**表1 满克头鄂博组划分沿革表 Table 1 Divisional history of the Manketou’ebo Formation**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 研究者 | 宁奇生唐克东 | 大兴安岭区测队 | 斯行健周志炎 | 吉林省煤管局 | 吉林省区测队 | 内蒙古的侏罗系（未刊） | 辽宁省第二区测队 | 辽宁省地层表 | 吉林区调队 | 内蒙古地层表 | 黑龙江区调二队 | 傅加友 | 内蒙古地质志 |
| 兴安盟 | 锡盟北部 | 镶黄旗赤峰地区 | 呼月伦贝盟 | 赤峰南部 | 大兴安岭中南部 | 镶黄旗-多伦地区 | 二连地区 |
| 时间 | 1959 | 1956-1959 | 1962 | 1966-1975 | 1974-1975 | 1982 | 1971-1973 | 1978 | 1977 | 1978 | 1981 | 1982 | 1991 |
| 地层单位名称 | 下兴安岭组 | 下兴安岭组 | 下兴安岭组 | 巨宝组 | 呼日格组 | 呼日格组 | 酸性火山岩组 | 满克头鄂博组 | 呼日格组 | 兴安岭群查干诺尔组 | 张家口组 | 上库力组下段木瑞组吉祥峰组 | 南台子组 | 满克头鄂博组 | 张家口组 | 查干诺尔组 |
| 厚度（m） | 1400-1700 | 1400-1700 |  | 315 | 315 | 315 |  | 208 |  | 1617 | 3430 |  | 1249 | 208-2348 | 460-3432 | 780-2608 |
| 研究者 | 内蒙古地层表（二代未刊） | 内蒙古岩石地层 | 中国地层典侏罗系 | 河北省区域地质调查研究所（1:25万区调） | 辽宁省地调院（1:25万区调） | 辽宁省地质志（二代） | 黑龙江省地质志（二代） | 内蒙古地质志（二代） | 本文 |
| 大兴安岭南部 |  | 霍林河-乌兰浩特地区 | 林西地区 | 翁牛特-敖汉地区 |  | 大兴安岭南部 | 隆化县（2001，J3）、张北县（2003，J3）、张家口（2007，J3）、丰宁县（2007，J3）、西老府（2008，K1） | 建平县幅（2004，J3） | 大兴安岭 |
| 时间 | 1991 | 1996 | 2000 | 2001-2008 | 2004 | 2017 | 2018 | 2018 | 2020 |
| 地层单位名称 | 查干诺尔组 | 满克头鄂博组 | 满克头鄂博组 | 满克头鄂博组 | 南台子组 | 满克头鄂博组 | 满克头鄂博组 | 张家口组一段 | 张家口组 | 张家口组K1 | 满克头鄂博组 | 满克头鄂博组 | 满克头鄂博组J3- K1 |
| 厚度（m） | 1443-1469 | 208 | 227-3033 | 518-1685 | 708-1272 | 208 | 197-2348 | 32-2565 | 495-1798 | 486 | 1368 | 208-1249 | 150-2121 |

**表2 满克头鄂博组主量（%）、微量和稀土元素（10-6）组成及相关地球化学参数**

Table 2 Major（%）, trace and rate earth（10-6） element contents and related geochemical paramcters of the Manketou’ebo Formation

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 送样号 | 岩石名称 | SiO2 | Al2O3 | Fe2O3 | FeO | CaO | MgO | K2O | Na2O | TiO2 | P2O5 | MnO | 灼失量 | 总量 | ALK | A/NK | A/CNK |
| TW2320 | 英安岩 | 71.47 | 14.18 | 1.52 | 0.19 | 1.52 | 0.45 | 4.83 | 3.22 | 0.31 | 0.069 | 0.026 | 2.09 | 99.875 | 8.05 | 1.347 | 1.067 |
| TW 2323 | 流纹岩 | 74.75 | 13.06 | 1.29 | 0.15 | 0.17 | 0.06 | 4.98 | 4.14 | 0.16 | 0.015 | 0.032 | 1.06 | 99.867 | 9.12 | 1.070 | 1.044 |
| TW 2329 | 流纹岩 | 75.96 | 12.90 | 1.34 | 0.25 | 0.16 | 0.12 | 3.84 | 4.00 | 0.095 | 0.010 | 0.020 | 1.17 | 99.865 | 7.84 | 1.201 | 1.17 |
| TW 2332 | 流纹质熔结凝灰岩 | 75.76 | 12.50 | 1.42 | 0.22 | 0.18 | 0.28 | 4.88 | 3.32 | 0.18 | 0.030 | 0.020 | 1.11 | 99.900 | 8.20 | 1.163 | 1.129 |
| 送样号 | 岩石名称 | Q | An | Ab | Or | A | P | C | Di | Hy | Il | Mt | Ap | DI | SI | σ | AR |
| TW 2320 | 英安岩 | 31.16 | 7.26 | 27.88 | 29.21 | 51.54 | 12.81 | 1.08 | 0 | 1.31 | 0.6 | 1.34 | 0.16 | 88.25 | 4.43 | 2.25 | 2.39 |
