表1刁泉矽卡岩矿化和蚀变的矿物生成顺序表

Table 1 Paragenetic sequence of ore and skarn minerals in the Diaoquan deposit

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| **表2 榍石电子探针数据分析结果（wt%）****Table 2 Electron microprobe analyses(wt%)of titanite** |
| 点号 | 类型 | F | SiO2 | TiO2 | CaO | MnO | Al2O3 | Fe2O3 | MgO | SnO2 | V2O3 | Na2O | K2O | Cr2O3 | Total |
| 热液榍石 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 18DQ-9-01 | Ty1a | 0.80  | 30.33  | 35.61  | 28.11  | 0.01  | 1.92  | 1.00  | 0.10  | 0.70  | 0.42  | 0.01  | - | 0.09  | 99.10  |
| 18DQ-9-02 | Ty1a | 0.70  | 29.77  | 35.04  | 28.12  | 0.01  | 2.11  | 1.04  | 0.13  | 0.57  | 0.47  | 0.01  | - | 0.17  | 98.14  |
| 18DQ-9-03 | Ty1a | 0.80  | 29.97  | 34.79  | 28.31  | 0.01  | 2.11  | 1.16  | 0.14  | 0.78  | 0.48  | 0.03  | - | 0.12  | 98.69  |
| 18DQ-9-04 | Ty1a | 0.74  | 29.84  | 34.73  | 27.97  | 0.01  | 1.67  | 0.99  | 0.10  | 1.24  | 0.40  | - | - | 0.07  | 97.77  |
| 18DQ-9-05 | Ty1a | 1.25  | 30.16  | 33.62  | 27.79  | 0.03  | 3.17  | 1.47  | 0.06  | 1.35  | 0.32  | 0.00  | - | 0.13  | 99.34  |
| 18DQ-9-06 | Ty1a | 1.02  | 30.17  | 33.27  | 28.29  | 0.04  | 2.61  | 1.03  | 0.10  | 1.01  | 0.45  | 0.01  | - | 0.09  | 98.08  |
| 18DQ-9-07 | Ty1a | 1.02  | 30.38  | 33.38  | 28.40  | 0.03  | 2.71  | 0.96  | 0.14  | 0.63  | 0.44  | - | - | 0.15  | 98.23  |
| 18DQ-9-08 | Ty1a | 0.69  | 29.94  | 35.19  | 27.98  | 0.00  | 1.70  | 1.03  | 0.11  | 0.84  | 0.35  | 0.01  | - | 0.10  | 97.92  |
| 18DQ-9-09 | Ty1a | 0.92  | 29.98  | 35.12  | 28.26  | 0.01  | 2.23  | 1.15  | 0.21  | 0.58  | 0.48  | 0.01  | - | 0.27  | 99.19  |
| 18DQ-9-10 | Ty1b | 0.89  | 28.91  | 31.32  | 27.49  | 0.04  | 2.07  | 1.27  | 0.14  | 4.25  | 0.33  | - | - | 0.10  | 96.84  |
| 18DQ-9-11 | Ty1b | 0.92  | 29.14  | 32.25  | 27.68  | 0.03  | 2.50  | 1.27  | 0.16  | 3.26  | 0.37  | - | - | 0.13  | 97.70  |
| 18DQ-9-12 | Ty1b | 0.80  | 29.57  | 31.35  | 27.55  | 0.06  | 1.99  | 1.63  | 0.12  | 4.08  | 0.29  | 0.02  | - | 0.17  | 97.61  |
| 18DQ-9-13 | Ty1b | 0.64  | 29.41  | 30.12  | 27.15  | 0.00  | 1.57  | 1.52  | 0.11  | 7.25  | 0.34  | - | - | 0.09  | 98.20  |
| 18DQ-9-14 | Ty1b | 1.63  | 30.05  | 30.98  | 27.80  | 0.04  | 4.27  | 1.28  | 0.18  | 1.30  | 0.34  | - | - | 0.15  | 98.02  |
| 18DQ-9-15 | Ty1b | 1.07  | 30.32  | 32.52  | 27.96  | 0.05  | 3.16  | 1.25  | 0.12  | 1.86  | 0.34  | 0.01  | - | 0.12  | 98.76  |
| 18DQ-9-16 | Ty1b | 0.88  | 28.98  | 30.80  | 27.28  | - | 1.99  | 1.43  | 0.09  | 5.67  | 0.37  | - | - | 0.19  | 97.67  |
| 18DQ-9-17 | Ty1b | 0.87  | 28.69  | 29.49  | 26.95  | 0.06  | 2.01  | 1.23  | 0.11  | 7.92  | 0.37  | - | - | 0.16  | 97.83  |
| 18DQ-9-18 | Ty1b | 1.23  | 30.01  | 31.94  | 27.91  | 0.05  | 3.08  | 1.17  | 0.16  | 2.26  | 0.34  | 0.00  | - | 0.15  | 98.29  |
| 18DQ-9-19 | Ty1b | 0.74  | 29.53  | 35.76  | 28.13  | - | 1.33  | 1.07  | 0.11  | 2.01  | 0.22  | 0.02  | - | 0.05  | 98.95  |
| 18DQ-9-20 | Ty1b | 1.55  | 29.38  | 28.52  | 27.20  | 0.04  | 4.23  | 1.32  | 0.14  | 3.80  | 0.31  | 0.01  | - | 0.20  | 96.72  |
| 18DQ-9-21 | Ty2a | 1.04  | 29.62  | 31.26  | 27.33  | 0.05  | 2.12  | 1.84  | 0.08  | 3.39  | 0.36  | 0.02  | - | 0.19  | 97.30  |
| 18DQ-9-22 | Ty2a | 1.10  | 29.41  | 31.29  | 27.37  | 0.03  | 2.20  | 1.97  | 0.10  | 3.83  | 0.32  | 0.01  | - | 0.22  | 97.86  |
