**附表1 东昆仑锰矿围岩主量元素分析结果（wt.%）**

**Table 1** Analysis results of major elements in surrounding rock of east Kunlun manganese deposit (wt.%)

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **矿床名称** | **送样编号** | **样品名称** | **Al2O3** | **SiO2** | **Fe2O3** | **FeO** | **MnO** | **CaO** | **K2O** | **MgO** | **Na2O** | **P2O5** | **TiO2** | **SO3** | **LOI** | **TFe2O3** |
| 三通沟  北锰矿 | ZK706-806 | 硅质粉砂岩 | 10.3 | 64.52 | 4.09 | 2.55 | 0.51 | 5.47 | 1.38 | 2.25 | 0.65 | 2.90 | 0.32 | 2.15 | 2.27 | 6.64 |
| ZK706-829 | 硅质粉砂岩 | 9.80 | 69.35 | 3.66 | 2.10 | 0.65 | 3.98 | 1.94 | 2.09 | 0.75 | 0.55 | 0.33 | 0.85 | 3.23 | 5.76 |
| ZK706-R1 | 碳质粉砂岩 | 10.8 | 63.69 | 4.24 | 8.18 | 0.60 | 1.39 | 1.44 | 3.41 | 0.79 | 0.39 | 0.47 | 0.17 | 4.06 | 12.4 |
| ZK706-R2 | 碳质粉砂岩 | 11.5 | 60.49 | 5.18 | 8.10 | 0.65 | 1.72 | 1.64 | 3.59 | 0.61 | 0.30 | 0.54 | 0.85 | 4.15 | 13.3 |
| ZK706-R3 | 碳质粉砂岩 | 11.3 | 58.74 | 5.22 | 9.14 | 0.66 | 1.84 | 1.51 | 3.80 | 0.68 | 0.31 | 0.54 | 1.70 | 4.28 | 14.4 |
| ZK706-R5 | 碳质粉砂岩 | 10.2 | 69.60 | 6.27 | 4.57 | 0.27 | 0.51 | 1.60 | 2.16 | 0.76 | 0.16 | 0.36 | 3.00 | 0.17 | 10.8 |
| ZK706-R4 | 硅质岩 | 2.91 | 83.18 | 3.13 | 3.05 | 0.20 | 0.81 | 0.26 | 0.97 | 0.03 | 0.26 | 0.22 | 1.37 | 1.82 | 6.18 |
| STG-8B | 硅质岩 | 2.47 | 92.77 |  |  | 0.03 | 0.20 | 0.66 | 0.23 | 0.08 | 0.06 | 0.13 |  | 1.78 | 0.95 |
| STG-9B-1 | 硅质岩 | 1.97 | 92.98 |  |  | 0.02 | 0.69 | 0.52 | 0.21 | 0.09 | 0.03 | 0.08 |  | 1.66 | 1.04 |
| STG-9B-3 | 硅质岩 | 3.68 | 91.39 |  |  | 0.02 | 0.27 | 0.80 | 0.25 | 0.13 | 0.05 | 0.16 |  | 1.87 | 0.79 |
| 洪水河  铁锰矿 | HP1-1 | 变砂岩 | 12.3 | 60.76 | 1.93 | 2.63 | 0.43 | 7.25 | 4.46 | 6.62 | 1.36 | 0.21 | 0.67 | 0.01 | 1.63 | 4.56 |
