附表1 海德乌拉辉绿岩LA⁃ICP⁃MS锆石U⁃Pb同位素分析数据

Table 1 LA⁃ICP⁃MS zircon U⁃Pb dating analysis data of the Haidewula diabase

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Th | U | Th/U | 测试结果 |  |  |  |  |  | 年龄(Ma) |  |  |  |  |  |
|  | (ppm) | (ppm) |  | *207Pb/206Pb* | 1σ | *207Pb/235U* | 1σ | *206Pb/238U* | 1σ | *207Pb/206Pb* | 1σ | *207Pb/235U* | 1σ | *206Pb/238U* | 1σ |
| HD⁃1 | 112 | 86 | 1.30 | 0.0521 | 0.0024 | 0.2888 | 0.0132 | 0.0404 | 0.0006 | 291 | 79 | 258 | 10 | 255 | 3 |
| HD⁃2 | 1800 | 1115 | 1.62 | 0.0536 | 0.0015 | 0.3773 | 0.0103 | 0.0510 | 0.0006 | 355 | 42 | 325 | 8 | 321 | 3 |
| HD⁃3 | 231 | 200 | 1.16 | 0.0512 | 0.0031 | 0.2956 | 0.0169 | 0.0422 | 0.0006 | 252 | 106 | 263 | 13 | 266 | 4 |
| HD⁃4 | 1162 | 1005 | 1.16 | 0.0595 | 0.0019 | 0.3095 | 0.0155 | 0.0366 | 0.0006 | 587 | 78 | 274 | 12 | 232 | 4 |
| HD⁃5 | 1407 | 1041 | 1.35 | 0.0548 | 0.0023 | 0.2887 | 0.0108 | 0.0384 | 0.0005 | 404 | 59 | 258 | 9 | 243 | 3 |
| HD⁃6 | 1007 | 501 | 2.01 | 0.0536 | 0.0015 | 0.2928 | 0.0083 | 0.0396 | 0.0005 | 356 | 40 | 261 | 7 | 251 | 3 |
| HD⁃7 | 467 | 342 | 1.36 | 0.0518 | 0.0021 | 0.2864 | 0.0115 | 0.0402 | 0.0005 | 275 | 71 | 256 | 9 | 254 | 3 |
| HD⁃8 | 1168 | 794 | 1.47 | 0.0617 | 0.0028 | 0.3133 | 0.0151 | 0.0368 | 0.0006 | 663 | 74 | 277 | 12 | 233 | 4 |
| HD⁃9 | 133 | 142 | 0.94 | 0.0563 | 0.0023 | 0.3076 | 0.0149 | 0.0393 | 0.0007 | 465 | 75 | 272 | 12 | 248 | 4 |
| HD⁃10 | 159 | 155 | 1.03 | 0.0508 | 0.0011 | 0.2782 | 0.0063 | 0.0396 | 0.0004 | 231 | 33 | 249 | 5 | 250 | 2 |
| HD⁃11 | 192 | 187 | 1.03 | 0.0519 | 0.0017 | 0.2692 | 0.0095 | 0.0374 | 0.0004 | 281 | 61 | 242 | 8 | 237 | 2 |
| HD⁃12 | 180 | 183 | 0.98 | 0.0556 | 0.0015 | 0.2895 | 0.0096 | 0.0375 | 0.0004 | 436 | 55 | 258 | 8 | 237 | 2 |
| HD⁃13 | 395 | 292 | 1.35 | 0.0519 | 0.0019 | 0.2670 | 0.0109 | 0.0371 | 0.0006 | 283 | 66 | 240 | 9 | 235 | 3 |
| HD⁃14 | 147 | 146 | 1.00 | 0.0553 | 0.0013 | 0.3295 | 0.0085 | 0.0430 | 0.0004 | 300 | 87 | 273 | 9 | 270 | 2 |
| HD⁃15 | 159 | 153 | 1.04 | 0.0516 | 0.0022 | 0.2720 | 0.0117 | 0.0382 | 0.0005 | 269 | 74 | 244 | 9 | 242 | 3 |
| HD⁃16 | 1184 | 724 | 1.63 | 0.0486 | 0.0017 | 0.2754 | 0.0093 | 0.0413 | 0.0004 | 128 | 59 | 247 | 7 | 261 | 3 |
| HD⁃17 | 1187 | 791 | 1.50 | 0.0502 | 0.0007 | 0.2625 | 0.0040 | 0.0378 | 0.0003 | 206 | 22 | 237 | 3 | 239 | 2 |
| HD⁃18 | 81 | 144 | 0.57 | 0.0508 | 0.0007 | 0.2644 | 0.0041 | 0.0377 | 0.0004 | 230 | 19 | 238 | 3 | 238 | 2 |
| HD⁃19 | 220 | 166 | 1.32 | 0.0591 | 0.0021 | 0.3113 | 0.0110 | 0.0383 | 0.0006 | 571 | 49 | 275 | 9 | 242 | 4 |
| HD⁃20 | 69 | 85 | 0.82 | 0.0512 | 0.0010 | 0.2792 | 0.0054 | 0.0394 | 0.0003 | 251 | 29 | 250 | 4 | 249 | 2 |
| HD⁃21 | 67 | 83 | 0.81 | 0.0512 | 0.0014 | 0.2810 | 0.0081 | 0.0397 | 0.0005 | 252 | 45 | 251 | 6 | 251 | 3 |
| HD⁃22 | 39 | 48 | 0.82 | 0.0511 | 0.0014 | 0.2770 | 0.0082 | 0.0392 | 0.0005 | 246 | 45 | 248 | 7 | 248 | 3 |
| HD⁃23 | 121 | 119 | 1.02 | 0.0521 | 0.0011 | 0.2930 | 0.0060 | 0.0407 | 0.0004 | 292 | 31 | 261 | 5 | 257 | 2 |
| HD⁃24 | 240 | 203 | 1.18 | 0.0517 | 0.0044 | 0.2650 | 0.0209 | 0.0380 | 0.0008 | 273 | 140 | 239 | 17 | 240 | 5 |