| 18DQ-9-23 | Ty2a | 1.06  | 29.51  | 30.31  | 27.16  | 0.01  | 2.40  | 1.79  | 0.08  | 5.23  | 0.28  | 0.03  | - | 0.11  | 97.96  |
| 18DQ-9-24 | Ty2a | 1.22  | 29.43  | 31.08  | 27.32  | 0.06  | 2.35  | 1.82  | 0.10  | 4.18  | 0.33  | - | - | 0.10  | 97.99  |
| 18DQ-9-25 | Ty2a | 1.08  | 29.87  | 32.22  | 27.60  | 0.05  | 2.88  | 1.35  | 0.07  | 2.56  | 0.24  | - | - | 0.11  | 98.03  |
| 18DQ-9-26 | Ty2a | 1.00  | 29.91  | 32.90  | 27.48  | 0.04  | 2.33  | 1.36  | 0.05  | 2.54  | 0.31  | 0.02  | - | 0.15  | 98.07  |
| 18DQ-9-27 | Ty2a | 0.96  | 29.42  | 32.64  | 27.22  | 0.02  | 2.15  | 1.34  | 0.07  | 2.97  | 0.32  | - | - | 0.15  | 97.23  |
| 18DQ-9-28 | Ty2a | 1.35  | 30.37  | 32.41  | 27.89  | 0.02  | 3.36  | 1.28  | 0.07  | 2.10  | 0.27  | - | - | 0.18  | 99.28  |
| 18DQ-9-29 | Ty2a | 0.81  | 29.92  | 32.12  | 27.56  | 0.03  | 2.23  | 1.39  | 0.08  | 3.36  | 0.35  | 0.00  | - | 0.10  | 97.96  |
| 18DQ-9-30 | Ty2a | 1.00  | 29.47  | 30.71  | 27.41  | 0.06  | 2.27  | 2.07  | 0.10  | 4.52  | 0.29  | 0.02  | - | 0.15  | 98.07  |
| 18DQ-9-31 | Ty2b | 2.15  | 30.35  | 30.57  | 28.20  | 0.10  | 5.76  | 1.20  | 0.18  | 0.28  | 0.33  | - | - | 0.21  | 99.34  |
| 18DQ-9-32 | Ty2b | 2.13  | 30.50  | 30.52  | 28.21  | 0.06  | 5.87  | 1.21  | 0.22  | 0.26  | 0.39  | - | - | 0.29  | 99.65  |
| 18DQ-9-33 | Ty2b | 2.00  | 30.56  | 30.43  | 28.10  | 0.05  | 5.09  | 1.50  | 0.30  | 0.60  | 0.32  | 0.00  | - | 0.21  | 99.15  |
| 18DQ-9-34 | Ty2b | 1.76  | 30.28  | 30.81  | 27.99  | 0.12  | 5.07  | 1.06  | 0.06  | 1.31  | 0.23  | - | - | 0.06  | 98.76  |
| 18DQ-9-35 | Ty2b | 2.05  | 30.40  | 29.92  | 28.27  | 0.09  | 5.63  | 1.19  | 0.17  | 0.26  | 0.36  | - | - | 0.36  | 98.70  |
| 18DQ-9-36 | Ty2b | 2.07  | 30.38  | 30.50  | 28.31  | 0.13  | 5.71  | 1.14  | 0.18  | 0.27  | 0.39  | 0.05  | - | 0.35  | 99.47  |
| 18DQ-9-37 | Ty2b | 2.09  | 30.11  | 29.63  | 28.47  | 0.16  | 6.55  | 0.99  | 0.17  | 0.23  | 0.29  | 0.01  | - | 0.34  | 99.05  |
| 18DQ-9-38 | Ty2b | 2.05  | 30.31  | 30.05  | 28.18  | - | 5.31  | 1.54  | 0.24  | 0.51  | 0.33  | 0.01  | - | 0.33  | 98.86  |
| 18DQ-9-39 | Ty2b | 0.49  | 29.51  | 34.04  | 27.86  | 0.05  | 1.93  | 1.11  | 0.00  | 2.89  | 0.31  | 0.01  | - | 0.13  | 98.30  |
| 18DQ-9-40 | Ty2b | 0.42  | 29.50  | 33.85  | 27.91  | 0.04  | 1.93  | 1.10  | 0.02  | 2.73  | 0.36  | 0.02  | - | 0.14  | 98.02  |
| 岩浆榍石 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 18DQ-3-001 |  | 0.65  | 30.16  | 35.54  | 27.99  | 0.02  | 1.83  | 1.41  | - | 0.00  | 0.41  | 0.01  | 0.01  | 0.02  | 98.04  |
| 18DQ-3-002 |  | 0.52  | 30.05  | 37.25  | 27.93  | 0.03  | 1.46  | 1.27  | 0.00  | 0.00  | 0.36  | - | - | - | 98.87  |
| 18DQ-3-003 |  | 0.58  | 29.86  | 36.36  | 27.75  | 0.03  | 1.75  | 1.51  | 0.15  | 0.00  | 0.40  | 0.03  | 0.01  | 0.04  | 98.45  |
| 18DQ-3-004 |  | 0.68  | 29.89  | 35.00  | 28.00  | 0.03  | 2.21  | 1.74  | - | 0.00  | 0.40  | 0.00  | - | - | 97.94  |
| 18DQ-3-005 |  | 0.49  | 30.09  | 36.97  | 27.94  | 0.02  | 1.55  | 1.21  | 0.02  | 0.00  | 0.43  | 0.03  | 0.01  | - | 98.74  |
| 18DQ-3-006 |  | 0.40  | 29.74  | 36.93  | 27.46  | 0.00  | 1.35  | 1.17  | - | 0.00  | 0.43  | 0.02  | - | 0.01  | 97.52  |
