ELECTRONIC ANNEX CAPTIONS

Table EA1:

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Sample | Distance to contact (km) | δ13C (VPDB)(‰) | δ13C (error)(‰) | δ18O (VPDB)(‰) | δ18O (error)(‰) | ∆47ARF (‰) | ∆47 error (‰) | Temperature (∆47ARF, °C) | Xdol sample | Mineral assemblage |
| 10H-107 | 0.09 | -0.273 | 0.003 | -10.341 | 0.005 | 0.520 | 0.010 | 99.7 | 0.018 | CC-Do-Tr-Di-Phl-Gr |
| 10H-107 | 0.09 | -0.188 | 0.004 | -10.417 | 0.005 | 0.392 | 0.011 | 223.8 | 0.018 | CC-Do-Tr-Di-Phl-Gr |
| 10H-107 | 0.09 | -0.187 | 0.003 | -10.373 | 0.006 | 0.438 | 0.012 | 163.6 | 0.018 | CC-Do-Tr-Di-Phl-Gr |
| 10H-107 | 0.09 | -0.194 | 0.004 | -10.620 | 0.006 | 0.428 | 0.013 | 174.6 | 0.018 | CC-Do-Tr-Di-Phl-Gr |
| 3H-38A | 0.15 | 0.698 | 0.004 | -10.023 | 0.006 | 0.489 | 0.010 | 119.7 | 0.033 | Cc-Do-Qz-Tr-Fo-Chl-Pl-(Tc)-Gr |
| 3H-38A | 0.15 | 0.705 | 0.004 | -10.328 | 0.009 | 0.437 | 0.011 | 164.7 | 0.033 | Cc-Do-Qz-Tr-Fo-Chl-Pl-(Tc)-Gr |
| 3H-38A | 0.15 | 0.695 | 0.003 | -10.402 | 0.003 | 0.425 | 0.007 | 178.0 | 0.033 | Cc-Do-Qz-Tr-Fo-Chl-Pl-(Tc)-Gr |
| 20H-99 | 0.23 | 0.784 | 0.003 | -9.669 | 0.002 | 0.452 | 0.009 | 149.8 | 0.097 | Cc-Do-Qz-Tc-Tr-Pl-Gr |
| 20H-99 | 0.23 | 0.750 | 0.003 | -9.922 | 0.007 | 0.394 | 0.015 | 220.5 | 0.097 | Cc-Do-Qz-Tc-Tr-Pl-Gr |
| 20H-99 | 0.23 | 0.731 | 0.004 | -9.920 | 0.004 | 0.391 | 0.011 | 225.4 | 0.097 | Cc-Do-Qz-Tc-Tr-Pl-Gr |
| 11H-116 | 1.88 | 1.184 | 0.002 | -9.545 | 0.003 | 0.430 | 0.014 | 172.3 | 0.057 | Cc-Do-Qz-Chl-Phl-Pl-Gr |
| 12-NPK-11b | 2.63 | 0.609 | 0.003 | -10.037 | 0.010 | 0.465 | 0.013 | 138.3 | 0.032 | Cc-Do-Qz-Chl-Gr |
| 12-NPK-5 | 4.01 | 0.704 | 0.003 | -9.722 | 0.009 | 0.406 | 0.010 | 202.4 | 0.030 | Cc-Do-Qz-Chl-Gr |
| 12-NPK-5 | 4.01 | 0.719 | 0.003 | -9.678 | 0.006 | 0.433 | 0.005 | 169.0 | 0.030 | Cc-Do-Qz-Chl-Gr |
| 12-NPK-5 | 4.01 | 0.722 | 0.001 | -9.778 | 0.003 | 0.451 | 0.007 | 150.8 | 0.030 | Cc-Do-Qz-Chl-Gr |
| 12H-122 | 5.36 | 0.773 | 0.002 | -9.825 | 0.003 | 0.445 | 0.010 | 156.5 | 0.033 | Cc-Do-Qz-Chl-Pl-Kfs-Gr |

Table EA1: Individual measurements of calcite clumped isotopes using the offline stepped acid digestion procedure.

