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**Zircon U-Pb ages and Hf isotope compositions of the Neoproterozoic magmatic rocks in the Helan Mountains, North China**

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**Supplementary Materials**

### Table S1 LA-ICP-MS zircon U-Pb dating results for the gabbro (HL-39) of the Xiaosongshan complex in northern Helan Mountains, North China.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Sample  Spot | 232Th（ppm) | 238U（ppm) | 232Th  /238U | *207Pb*  */206Pb* | *1σ* | *207Pb*  */235U* | *1σ* | *206Pb*  */238U* | *1σ* | *208Pb*  */232Th* | *1σ* | *207Pb/206Pb*  *（Ma）* | *207Pb/235U*  *（Ma）* | *206Pb/238U*  *（Ma）* | *208Pb/232Th*  *（Ma）* |
| HL-39-1 | 52 | 86 | 0.60 | 0.070 | 0.004 | 1.37 | 0.065 | 0.1384 | 0.002 | 0.04093 | 0.001 | 938±72 | 862±28 | 836±14 | 811±29 |
| HL-39-2 | 83 | 129 | 0.65 | 0.068 | 0.003 | 1.30 | 0.061 | 0.1383 | 0.002 | 0.04247 | 0.001 | 863±77 | 845±27 | 835±10 | 841±25 |
| HL-39-3 | 57 | 96 | 0.59 | 0.069 | 0.003 | 1.31 | 0.064 | 0.1379 | 0.002 | 0.04142 | 0.001 | 893±77 | 851±28 | 833±11 | 820±28 |
| HL-39-4 | 47 | 96 | 0.48 | 0.066 | 0.003 | 1.26 | 0.057 | 0.1383 | 0.002 | 0.04104 | 0.002 | 799±71 | 829±26 | 835±11 | 813±29 |
| HL-39-5 | 66 | 128 | 0.52 | 0.064 | 0.003 | 1.23 | 0.053 | 0.1383 | 0.002 | 0.04381 | 0.002 | 749±68 | 815±24 | 835±11 | 866±31 |
| HL-39-6 | 52 | 86 | 0.61 | 0.065 | 0.004 | 1.24 | 0.071 | 0.1389 | 0.002 | 0.04202 | 0.002 | 784±96 | 820±32 | 838±12 | 832±30 |
| HL-39-7 | 35 | 60 | 0.58 | 0.066 | 0.004 | 1.25 | 0.073 | 0.1390 | 0.002 | 0.04617 | 0.002 | 814±93 | 824±33 | 839±14 | 912±36 |
| HL-39-8 | 60 | 92 | 0.65 | 0.067 | 0.003 | 1.27 | 0.060 | 0.1375 | 0.002 | 0.04312 | 0.002 | 837±75 | 834±27 | 831±11 | 853±32 |
| HL-39-9 | 87 | 176 | 0.49 | 0.070 | 0.003 | 1.34 | 0.049 | 0.1386 | 0.002 | 0.04306 | 0.001 | 924±54 | 864±21 | 837±10 | 852±29 |
| HL-39-10 | 33.0 | 67 | 0.49 | 0.067 | 0.004 | 1.27 | 0.082 | 0.1379 | 0.002 | 0.04201 | 0.002 | 840±107 | 833±37 | 833±13 | 832±42 |
| HL-39-11 | 29.9 | 69 | 0.43 | 0.071 | 0.004 | 1.35 | 0.073 | 0.1379 | 0.002 | 0.04262 | 0.002 | 953±84 | 869±32 | 833±13 | 844±43 |
| HL-39-12 | 38 | 66 | 0.57 | 0.071 | 0.004 | 1.34 | 0.075 | 0.1382 | 0.003 | 0.04408 | 0.002 | 966±81 | 865±3 | 834±16 | 872±41 |