| 18DQ-3-007 |  | 0.68  | 29.94  | 35.43  | 27.63  | - | 1.70  | 1.46  | 0.00  | 0.00  | 0.35  | 0.02  | - | 0.02  | 97.21  |
| 18DQ-3-008 |  | 0.51  | 29.92  | 35.95  | 27.75  | - | 1.62  | 1.37  | 0.01  | 0.00  | 0.38  | - | 0.00  | 0.00  | 97.51  |
| 18DQ-3-009 |  | 0.51  | 29.77  | 36.53  | 27.93  | - | 1.46  | 1.30  | 0.02  | 0.00  | 0.35  | - | - | - | 97.87  |
| 18DQ-3-010 |  | 0.43  | 29.79  | 36.17  | 27.84  | 0.02  | 1.51  | 1.37  | 0.01  | 0.00  | 0.42  | 0.01  | 0.00  | 0.02  | 97.60  |

备注：“-”低于检测限；“Ty1a”代表榍石Type1核部；“Ty1b”代表榍石Type1边部；“Ty2a”代表榍石Type2核部；“Ty2b”代表榍石Type2边部

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| **表3 榍石LA-ICPMS微量元素分析结果（ppm）****Table 3 Trace element analysis results (ppm) of the titanite by LA-ICPMS** |
| 点号 | 类型 | Y | Nb | La | Ce | Pr | Nd | Sm | Eu | Gd | Tb | Dy | Ho | Er | Tm | Yb | Lu | Hf | Ta | Th | U | Th/U | Lu/Hf | Eu\* | Ce\* |
| 矽卡岩中榍石 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 18DQ-9-01 | Ty1a | 602 | 1343 | 56.4 | 195 | 26.9 | 164 | 95.2 | 36.2 | 132 | 27.4 | 171 | 27.8 | 59.1 | 6.78 | 31.4 | 2.20 | 116 | 62.3 | 0.57 | 8.79 | 0.06 | 0.019 | 0.98 | 1.22 |
| 18DQ-9-02 | Ty1a | 577 | 928 | 39.6 | 147 | 21.9 | 133 | 81.0 | 31.0 | 120 | 25.1 | 159 | 26.7 | 57.0 | 6.09 | 31.5 | 2.10 | 64.6 | 68.0 | 0.50 | 8.03 | 0.06 | 0.033 | 0.96 | 1.21 |
| 18DQ-9-03 | Ty1a | 252 | 595 | 34.0 | 107 | 15.3 | 89.9 | 47.9 | 21.1 | 65.4 | 12.4 | 73.8 | 11.9 | 23.7 | 2.58 | 12.7 | 0.87 | 148 | 87.6 | 0.44 | 3.14 | 0.14 | 0.006 | 1.15 | 1.14 |
| 18DQ-9-04 | Ty1a | 168 | 650 | 23.9 | 70.0 | 9.48 | 52.4 | 25.6 | 8.89 | 32.8 | 6.67 | 39.5 | 6.91 | 15.7 | 1.82 | 10.4 | 0.92 | 265 | 56.3 | 0.87 | 2.39 | 0.37 | 0.003 | 0.94 | 1.14 |
| 18DQ-9-05 | Ty1b | 1171 | 251 | 40.3 | 255 | 50.8 | 319 | 163 | 14.8 | 232 | 44.5 | 276 | 50.8 | 110 | 13.0 | 64.5 | 4.64 | 369 | 21.0 | 0.80 | 1.75 | 0.46 | 0.013 | 0.23 | 1.18 |
| 18DQ-9-06 | Ty1b | 997 | 1265 | 67.2 | 329 | 57.7 | 347 | 180 | 41.9 | 238 | 45.6 | 265 | 44.2 | 91.6 | 10.3 | 50.4 | 3.61 | 229 | 104 | 1.71 | 71.9 | 0.02 | 0.016 | 0.62 | 1.21 |
| 18DQ-9-07 | Ty1b | 2049 | 509 | 143 | 732 | 128 | 763 | 317 | 84.1 | 398 | 72.9 | 462 | 81.7 | 190 | 23.8 | 120 | 10.1 | 436 | 46.2 | 4.15 | 50.2 | 0.08 | 0.023 | 0.72 | 1.22 |
| 18DQ-9-08 | Ty1b | 1967 | 674 | 119 | 672 | 130 | 752 | 312 | 50.2 | 393 | 72.9 | 461 | 81.4 | 188 | 22.8 | 118 | 9.21 | 354 | 66.8 | 3.55 | 107 | 0.03 | 0.026 | 0.44 | 1.17 |
| 18DQ-9-09 | Ty1b | 705 | 446 | 33.3 | 183 | 33.2 | 212 | 107 | 24.4 | 161 | 29.6 | 180 | 31.5 | 67.7 | 7.46 | 38.1 | 2.87 | 141 | 28.6 | 0.65 | 3.13 | 0.21 | 0.020 | 0.57 | 1.22 |
| 18DQ-9-10 | Ty1b | 644 | 473 | 36.2 | 173 | 30.6 | 196 | 101 | 24.8 | 140 | 26.5 | 158 | 27.8 | 62.3 | 7.24 | 36.3 | 2.84 | 175 | 41.1 | 1.01 | 2.82 | 0.36 | 0.016 | 0.64 | 1.19 |
| 18DQ-9-11 | Ty1b | 1517 | 552 | 81.5 | 464 | 81.1 | 490 | 218 | 18.8 | 275 | 55.2 | 340 | 60.8 | 134 | 16.5 | 86.1 | 6.51 | 467 | 84.9 | 1.02 | 18.2 | 0.06 | 0.014 | 0.23 | 1.27 |
| 18DQ-9-12 | Ty1b | 867 | 656 | 38.4 | 211 | 41.1 | 269 | 145 | 27.0 | 194 | 37.3 | 226 | 37.4 | 77.3 | 8.75 | 42.6 | 3.35 | 205 | 42.8 | 1.29 | 13.7 | 0.09 | 0.016 | 0.49 | 1.16 |
