

表 1 地苏嘎、普朗和休瓦促楣石 LA-ICP-MS 测试结果

Appendix table 1 The LA-ICP-MS results of titanites from Pulang, Disuga and Xiuwacu

| 样号     | Sc   | V    | Cr   | Cu   | Zn   | Rb    | Sr   | Y    | Zr   | Mo   | Ag    | In   | Sn  | La   | Pr   | Ce   | Nd   | Sm   | Eu   | Gd   | Tb   |
|--------|------|------|------|------|------|-------|------|------|------|------|-------|------|-----|------|------|------|------|------|------|------|------|
| DSG-01 | 14.1 | 1168 | 93.2 | 1.63 | 5.51 | 1.60  | 72.0 | 3490 | 724  | 65.8 | 0.15  | 1.24 | 294 | 2430 | 1260 | 7249 | 6010 | 1355 | 232  | 1037 | 148  |
| DSG-02 | 14.3 | 1138 | 118  | 1.39 | 4.12 | 0.29  | 28.9 | 1908 | 608  | 85.0 | 0.16  | 0.97 | 232 | 2099 | 790  | 4417 | 3224 | 607  | 105  | 465  | 63.7 |
| DSG-03 | 10.2 | 1049 | 63.3 | 1.67 | 4.82 | 4.23  | 213  | 1885 | 709  | 74.7 | 0.17  | 0.86 | 208 | 2113 | 870  | 4963 | 3718 | 735  | 135  | 537  | 70.6 |
| DSG-04 | 16.5 | 1172 | 77.4 | 4.57 | 3.87 | 0.40  | 78.5 | 3937 | 704  | 62.8 | 0.084 | 1.20 | 287 | 2307 | 1338 | 7699 | 6478 | 1598 | 269  | 1231 | 176  |
| DSG-05 | 14.8 | 1243 | 78.2 | 1.78 | 5.47 | 1.15  | 62.5 | 3449 | 640  | 55.4 | 0.089 | 1.03 | 256 | 2102 | 1150 | 6683 | 5551 | 1326 | 219  | 1020 | 146  |
| DSG-06 | 8.81 | 981  | 86.1 | 1.30 | 5.63 | 0.17  | 59.1 | 1133 | 552  | 80.7 | 0.039 | 0.39 | 113 | 1548 | 523  | 2969 | 2147 | 413  | 84.4 | 315  | 41.6 |
| DSG-07 | 8.14 | 983  | 84.0 | 1.45 | 3.54 | 0.21  | 63.3 | 1330 | 558  | 76.7 | 0.13  | 0.45 | 119 | 1662 | 596  | 3396 | 2497 | 499  | 104  | 379  | 51.2 |
| DSG-08 | 10.6 | 1040 | 97.5 | 1.49 | 4.41 | 0.70  | 77.2 | 1810 | 626  | 63.6 | 0.16  | 0.64 | 153 | 1863 | 777  | 4465 | 3368 | 688  | 135  | 517  | 70.9 |
| DSG-09 | 11.7 | 1111 | 50.1 | 1.70 | 4.55 | 0.24  | 73.2 | 2398 | 663  | 73.5 | 0.12  | 0.79 | 211 | 1886 | 903  | 5244 | 4127 | 929  | 165  | 705  | 98   |
| DSG-10 | 18.3 | 1184 | 84.3 | 93.8 | 4.35 | 0.57  | 72.3 | 4206 | 4703 | 59.2 | 0.82  | 1.16 | 273 | 2298 | 1372 | 7919 | 6678 | 1704 | 278  | 1303 | 187  |
| DSG-11 | 9.67 | 1035 | 90.2 | 1.35 | 3.99 | 0.20  | 55.2 | 1359 | 527  | 74.9 | 0.084 | 0.52 | 123 | 1723 | 613  | 3474 | 2534 | 497  | 99.6 | 376  | 50.4 |
| PL-01  | 7.84 | 986  | 86.0 | 1.50 | 4.22 | 0.025 | 60.0 | 875  | 598  | 72.3 | 0.14  | 0.38 | 108 | 1476 | 462  | 2592 | 1796 | 326  | 61.2 | 239  | 31.2 |
| PL-02  | 8.46 | 966  | 90.3 | 1.43 | 2.98 | 0.19  | 77.2 | 1657 | 662  | 83.8 | 0.11  | 0.61 | 163 | 2061 | 765  | 4409 | 3224 | 653  | 126  | 487  | 67.2 |
| PL-03  | 7.88 | 971  | 87.6 | 1.40 | 3.94 | 0.026 | 75.3 | 1196 | 703  | 81.7 | 0.24  | 0.49 | 125 | 1768 | 581  | 3287 | 2371 | 455  | 91.1 | 339  | 45.4 |
| PL-04  | 8.69 | 981  | 75.7 | 1.52 | 3.63 | 0.22  | 74.3 | 1226 | 656  | 75.1 | 0.11  | 0.53 | 206 | 1672 | 581  | 3277 | 2398 | 469  | 92.0 | 348  | 46.5 |
| PL-05  | 7.71 | 1015 | 87.2 | 1.36 | 4.03 | 0.085 | 58.7 | 976  | 590  | 78.8 | 0.12  | 0.42 | 108 | 1466 | 473  | 2670 | 1898 | 350  | 69.9 | 254  | 34.6 |
| PL-06  | 9.79 | 1021 | 74.8 | 1.45 | 3.74 | 0.24  | 72.2 | 1581 | 617  | 67.6 | 0.099 | 0.52 | 142 | 1747 | 701  | 3950 | 2999 | 613  | 116  | 445  | 62.1 |
| PL-07  | 8.39 | 1000 | 74.2 | 1.35 | 3.46 | 0.024 | 59.6 | 875  | 624  | 78.9 | 0.083 | 0.48 | 114 | 1440 | 444  | 2500 | 1719 | 307  | 58.6 | 224  | 30.5 |
| PL-08  | 7.14 | 989  | 76.3 | 1.58 | 3.35 | 0.016 | 75.3 | 969  | 642  | 82.0 | 0.092 | 0.43 | 111 | 1619 | 507  | 2869 | 2009 | 372  | 72.2 | 269  | 35.8 |
| PL-09  | 9.01 | 1016 | 66.4 | 1.79 | 4.04 | 0.21  | 70.6 | 1896 | 669  | 73.4 | 0.12  | 0.82 | 188 | 1981 | 812  | 4617 | 3558 | 743  | 134  | 553  | 76.9 |
| PL-10  | 11.3 | 1139 | 60.8 | 1.44 | 6.46 | 0.25  | 69.0 | 2789 | 629  | 73.4 | 0.08  | 0.92 | 241 | 2229 | 1114 | 6313 | 5075 | 1126 | 192  | 818  | 116  |
| PL-11  | 6.90 | 976  | 83.9 | 1.43 | 4.07 | 0.081 | 76.0 | 881  | 659  | 89.3 | 0.12  | 0.44 | 113 | 1701 | 493  | 2779 | 1894 | 328  | 65.3 | 245  | 32.5 |
| PL-12  | 10.7 | 1047 | 72.9 | 1.82 | 5.79 | 0.21  | 77.9 | 2138 | 719  | 64.3 | 0.11  | 0.76 | 200 | 2087 | 889  | 5084 | 3946 | 816  | 153  | 614  | 84.3 |