| HL-39-13 | 59 | 89 | 0.67 | 0.065 | 0.003 | 1.28 | 0.056 | 0.1384 | 0.002 | 0.03951 | 0.001 | 780±71 | 809±26 | 835±12 | 783±26 |
| HL-39-14 | 25.9 | 50 | 0.51 | 0.069 | 0.004 | 1.30 | 0.076 | 0.1391 | 0.003 | 0.04644 | 0.002 | 898±86 | 845±33 | 840±16 | 917±43 |
| HL-39-15 | 47 | 96 | 0.49 | 0.069 | 0.004 | 1.33 | 0.067 | 0.1386 | 0.002 | 0.04214 | 0.002 | 911±78 | 858±29 | 837±2 | 834±37 |
| HL-39-16 | 38 | 72 | 0.52 | 0.070 | 0.004 | 1.32 | 0.067 | 0.1386 | 0.002 | 0.04146 | 0.002 | 940±76 | 856±29 | 836±13 | 821±36 |
| HL-39-17 | 20.0 | 44 | 0.45 | 0.073 | 0.005 | 1.36 | 0.085 | 0.1391 | 0.003 | 0.04391 | 0.002 | 1024±93 | 873±37 | 839±16 | 869±45 |
| HL-39-18 | 113 | 182 | 0.62 | 0.069 | 0.002 | 1.32 | 0.046 | 0.1385 | 0.002 | 0.03937 | 0.001 | 894±51 | 852±20 | 836±10 | 780±23 |
| HL-39-19 | 28.8 | 77 | 0.38 | 0.067 | 0.003 | 1.29 | 0.067 | 0.1387 | 0.002 | 0.04298 | 0.002 | 834±81 | 840±30 | 837±12 | 851±39 |
| HL-39-20 | 32.0 | 58 | 0.55 | 0.070 | 0.004 | 1.32 | 0.069 | 0.1382 | 0.002 | 0.04174 | 0.002 | 919±83 | 853±30 | 835±12 | 826±38 |

### Table S2 LA-ICP-MS zircon U-Pb dating results for the granite (HL-30) of the Xiaosongshan complex in northern Helan Mountains, North China.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Sample | 232Th | 238U |  | Isotope ratios | | | | | | Age（Ma） | | | | | |
| Spot | （ppm) | （ppm) | 232Th/238U | 207*Pb/*206*Pb* | *1σ* | 207Pb/235U | *1σ* | 206Pb/238U | *1σ* | 207*Pb/*206*Pb* | *1σ* | 207Pb/235U | *1σ* | 206Pb/238U | *1σ* |
| HL-30-1 | 181 | 321 | 0.56 | 0.0630 | 0.0019 | 1.2415 | 0.0386 | 0.1416 | 0.0015 | 707 | 67 | 820 | 17 | 854 | 8 |
| HL-30-2 | 251 | 498 | 0.50 | 0.0662 | 0.0017 | 1.3072 | 0.0327 | 0.1418 | 0.0013 | 813 | 49 | 849 | 14 | 855 | 7 |
| HL-30-3 | 171 | 355 | 0.48 | 0.0639 | 0.0017 | 1.3351 | 0.0343 | 0.1499 | 0.0014 | 739 | 56 | 861 | 15 | 900 | 8 |
| HL-30-4 | 171 | 320 | 0.53 | 0.0651 | 0.0019 | 1.2843 | 0.0350 | 0.1416 | 0.0016 | 776 | 59 | 839 | 16 | 854 | 9 |
| HL-30-5 | 219 | 388 | 0.57 | 0.0674 | 0.0022 | 1.3316 | 0.0404 | 0.1415 | 0.0014 | 850 | 67 | 860 | 18 | 853 | 8 |
| HL-30-6 | 488 | 674 | 0.72 | 0.0728 | 0.0020 | 1.4416 | 0.0371 | 0.1415 | 0.0013 | 1009 | 57 | 906 | 15 | 853 | 7 |
| HL-30-7 | 414 | 542 | 0.76 | 0.0684 | 0.0018 | 1.3573 | 0.0356 | 0.1416 | 0.0015 | 880 | 53 | 871 | 15 | 854 | 9 |
| HL-30-8 | 64 | 180 | 0.35 | 0.0718 | 0.0030 | 1.4104 | 0.0485 | 0.1423 | 0.0021 | 989 | 83 | 893 | 20 | 858 | 12 |