| 18DQ-9-13 | Ty1b | 1184 | 250 | 45.9 | 284 | 53.8 | 338 | 164 | 14.3 | 236 | 45.0 | 278 | 50.3 | 110 | 13.3 | 66.8 | 5.00 | 328 | 19.2 | 0.77 | 1.71 | 0.45 | 0.015 | 0.22 | 1.22 |
| 18DQ-9-14 | Ty1b | 972 | 1330 | 75.4 | 368 | 65.0 | 375 | 194 | 38.2 | 240 | 44.9 | 266 | 41.5 | 83.9 | 9.52 | 47.6 | 3.42 | 371 | 156 | 2.30 | 67.1 | 0.03 | 0.009 | 0.54 | 1.20 |
| 18DQ-9-15 | Ty1b | 1181 | 281 | 33.3 | 208 | 41.3 | 281 | 142 | 28.2 | 210 | 40.8 | 255 | 49.5 | 117 | 13.7 | 71.1 | 6.41 | 168 | 21.2 | 1.10 | 2.89 | 0.38 | 0.038 | 0.50 | 1.18 |
| 18DQ-9-16 | Ty1b | 1545 | 732 | 128.9 | 659 | 115 | 635 | 261 | 44.7 | 311 | 57.8 | 351 | 60.9 | 135 | 15.9 | 84.6 | 6.45 | 547 | 85.6 | 3.20 | 76.0 | 0.04 | 0.012 | 0.48 | 1.23 |
| 18DQ-9-17 | Ty1b | 2038 | 692 | 107.7 | 586 | 106 | 604 | 272 | 23.0 | 373 | 72.0 | 453 | 81.8 | 183 | 22.1 | 109 | 8.37 | 322 | 113 | 1.29 | 19.5 | 0.07 | 0.026 | 0.22 | 1.22 |
| 18DQ-9-18 | Ty1b | 1462 | 393 | 44.9 | 281 | 57.2 | 367 | 174 | 21.0 | 256 | 49.4 | 322 | 60.5 | 137 | 17.2 | 86.9 | 6.99 | 355 | 27.5 | 1.05 | 2.59 | 0.41 | 0.020 | 0.30 | 1.16 |
| 18DQ-9-19 | Ty1b | 1226 | 415 | 71.0 | 443 | 83.5 | 501 | 214 | 36.1 | 271 | 50.2 | 294 | 56.3 | 117 | 13.8 | 71.9 | 5.38 | 433 | 45.6 | 2.23 | 23.07 | 0.10 | 0.012 | 0.46 | 1.23 |
| 18DQ-9-20 | Ty2a | 1823 | 466 | 14.6 | 115 | 30.1 | 259 | 229 | 50.5 | 383 | 71.5 | 436 | 70.3 | 153 | 15.5 | 76.4 | 4.56 | 365 | 56.5 | 13.3 | 114 | 0.12 | 0.012 | 0.52 | 0.99 |
| 18DQ-9-21 | Ty2a | 1819 | 597 | 24.5 | 180 | 44.6 | 362 | 266 | 53.5 | 414 | 73.7 | 452 | 70.2 | 143 | 13.9 | 73.5 | 4.24 | 329 | 68.2 | 13.4 | 165 | 0.08 | 0.013 | 0.49 | 1.03 |
| 18DQ-9-22 | Ty2a | 1507 | 491 | 17.8 | 137 | 35.6 | 289 | 245 | 59.1 | 371 | 64.2 | 383 | 58.9 | 122 | 12.0 | 61.3 | 3.64 | 313 | 53.2 | 20.8 | 128 | 0.16 | 0.012 | 0.60 | 0.99 |
| 18DQ-9-23 | Ty2a | 1083 | 491 | 11.4 | 90.2 | 22.0 | 189 | 164 | 36.8 | 246 | 45.3 | 277 | 41.9 | 90.6 | 9.06 | 48.0 | 2.99 | 251 | 51.0 | 15.4 | 76.1 | 0.20 | 0.012 | 0.56 | 1.05 |
| 18DQ-9-24 | Ty2a | 2015 | 624 | 19.9 | 148 | 36.8 | 309 | 260 | 61.0 | 405 | 75.8 | 473 | 74.8 | 161 | 16.9 | 92.4 | 5.35 | 309 | 55.6 | 17.0 | 294 | 0.06 | 0.017 | 0.57 | 1.03 |
| 18DQ-9-25 | Ty2a | 1676 | 418 | 16.7 | 131 | 35.2 | 300 | 250 | 50.6 | 393 | 67.9 | 418 | 63.8 | 135 | 12.9 | 64.4 | 3.85 | 357 | 73.4 | 12.3 | 55.3 | 0.22 | 0.011 | 0.49 | 0.97 |
| 18DQ-9-26 | Ty2a | 1832 | 425 | 18.1 | 141 | 36.5 | 299 | 248 | 54.9 | 415 | 74.9 | 433 | 70.6 | 157 | 14.8 | 77.4 | 4.45 | 370 | 74.4 | 12.8 | 110 | 0.12 | 0.012 | 0.52 | 1.00 |
| 18DQ-9-27 | Ty2a | 1604 | 327 | 12.0 | 94 | 25.7 | 230 | 198 | 43.5 | 326 | 62.3 | 385 | 63.6 | 134 | 13.1 | 69.7 | 4.19 | 277 | 50.3 | 9.69 | 73.0 | 0.13 | 0.015 | 0.52 | 0.95 |
| 18DQ-9-28 | Ty2a | 1487 | 445 | 18.2 | 140 | 36.1 | 296 | 236 | 49.9 | 363 | 63.8 | 386 | 56.6 | 121 | 11.3 | 58.9 | 3.65 | 306 | 70.5 | 15.0 | 119 | 0.13 | 0.012 | 0.52 | 1.00 |
| 18DQ-9-29 | Ty2a | 1809 | 700 | 23.0 | 166 | 44.3 | 381 | 291 | 54.1 | 458 | 82.1 | 469 | 75.1 | 143 | 14.9 | 69.3 | 4.54 | 290 | 73.6 | 13.6 | 141 | 0.10 | 0.016 | 0.45 | 0.96 |
| 18DQ-9-30 | Ty2a | 1666 | 514 | 19.2 | 138 | 38.2 | 332 | 273 | 70.2 | 433 | 78.4 | 444 | 70.6 | 135 | 14.0 | 63.9 | 4.33 | 338 | 54.3 | 25.4 | 160 | 0.16 | 0.013 | 0.62 | 0.94 |