|        |      |     |      |      |      |      |      |       |     |      |       |      |      |      |     |      |      |      |      |      |      |
|--------|------|-----|------|------|------|------|------|-------|-----|------|-------|------|------|------|-----|------|------|------|------|------|------|
| PL-13  | 7.81 | 993 | 69.2 | 1.46 | 5.56 | 0.16 | 65.2 | 1069  | 607 | 78.1 | 0.095 | 0.36 | 109  | 1457 | 497 | 2795 | 2039 | 385  | 78.0 | 287  | 38.7 |
| XWC-01 | 144  | 545 | 143  | 1.09 | 4.91 | 1.21 | 7.97 | 15200 | 513 | 35.4 | 0.16  | 7.41 | 1836 | 518  | 696 | 4453 | 4507 | 2011 | 45.1 | 2162 | 405  |
| XWC-02 | 87.5 | 419 | 31.7 | 1.19 | 4.34 | 0.85 | 6.75 | 12033 | 500 | 49.1 | 0.11  | 6.07 | 1471 | 610  | 679 | 3951 | 3733 | 1364 | 37.0 | 1362 | 259  |
| XWC-03 | 120  | 295 | 41.5 | 1.15 | 4.3  | 0.76 | 7.06 | 10525 | 226 | 27.9 | 0.098 | 6.37 | 1631 | 354  | 631 | 3667 | 3622 | 1337 | 35.1 | 1336 | 247  |