| TW 2323 | 流纹岩 | 31.51 | 0.75 | 35.47 | 29.8 | 64.4 | 1.62 | 0.59 | 0 | 0.34 | 0.31 | 1.2 | 0.04 | 96.78 | 0.57 | 2.61 | 4.35 |
| TW 2329 | 流纹岩 | 37.83 | 0.74 | 34.31 | 23 | 56.24 | 1.81 | 1.92 | 0 | 0.72 | 0.18 | 1.27 | 0.02 | 95.14 | 1.26 | 1.86 | 4.00 |
| TW 2332 | 流纹质熔结凝灰岩 | 37.41 | 0.71 | 28.45 | 29.21 | 56.98 | 1.39 | 1.52 | 0 | 0.96 | 0.35 | 1.33 | 0.07 | 95.07 | 2.78 | 2.04 | 3.20 |
| 送样号 | 岩石名称 | Cr | Ni | Co | Rb | Cs | Sr | Ba | V | Sc | Nb | Ta | Zr | Hf | Ga | U | Th |
| TW 2320 | 英安岩 | 8.18 | 3.55 | 2.57 | 219 | 10.7 | 137 | 480 | 27.7 | 3.56 | 9.88 | 1.09 | 205 | 5.60 | 14.2 | 3.05 | 27.4 |
| TW 2323 | 流纹岩 | 1.99 | 2.83 | 0.24 | 145 | 7.77 | 19.7 | 26.8 | 9.58 | 5.10 | 17.0 | 1.17 | 316 | 10.1 | 13.0 | 3.11 | 11.1 |
| TW 2329 | 流纹岩 | 2.08 | 1.10 | 0.18 | 186 | 8.74 | 29.5 | 35.3 | 2.80 | 3.62 | 17.9 | 1.74 | 306 | 10.1 | 14.1 | 6.14 | 12.0 |
| DG2332 | 流纹质熔结凝灰岩 | 7.81 | 2.12 | 1.08 | 185 | 9.51 | 50.8 | 118 | 13.2 | 2.78 | 12.4 | 1.25 | 244 | 7.74 | 12.6 | 4.24 | 18.9 |
| 送样号 | La | Ce | Pr | Nd | Sm | Eu | Gd | Tb | Dy | Ho | Er | Tm | Yb | Lu | Y | ΣREE | LREE/ HREE | （La/Yb）N | δEu |
| TW 2320 | 42.4 | 77.0 | 9.24 | 31.1 | 5.26 | 0.97 | 4.24 | 0.55 | 2.66 | 0.50 | 1.31 | 0.19 | 1.19 | 0.17 | 13.7 | 176.78 | 15.35 | 25.56 | 0.61 |
| TW 2323 | 21.1 | 60.8 | 5.17 | 18.0 | 3.48 | 0.12 | 2.98 | 0.43 | 2.40 | 0.48 | 1.30 | 0.20 | 1.34 | 0.21 | 13.2 | 118.01 | 11.63 | 11.29 | 0.11 |
| TW 2329 | 7.34 | 22.6 | 1.86 | 6.68 | 1.55 | 0.026 | 1.46 | 0.31 | 2.18 | 0.46 | 1.21 | 0.18 | 1.10 | 0.16 | 12.6 | 47.116 | 5.67 | 4.79 | 0.05 |
| TW 2332 | 34.7 | 67.6 | 8.58 | 31.2 | 6.04 | 0.24 | 4.98 | 0.76 | 4.21 | 0.78 | 1.92 | 0.26 | 1.64 | 0.24 | 20.7 | 163.15 | 10.03 | 15.18 | 0.13 |
| 数据由河北省区域地质矿产调查研究所实验室测试.  |

**表3 TW2320-TW2332锆石U-Pb分析结果** Table 3 Zircon U-Pb analyses of TW2320- **TW2332**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 样品测点 | 元素含量(×10-6) | Th/U | 同位素比值 | 年龄(Ma) |
| Pb | U | Th | 206Pb/238U | 1σ | 207Pb/235U | 1σ | 207Pb/206Pb | 1σ | 206Pb/238U | 1σ | 207Pb/235U | 1σ |
| TW2320.1 | 28 | 1232 | 511 | 0.41 | 0.02188 | 0.00035 | 0.14716 | 0.00482 | 0.04883 | 0.04883 | 139.53 | 1.86 | 139.40 | 3.50 |
| TW2320.2 | 58 | 2389 | 1802 | 0.75 | 0.02168 | 0.00028 | 0.14747 | 0.00331 | 0.04937 | 0.04937 | 138.25 | 1.61 | 139.67 | 2.56 |
| TW2320.3 | 58 | 2543 | 1707 | 0.67 | 0.02045 | 0.00030 | 0.15187 | 0.00495 | 0.05382 | 0.05382 | 130.51 | 1.75 | 143.56 | 3.49 |