| 18DQ-9-31 | Ty2a | 1882 | 669 | 26.7 | 178 | 46.4 | 380 | 294 | 58.5 | 461 | 85.4 | 495 | 77.8 | 151 | 15.7 | 72.7 | 4.79 | 338 | 76.2 | 14.4 | 145 | 0.10 | 0.014 | 0.48 | 0.97 |
| 18DQ-9-32 | Ty2b | 1415 | 106 | 7.04 | 58.1 | 16.5 | 148 | 139 | 35.1 | 257 | 49.9 | 321 | 55.4 | 131 | 13.8 | 72.9 | 4.61 | 23.0 | 9.05 | 13.5 | 8.55 | 1.58 | 0.200 | 0.56 | 0.94 |
| 18DQ-9-33 | Ty2b | 1352 | 86.6 | 8.00 | 68.6 | 19.6 | 180 | 160 | 40.1 | 288 | 52.6 | 324 | 51.7 | 111 | 11.2 | 56.4 | 3.72 | 10.4 | 5.68 | 22.2 | 12.9 | 1.71 | 0.359 | 0.57 | 0.93 |
| 18DQ-9-34 | Ty2b | 1786 | 186 | 6.73 | 62.8 | 17.5 | 174 | 177 | 38.5 | 323 | 63.4 | 420 | 69.1 | 160 | 17.1 | 94.6 | 6.44 | 35.3 | 12.9 | 30.4 | 33.3 | 0.91 | 0.183 | 0.49 | 0.97 |
| 18DQ-9-35 | Ty2b | 1502 | 80.9 | 6.33 | 57.8 | 16.7 | 154 | 149 | 37.1 | 277 | 53.3 | 335 | 57.5 | 126 | 12.8 | 66.9 | 4.47 | 7.56 | 5.29 | 16.0 | 10.1 | 1.59 | 0.591 | 0.55 | 0.93 |
| 18DQ-9-36 | Ty2b | 1822 | 553 | 5.27 | 51.5 | 14.6 | 130 | 149 | 34.0 | 297 | 61.8 | 424 | 68.9 | 153 | 14.9 | 75.5 | 4.36 | 281 | 65.9 | 9.26 | 8.60 | 1.08 | 0.016 | 0.48 | 0.96 |
| 18DQ-9-37 | Ty2b | 1243 | 96.9 | 4.22 | 39.3 | 10.9 | 105 | 106 | 23.9 | 190 | 38.6 | 270 | 46.5 | 113 | 12.0 | 65.6 | 4.02 | 20.0 | 9.49 | 10.8 | 6.65 | 1.62 | 0.201 | 0.51 | 0.97 |
| 18DQ-9-38 | Ty2b | 1345 | 93.9 | 5.28 | 45.6 | 12.4 | 113 | 107 | 27.1 | 213 | 43.7 | 301 | 51.4 | 122 | 12.7 | 69.3 | 4.59 | 9.46 | 7.50 | 12.9 | 11.6 | 1.12 | 0.486 | 0.54 | 0.98 |
| 18DQ-9-39 | Ty2b | 1281 | 83.5 | 5.51 | 50.2 | 15.9 | 160 | 153 | 40.0 | 284 | 52.9 | 319 | 54.3 | 106 | 11.7 | 53.9 | 4.05 | 8.52 | 5.68 | 22.5 | 10.8 | 2.08 | 0.475 | 0.58 | 0.86 |
| 花岗斑岩中榍石 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 18DQ-3-01 |  | 678 | 999 | 777 | 2466 | 291 | 1169 | 224 | 36.1 | 172 | 23.5 | 148 | 24.5 | 72.8 | 8.5 | 55.9 | 5.25 | 139 | 85.5 | 61.6 | 17.5 | 3.52 | 0.038 | 0.54 | 1.27 |
| 18DQ-3-02 |  | 1023 | 1957 | 1938 | 5168 | 555 | 1926 | 329 | 32.3 | 242 | 35.2 | 205 | 39.0 | 108 | 13.7 | 86.3 | 8.40 | 255 | 114 | 118 | 36.6 | 3.23 | 0.033 | 0.33 | 1.20 |
| 18DQ-3-03 |  | 749 | 1208 | 910 | 2666 | 304 | 1249 | 237 | 34.5 | 179 | 26.0 | 145 | 26.4 | 74.1 | 9.03 | 58.0 | 5.76 | 160 | 104 | 78.3 | 20.8 | 3.76 | 0.036 | 0.49 | 1.24 |
| 18DQ-3-04 |  | 609 | 1093 | 801 | 2201 | 262 | 1112 | 177 | 22.6 | 136 | 19.2 | 124 | 22.8 | 62.3 | 8.63 | 54.7 | 5.87 | 180 | 74.3 | 77.7 | 16.6 | 4.68 | 0.033 | 0.43 | 1.17 |
| 18DQ-3-05 |  | 589 | 681 | 635 | 1711 | 218 | 839 | 144 | 18.9 | 122 | 17.7 | 106 | 21.1 | 59.7 | 7.45 | 54.4 | 5.51 | 145 | 37.9 | 54.1 | 14.4 | 3.76 | 0.038 | 0.42 | 1.12 |
| 18DQ-3-06 |  | 615 | 1296 | 840 | 2456 | 280 | 989 | 191 | 21.0 | 146 | 21.1 | 132 | 24.4 | 63.8 | 8.58 | 57.3 | 5.92 | 178 | 75.0 | 72.6 | 17.8 | 4.07 | 0.033 | 0.37 | 1.24 |
| 18DQ-3-07 |  | 545 | 922 | 722 | 2095 | 243 | 886 | 156 | 28.3 | 126 | 17.9 | 105 | 19.8 | 56.8 | 7.30 | 48.4 | 4.89 | 135 | 47.8 | 65.2 | 17.1 | 3.82 | 0.036 | 0.60 | 1.22 |
| 18DQ-3-08 |  | 730 | 1210 | 880 | 2707 | 306 | 1236 | 229 | 37.3 | 191 | 26.1 | 151 | 27.0 | 72.0 | 9.01 | 59.5 | 5.58 | 154 | 108 | 75.4 | 20.3 | 3.71 | 0.036 | 0.53 | 1.28 |
| 18DQ-3-09 |  | 624 | 908 | 802 | 2374 | 269 | 1063 | 189 | 28.5 | 151 | 21.0 | 129 | 23.8 | 66.0 | 8.20 | 54.9 | 5.44 | 147 | 38.2 | 64.1 | 17.7 | 3.62 | 0.037 | 0.50 | 1.25 |