| HP1-3 | 变砂岩 | 10.5 | 63.53 | 3.23 | 5.20 | 0.24 | 2.31 | 3.87 | 4.13 | 3.12 | 0.11 | 0.57 | 0.08 | 1.29 | 8.43 |
| HSH01-B10# | 变粉砂岩 | 11.8 | 67.53 | -- | -- | 0.44 | 2.19 | 4.12 | 4.35 | 0.63 | 0.16 | 0.77 | -- | 1.89 | 5.39 |
| HSH02-B8# | 变粉砂岩 | 11.1 | 65.70 | -- | -- | 0.60 | 2.58 | 3.65 | 3.73 | 0.66 | 0.14 | 0.69 | -- | 5.46 | 4.86 |
| HSH02-B9# | 变粉砂岩 | 10.5 | 53.59 | -- | -- | 1.62 | 6.38 | 3.14 | 5.32 | 1.82 | 0.13 | 0.59 | -- | 10.62 | 5.88 |
| 三通沟北  VI-VII  锰矿带 | ZK01-51 | 碳质粉砂岩 | 13.1 | 58.96 | 4.51 | 0.44 | 0.44 | 0.58 | 5.13 | 1.49 | 0.06 | 0.38 | 0.67 | 8.64 | 2.90 | 4.95 |
| ZK01-53 | 碳质粉砂岩 | 11.6 | 56.52 | 3.84 | 0.90 | 4.10 | 1.68 | 4.28 | 2.11 | 0.08 | 0.17 | 0.50 | 8.50 | 5.07 | 4.74 |
| ZK01-56 | 碳质粉砂岩 | 12.1 | 60.34 | 4.63 | 0.57 | 0.90 | 0.82 | 4.73 | 1.86 | 0.09 | 0.29 | 0.64 | 8.75 | 1.31 | 5.20 |
| ZK01-59 | 碳质粉砂岩 | 10.7 | 57.99 | 4.50 | 0.51 | 1.62 | 2.92 | 3.99 | 2.14 | 0.08 | 0.13 | 0.53 | 8.97 | 3.72 | 5.01 |
| ZK01-65 | 碳质粉砂岩 | 13.59 | 59.61 | 4.14 | 0.56 | 0.55 | 0.94 | 4.95 | 1.91 | 0.11 | 0.29 | 0.65 | 8.70 | 1.18 | 4.70 |
| ZK01-67 | 碳质粉砂岩 | 12.34 | 61.20 | 5.77 | 0.41 | 0.62 | 1.01 | 4.49 | 1.72 | 0.06 | 0.25 | 0.58 | 7.92 | 3.31 | 6.18 |
| ZK01-49 | 硅质粉砂岩 | 14.17 | 70.11 | 3.47 | 0.43 | 0.08 | 0.14 | 5.86 | 1.54 | 0.09 | 0.08 | 0.64 | 1.64 | 0.14 | 3.90 |
| ZK01-55.5 | 硅质粉砂岩 | 10.52 | 70.57 | 4.94 | 0.46 | 0.33 | 0.42 | 4.80 | 1.55 | 0.08 | 0.21 | 0.60 | 3.35 | 1.28 | 5.40 |
|  | ZK01-61 | 硅质粉砂岩 | 10.64 | 70.64 | 3.79 | 0.33 | 0.15 | 0.46 | 3.92 | 1.45 | 0.06 | 0.10 | 0.48 | 4.98 | 2.57 | 4.12 |