续表 2

| 样号     | Sc   | V   | Cr   | Cu   | Zn   | Rb   | Sr   | Y     | Zr  | Mo   | Ag    | In   | Sn   | La  | Pr  | Ce   | Nd   | Sm   | Eu   | Gd   | Tb  |
|--------|------|-----|------|------|------|------|------|-------|-----|------|-------|------|------|-----|-----|------|------|------|------|------|-----|
| XWC-04 | 111  | 291 | 22.3 | 1.21 | 4.74 | 0.93 | 6.96 | 12309 | 370 | 16.7 | 0.12  | 7.90 | 1951 | 453 | 732 | 4340 | 4273 | 1606 | 39.5 | 1606 | 295 |
| XWC-05 | 79.6 | 363 | 37.6 | 1.02 | 5.24 | 1.13 | 7.91 | 12174 | 467 | 42.4 | 0.086 | 4.73 | 1198 | 660 | 736 | 4373 | 4194 | 1589 | 37.0 | 1588 | 297 |
| XWC-06 | 122  | 359 | 44.9 | 1.06 | 6.81 | 15.8 | 8.26 | 14914 | 491 | 41.7 | 0.14  | 9.59 | 2348 | 635 | 828 | 5076 | 5049 | 2100 | 46.2 | 2124 | 394 |
| XWC-07 | 150  | 420 | 102  | 1.19 | 4.66 | 1.18 | 6.26 | 13534 | 456 | 53.2 | 0.089 | 8.05 | 1993 | 520 | 673 | 4070 | 4074 | 1686 | 35.1 | 1776 | 328 |
| XWC-08 | 158  | 334 | 64.1 | 1.08 | 3.38 | 0.68 | 6.27 | 10458 | 243 | 17.7 | 0.09  | 6.48 | 1577 | 379 | 466 | 2837 | 2833 | 1211 | 42.1 | 1277 | 240 |
| XWC-09 | 101  | 426 | 56.2 | 0.97 | 4.81 | 0.91 | 9.29 | 12220 | 579 | 45.0 | 6.40  | 6.29 | 1591 | 605 | 676 | 4160 | 4040 | 1695 | 47.9 | 1781 | 337 |
| XWC-10 | 116  | 313 | 42.8 | 1.06 | 4.28 | 0.74 | 6.41 | 10434 | 255 | 17.4 | 0.092 | 6.66 | 1657 | 318 | 462 | 2846 | 2866 | 1247 | 48.8 | 1301 | 244 |
| XWC-11 | 107  | 442 | 116  | 1.24 | 4.90 | 12.3 | 7.59 | 13050 | 501 | 48.8 | 0.14  | 5.65 | 1350 | 586 | 681 | 4159 | 4058 | 1714 | 40.2 | 1835 | 347 |
| XWC-12 | 87.1 | 400 | 83.4 | 1.26 | 5.00 | 0.97 | 6.59 | 11591 | 445 | 48.5 | 0.12  | 4.84 | 1183 | 584 | 676 | 3961 | 3786 | 1457 | 34.8 | 1443 | 274 |
| XWC-13 | 183  | 545 | 157  | 1.21 | 3.79 | 1.05 | 7.28 | 9990  | 293 | 22.7 | 0.085 | 5.95 | 1472 | 389 | 398 | 2347 | 2218 | 937  | 40.2 | 1087 | 215 |