| HL-30-9 | 130 | 306 | 0.42 | 0.0678 | 0.0019 | 1.3358 | 0.0374 | 0.1415 | 0.0015 | 865 | 80 | 861 | 16 | 853 | 9 |
| HL-30-10 | 149 | 268 | 0.56 | 0.0698 | 0.0023 | 1.3805 | 0.0444 | 0.1419 | 0.0020 | 924 | 66 | 881 | 19 | 855 | 11 |
| HL-30-11 | 372 | 578 | 0.64 | 0.0696 | 0.0018 | 1.3699 | 0.0338 | 0.1415 | 0.0012 | 917 | 52 | 876 | 14 | 853 | 7 |
| HL-30-12 | 240 | 382 | 0.63 | 0.0694 | 0.0018 | 1.3730 | 0.0360 | 0.1418 | 0.0014 | 911 | 52 | 877 | 15 | 855 | 8 |
| HL-30-13 | 146 | 307 | 0.48 | 0.0658 | 0.0019 | 1.2929 | 0.0373 | 0.1417 | 0.0017 | 1200 | 61 | 843 | 17 | 854 | 9 |
| HL-30-14 | 172 | 361 | 0.48 | 0.0648 | 0.0020 | 1.2737 | 0.0384 | 0.1415 | 0.0015 | 769 | 65 | 834 | 17 | 853 | 8 |
| HL-30-15 | 193 | 337 | 0.57 | 0.0689 | 0.0021 | 1.4424 | 0.0470 | 0.1500 | 0.0018 | 895 | 64 | 907 | 20 | 901 | 10 |
| HL-30-16 | 248 | 396 | 0.63 | 0.0673 | 0.0020 | 1.3228 | 0.0372 | 0.1416 | 0.0014 | 856 | 61 | 856 | 16 | 854 | 8 |
| HL-30-17 | 84 | 217 | 0.39 | 0.0703 | 0.0024 | 1.3717 | 0.0449 | 0.1410 | 0.0015 | 1000 | 70 | 877 | 19 | 850 | 8 |
| HL-30-18 | 280 | 444 | 0.63 | 0.0704 | 0.0021 | 1.3728 | 0.0394 | 0.1412 | 0.0017 | 943 | 66 | 877 | 17 | 852 | 9 |

### Table S3 Zircon Hf isotopic data for the gabbro (HL-39) of the Xiaosongshan complex in northern Helan Mountains, North China.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Sample  spot | 176Hf/  177Hf | 1σ | 176Lu/  177Hf | 1σ | 176Yb/  177Hf | 1σ | εHf(t) | TDM1  (Ma) | TDM2  (Ma) |
| HL-39-01 | 0.282450 | 0.000010 | 0.000709 | 0.000002 | 0.034272 | 0.000238 | 6.69 | 1124 | 1241 |
| HL-39-02 | 0.282447 | 0.000009 | 0.000615 | 0.000000 | 0.030014 | 0.000239 | 6.61 | 1126 | 1246 |
| HL-39-03 | 0.282431 | 0.000009 | 0.000440 | 0.000007 | 0.020664 | 0.000224 | 6.17 | 1142 | 1270 |
| HL-39-04 | 0.282426 | 0.000011 | 0.000331 | 0.000004 | 0.015585 | 0.000125 | 6.03 | 1147 | 1278 |
| HL-39-05 | 0.282439 | 0.000009 | 0.000524 | 0.000002 | 0.026297 | 0.000296 | 6.38 | 1135 | 1258 |
| HL-39-06 | 0.282478 | 0.000010 | 0.000348 | 0.000006 | 0.017540 | 0.000433 | 7.87 | 1075 | 1176 |
| HL-39-07 | 0.282456 | 0.000011 | 0.000581 | 0.000001 | 0.030586 | 0.000154 | 6.96 | 1113 | 1227 |
| HL-39-08 | 0.282458 | 0.000010 | 0.000435 | 0.000003 | 0.019118 | 0.000270 | 7.11 | 1106 | 1218 |