#据张强等（2018）；##据李杰等（2023）

**附表2 东昆仑锰矿围岩微量元素含量分析结果** (10-6)

**Table 2** Analysis results of trace elements in surrounding rock of east Kunlun Manganese deposit (10-6)

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **矿床名称** | **检测项目** | **样品名称** | **Rb** | **Ba** | **Sr** | **Cr** | **Co** | **Sc** | **Ti** | **Nb** | **Ta** | **Zr** | **Hf** | **U** | **Th** |
| 三通沟  北锰矿 | ZK706-806 | 硅质粉砂岩 | 52.3 | 196 | 228 | 70.0 | 31.9 | 10.0 | 0.189 | 5.90 | 0.40 | 87.0 | 2.10 | 4.69 | 6.57 |
| ZK706-829 | 硅质粉砂岩 | 87.3 | 285 | 56.0 | 70.0 | 39.7 | 9.80 | 0.197 | 7.20 | 0.56 | 70.0 | 1.80 | 3.44 | 9.23 |
| ZK706-R1 | 碳质粉砂岩 | 66.5 | 173 | 50.3 | 90.0 | 48.2 | 13.5 | 0.263 | 10.8 | 0.79 | 97.0 | 2.50 | 3.56 | 13.3 |
| ZK706-R2 | 碳质粉砂岩 | 74.5 | 189 | 38.7 | 120 | 71.5 | 14.8 | 0.306 | 11.6 | 0.87 | 113 | 3.00 | 3.41 | 14.4 |
| ZK706-R3 | 碳质粉砂岩 | 70.0 | 202 | 54.1 | 110 | 80.4 | 14.6 | 0.299 | 12.8 | 0.90 | 114 | 3.00 | 3.64 | 14.7 |
| ZK706-R5 | 碳质粉砂岩 | 68.2 | 205 | 25.1 | 90.0 | 38.4 | 10.7 | 0.222 | 8.30 | 0.63 | 75.0 | 1.90 | 3.73 | 9.80 |
| ZK706-R4 | 硅质岩 | 12.2 | 67.5 | 23.0 | 50.0 | 57.4 | 3.70 | 0.075 | 3.60 | 0.21 | 36.0 | 0.80 | 4.51 | 3.30 |
| STG-8B## | 硅质岩 | 27.6 | 808 | 21.0 | 41.4 | 0.82 | 2.43 | 0.04 | 3.05 | 0.23 | 30.1 | 0.86 | 1.91 | 3.14 |
| STG-9B-1## | 硅质岩 | 21.8 | 347 | 77.4 | 33.7 | 0.92 | 1.65 | 0.03 | 1.86 | 0.14 | 20.1 | 0.51 | 1.55 | 1.90 |
| STG-9B-3## | 硅质岩 | 34.6 | 424 | 38.2 | 43.2 | 1.23 | 2.93 | 0.06 | 4.20 | 0.32 | 54.7 | 1.41 | 2.50 | 4.40 |
| 洪水河  铁锰矿 | HP1-1 | 变砂岩 | 156 | 3080 | 102.5 | 80.0 | 43.6 | 19.0 | 0.406 | 18.8 | 1.36 | 304 | 7.20 | 2.06 | 14.6 |
| HP1-3 | 变砂岩 | 341 | 1000 | 109 | 40.0 | 56.7 | 17.8 | 0.34 | 12.6 | 0.93 | 174 | 4.30 | 1.17 | 9.55 |
| HSH01-B10# | 变粉砂岩 | 152 | 421 | 96.7 | 90.0 | -- | -- | -- | 13.2 | 1.10 | 157 | 4.00 | 1.58 | 15.4 |
| HSH02-B8# | 变粉砂岩 | 159 | 484 | 134 | 80.0 | -- | -- | -- | 12.5 | 1.10 | 147 | 3.80 | 1.55 | 14.5 |
| HSH02-B9# | 变粉砂岩 | 147 | 3490 | 222 | 60.0 | -- | -- | -- | 11.7 | 1.00 | 153 | 4.20 | 1.65 | 12.0 |
| 三通沟  北VI-VII锰矿带 | ZK01-51 | 碳质粉砂岩 | 134 | 1140 | 69.3 | 100 | 23.8 | 11.6 | 0.38 | 18.7 | 1.12 | 166 | 4.50 | 13.9 | 19.9 |
| ZK01-53 | 碳质粉砂岩 | 121 | 725 | 55.3 | 60.0 | 15.4 | 11.4 | 0.28 | 10.3 | 0.76 | 110 | 3.10 | 7.13 | 11.9 |
| ZK01-56 | 碳质粉砂岩 | 128 | 881 | 54.3 | 90.0 | 22.6 | 12.0 | 0.35 | 15.2 | 1.10 | 147 | 4.10 | 10.8 | 16.1 |
| ZK01-59 | 碳质粉砂岩 | 101 | 676 | 79.5 | 70.0 | 20.5 | 13.0 | 0.30 | 11.1 | 0.81 | 121 | 3.20 | 7.39 | 12.4 |
| ZK01-65 | 碳质粉砂岩 | 135 | 715 | 64.2 | 90.0 | 22.2 | 14.6 | 0.36 | 14.3 | 1.06 | 152 | 4.20 | 9.93 | 17.1 |
| ZK01-67 | 碳质粉砂岩 | 122 | 811 | 84.3 | 80.0 | 24.3 | 12.8 | 0.30 | 13.8 | 0.86 | 138 | 3.70 | 8.10 | 16.5 |
| ZK01-49 | 硅质粉砂岩 | 145 | 1530 | 63.0 | 90.0 | 11.3 | 12.2 | 0.36 | 15.4 | 1.08 | 146 | 3.90 | 10.1 | 14.3 |
| ZK01-55.5 | 硅质粉砂岩 | 126 | 928 | 60.8 | 80.0 | 19.3 | 11.6 | 0.33 | 13.8 | 0.99 | 139 | 3.80 | 8.76 | 13.1 |
| ZK01-61 | 硅质粉砂岩 | 102 | 729 | 31.7 | 70.0 | 18.0 | 9.00 | 0.28 | 10.7 | 0.81 | 112 | 3.00 | 5.40 | 12.3 |