| 样号     | Dy  | Ho   | Er  | Tm   | Yb  | Lu   | Hf   | Nb   | Ta   | W    | Au    | Pb   | Th  | U    | Th/U | ΣREE  | LREE  | HREE | LREE/<br>HREE | δEu  | δCe  |
|--------|-----|------|-----|------|-----|------|------|------|------|------|-------|------|-----|------|------|-------|-------|------|---------------|------|------|
| DSG-01 | 793 | 143  | 355 | 48.4 | 293 | 33.4 | 61.5 | 1985 | 363  | 8.21 | 0.38  | 2.32 | 666 | 82.8 | 0.16 | 21388 | 18536 | 2851 | 6.50          | 0.60 | 1.00 |
| DSG-02 | 350 | 67.4 | 183 | 28.0 | 193 | 24.8 | 54.8 | 1350 | 156  | 8.15 | 0.18  | 26.5 | 630 | 79.1 | 0.01 | 12618 | 11243 | 1375 | 8.18          | 0.58 | 0.84 |
| DSG-03 | 376 | 69.9 | 183 | 25.9 | 173 | 22.1 | 51.0 | 1774 | 250  | 8.87 | 0.28  | 3.68 | 784 | 90.5 | 0.08 | 13991 | 12534 | 1457 | 8.60          | 0.63 | 0.90 |
| DSG-04 | 945 | 167  | 408 | 53.2 | 315 | 35.7 | 53.5 | 1737 | 286  | 6.92 | 0.19  | 2.54 | 571 | 74.2 | 0.07 | 23020 | 19689 | 3330 | 5.91          | 0.56 | 1.06 |
| DSG-05 | 797 | 141  | 348 | 48.2 | 289 | 32.9 | 48.7 | 1350 | 210  | 8.10 | 0.26  | 3.63 | 557 | 74.9 | 0.07 | 19854 | 17031 | 2823 | 6.03          | 0.56 | 1.04 |
| DSG-06 | 220 | 42   | 107 | 15.5 | 108 | 14.7 | 37.4 | 1092 | 90   | 8.93 | 0.045 | 1.64 | 555 | 93.0 | 0.03 | 8549  | 7686  | 864  | 8.90          | 0.69 | 0.81 |
| DSG-07 | 273 | 49.9 | 128 | 18.2 | 122 | 16.0 | 36.6 | 1138 | 97.3 | 8.66 | 0.21  | 1.69 | 552 | 90.1 | 0.12 | 9791  | 8754  | 1036 | 8.45          | 0.70 | 0.84 |
| DSG-08 | 381 | 69.9 | 178 | 24.9 | 160 | 19.7 | 41.9 | 1130 | 119  | 6.76 | 0.084 | 1.95 | 520 | 76.6 | 0.04 | 12716 | 11295 | 1421 | 7.95          | 0.66 | 0.91 |

|        |      |      |      |      |     |      |      |      |      |      |       |      |     |      |      |       |       |      |      |      |      |
|--------|------|------|------|------|-----|------|------|------|------|------|-------|------|-----|------|------|-------|-------|------|------|------|------|
| DSG-09 | 528  | 94.8 | 239  | 33.4 | 214 | 26.0 | 45.0 | 1507 | 180  | 8.39 | 0.30  | 18.2 | 533 | 80.5 | 0.02 | 15192 | 13253 | 1939 | 6.83 | 0.60 | 0.98 |
| DSG-10 | 1010 | 176  | 425  | 55.5 | 328 | 36.9 | 152  | 1457 | 225  | 6.59 | 0.27  | 3.33 | 563 | 79.5 | 0.08 | 23771 | 20249 | 3522 | 5.75 | 0.55 | 1.07 |
| DSG-11 | 273  | 50.7 | 131  | 18.4 | 122 | 15.6 | 36.1 | 1160 | 99   | 8.68 | 0.13  | 2.91 | 521 | 90.2 | 0.04 | 9977  | 8941  | 1036 | 8.63 | 0.68 | 0.83 |
| PL-01  | 170  | 31.2 | 83.8 | 12.6 | 87  | 12.2 | 38.4 | 1011 | 97.9 | 7.50 | 0.093 | 1.56 | 508 | 85.8 | 0.06 | 7380  | 6713  | 667  | 10.1 | 0.64 | 0.76 |
| PL-02  | 355  | 64.2 | 160  | 22.0 | 143 | 18.0 | 47.6 | 1722 | 197  | 9.35 | 0.23  | 1.53 | 707 | 91.0 | 0.15 | 12554 | 11238 | 1316 | 8.54 | 0.65 | 0.86 |
| PL-03  | 243  | 44.5 | 116  | 16.5 | 111 | 15.2 | 48.2 | 1460 | 154  | 10.2 | 0.11  | 2.24 | 714 | 101  | 0.05 | 9484  | 8554  | 931  | 9.19 | 0.68 | 0.79 |
| PL-04  | 254  | 45.9 | 117  | 16.8 | 114 | 15.0 | 43.3 | 1215 | 120  | 9.91 | 0.098 | 1.06 | 597 | 88.1 | 0.09 | 9446  | 8489  | 957  | 8.87 | 0.67 | 0.81 |
| PL-05  | 189  | 34.7 | 92.6 | 13.8 | 98  | 13.7 | 39.4 | 1051 | 92.5 | 9.52 | 0.10  | 1.32 | 545 | 89.5 | 0.08 | 7659  | 6928  | 731  | 9.48 | 0.68 | 0.78 |