| HL-39-09 | 0.282428 | 0.000010 | 0.000299 | 0.000002 | 0.015063 | 0.000206 | 6.12 | 1143 | 1273 |
| HL-39-10 | 0.282437 | 0.000010 | 0.000360 | 0.000001 | 0.016955 | 0.000087 | 6.42 | 1132 | 1257 |
| HL-39-11 | 0.282427 | 0.000011 | 0.000278 | 0.000004 | 0.012570 | 0.000168 | 6.10 | 1144 | 1274 |
| HL-39-12 | 0.282421 | 0.000009 | 0.000361 | 0.000005 | 0.016913 | 0.000369 | 5.83 | 1155 | 1289 |
| HL-39-13 | 0.282467 | 0.000011 | 0.000553 | 0.000002 | 0.026382 | 0.000133 | 7.38 | 1096 | 1203 |
| HL-39-14 | 0.282431 | 0.000010 | 0.000355 | 0.000001 | 0.016683 | 0.000147 | 6.19 | 1141 | 1269 |
| HL-39-15 | 0.282434 | 0.000009 | 0.000293 | 0.000002 | 0.013357 | 0.000060 | 6.36 | 1134 | 1260 |

### Table S4 Zircon Hf isotopic data for the granite (HL-30) of the Xiaosongshan complex in northern Helan Mountains, North China.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Sample  spot | 176Hf/  177Hf | 1σ | 176Lu/  177Hf | 1σ | 176Yb/  177Hf | 1σ | εHf(t) | TDM1  (Ma) | TDM2  (Ma) |
| HL-30-1 | 0.282303 | 0.000010 | 0.002243 | 0.000009 | 0.103088 | 0.000343 | 1.05 | 1385 | 1569 |
| HL-30-2 | 0.282265 | 0.000009 | 0.001500 | 0.000012 | 0.067673 | 0.000891 | 0.15 | 1410 | 1619 |
| HL-30-3 | 0.282279 | 0.000010 | 0.001657 | 0.000013 | 0.075228 | 0.000766 | 1.48 | 1397 | 1581 |
| HL-30-4 | 0.282306 | 0.000013 | 0.002719 | 0.000033 | 0.125627 | 0.002424 | 0.87 | 1399 | 1579 |
| HL-30-5 | 0.282322 | 0.000012 | 0.003023 | 0.000117 | 0.140644 | 0.005873 | 1.29 | 1387 | 1556 |
| HL-30-6 | 0.282299 | 0.000013 | 0.003991 | 0.000018 | 0.187297 | 0.001595 | -0.10 | 1461 | 1632 |
| HL-30-7 | 0.282285 | 0.000011 | 0.000806 | 0.000003 | 0.034849 | 0.000248 | 1.25 | 1357 | 1558 |
| HL-30-8 | 0.282255 | 0.000011 | 0.002003 | 0.000035 | 0.091257 | 0.001439 | -0.51 | 1445 | 1655 |
| HL-30-9 | 0.282302 | 0.000017 | 0.003632 | 0.000131 | 0.153352 | 0.003944 | 0.23 | 1441 | 1614 |
| HL-30-10 | 0.282299 | 0.000010 | 0.001111 | 0.000020 | 0.049758 | 0.000855 | 1.55 | 1349 | 1542 |
| HL-30-11 | 0.282304 | 0.000009 | 0.001470 | 0.000022 | 0.065717 | 0.001291 | 1.53 | 1355 | 1543 |
| HL-30-12 | 0.282306 | 0.000011 | 0.001749 | 0.000006 | 0.064401 | 0.000584 | 1.44 | 1362 | 1548 |
| HL-30-13 | 0.282295 | 0.000017 | 0.002666 | 0.000042 | 0.116807 | 0.001585 | 0.51 | 1413 | 1599 |
| HL-30-14 | 0.282366 | 0.000012 | 0.003719 | 0.000086 | 0.174859 | 0.005042 | 2.43 | 1348 | 1493 |