#据张强等（2018）；##据李杰等（2023）

单位：除Ti为10-2外，其他均为10-6；--：未检测

**附表3 东昆仑锰矿稀土元素分析结果（**10-6**）**

**Table 1** Analysis results of rare earth elements in surrounding rock of east Kunlun Manganese deposit (10-6)

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **矿区** | **编号** | **样品** | **La** | **Ce** | **Pr** | **Nd** | **Sm** | **Eu** | **Gd** | **Tb** | **Dy** | **Y** | **Ho** | **Er** | **Tm** | **Yb** | **Lu** | **Eu/Eu\*** | **Ce/Ce\*** | **Pr/Pr\*** |
| 洪水河 | HP1-1 | 变质砂岩 | 45.1 | 110 | 12.0 | 47.2 | 10.6 | 1.86 | 10.5 | 1.71 | 9.79 | 59.3 | 2.05 | 6.00 | 0.83 | 5.28 | 0.86 | 0.83 | 1.08 | 0.98 |
| HP1-3 | 变质砂岩 | 37.3 | 105 | 9.61 | 35.2 | 7.37 | 1.73 | 7.95 | 1.21 | 7.59 | 42.6 | 1.37 | 3.84 | 0.61 | 3.68 | 0.66 | 1.06 | 1.28 | 0.92 |
| HSH01-B10# | 粉砂质千枚岩 | 42.7 | 106 | 9.36 | 36.5 | 7.52 | 1.58 | 7.29 | 1.17 | 6.67 | 37.8 | 1.30 | 2.78 | 0.56 | 3.64 | 0.55 | 1.00 | 1.22 | 0.88 |
| HSH02-B8# | 粉砂岩 | 38.6 | 94.7 | 8.66 | 33.8 | 7.01 | 1.39 | 6.71 | 1.04 | 6.40 | 37.3 | 1.27 | 3.58 | 0.55 | 3.61 | 0.55 | 0.95 | 1.20 | 0.90 |
| HSH02-B9# | 粉砂岩 | 33.5 | 72.1 | 7.75 | 29.3 | 6.37 | 1.29 | 6.08 | 1.03 | 6.09 | 38.1 | 1.21 | 3.60 | 0.58 | 3.70 | 0.61 | 0.97 | 1.03 | 0.99 |
| 三通沟VI-VII带 | ZK01-51 | 碳质粉砂岩 | 51.4 | 90.5 | 11.0 | 41.6 | 6.92 | 1.19 | 3.97 | 0.44 | 2.30 | 13.2 | 0.48 | 1.61 | 0.25 | 1.74 | 0.31 | 1.05 | 0.88 | 1.05 |
| ZK01-53 | 碳质粉砂岩 | 43.5 | 82.9 | 10.9 | 42.1 | 6.31 | 1.23 | 5.69 | 1.07 | 6.00 | 40.2 | 1.41 | 3.85 | 0.56 | 2.31 | 0.41 | 0.97 | 0.88 | 1.06 |
| ZK01-56 | 碳质粉砂岩 | 41.2 | 82.9 | 9.68 | 36.5 | 6.88 | 1.22 | 4.63 | 0.56 | 2.95 | 17.0 | 0.62 | 1.96 | 0.30 | 1.99 | 0.35 | 1.01 | 0.96 | 1.04 |
| ZK01-59 | 碳质粉砂岩 | 30.3 | 58.9 | 6.76 | 24.3 | 5.03 | 0.93 | 4.60 | 0.75 | 4.66 | 27.9 | 0.95 | 2.93 | 0.44 | 1.67 | 0.43 | 0.91 | 0.95 | 1.05 |
| ZK01-65 | 碳质粉砂岩 | 50.4 | 90.5 | 9.65 | 46.2 | 7.49 | 1.20 | 6.30 | 1.07 | 6.34 | 43.2 | 1.46 | 4.07 | 0.55 | 2.14 | 0.40 | 0.82 | 0.94 | 0.87 |
| ZK01-67 | 碳质粉砂岩 | 40.6 | 83.0 | 9.57 | 36.2 | 7.18 | 1.15 | 4.89 | 0.56 | 2.49 | 12.4 | 0.45 | 1.31 | 0.20 | 1.34 | 0.24 | 0.91 | 0.97 | 1.03 |