续表 2

| 样号     | Dy   | Ho   | Er   | Tm   | Yb   | Lu   | Hf   | Nb    | Ta   | W    | Au    | Pb   | Th   | U    | Th/U | ΣREE  | LREE  | HREE | LREE/<br>HREE | δEu  | δCe  |
|--------|------|------|------|------|------|------|------|-------|------|------|-------|------|------|------|------|-------|-------|------|---------------|------|------|
| PL-06  | 331  | 60.6 | 154  | 21.5 | 140  | 17.4 | 41.1 | 1215  | 128  | 7.03 | 0.11  | 2.09 | 533  | 81.0 | 0.05 | 11357 | 10125 | 1232 | 8.22          | 0.65 | 0.88 |
| PL-07  | 165  | 30.5 | 81.2 | 12.3 | 90.4 | 13.3 | 42.4 | 1087  | 105  | 9.74 | 0.12  | 4.94 | 568  | 86.9 | 0.02 | 7114  | 6468  | 647  | 10.0          | 0.65 | 0.76 |
| PL-08  | 189  | 35.0 | 91.7 | 13.0 | 92.3 | 12.8 | 41.5 | 1186  | 111  | 9.43 | 0.097 | 1.62 | 601  | 90.7 | 0.06 | 8187  | 7449  | 739  | 10.1          | 0.67 | 0.77 |
| PL-09  | 414  | 73.8 | 188  | 25.9 | 163  | 20.1 | 47.9 | 1599  | 222  | 8.46 | 0.18  | 13.3 | 682  | 87.6 | 0.01 | 13362 | 11846 | 1516 | 7.82          | 0.61 | 0.89 |
| PL-10  | 621  | 112  | 278  | 38.3 | 234  | 27.5 | 45.3 | 1692  | 216  | 6.98 | 0.18  | 2.33 | 561  | 77.6 | 0.08 | 18294 | 16049 | 2244 | 7.15          | 0.58 | 0.98 |
| PL-11  | 174  | 31.9 | 82.7 | 12.3 | 87.6 | 12.5 | 44.2 | 1273  | 120  | 10.8 | 0.097 | 1.96 | 712  | 99.9 | 0.05 | 7939  | 7260  | 679  | 10.7          | 0.67 | 0.73 |
| PL-12  | 460  | 82.5 | 211  | 29.3 | 189  | 23.1 | 52.0 | 1509  | 221  | 7.57 | 0.27  | 2.15 | 639  | 83.8 | 0.13 | 14667 | 12974 | 1693 | 7.66          | 0.63 | 0.91 |
| PL-13  | 208  | 38.7 | 101  | 15.0 | 104  | 13.9 | 38.9 | 1088  | 99.2 | 9.17 | 0.11  | 2.03 | 534  | 85.7 | 0.05 | 8059  | 7252  | 807  | 8.99          | 0.69 | 0.80 |
| XWC-01 | 2614 | 526  | 1513 | 238  | 1655 | 197  | 61.7 | 12174 | 3339 | 24.6 | 3.02  | 1.94 | 204  | 155  | 1.56 | 21541 | 12230 | 9310 | 1.31          | 0.07 | 1.53 |
| XWC-02 | 1743 | 375  | 1183 | 205  | 1547 | 198  | 64.4 | 12759 | 4456 | 28.5 | 4.28  | 3.12 | 151  | 178  | 1.37 | 17246 | 10374 | 6872 | 1.51          | 0.08 | 1.33 |
| XWC-03 | 1612 | 326  | 989  | 173  | 1364 | 194  | 34.9 | 10026 | 3440 | 15.0 | 2.92  | 2.41 | 96.8 | 78.8 | 1.21 | 15887 | 9647  | 6241 | 1.55          | 0.08 | 1.47 |
| XWC-04 | 1896 | 388  | 1157 | 199  | 1522 | 218  | 35.6 | 17173 | 4901 | 23.5 | 4.31  | 2.22 | 155  | 123  | 1.94 | 18724 | 11443 | 7281 | 1.57          | 0.07 | 1.48 |
| XWC-05 | 1933 | 400  | 1189 | 196  | 1411 | 172  | 54.5 | 12238 | 4617 | 29.7 | 3.86  | 2.18 | 160  | 163  | 1.77 | 18776 | 11590 | 7185 | 1.61          | 0.07 | 1.36 |
| XWC-06 | 2518 | 496  | 1419 | 230  | 1622 | 195  | 62.0 | 11362 | 5322 | 23.5 | 4.52  | 2.91 | 180  | 142  | 1.55 | 22732 | 13734 | 8997 | 1.53          | 0.07 | 1.46 |
| XWC-07 | 2117 | 432  | 1274 | 217  | 1626 | 214  | 66.3 | 12439 | 5002 | 24.5 | 4.02  | 2.51 | 142  | 143  | 1.60 | 19042 | 11058 | 7984 | 1.38          | 0.06 | 1.43 |