Table EA2:

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Sample | Distance to contact (km) | δ13C (VPDB)(‰) | δ13C (error)(‰) | δ18O (VPDB)(‰) | δ18O (error)(‰) | ∆47ARF (‰) | ∆47 error (‰) | Temperature (∆47ARF, °C) | Xdol sample | Mineral assemblage |
| 10H-107 | 0.09 | 0.218 | 0.002 | -9.963 | 0.004 | 0.356 | 0.009 | 298.8 | 0.018 | CC-Do-Tr-Di-Phl-Gr |
| 10H-107 | 0.09 | 0.212 | 0.002 | -9.889 | 0.004 | 0.346 | 0.009 | 327.7 | 0.018 | CC-Do-Tr-Di-Phl-Gr |
| 3H-38A | 0.15 | 1.096 | 0.005 | -9.996 | 0.010 | 0.328 | 0.011 | 395.1 | 0.033 | Cc-Do-Qz-Tr-Fo-Chl-Pl-(Tc)-Gr |
| 3H-38A | 0.15 | 1.135 | 0.005 | -9.911 | 0.020 | 0.345 | 0.009 | 330.9 | 0.033 | Cc-Do-Qz-Tr-Fo-Chl-Pl-(Tc)-Gr |
| 3H-38A | 0.15 | 1.116 | 0.005 | -9.968 | 0.014 | 0.346 | 0.015 | 327.7 | 0.033 | Cc-Do-Qz-Tr-Fo-Chl-Pl-(Tc)-Gr |
| 20H-99 | 0.23 | 1.476 | 0.003 | -9.012 | 0.004 | 0.326 | 0.011 | 404.2 | 0.097 | Cc-Do-Qz-Tc-Tr-Pl-Gr |
| 20H-99 | 0.23 | 1.489 | 0.002 | -8.983 | 0.004 | 0.346 | 0.007 | 327.7 | 0.097 | Cc-Do-Qz-Tc-Tr-Pl-Gr |
| 11H-116 | 1.88 | 1.600 | 0.003 | -9.408 | 0.007 | 0.386 | 0.008 | 234.0 | 0.057 | Cc-Do-Qz-Chl-Phl-Pl-Gr |
| 11H-116 | 1.88 | 1.688 | 0.002 | -9.504 | 0.004 | 0.323 | 0.009 | 418.7 | 0.057 | Cc-Do-Qz-Chl-Phl-Pl-Gr |
| 11H-116 | 1.88 | 1.674 | 0.003 | -9.478 | 0.004 | 0.363 | 0.008 | 281.2 | 0.057 | Cc-Do-Qz-Chl-Phl-Pl-Gr |
| 11H-116 | 1.88 | 1.687 | 0.003 | -9.383 | 0.003 | 0.342 | 0.012 | 340.8 | 0.057 | Cc-Do-Qz-Chl-Phl-Pl-Gr |
| 12-NPK-11b | 2.63 | 1.463 | 0.005 | -8.977 | 0.008 | 0.467 | 0.014 | 136.7 | 0.032 | Cc-Do-Qz-Chl-Gr |
| 12-NPK-11b | 2.63 | 1.457 | 0.005 | -8.947 | 0.009 | 0.453 | 0.010 | 148.9 | 0.032 | Cc-Do-Qz-Chl-Gr |
| 12-NPK-5 | 4.01 | 1.846 | 0.003 | -8.542 | 0.003 | 0.400 | 0.009 | 211.2 | 0.030 | Cc-Do-Qz-Chl-Gr |
| 12-NPK-5 | 4.01 | 1.863 | 0.005 | -8.502 | 0.006 | 0.408 | 0.016 | 199.6 | 0.030 | Cc-Do-Qz-Chl-Gr |
| 12H-122 | 5.36 | 2.695 | 0.003 | -8.588 | 0.008 | 0.439 | 0.016 | 162.6 | 0.033 | Cc-Do-Qz-Chl-Pl-Kfs-Gr |

Table EA2: Individual measurements of dolomite clumped isotopes using the offline stepped acid digestion procedure.

Table EA3:

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Sample | Distance to contact (km) | δ13C (VPDB)(‰) | δ13C (error)(‰) | δ18O (VPDB)(‰) | δ18O (error)(‰) | ∆47ARF (‰) | ∆47 error (‰) | Temperature (∆47ARF, °C) | Xdol sample | Mineral assemblage |
| 10H-107 | 0.09 | -0.167 | 0.002 | -10.228 | 0.003 | 0.447 | 0.011 | 154.6 | 0.018 | CC-Do-Tr-Di-Phl-Gr |
| 10H-107 | 0.09 | -0.234 | 0.004 | -10.504 | 0.010 | 0.470 | 0.014 | 134.2 | 0.018 | CC-Do-Tr-Di-Phl-Gr |
| 10H-107 | 0.09 | -0.208 | 0.004 | -10.490 | 0.010 | 0.442 | 0.016 | 159.5 | 0.018 | CC-Do-Tr-Di-Phl-Gr |
| 3H-38A | 0.15 | 0.778 | 0.008 | -10.225 | 0.012 | 0.459 | 0.012 | 143.5 | 0.033 | Cc-Do-Qz-Tr-Fo-Chl-Pl-(Tc)-Gr |
| 3H-38A | 0.15 | 0.772 | 0.007 | -10.209 | 0.008 | 0.443 | 0.008 | 158.5 | 0.033 | Cc-Do-Qz-Tr-Fo-Chl-Pl-(Tc)-Gr |
| 3H-38A | 0.15 | 0.763 | 0.007 | -10.223 | 0.011 | 0.445 | 0.010 | 156.5 | 0.033 | Cc-Do-Qz-Tr-Fo-Chl-Pl-(Tc)-Gr |
| 3H-38A | 0.15 | 0.749 | 0.005 | -10.349 | 0.010 | 0.431 | 0.011 | 171.2 | 0.033 | Cc-Do-Qz-Tr-Fo-Chl-Pl-(Tc)-Gr |
| 3H-38A | 0.15 | 0.787 | 0.012 | -10.263 | 0.004 | 0.456 | 0.012 | 146.2 | 0.033 | Cc-Do-Qz-Tr-Fo-Chl-Pl-(Tc)-Gr |
| 3H-38A | 0.15 | 0.791 | 0.003 | -10.153 | 0.002 | 0.434 | 0.011 | 167.9 | 0.033 | Cc-Do-Qz-Tr-Fo-Chl-Pl-(Tc)-Gr |
| 3H-38A | 0.15 | 0.764 | 0.002 | -10.067 | 0.009 | 0.428 | 0.013 | 174.6 | 0.033 | Cc-Do-Qz-Tr-Fo-Chl-Pl-(Tc)-Gr |
| 3H-38A | 0.15 | 0.751 | 0.006 | -10.225 | 0.020 | 0.417 | 0.016 | 187.8 | 0.033 | Cc-Do-Qz-Tr-Fo-Chl-Pl-(Tc)-Gr |
| 3H-38A | 0.15 | 0.705 | 0.003 | -10.330 | 0.008 | 0.452 | 0.007 | 149.8 | 0.033 | Cc-Do-Qz-Tr-Fo-Chl-Pl-(Tc)-Gr |
| 20H-99 | 0.23 | 0.808 | 0.002 | -9.699 | 0.002 | 0.421 | 0.012 | 182.8 | 0.097 | Cc-Do-Qz-Tc-Tr-Pl-Gr |
| 20H-99 | 0.23 | 0.811 | 0.002 | -9.693 | 0.003 | 0.430 | 0.010 | 172.3 | 0.097 | Cc-Do-Qz-Tc-Tr-Pl-Gr |
| 11H-116 | 1.88 | 0.921 | 0.008 | -10.173 | 0.008 | 0.493 | 0.012 | 116.9 | 0.057 | Cc-Do-Qz-Chl-Phl-Pl-Gr |
| 11H-116 | 1.88 | 0.903 | 0.009 | -10.203 | 0.010 | 0.476 | 0.014 | 129.4 | 0.057 | Cc-Do-Qz-Chl-Phl-Pl-Gr |
| 11H-116 | 1.88 | 0.936 | 0.005 | -9.967 | 0.006 | 0.431 | 0.010 | 171.2 | 0.057 | Cc-Do-Qz-Chl-Phl-Pl-Gr |
| 11H-116 | 1.88 | 0.936 | 0.002 | -9.987 | 0.006 | 0.475 | 0.014 | 130.2 | 0.057 | Cc-Do-Qz-Chl-Phl-Pl-Gr |
| 11H-116 | 1.88 | 0.968 | 0.002 | -9.908 | 0.006 | 0.446 | 0.016 | 155.6 | 0.057 | Cc-Do-Qz-Chl-Phl-Pl-Gr |
| 11H-116 | 1.88 | 0.970 | 0.001 | -9.882 | 0.003 | 0.428 | 0.011 | 174.6 | 0.057 | Cc-Do-Qz-Chl-Phl-Pl-Gr |
| 12-NPK-11b | 2.63 | 0.619 | 0.006 | -9.875 | 0.006 | 0.464 | 0.015 | 139.2 | 0.032 | Cc-Do-Qz-Chl-Gr |
| 12-NPK-11b | 2.63 | 0.619 | 0.005 | -9.864 | 0.011 | 0.477 | 0.018 | 128.6 | 0.032 | Cc-Do-Qz-Chl-Gr |
| 12-NPK-5 | 4.01 | 0.714 | 0.002 | -9.725 | 0.007 | 0.429 | 0.011 | 173.4 | 0.030 | Cc-Do-Qz-Chl-Gr |
| 12-NPK-5 | 4.01 | 0.671 | 0.003 | -9.798 | 0.008 | 0.452 | 0.012 | 149.8 | 0.030 | Cc-Do-Qz-Chl-Gr |
| 12H-122 | 5.36 | 0.849 | 0.009 | -10.009 | 0.016 | 0.491 | 0.009 | 118.3 | 0.033 | Cc-Do-Qz-Chl-Pl-Kfs-Gr |
| 12H-122 | 5.36 | 0.848 | 0.009 | -10.038 | 0.016 | 0.472 | 0.012 | 132.6 | 0.033 | Cc-Do-Qz-Chl-Pl-Kfs-Gr |
| 12H-122 | 5.36 | 0.636 | 0.002 | -10.557 | 0.004 | 0.473 | 0.013 | 131.8 | 0.033 | Cc-Do-Qz-Chl-Pl-Kfs-Gr |
| 12H-122 | 5.36 | 0.842 | 0.004 | -10.057 | 0.021 | 0.430 | 0.016 | 172.3 | 0.033 | Cc-Do-Qz-Chl-Pl-Kfs-Gr |