| 18DQ-3-10 |  | 622 | 996 | 777 | 2586 | 279 | 1088 | 213 | 33.5 | 166 | 21.9 | 123 | 22.6 | 66.7 | 7.77 | 50.4 | 5.48 | 148 | 89.7 | 70.4 | 18.8 | 3.75 | 0.037 | 0.53 | 1.36 |
| 18DQ-3-11 |  | 478 | 564 | 488 | 1424 | 175 | 724 | 120 | 26.1 | 114 | 16.6 | 94 | 17.3 | 49.3 | 6.48 | 40.6 | 4.21 | 105 | 35.3 | 42.3 | 12.3 | 3.44 | 0.040 | 0.67 | 1.19 |
| 18DQ-3-12 |  | 732 | 920 | 759 | 2539 | 333 | 1325 | 286 | 45.4 | 216 | 28.4 | 157 | 27.3 | 78.0 | 9.00 | 60.1 | 5.71 | 132 | 83.0 | 51.9 | 14.9 | 3.48 | 0.043 | 0.54 | 1.24 |
| 18DQ-3-13 |  | 732 | 753 | 707 | 2285 | 307 | 1319 | 254 | 41.6 | 199 | 26.6 | 155 | 27.1 | 75.9 | 7.95 | 57.5 | 5.43 | 101 | 65.4 | 46.8 | 12.8 | 3.65 | 0.054 | 0.54 | 1.20 |
| 18DQ-3-14 |  | 718 | 784 | 729 | 2521 | 307 | 1287 | 274 | 45.3 | 211 | 28.1 | 162 | 28.2 | 77.1 | 8.62 | 58.8 | 6.05 | 122 | 67.8 | 46.6 | 12.4 | 3.74 | 0.050 | 0.56 | 1.31 |
| 18DQ-3-15 |  | 750 | 954 | 739 | 2488 | 337 | 1392 | 278 | 44.8 | 218 | 28.3 | 169 | 29.1 | 76.7 | 9.26 | 59.7 | 6.02 | 136 | 88.3 | 53.0 | 14.3 | 3.71 | 0.044 | 0.54 | 1.22 |
| 18DQ-3-16 |  | 602 | 800 | 665 | 1889 | 248 | 897 | 160 | 22.2 | 131 | 18.1 | 114 | 21.7 | 61.8 | 8.00 | 55.5 | 5.82 | 146 | 48.2 | 58.3 | 14.6 | 3.99 | 0.040 | 0.46 | 1.14 |
| 18DQ-3-17 |  | 612 | 755 | 645 | 1967 | 227 | 876 | 162 | 21.7 | 138 | 19.3 | 114 | 21.2 | 62.0 | 7.52 | 52.8 | 5.57 | 131 | 44.7 | 55.1 | 14.4 | 3.83 | 0.043 | 0.43 | 1.26 |
| 18DQ-3-18 |  | 770 | 1288 | 884 | 2573 | 338 | 1341 | 266 | 32.3 | 208 | 29.1 | 158 | 29.5 | 78.5 | 9.43 | 64.7 | 6.05 | 181 | 108 | 67.3 | 16.5 | 4.08 | 0.033 | 0.41 | 1.15 |
| 18DQ-3-19 |  | 873 | 1000 | 914 | 2851 | 362 | 1528 | 285 | 29.4 | 218 | 33.0 | 183 | 32.2 | 91.6 | 10.8 | 71.7 | 7.50 | 176 | 73.8 | 67.2 | 16.5 | 4.06 | 0.043 | 0.35 | 1.22 |
| 18DQ-3-20 |  | 813 | 1165 | 892.58 | 2857 | 361 | 1592 | 297 | 45.4 | 231 | 31.0 | 182 | 30.0 | 82.2 | 9.14 | 61.4 | 6.35 | 130 | 119 | 64.5 | 14.5 | 4.44 | 0.049 | 0.51 | 1.23 |

备注： “Ty1a”代表榍石Type1核部；“Ty1b”代表榍石Type1边部；“Ty2a”代表榍石Type2核部；“Ty2b”代表榍石Type2边部

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| **表4榍石LA-ICPMS U-Pb同位素分析结果****Table 4 LA-ICPMS U-Pb isotope data for titanite**  |
| 点号 | U(ppm) | Pb(ppm) | 238U/206Pb | 2σ | 207Pb/206Pb | 2σ | Roh |
| 榍石 Type 1 |  |  |  |  |  |  |  |
| DQ9-01 | 1.75 | 0.12 | 13.9 | 2.1 | 0.509 | 0.075 | 0.060 |
| DQ9-02 | 8.79 | 0.31 | 33.5 | 6.3 | 0.265 | 0.044 | 0.002 |
| DQ9-03 | 71.9 | 1.55 | 46.2 | 2.4 | 0.115 | 0.012 | 0.121 |
| DQ9-04 | 2.69 | 0.20 | 19.2 | 3.1 | 0.469 | 0.086 | 0.074 |
| DQ9-05 | 9.73 | 0.57 | 30.4 | 4.1 | 0.348 | 0.020 | 0.084 |
| DQ9-06 | 50.2 | 1.62 | 39.1 | 2.8 | 0.136 | 0.018 | 0.150 |
| DQ9-07 | 107 | 2.41 | 47.6 | 2.1 | 0.071 | 0.007 | 0.107 |
| DQ9-08 | 3.13 | 0.15 | 22.1 | 3.5 | 0.437 | 0.020 | 0.067 |
| DQ9-09 | 2.82 | 0.48 | 14.5 | 2.7 | 0.515 | 0.096 | 0.084 |
| DQ9-10 | 18.2 | 1.20 | 30.5 | 3.4 | 0.311 | 0.030 | 0.127 |
| DQ9-11 | 13.7 | 1.10 | 23.7 | 2.6 | 0.352 | 0.036 | 0.135 |
| DQ9-12 | 67.1 | 1.59 | 44.2 | 3.0 | 0.076 | 0.010 | 0.151 |
| DQ9-13 | 5.70 | 0.44 | 22.8 | 3.3 | 0.404 | 0.059 | 0.071 |
| DQ9-14 | 2.89 | 0.17 | 20.6 | 3.8 | 0.426 | 0.072 | 0.036 |
| DQ9-15 | 76.0 | 1.73 | 46.5 | 2.2 | 0.081 | 0.010 | 0.137 |