|        |      |     |      |     |      |     |      |       |      |      |      |      |      |      |      |       |       |      |      |      |      |
|--------|------|-----|------|-----|------|-----|------|-------|------|------|------|------|------|------|------|-------|-------|------|------|------|------|
| XWC-08 | 1572 | 322 | 975  | 171 | 1342 | 192 | 37.3 | 12640 | 3584 | 16.8 | 2.84 | 2.15 | 79.8 | 90.0 | 1.32 | 13859 | 7768  | 6090 | 1.28 | 0.10 | 1.43 |
| XWC-09 | 2207 | 441 | 1256 | 197 | 1342 | 160 | 65.8 | 12871 | 3794 | 22.3 | 3.34 | 1.57 | 199  | 158  | 2.13 | 18944 | 11224 | 7721 | 1.45 | 0.08 | 1.41 |
| XWC-10 | 1570 | 325 | 985  | 172 | 1320 | 187 | 35.4 | 12294 | 2963 | 15.4 | 2.63 | 1.68 | 76.9 | 99.4 | 1.57 | 13891 | 7788  | 6103 | 1.28 | 0.12 | 1.50 |
| XWC-11 | 2246 | 459 | 1320 | 207 | 1403 | 167 | 48.4 | 10925 | 2740 | 27.9 | 2.43 | 2.05 | 176  | 161  | 1.19 | 19222 | 11238 | 7984 | 1.41 | 0.07 | 1.41 |
| XWC-12 | 1804 | 375 | 1141 | 192 | 1375 | 170 | 49.0 | 11338 | 3747 | 27.9 | 3.58 | 7.22 | 139  | 171  | 0.50 | 17272 | 10498 | 6774 | 1.55 | 0.07 | 1.35 |
| XWC-13 | 1489 | 335 | 1070 | 191 | 1497 | 224 | 32.3 | 12683 | 1711 | 22.2 | 1.43 | 5.69 | 109  | 117  | 0.25 | 12438 | 6329  | 6109 | 1.04 | 0.12 | 1.31 |

注:  $\delta\text{Eu}=\text{Eu}_N/(\text{Sm}_N\times\text{Gd}_N)^{1/2}$ ,  $\delta\text{Ce}=\text{Ce}_N/(\text{La}_N\times\text{Pr}_N)^{1/2}$ .