| TW2320.4 | 53 | 2235 | 1477 | 0.66 | 0.02174 | 0.00035 | 0.14691 | 0.00390 | 0.04901 | 0.04901 | 138.67 | 1.88 | 139.18 | 2.93 |
| TW2320.5 | 24 | 1085 | 400 | 0.37 | 0.02132 | 0.00037 | 0.16026 | 0.01445 | 0.05393 | 0.05393 | 135.99 | 1.97 | 150.93 | 9.10 |
| TW2320.6 | 50 | 2140 | 1385 | 0.65 | 0.02183 | 0.00038 | 0.14762 | 0.00365 | 0.04910 | 0.04910 | 139.19 | 1.98 | 139.81 | 2.77 |
| TW2320.7 | 35 | 1502 | 860 | 0.57 | 0.02185 | 0.00034 | 0.14428 | 0.00434 | 0.04799 | 0.04799 | 139.31 | 1.84 | 136.85 | 3.25 |
| TW2320.8 | 41 | 1771 | 1129 | 0.64 | 0.02167 | 0.00025 | 0.14477 | 0.00388 | 0.04846 | 0.04846 | 138.22 | 1.49 | 137.29 | 2.96 |
| TW2320.9 | 61 | 2550 | 1899 | 0.74 | 0.02184 | 0.00032 | 0.15034 | 0.00364 | 0.04989 | 0.04989 | 139.29 | 1.76 | 142.21 | 2.72 |
| TW2320.10 | 45 | 1901 | 1168 | 0.61 | 0.02182 | 0.00026 | 0.15599 | 0.00414 | 0.05181 | 0.05181 | 139.16 | 1.53 | 147.19 | 2.93 |
| TW2320.11 | 37 | 1692 | 755 | 0.45 | 0.02144 | 0.00028 | 0.15118 | 0.00455 | 0.05108 | 0.05108 | 136.78 | 1.61 | 142.95 | 3.26 |
| TW2320.12 | 31 | 1393 | 634 | 0.45 | 0.02166 | 0.00028 | 0.14429 | 0.00439 | 0.04829 | 0.04829 | 138.14 | 1.61 | 136.85 | 3.28 |
| TW2320.13 | 26 | 1165 | 432 | 0.37 | 0.02187 | 0.00032 | 0.14922 | 0.00522 | 0.04950 | 0.04950 | 139.47 | 1.74 | 141.23 | 3.71 |
| TW2320.14 | 26 | 1170 | 404 | 0.35 | 0.02176 | 0.00037 | 0.14625 | 0.00517 | 0.04877 | 0.04877 | 138.75 | 1.93 | 138.60 | 3.75 |
| TW2320.15 | 28 | 1299 | 439 | 0.34 | 0.02156 | 0.00027 | 0.14715 | 0.00470 | 0.04947 | 0.04947 | 137.52 | 1.56 | 139.39 | 3.43 |
| TW2320.16 | 55 | 2312 | 1356 | 0.59 | 0.02222 | 0.00040 | 0.14849 | 0.00349 | 0.04852 | 0.04852 | 141.70 | 2.01 | 140.58 | 2.66 |
| TW2320.17 | 28 | 1296 | 410 | 0.32 | 0.02198 | 0.00034 | 0.14632 | 0.00449 | 0.04832 | 0.04832 | 140.13 | 1.80 | 138.66 | 3.31 |
| TW2320.18 | 25 | 1144 | 315 | 0.28 | 0.02188 | 0.00035 | 0.15191 | 0.00542 | 0.05032 | 0.05032 | 139.52 | 1.86 | 143.60 | 3.78 |
| TW2320.19 | 52 | 2209 | 1160 | 0.53 | 0.02224 | 0.00046 | 0.15365 | 0.00348 | 0.05038 | 0.05038 | 141.77 | 2.27 | 145.13 | 2.58 |
| TW2320.20 | 26 | 1205 | 302 | 0.25 | 0.02177 | 0.00040 | 0.14770 | 0.00529 | 0.04916 | 0.04916 | 138.81 | 2.06 | 139.88 | 3.79 |
| TW2320.21 | 37 | 1662 | 593 | 0.36 | 0.02205 | 0.00039 | 0.14997 | 0.00449 | 0.04934 | 0.04934 | 140.57 | 2.00 | 141.88 | 3.24 |