Table EA3: Individual clumped isotope measurements of bulk powders using an online common acid bath (mixed calcite and dolomite).

Table EA4:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Sample | δ13C (VPDB)(‰) | δ13C (error)(‰) | δ18O (VPDB)(‰) | δ18O (error)(‰) | ∆47ARF(‰) | ∆47 error(‰) | Temperature (∆47 ARF, °C) |
| Gabbs-17 | -5.893 | 0.011 | -15.514 | 0.011 | 0.346 | 0.009 | 327.7 |
| Gabbs-17 | -5.931 | 0.011 | -15.522 | 0.010 | 0.332 | 0.007 | 377.9 |
| ML-INYO | -0.558 | 0.007 | -7.522 | 0.006 | 0.330 | 0.011 | 386.3 |
| ML-INYO | -0.576 | 0.003 | -7.508 | 0.006 | 0.316 | 0.005 | 457.0 |

Table EA4: Individual clumped isotope measurements of two high-grade dolomite marbles from the Western US. Gabbs-17 is a massive, buff, crystalline dolomite marble from Gabbs, NV, that was regionally metamorphosed as part of Tertiary fold and thrust belt, with additional contact metamorphism due to intrusion of granitic plutons (Humphrey and Wyatt, 1958; Cathles et al., 1997). ML-INYO is a white, crystalline dolomite marble from Inyo Range, CA regionally metamorphosed due to burial beneath ~10 km of section Cambrian and younger (Nelson, 1962). Gabbs-17 is part of the Caltech Working Mineral Collection, sampler unknown. ML-INYO was collected by G.R. Rossman.

Table EA5:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Method | Sample | δ13C (VPDB)(‰) | δ13C (error)(‰) | δ18O (VPDB)(‰) | δ18O (error)(‰) | ∆47ARF(‰) | ∆47 error(‰) |
| Calcite, online | Carrara marble | 2.114 | 0.005 | -2.152 | 0.010 | 0.411 | 0.014 |
| 2.060 | 0.005 | -2.261 | 0.026 | 0.404 | 0.010 |
| 2.108 | 0.003 | -2.155 | 0.013 | 0.420 | 0.010 |
| 2.101 | 0.006 | -2.167 | 0.023 | 0.405 | 0.009 |
| 2.095 | 0.004 | -2.196 | 0.013 | 0.446 | 0.010 |
| 2.033 | 0.004 | -2.301 | 0.010 | 0.433 | 0.009 |
| 2.098 | 0.005 | -2.174 | 0.012 | 0.436 | 0.017 |
| 2.108 | 0.005 | -2.155 | 0.010 | 0.423 | 0.015 |
|  |
| Calcite offline: 0-2 hrs at 25 °C | Carrara mable + SS07 dolomite | 2.064 | 0.002 | -1.863 | 0.005 | 0.446 | 0.010 |
| 2.097 | 0.004 | -1.814 | 0.008 | 0.417 | 0.015 |
|  |
| Dolomite online | SS07 dolomite | 7.525 | 0.003 | -2.310 | 0.014 | 0.598 | 0.013 |
| 7.535 | 0.004 | -2.270 | 0.011 | 0.597 | 0.012 |
| 7.539 | 0.002 | -2.247 | 0.024 | 0.600 | 0.012 |
|  |
| Dolomite offline: 24-48 hrs at 50 °C | Carrara mable + SS07 dolomite | 7.722 | 0.003 | -2.025 | 0.016 | 0.600 | 0.015 |
| 7.729 | 0.004 | -2.065 | 0.010 | 0.602 | 0.012 |
| 7.737 | 0.006 | -1.972 | 0.012 | 0.622 | 0.014 |