附表2海德乌拉辉绿岩主量元素(%)和微量元素(ppm)分析结果

Table 2 Major (%) and trace element (ppm) contents of the Haidewula diabase.

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 样品 | HD20⁃51 | zk105⁃4 | zk105⁃3 | HD20⁃47 | HD⁃4 | zk105⁃1 | HD20⁃75 | SH⁃01 | SH⁃02 | SH⁃03 | SH⁃04 | SH⁃05 |
| SiO2 | 46.6 | 47.5 | 48.7 | 48.9 | 49.9 | 50.0 | 50.6 | 51.9 | 50.9 | 51.2 | 51.1 | 51.0 |
| TiO2 | 2.46 | 2.43 | 2.28 | 2.19 | 2.47 | 2.23 | 1.79 | 1.75 | 1.85 | 1.87 | 2.05 | 2.04 |
| Al2O3 | 16.8 | 16.0 | 15.1 | 14.7 | 16.9 | 15.0 | 14.9 | 15.3 | 14.7 | 14.7 | 15.9 | 15.8 |
| Fe2O3T | 11.2 | 12.3 | 12.2 | 10.6 | 9.78 | 11.0 | 8.88 | 10.1 | 11.0 | 11.1 | 9.72 | 9.75 |
| MnO | 0.16 | 0.13 | 0.15 | 0.18 | 0.09 | 0.15 | 0.16 | 0.12 | 0.15 | 0.15 | 0.13 | 0.13 |
| MgO | 5.06 | 4.74 | 5.11 | 3.46 | 5.23 | 5.34 | 5.31 | 4.73 | 6.30 | 6.34 | 2.77 | 2.76 |
| CaO | 5.27 | 4.69 | 3.96 | 6.52 | 2.73 | 4.20 | 5.38 | 4.34 | 3.93 | 3.96 | 4.47 | 4.47 |
| Na2O | 4.48 | 5.12 | 3.76 | 4.67 | 5.25 | 3.63 | 4.86 | 4.31 | 3.74 | 3.74 | 6.41 | 6.37 |
| K2O | 1.62 | 1.09 | 2.82 | 1.55 | 2.29 | 3.32 | 1.72 | 2.39 | 1.86 | 1.87 | 1.72 | 1.70 |
| P2O5 | 0.73 | 0.79 | 0.68 | 0.73 | 0.82 | 0.68 | 0.54 | 0.51 | 0.58 | 0.58 | 0.64 | 0.65 |
| LOI | 5.06 | 4.61 | 4.56 | 6.02 | 4.44 | 4.40 | 5.94 | 4.39 | 3.78 | 3.90 | 4.61 | 4.72 |
| 总量 | 99.37 | 99.34 | 99.30 | 99.49 | 99.84 | 99.95 | 100.14 | 99.81 | 98.80 | 99.47 | 99.48 | 99.36 |
| Na2O/K2O | 2.77 | 4.70 | 1.33 | 3.01 | 2.29 | 1.09 | 2.83 | 1.80 | 2.01 | 2.00 | 3.73 | 3.75 |
| K2O+Na2O | 6.10 | 6.21 | 6.58 | 6.22 | 7.54 | 6.95 | 6.58 | 6.70 | 5.60 | 5.61 | 8.13 | 8.07 |
| Mg# | 0.474 | 0.436 | 0.457 | 0.395 | 0.517 | 0.492 | 0.545 | 0.483 | 0.534 | 0.533 | 0.363 | 0.361 |
| FeOt/MgO | 2.00 | 2.33 | 2.14 | 2.75 | 1.68 | 1.86 | 1.51 | 1.93 | 1.57 | 1.57 | 3.16 | 3.18 |
| Sc | 27.1 | 27.9 | 25.3 | 24.9 | 24.6 | 26.0 | 23.1 | 21.8 | 23.8 | 23.0 | 24.1 | 24.1 |