| TW2320.22 | 33 | 1467 | 548 | 0.37 | 0.02192 | 0.00038 | 0.14809 | 0.00452 | 0.04900 | 0.04900 | 139.79 | 1.96 | 140.23 | 3.29 |
| TW2320.23 | 28 | 1260 | 339 | 0.27 | 0.02210 | 0.00040 | 0.15050 | 0.00473 | 0.04953 | 0.04953 | 140.92 | 2.02 | 142.35 | 3.38 |
| TW2320.24 | 38 | 1658 | 697 | 0.42 | 0.02220 | 0.00039 | 0.15141 | 0.00428 | 0.04949 | 0.04949 | 141.56 | 2.00 | 143.15 | 3.09 |
| TW2320.25 | 43 | 1880 | 787 | 0.42 | 0.02222 | 0.00041 | 0.16463 | 0.00626 | 0.05347 | 0.05347 | 141.70 | 2.06 | 154.75 | 4.00 |
| TW2320.26 | 29 | 1315 | 536 | 0.41 | 0.02135 | 0.00025 | 0.14273 | 0.00496 | 0.04846 | 0.04846 | 136.18 | 1.49 | 135.47 | 3.69 |
| TW2320.27 | 47 | 2100 | 875 | 0.42 | 0.02177 | 0.00032 | 0.14971 | 0.00551 | 0.04991 | 0.04991 | 138.83 | 1.73 | 141.65 | 3.88 |
| TW2320.28 | 100 | 4130 | 2951 | 0.71 | 0.02178 | 0.00032 | 0.15301 | 0.00311 | 0.05099 | 0.05099 | 138.91 | 1.75 | 144.57 | 2.38 |
| TW2320.29 | 46 | 2043 | 1098 | 0.54 | 0.02139 | 0.00028 | 0.14645 | 0.00368 | 0.04967 | 0.04967 | 136.46 | 1.62 | 138.78 | 2.80 |
| TW2320.30 | 33 | 1430 | 619 | 0.43 | 0.02194 | 0.00037 | 0.15681 | 0.00554 | 0.05170 | 0.05170 | 139.88 | 1.92 | 147.91 | 3.75 |
| TW2323.1 | 23 | 1013 | 466 | 0.46 | 0.02233 | 0.00040 | 0.15079 | 0.00517 | 0.04900 | 0.00140 | 142.34 | 2.01 | 142.61 | 3.65 |
| TW2323.2 | 5 | 209 | 61 | 0.29 | 0.02158 | 0.00037 | 0.15135 | 0.02436 | 0.05077 | 0.00809 | 137.61 | 1.97 | 143.10 | 16.15 |
| TW2323.3 | 11 | 501 | 186 | 0.37 | 0.02156 | 0.00031 | 0.14182 | 0.00942 | 0.04764 | 0.00306 | 137.54 | 1.71 | 134.66 | 6.75 |
| TW2323.4 | 87 | 3277 | 2356 | 0.72 | 0.02152 | 0.00018 | 0.26099 | 0.02158 | 0.08782 | 0.00710 | 137.27 | 1.27 | 235.46 | 8.36 |
| TW2323.5 | 8 | 370 | 148 | 0.40 | 0.02254 | 0.00040 | 0.15317 | 0.01283 | 0.04918 | 0.00399 | 143.67 | 2.00 | 144.71 | 8.47 |
| TW2323.6 | 51 | 977 | 622 | 0.64 | 0.03161 | 0.00147 | 1.17633 | 0.14517 | 0.24624 | 0.02081 | 200.64 | 4.73 | 789.60 | 12.40 |
| TW2323.7 | 20 | 819 | 439 | 0.54 | 0.02290 | 0.00033 | 0.15622 | 0.00601 | 0.04953 | 0.00176 | 145.94 | 1.73 | 147.39 | 4.04 |
| TW2323.8 | 36 | 1617 | 817 | 0.51 | 0.02100 | 0.00021 | 0.15707 | 0.00394 | 0.05431 | 0.00133 | 134.00 | 1.39 | 148.14 | 2.80 |
| TW2323.9 | 43 | 1875 | 938 | 0.50 | 0.02158 | 0.00025 | 0.16086 | 0.00379 | 0.05420 | 0.00132 | 137.63 | 1.50 | 151.46 | 2.66 |
| TW2323.10 | 47 | 463 | 457 | 0.99 | 0.04217 | 0.00257 | 2.85569 | 0.31072 | 0.45618 | 0.02252 | 266.25 | 6.17 | 1370.31 | 10.95 |