Table EA5: Individual measurements of the calcite standard Carrara marble, an in-house dolomite standard (SS-07), and mixtures of the two subjected to the stepped extraction procedure described in section 4.2 of the main text. Offline extractions of calcite or dolomite from mixtures of the standards were only compared to online (i.e., common acid bath) measurements of pure phases from the same analytical session in order to minimize the effect of instrumental drift on δ13C and δ18O values. For these offline extractions, the two standards were mixed in proportions comparable to those observed in the natural samples(i.e., Xdolomite values of 0.02-0.1 by moles).

Table EA6:

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Reaction temperature (°C) | Measurement session | δ13C (VPDB) (‰) | δ13C (error) (‰) | δ18O (VPDB) (‰) | δ18O (error) (‰) | ∆47ARF (‰), No acid correction | ∆47ARF (‰), Acid corrected | ∆47 error (‰) |
| 90 | April 2013 | 7.286 | 0.006 | -1.696 | 0.014 | 0.506 | 0.598 | 0.012 |
| 90 | April 2013 | 7.376 | 0.013 | -1.566 | 0.011 | 0.540 | 0.632 | 0.009 |
| 90 | April 2013 | 7.290 | 0.009 | -1.685 | 0.016 | 0.519 | 0.611 | 0.014 |
| 90 | April 2013 | 7.351 | 0.009 | -1.671 | 0.018 | 0.514 | 0.606 | 0.011 |
| 90 | April 2013 | 7.365 | 0.007 | -1.632 | 0.011 | 0.530 | 0.622 | 0.018 |
| 90 | April 2013 | 7.266 | 0.007 | -1.881 | 0.018 | 0.506 | 0.598 | 0.008 |
| 90 | April 2013 | 7.264 | 0.004 | -1.831 | 0.007 | 0.511 | 0.603 | 0.006 |
| 90 | May 2013 | 7.280 | 0.005 | -1.794 | 0.007 | 0.534 | 0.626 | 0.009 |
| 90 | May 2013 | 7.208 | 0.004 | -1.938 | 0.007 | 0.521 | 0.613 | 0.008 |
| 90 | July 2013 | 7.525 | 0.002 | -2.310 | 0.005 | 0.506 | 0.598 | 0.010 |
| 90 | July 2013 | 7.535 | 0.003 | -2.270 | 0.004 | 0.505 | 0.597 | 0.009 |
| 90 | July 2013 | 7.539 | 0.003 | -2.247 | 0.003 | 0.508 | 0.600 | 0.010 |
|  |  |  |  |  |  |  |  |  |
| 50 | July 2013 | 7.613 | 0.003 | -2.065 | 0.007 | 0.577 | 0.617 | 0.016 |
| 50 | July 2013 | 7.612 | 0.004 | -2.004 | 0.005 | 0.572 | 0.612 | 0.015 |
| 50 | October 2013 | 8.167 | 0.002 | -1.327 | 0.004 | 0.562 | 0.602 | 0.011 |
| 50 | October 2013 | 8.182 | 0.003 | -1.306 | 0.002 | 0.563 | 0.603 | 0.011 |

Table EA6: Individual measurements used to determine the ∆47 acid digestion fractionation of dolomite when reacted at 50 °C in McCrea (1950)-style vessels, by comparison with the mean ∆47 value of the same standard (SS07) when reacted by the common acid bath technique at 90 °C. With an acid digestion fractionation correction of 0.040‰, the mean of the offline 50 °C measurements agrees with the mean of the online 90 °C measurements (with the accepted fractionation correction of 0.092‰).

Works cited:

Cathles L. M., Erendi A. H. J. and Barrie T. (1997) How long can a hydrothermal system be sustained by a single intrusive event? *Economic Geology* **92**, 766–771.

Humphrey F. L. and Wyatt M. (1958) Scheelite in feldspathized granodiorite at the Victory Mine, Gabbs, Nevada. *Economic Geology* **53**, 38-64.

Nelson C. A. (1962) Lower Cambrian-Precambrian Succession, White-Inyo Mountains, California. *Geological Society of America Bulletin* **73**, 139–144.