| DQ9-16 | 19.5 | 0.67 | 39.8 | 3.4 | 0.166 | 0.019 | 0.143 |
| DQ9-17 | 90.4 | 2.35 | 43.5 | 2.0 | 0.098 | 0.015 | 0.159 |
| DQ9-18 | 2.59 | 0.12 | 21.1 | 3.3 | 0.475 | 0.099 | 0.255 |
| DQ9-19 | 3.45 | 0.60 | 13.8 | 2.0 | 0.521 | 0.052 | 0.138 |
| DQ9-20 | 23.1 | 0.88 | 34.1 | 4.1 | 0.237 | 0.051 | 0.248 |
| DQ9-21 | 3.14 | 0.57 | 12.8 | 2.3 | 0.518 | 0.043 | 0.120 |
| DQ9-22 | 37.0 | 1.21 | 40.4 | 2.7 | 0.141 | 0.021 | 0.168 |
| DQ9-23 | 2.39 | 0.27 | 14.3 | 1.7 | 0.484 | 0.047 | 0.131 |
| DQ9-24 | 141 | 3.17 | 45.6 | 2.3 | 0.066 | 0.008 | 0.135 |
| DQ9-25 | 160 | 3.58 | 47.0 | 1.7 | 0.058 | 0.007 | 0.124 |
| DQ9-26 | 145 | 3.21 | 45.8 | 1.8 | 0.059 | 0.006 | 0.116 |
| 榍石 Type 2 |  |  |  |  |  |  |  |
| 18DQ-9-1 | 114 | 2.67 | 46.6 | 2.5 | 0.077 | 0.008 | 0.061 |
| 18DQ-9-2 | 165 | 3.42 | 49.5 | 2.1 | 0.070 | 0.008 | 0.060 |
| 18DQ-9-3 | 128 | 3.01 | 45.3 | 2.3 | 0.068 | 0.008 | 0.069 |
| 18DQ-9-4 | 76.1 | 1.91 | 44.7 | 2.1 | 0.089 | 0.012 | 0.070 |
| 18DQ-9-5 | 8.55 | 2.00 | 13.6 | 2.3 | 0.655 | 0.049 | 0.015 |
| 18DQ-9-6 | 12.9 | 1.27 | 24.6 | 2.3 | 0.403 | 0.036 | 0.058 |
| 18DQ-9-7 | 33.3 | 4.47 | 19.8 | 1.1 | 0.556 | 0.030 | 0.035 |
| 18DQ-9-8 | 10.1 | 0.87 | 27.7 | 3.4 | 0.427 | 0.039 | 0.062 |
| 18DQ-9-9 | 294 | 8.06 | 43.6 | 2.2 | 0.130 | 0.010 | 0.044 |
| 18DQ-9-10 | 55.3 | 2.76 | 32.7 | 1.9 | 0.277 | 0.018 | 0.042 |
| 18DQ-9-11 | 110 | 2.41 | 46.4 | 3.0 | 0.071 | 0.010 | 0.082 |
| 18DQ-9-12 | 8.60 | 1.06 | 21.0 | 4.1 | 0.518 | 0.086 | 0.110 |
| 18DQ-9-13 | 6.65 | 1.04 | 16.9 | 2.2 | 0.539 | 0.052 | 0.066 |
| 18DQ-9-14 | 11.6 | 0.72 | 29.0 | 3.3 | 0.378 | 0.050 | 0.083 |
| 18DQ-9-15 | 73.0 | 1.94 | 43.5 | 2.4 | 0.108 | 0.012 | 0.065 |
| 18DQ-9-16 | 119 | 2.75 | 47.1 | 2.1 | 0.086 | 0.009 | 0.060 |
| 花岗斑岩榍石 |  |  |  |  |  |  |  |
| 18DQ-3-01 | 17.5 | 1.81 | 26.1 | 2.5 | 0.436 | 0.020 | 0.032 |
| 18DQ-3-02 | 36.6 | 3.28 | 27.9 | 2.8 | 0.384 | 0.024 | 0.044 |
| 18DQ-3-03 | 20.8 | 1.78 | 30.4 | 2.9 | 0.369 | 0.022 | 0.041 |
| 18DQ-3-04 | 16.6 | 4.13 | 13.4 | 2.2 | 0.692 | 0.078 | 0.077 |
| 18DQ-3-05 | 14.4 | 1.22 | 31.7 | 3.9 | 0.352 | 0.046 | 0.084 |
| 18DQ-3-06 | 17.8 | 3.06 | 18.9 | 3.4 | 0.566 | 0.045 | 0.035 |
| 18DQ-3-07 | 17.1 | 1.29 | 34.3 | 3.8 | 0.288 | 0.052 | 0.107 |
| 18DQ-3-08 | 20.3 | 1.53 | 33.1 | 3.2 | 0.319 | 0.042 | 0.081 |
| 18DQ-3-09 | 17.7 | 1.24 | 35.1 | 3.6 | 0.344 | 0.035 | 0.066 |
| 18DQ-3-10 | 18.8 | 1.67 | 31.6 | 5.6 | 0.407 | 0.045 | 0.076 |
| 18DQ-3-11 | 12.3 | 1.26 | 25.5 | 4.3 | 0.444 | 0.028 | 0.046 |
| 18DQ-3-12 | 14.9 | 1.16 | 30.1 | 4.4 | 0.344 | 0.077 | 0.133 |
| 18DQ-3-13 | 12.8 | 5.92 | 7.5 | 1.0 | 0.744 | 0.042 | 0.010 |
| 18DQ-3-14 | 12.4 | 1.45 | 25.0 | 3.3 | 0.467 | 0.056 | 0.079 |
| 18DQ-3-15 | 14.3 | 1.46 | 25.4 | 2.7 | 0.435 | 0.046 | 0.069 |
| 18DQ-3-16 | 14.6 | 1.20 | 28.9 | 3.0 | 0.335 | 0.049 | 0.088 |
| 18DQ-3-17 | 14.4 | 1.16 | 31.2 | 3.6 | 0.338 | 0.038 | 0.074 |
| 18DQ-3-18 | 16.5 | 1.71 | 27.4 | 3.8 | 0.435 | 0.060 | 0.090 |
| 18DQ-3-19 | 16.5 | 2.20 | 22.0 | 2.1 | 0.506 | 0.047 | 0.060 |
| 18DQ-3-20 | 14.5 | 1.27 | 30.6 | 3.3 | 0.343 | 0.041 | 0.076 |

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| **表5 锆石LA-ICPMS U-Pb同位素分析结果****Table 5 LA-ICPMS U-Pb isotope data for zircon** |