| V | 189 | 161 | 149 | 174 | 128 | 148 | 149 | 147 | 145 | 145 | 141 | 147 |
| Cr | 100 | 118 | 114 | 110 | 118 | 116 | 200 | 180 | 170 | 180 | 200 | 200 |
| Co | 33.6 | 39.1 | 31.7 | 29.9 | 56.1 | 32.8 | 29.7 | 28.1 | 28.4 | 29.7 | 28.8 | 27.6 |
| Ni | 39.8 | 44.3 | 44.2 | 40.6 | 79.2 | 48.3 | 65.6 | 57.8 | 65.1 | 65.2 | 66.1 | 66.2 |
| Rb | 68.1 | 46.5 | 149 | 61.9 | 81.5 | 155 | 72.5 | 103 | 78.4 | 77.5 | 63.0 | 63.4 |
| Ba | 666 | 640 | 363 | 737 | 474 | 603 | 673 | 521 | 440 | 431 | 356 | 348 |
| Sr | 338 | 419 | 187 | 294 | 366 | 245 | 402 | 245 | 305 | 301 | 131 | 133 |
| Y | 51.2 | 55.6 | 49.3 | 53.9 | 58.0 | 49.7 | 46.1 | 44.4 | 46.8 | 47.0 | 54.0 | 53.4 |
| Hf | 8.10 | 8.30 | 7.10 | 7.30 | 8.40 | 7.60 | 7.20 | 7.10 | 6.90 | 6.90 | 8.00 | 7.80 |
| Zr | 348 | 376 | 335 | 320 | 383 | 333 | 312 | 311 | 311 | 309 | 354 | 351 |
| Ta | 1.09 | 0.98 | 0.87 | 0.94 | 0.99 | 0.86 | 1.00 | 0.91 | 0.91 | 0.91 | 0.98 | 0.99 |
| Nb | 19.0 | 19.2 | 16.8 | 17.2 | 19.7 | 16.6 | 16.5 | 15.8 | 15.8 | 15.5 | 16.9 | 17.3 |
| Pb | 13.5 | 16.4 | 9.5 | 14.9 | 59.5 | 12.9 | 14.3 | 10.2 | 11.9 | 11.9 | 76.0 | 74.4 |
| Th | 6.21 | 6.52 | 5.67 | 5.62 | 7.46 | 5.84 | 7.07 | 6.50 | 5.96 | 6.01 | 7.04 | 7.07 |
| U | 2.15 | 2.04 | 1.78 | 2.02 | 8.76 | 2.01 | 2.41 | 1.50 | 1.43 | 1.44 | 4.05 | 4.08 |
| La | 32.7 | 39.6 | 34.4 | 33.2 | 36.0 | 37.0 | 31.6 | 34.5 | 35.4 | 34.5 | 39.3 | 38.7 |
| Ce | 81.3 | 87.1 | 76.1 | 76.5 | 81.8 | 79.3 | 73.8 | 76.4 | 78.3 | 76.6 | 88.4 | 88.3 |
| Pr | 10.4 | 11.7 | 10.1 | 10.4 | 10.9 | 10.3 | 9.66 | 9.45 | 9.58 | 9.46 | 10.9 | 11.1 |
| Nd | 43.6 | 49.4 | 41.8 | 44.2 | 47.0 | 43.3 | 40.4 | 39.1 | 41.2 | 40.4 | 46.4 | 45.9 |
| Sm | 10.02 | 10.90 | 9.87 | 10.15 | 10.55 | 9.82 | 8.84 | 8.21 | 8.69 | 8.59 | 9.80 | 9.76 |
| Eu | 2.75 | 2.81 | 2.57 | 2.73 | 2.32 | 2.56 | 2.40 | 2.12 | 2.32 | 2.29 | 2.36 | 2.42 |
