 0.11 | 0.50 | 0.51 | 10.71 | 9.53 | 0.02 | <0.01 | 8.23 | 8.14 | 0.52 | 0.19 | 0.28 | 0.54 | 0.08 | 0.08 |
| K2O | 0.02 | 0.02 | 0.01 | 0.01 | 0.06 | 0.34 | 0.09 | 0.14 | <0.01 | <0.01 | 7.54 | 10.48 | 0.01 | 0.10 | <0.01 | <0.01 |
| Total | 86.74 | 86.66 | 100.22 | 98.62 | 96.06 | 95.08 | 88.21 | 88.77 | 95.14 | 95.15 | 94.99 | 94.96 | 86.30 | 90.44 | 92.24 | 94.38 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Cations pfu | |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Si | 3.172 | 3.123 | 1.744 | 1.800 | 8.173 | 8.065 | 2.005 | 2.006 | 3.006 | 3.010 | 3.609 | 3.665 | 2.947 | 2.920 | 3.002 | 2.970 |
| Ti | 0.001 | 0.003 | 0.075 | 0.059 | 0.009 | 0.049 | 0.005 | 0.008 | 0.002 | 0.000 | 0.028 | 0.003 | 0.029 | 0.009 | 0.001 | 0.011 |
| Al | 1.813 | 1.685 | 0.298 | 0.227 | 0.878 | 0.885 | 1.993 | 1.975 | 0.000 | 0.004 | 1.385 | 1.636 | 2.191 | 2.156 | 2.036 | 2.012 |
| Cr | 0.021 | 0.047 | 0.001 | 0.003 | 0.002 | 0.001 | 0.001 | 0.001 | 0.000 | 0.001 | 0.000 | 0.001 | 0.005 | 0.003 | 0.001 | 0.002 |
| Mg | 3.055 | 4.846 | 0.745 | 0.576 | 0.321 | 0.672 | 0.001 | 0.002 | 0.001 | 0.001 | 0.643 | 0.516 | 0.339 | 0.908 | 0.000 | 0.010 |
| Fe | 1.712 | 0.287 | 0.258 | 0.526 | 2.895 | 2.308 | 0.049 | 0.068 | 0.015 | 0.003 | 0.582 | 0.218 | 0.462 | 0.428 | 0.004 | 0.022 |
| Mn | 0.015 | 0.000 | 0.003 | 0.008 | 0.019 | 0.176 | 0.002 | 0.000 | 0.053 | 0.004 | 0.006 | 0.004 | 0.007 | 0.002 | 0.000 | 0.002 |
| Ni | 0.000 | 0.000 | 0.000 | 0.000 | 0.005 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.000 | 0.000 |
| Ca | 0.102 | 0.006 | 0.889 | 0.807 | 0.479 | 0.834 | 0.932 | 0.933 | 1.964 | 2.019 | 0.051 | 0.009 | 1.922 | 1.515 | 1.928 | 1.976 |
| Na | 0.038 | 0.020 | 0.036 | 0.039 | 3.184 | 2.836 | 0.002 | 0.000 | 0.904 | 0.890 | 0.069 | 0.025 | 0.047 | 0.085 | 0.011 | 0.010 |
| K | 0.003 | 0.002 | 0.000 | 0.001 | 0.011 | 0.067 | 0.006 | 0.009 | 0.000 | 0.000 | 0.664 | 0.900 | 0.001 | 0.010 | 0.000 | 0.000 |
| Sum | 9.931 | 10.019 | 4.050 | 4.046 | 15.976 | 15.894 | 4.997 | 5.002 | 5.944 | 5.933 | 7.037 | 6.976 | 7.950 | 8.039 | 6.984 | 7.017 |

*Note.* Cations pfu calculated on the basis of 6 O for Cpx, 14 O for Chl, 11 O for Prh, 12 O for Pmp, 11 O for Ph, 8 O for Lws, 23 O for Gln.

Abbreviations: Chl, chlorite; Cpx, clinopyroxene; Gln, glaucophane; Lws, lawsonite; pfu, per formula unit; Ph, phengite; Pmp, pumpellyite; Prh, prehnite.

Table S2: Pore water Sr concentrations and isotopic compositions.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Sample | Seamount | Depth [m bsf]a | Sr [nM] | 87Sr/86Sr |
| U1492C-1H-2 | Yinazao | 0.0 | 536 | 0.70598 |
| U1492C-1H-4 | Yinazao | 0.0 | 660 | 0.70584 |
| U1492C-3F-1 | Yinazao | 7.0 | 688 | 0.70566 |
| U1492C-3F-2 | Yinazao | 7.0 | 687 | 0.70566 |
| U1492C-5F-2 | Yinazao | 14.2 | 667 | 0.70568 |
| U1492C-8F-2 | Yinazao | 28.2 | 679 | 0.70566 |
| U1492C-11F-2 | Yinazao | 37.6 | 681 | 0.70567 |
| U1492C-12F-1 | Yinazao | 42.3 | 688 | 0.70569 |
| U1492C-13F-1 | Yinazao | 47.0 | 687 | 0.70567 |
| U1492C-16F-1 | Yinazao | 61.1 | 503 | 0.70594 |
| U1492C-19F-2 | Yinazao | 75.2 | 613 | 0.70569 |
| U1492C-22F-1 | Yinazao | 89.3 | 741 | 0.70567 |
| U1492C-24F-2 | Yinazao | 98.7 | 738 | 0.70567 |
| U1492C-26F-1 | Yinazao | 108.1 | 729 | 0.70566 |
| U1492C-27F-1 | Yinazao | 112.8 | 746 | 0.70567 |
| U1497A-2F-2 | Fantangisña | 0.9 | 265 | 0.70585 |
| U1497A-6F-1 | Fantangisña | 16.7 | 629 | 0.70495 |
| U1497B-3F-2 | Fantangisña | 8.4 | 336 | 0.70573 |
| U1497B-6F-1 | Fantangisña | 17.8 | 584 | 0.70507 |
| U1496A-2F-1 | Asùt Tesoru | 3.2 | 15.4 | 0.70514 |
| U1496A-3F-4 | Asùt Tesoru | 7.9 | 20.1 | 0.70515 |
| U1496A-6F-3 | Asùt Tesoru | 22.0 | 16.8 | 0.70516 |
| U1496A-9F-1 | Asùt Tesoru | 36.1 | 19.9 | 0.70527 |
| U1496B-2F-1 | Asùt Tesoru | 1.9 | 9.3 | 0.70588 |
| U1496B-3F-2 | Asùt Tesoru | 6.6 | 11 | 0.70526 |
| U1496B-3F-5 | Asùt Tesoru | 6.6 | 12.4 | 0.70517 |
| U1496B-5F-2 | Asùt Tesoru | 16.0 | 10.4 | 0.70510 |
| U1496C-12G-3 | Asùt Tesoru | 98.8 | 21 | 0.70576 |
| U1496C-13G-3 | Asùt Tesoru | 102.5 | 21.7 | 0.70549 |
| U1496C-WSTPb | Asùt Tesoru | 42.0 | 86.5 | 0.70675 |

*Note.* a Given depths are tops of individual cores.

b WSTP is water-sampling temperature probe; the sample was collected 9.5 days after circulation of drilling fluids had ceased in the bore hole; see Fryer et al. (2018d).