| 　点号 | Th | U | 207Pb/206Pb | 1σ | 207Pb/235U | 1σ | 206Pb/238U | 1σ | 207Pb/235U | 1σ | 206Pb/238U | 1σ |
| (ppm) | Ma | Ma | Ma | Ma |
| 黑云母石英二长岩 |  |  |  |  |  |  |  |  |  |  |  |  |
| 18DQ-1-01 | 306 | 428 | 0.0439 | 0.0019 | 0.1388 | 0.0061 | 0.0229 | 0.0003 | 132 | 5 | 146 | 2 |
| 18DQ-1-02 | 179 | 244 | 0.0443 | 0.0028 | 0.1295 | 0.0071 | 0.0217 | 0.0003 | 124 | 6 | 139 | 2 |
| 18DQ-1-03 | 195 | 258 | 0.0487 | 0.003 | 0.139 | 0.0075 | 0.0214 | 0.0004 | 132 | 7 | 136 | 2 |
| 18DQ-1-04 | 140 | 312 | 0.0489 | 0.0027 | 0.1438 | 0.0081 | 0.0214 | 0.0003 | 136 | 7 | 137 | 2 |
| 18DQ-1-05 | 158 | 382 | 0.0525 | 0.0029 | 0.1571 | 0.0085 | 0.0215 | 0.0003 | 148 | 7 | 137 | 2 |
| 18DQ-1-06 | 104 | 216 | 0.0493 | 0.0036 | 0.1424 | 0.0097 | 0.0213 | 0.0004 | 135 | 9 | 136 | 2 |
| 18DQ-1-07 | 177 | 231 | 0.0467 | 0.0031 | 0.139 | 0.0086 | 0.0217 | 0.0004 | 132 | 8 | 139 | 2 |
| 18DQ-1-08 | 132 | 183 | 0.0514 | 0.0041 | 0.1485 | 0.0111 | 0.0215 | 0.0004 | 141 | 10 | 137 | 2 |
| 18DQ-1-09 | 199 | 242 | 0.0505 | 0.0032 | 0.1462 | 0.0088 | 0.0214 | 0.0004 | 139 | 8 | 136 | 3 |
| 18DQ-1-10 | 265 | 309 | 0.0482 | 0.0027 | 0.1425 | 0.0079 | 0.0215 | 0.0003 | 135 | 7 | 137 | 2 |
| 18DQ-1-11 | 235 | 311 | 0.0536 | 0.0029 | 0.156 | 0.0078 | 0.0215 | 0.0003 | 147 | 7 | 137 | 2 |
| 18DQ-1-12 | 111 | 164 | 0.0511 | 0.0034 | 0.1479 | 0.0085 | 0.0218 | 0.0005 | 140 | 8 | 139 | 3 |
| 18DQ-1-13 | 290 | 369 | 0.0478 | 0.0023 | 0.1403 | 0.0069 | 0.0215 | 0.0003 | 133 | 6 | 137 | 2 |
| 18DQ-1-14 | 181 | 229 | 0.0534 | 0.0035 | 0.1557 | 0.009 | 0.0214 | 0.0003 | 147 | 8 | 136 | 2 |
| 18DQ-1-15 | 178 | 271 | 0.0502 | 0.0031 | 0.1472 | 0.0084 | 0.0219 | 0.0004 | 139 | 7 | 140 | 3 |
| 花岗斑岩 |  |  |  |  |  |  |  |  |  |  |  |  |
| 18DQ-3-01 | 164 | 295 | 0.0505 | 0.0030 | 0.1447 | 0.0079 | 0.0208 | 0.0003 | 137 | 7 | 133 | 2 |
| 18DQ-3-02 | 92.2 | 104 | 0.0977 | 0.0090 | 0.2968 | 0.0291 | 0.0217 | 0.0006 | 264 | 23 | 138 | 4 |
| 18DQ-3-03 | 52.4 | 92 | 0.0676 | 0.0065 | 0.1939 | 0.015 | 0.0221 | 0.0005 | 180 | 13 | 141 | 3 |
| 18DQ-3-04 | 120 | 162 | 0.0555 | 0.0044 | 0.1634 | 0.0104 | 0.0217 | 0.0004 | 154 | 9 | 139 | 2 |
| 18DQ-3-05 | 65.1 | 138 | 0.0609 | 0.0052 | 0.1686 | 0.0128 | 0.0208 | 0.0004 | 158 | 11 | 133 | 3 |
| 18DQ-3-06 | 122 | 228 | 0.0547 | 0.0038 | 0.1674 | 0.011 | 0.0223 | 0.0004 | 157 | 10 | 142 | 3 |
| 18DQ-3-07 | 166 | 235 | 0.0572 | 0.0043 | 0.1614 | 0.0113 | 0.0207 | 0.0004 | 152 | 10 | 132 | 2 |
| 18DQ-3-08 | 60.8 | 94 | 0.0549 | 0.0064 | 0.1524 | 0.0138 | 0.021 | 0.0005 | 144 | 12 | 134 | 3 |
| 18DQ-3-09 | 188 | 336 | 0.0513 | 0.0029 | 0.1473 | 0.0075 | 0.0209 | 0.0003 | 139 | 7 | 133 | 2 |
| 18DQ-3-10 | 78.7 | 181 | 0.0583 | 0.0045 | 0.1677 | 0.0115 | 0.0211 | 0.0004 | 157 | 10 | 135 | 2 |
| 18DQ-3-11 | 60.5 | 134 | 0.0508 | 0.0047 | 0.1493 | 0.0107 | 0.0222 | 0.0005 | 141 | 9 | 142 | 3 |
| 18DQ-3-12 | 80.9 | 173 | 0.0508 | 0.0038 | 0.1534 | 0.0094 | 0.0224 | 0.0004 | 145 | 8 | 143 | 3 |
| 18DQ-3-13 | 147 | 315 | 0.0582 | 0.0032 | 0.172 | 0.0089 | 0.0217 | 0.0003 | 161 | 8 | 139 | 2 |
| 18DQ-3-14 | 277 | 331 | 0.0511 | 0.0027 | 0.1459 | 0.0074 | 0.021 | 0.0003 | 138 | 7 | 134 | 2 |
| 18DQ-3-15 | 150 | 285 | 0.0594 | 0.0038 | 0.1719 | 0.011 | 0.021 | 0.0003 | 161 | 10 | 134 | 2 |