| Gd | 11.1 | 11.4 | 10.2 | 11.1 | 10.7 | 10.1 | 9.64 | 8.55 | 9.11 | 9.00 | 9.84 | 9.74 |
| Tb | 1.65 | 1.79 | 1.59 | 1.62 | 1.77 | 1.63 | 1.43 | 1.31 | 1.38 | 1.37 | 1.50 | 1.50 |
| Dy | 9.71 | 10.3 | 9.04 | 9.63 | 10.4 | 8.72 | 8.30 | 7.82 | 8.29 | 8.26 | 9.12 | 9.18 |
| Ho | 1.98 | 2.30 | 2.04 | 2.02 | 2.30 | 1.97 | 1.73 | 1.61 | 1.71 | 1.68 | 1.86 | 1.90 |
| Er | 5.43 | 5.81 | 5.09 | 5.39 | 6.09 | 5.22 | 4.69 | 4.59 | 4.86 | 4.42 | 5.07 | 5.12 |
| Tm | 0.79 | 0.87 | 0.72 | 0.76 | 0.92 | 0.81 | 0.67 | 0.67 | 0.68 | 0.68 | 0.77 | 0.72 |
| Yb | 4.86 | 5.29 | 4.84 | 4.84 | 5.82 | 4.90 | 4.29 | 4.18 | 4.33 | 4.28 | 4.79 | 4.81 |
| Lu | 0.71 | 0.82 | 0.63 | 0.73 | 0.88 | 0.67 | 0.65 | 0.63 | 0.66 | 0.67 | 0.74 | 0.75 |
| ΣREE | 217.00 | 240.09 | 208.99 | 213.27 | 227.45 | 216.30 | 198.10 | 199.14 | 206.51 | 202.20 | 230.85 | 229.90 |
| δEu | 0.8 | 0.77 | 0.78 | 0.79 | 0.67 | 0.79 | 0.79 | 0.77 | 0.8 | 0.8 | 0.73 | 0.76 |
| Sm/Yb | 2.06 | 2.06 | 2.04 | 2.1 | 1.81 | 2 | 2.06 | 1.96 | 2.01 | 2.01 | 2.05 | 2.03 |
| Zr/Hf | 43 | 45.3 | 47.2 | 43.8 | 45.6 | 43.8 | 43.3 | 43.8 | 45.1 | 44.8 | 44.3 | 45 |
| Nb/Ta | 17.4 | 19.6 | 19.3 | 18.3 | 19.9 | 19.3 | 16.5 | 17.4 | 17.4 | 17.03297 | 17.2 | 17.5 |
| Zr/Nb | 18.3 | 19.6 | 19.9 | 18.6 | 19.4 | 20.1 | 18.9 | 19.7 | 19.7 | 19.9 | 20.9 | 20.3 |
| Nb/La | 0.581 | 0.485 | 0.488 | 0.518 | 0.547 | 0.449 | 0.522 | 0.458 | 0.446 | 0.449 | 0.43 | 0.447 |
| Nb/Yb | 3.91 | 3.63 | 3.47 | 3.55 | 3.38 | 3.39 | 3.85 | 3.78 | 3.65 | 3.62 | 3.53 | 3.6 |
| Th/Yb | 1.28 | 1.23 | 1.17 | 1.16 | 1.28 | 1.19 | 1.65 | 1.56 | 1.38 | 1.4 | 1.47 | 1.47 |
| Nb/Th | 3.06 | 2.94 | 2.96 | 3.06 | 2.64 | 2.84 | 2.33 | 2.43 | 2.65 | 2.58 | 2.4 | 2.45 |
| Th/Zr | 0.0178 | 0.0173 | 0.0169 | 0.0176 | 0.0195 | 0.0175 | 0.0227 | 0.0209 | 0.0192 | 0.0194 | 0.0199 | 0.0201 |