| ZK01-61 | 硅质粉砂岩 | 22.7 | 43.2 | 4.98 | 18.1 | 3.51 | 0.58 | 2.93 | 0.44 | 2.70 | 16.5 | 0.56 | 1.66 | 0.26 | 1.60 | 0.27 | 0.85 | 0.94 | 1.05 |
| ZK01-55.5 | 硅质粉砂岩 | 29.7 | 56.2 | 6.47 | 24.5 | 4.79 | 0.76 | 2.99 | 0.35 | 1.77 | 10.2 | 0.35 | 1.05 | 0.18 | 1.21 | 0.22 | 0.94 | 0.94 | 1.03 |
| ZK01-49 | 硅质粉砂岩 | 50.7 | 106.0 | 11.90 | 43.8 | 8.00 | 0.99 | 5.52 | 0.80 | 4.88 | 32.7 | 1.03 | 3.02 | 0.42 | 2.43 | 0.41 | 0.70 | 1.00 | 1.03 |
| 三通沟北 | ZK706-806 | 硅质粉砂岩 | 84.2 | 205 | 17.8 | 76.3 | 18.3 | 4.92 | 21.6 | 3.13 | 18.5 | 13.0 | 3.66 | 9.38 | 1.15 | 5.83 | 0.88 | 1.15 | 1.22 | 0.84 |
| ZK706-829 | 硅质粉砂岩 | 22.1 | 49.0 | 5.23 | 19.5 | 3.99 | 0.69 | 3.32 | 0.53 | 3.16 | 16.8 | 0.61 | 1.73 | 0.26 | 1.61 | 0.26 | 0.89 | 1.05 | 0.99 |
| ZK706-R1 | 碳质粉砂岩 | 34.1 | 91.4 | 8.06 | 30.2 | 5.88 | 1.19 | 5.18 | 0.75 | 4.33 | 23.4 | 0.84 | 2.40 | 0.34 | 2.09 | 0.33 | 1.02 | 1.27 | 0.90 |
| ZK706-R2 | 碳质粉砂岩 | 30.4 | 78.4 | 6.96 | 26.1 | 5.03 | 0.94 | 4.34 | 0.63 | 3.73 | 20.6 | 0.75 | 2.20 | 0.34 | 2.24 | 0.37 | 0.95 | 1.24 | 0.90 |
| ZK706-R3 | 碳质粉砂岩 | 55.4 | 142.5 | 11.70 | 44.6 | 8.33 | 1.47 | 7.37 | 1.09 | 6.39 | 35.2 | 1.25 | 3.52 | 0.53 | 3.15 | 0.51 | 0.88 | 1.29 | 0.85 |
| ZK706-R5 | 碳质粉砂岩 | 30.0 | 78.3 | 6.77 | 25.9 | 5.13 | 0.93 | 4.46 | 0.66 | 4.01 | 21.5 | 0.81 | 2.35 | 0.34 | 2.12 | 0.35 | 0.92 | 1.27 | 0.88 |
| ZK706-R4 | 硅质岩 | 28.6 | 52.0 | 6.26 | 25.9 | 5.52 | 0.95 | 5.37 | 0.78 | 4.80 | 29.4 | 0.98 | 2.71 | 0.37 | 2.19 | 0.35 | 0.82 | 0.90 | 1.00 |
| STG-8B## | 硅质岩 | 8.40 | 15.00 | 1.91 | 7.02 | 1.19 | 0.19 | 0.85 | 0.14 | 0.90 | 6.03 | 0.18 | 0.55 | 0.09 | 0.61 | 0.09 | 0.88 | 0.86 | 1.09 |
| STG-9B-1## | 硅质岩 | 5.99 | 11.88 | 1.53 | 5.68 | 1.00 | 0.19 | 0.80 | 0.13 | 0.76 | 5.03 | 0.16 | 0.49 | 0.07 | 0.51 | 0.07 | 1.01 | 0.90 | 1.09 |
| STG-9B-3## | 硅质岩 | 10.74 | 20.70 | 2.57 | 9.66 | 1.92 | 0.34 | 1.62 | 0.25 | 1.47 | 10.38 | 0.34 | 0.93 | 0.15 | 1.05 | 0.15 | 0.94 | 0.91 | 1.07 |

#据张强等（2018）；##据李杰等（2023）

(Pr/Pr\*)PAAS = [2Pr/(Ce + Nd)]PAAS; (Ce/Ce\*)PAAS = [2Ce/(La + Pr)]PAAS; (Eu/Eu\*) PAAS = [2Eu/(Sm+ Gd)]PAAS