附表3 海德乌拉辉绿岩Sr⁃Nd同位素组成

Table 3 Sr⁃Nd isotopic compositions of the Haidewula diabase

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 样品 | Sm (10-6) | Nd (10-6) | 147Sm/144Nd | 143Nd/144Nd (2σ) | εNd(*t*) | 2σ | TDMC (Ma) | Rb (10-6) | Sr (10-6) | 87Rb/86Sr | 87Sr/86Sr (2σ) | (87Sr/86Sr)i |
| SH⁃01 | 8.21 | 39.1 | 0.126 868 | 0.512 363 6(8) | ⁃3.2 | 0.2 | 127 6 | 103.0 | 245 | 1.210 584 | 0.717 087(10) | 0.712 954 |
| SH⁃02 | 8.69 | 41.2 | 0.127 440 | 0.512 377 2(8) | -3.0 | 0.2 | 125 6 | 78.4 | 305 | 0.743 795 | 0.714 213(10) | 0.711 674 |
| SH⁃03 | 8.59 | 40.4 | 0.128 468 | 0.512 373 6(10) | -3.1 | 0.2 | 126 4 | 77.5 | 301 | 0.745 027 | 0.714 158(14) | 0.711 614 |
| SH⁃04 | 9.80 | 46.4 | 0.127 612 | 0.512 387 3(8) | -2.8 | 0.2 | 124 0 | 63.0 | 131 | 1.391 574 | 0.716 538(8) | 0.711 788 |
| SH⁃05 | 9.76 | 45.9 | 0.128 476 | 0.512 378 9(10) | -3.0 | 0.2 | 125 6 | 63.4 | 133 | 1.384 556 | 0.716 596(10) | 0.711 869 |

注：表中εNd(t) = [(143Nd/144Nd)S(t)/(143Nd/144Nd)CHUR(t) – 1] × 10000; (143Nd/144Nd)CHUR(t) = (143Nd/144Nd)CHUR(0) – (147Sm/144Nd)CHUR(0) × (eλt – 1);

TDMC(Nd) = 1/λ × ln (1 + ((143Nd/144Nd)S – (143Nd/144Nd)DM – ((147Sm/144Nd)S – (147Sm/144Nd)C) ×(eλt – 1))/( (147Sm/144Nd)C – (147Sm/144Nd)DM)), 其中 (143Nd/144Nd)S 和 (147Sm/144Nd)S代表样品测量值, λ = 6.54×10–12(Lugmair and Marti, 1978), (143Nd/144Nd)CHUR = 0.512638 (Goldstein *et al*., 1984), (147Sm/144Nd)CHUR = 0.1967 (Jacobsen and Wasserburg, 1980), (143Nd/144Nd)DM = 0.513151, (147Sm/144Nd)DM = 0.2136 (Liew and Hofmann, 1988) and (147Sm/144Nd)C = 0.118 (Jahn and Condie, 1995).

(87Sr/88Sr)i、εNd(*t*)和TDMC校正到*t* = 238 Ma.

表4 图6a中模拟计算中所用参数

Table 4 Parameter data of the end⁃menbers used for mixing modelling in Figure 6a

|  |  |  |  |
| --- | --- | --- | --- |
|  | MORB | OIB | S型花岗岩 |
| Nd (ppm) | 8.93 | 39.0 | 30.4 |
| εNd(t)\* | 12.9 | 4.0 | -13.2 |
| Sr (ppm) | 192 | 582 | 187 |
| (87Sr/86Sr)i\* | 0.707729 | 0.703894 | 0.74205 |
| 参考文献 | 郭安林等(2007a) | 郭安林等(2007a)；马丽艳等(2007) | 余能等(2005)；巴金等(2012) |

\*同位素初始值均校正到*t*= 238 Ma.