| TW2323.11 | 31 | 1430 | 544 | 0.38 | 0.02107 | 0.00027 | 0.14243 | 0.00404 | 0.04906 | 0.00124 | 134.43 | 1.58 | 135.21 | 3.10 |
| TW2323.12 | 63 | 2811 | 1588 | 0.57 | 0.02081 | 0.00022 | 0.15867 | 0.00354 | 0.05527 | 0.00090 | 132.76 | 1.42 | 149.54 | 2.55 |
| TW2323.13 | 78 | 2998 | 2389 | 0.80 | 0.02108 | 0.00039 | 0.27899 | 0.01456 | 0.09475 | 0.00384 | 134.45 | 2.08 | 249.86 | 5.36 |
| TW2323.14 | 43 | 1760 | 843 | 0.48 | 0.02165 | 0.00021 | 0.23909 | 0.00625 | 0.08019 | 0.00197 | 138.05 | 1.36 | 217.68 | 2.89 |
| TW2323.15 | 44 | 1917 | 808 | 0.42 | 0.02215 | 0.00032 | 0.14648 | 0.00367 | 0.04798 | 0.00092 | 141.22 | 1.74 | 138.80 | 2.80 |
| TW2323.16 | 27 | 1281 | 462 | 0.36 | 0.02068 | 0.00024 | 0.13586 | 0.00421 | 0.04765 | 0.00132 | 131.96 | 1.48 | 129.35 | 3.34 |
| TW2323.17 | 66 | 2870 | 1965 | 0.68 | 0.02082 | 0.00029 | 0.14121 | 0.00316 | 0.04916 | 0.00069 | 132.82 | 1.68 | 134.12 | 2.56 |
| TW2323.18 | 53 | 2381 | 1142 | 0.48 | 0.02110 | 0.00031 | 0.15286 | 0.00550 | 0.05234 | 0.00136 | 134.62 | 1.75 | 144.44 | 3.81 |
| TW2323.19 | 18 | 681 | 681 | 1.00 | 0.02213 | 0.00036 | 0.14897 | 0.00844 | 0.04880 | 0.00256 | 141.09 | 1.86 | 141.00 | 5.80 |
| TW2323.20 | 38 | 1641 | 823 | 0.50 | 0.02149 | 0.00029 | 0.16028 | 0.00495 | 0.05415 | 0.00151 | 137.06 | 1.64 | 150.95 | 3.33 |
| TW2323.21 | 44 | 1971 | 954 | 0.48 | 0.02137 | 0.00026 | 0.14198 | 0.00353 | 0.04818 | 0.00098 | 136.31 | 1.55 | 134.81 | 2.78 |
| TW2323.22 | 27 | 1238 | 506 | 0.41 | 0.02104 | 0.00027 | 0.14220 | 0.00441 | 0.04910 | 0.00145 | 134.22 | 1.60 | 135.01 | 3.34 |
| TW2323.23 | 26 | 1154 | 455 | 0.39 | 0.02178 | 0.00027 | 0.16291 | 0.00516 | 0.05430 | 0.00162 | 138.91 | 1.57 | 153.24 | 3.40 |
| TW2323.24 | 47 | 1880 | 953 | 0.51 | 0.02182 | 0.00026 | 0.23793 | 0.01063 | 0.07980 | 0.00414 | 139.13 | 1.52 | 216.73 | 4.64 |
| TW2323.25 | 50 | 2074 | 1085 | 0.52 | 0.02244 | 0.00025 | 0.17057 | 0.00394 | 0.05516 | 0.00107 | 143.05 | 1.47 | 159.92 | 2.62 |
| TW2323.26 | 33 | 992 | 528 | 0.53 | 0.02537 | 0.00056 | 0.45471 | 0.04259 | 0.12516 | 0.00998 | 161.49 | 2.39 | 380.57 | 9.45 |
| TW2323.27 | 49 | 1857 | 1006 | 0.54 | 0.02213 | 0.00040 | 0.30628 | 0.02744 | 0.09731 | 0.00743 | 141.11 | 2.03 | 271.29 | 9.05 |
| TW2323.28 | 48 | 2112 | 985 | 0.47 | 0.02192 | 0.00023 | 0.14431 | 0.00340 | 0.04774 | 0.00093 | 139.79 | 1.42 | 136.88 | 2.66 |
| TW2323.29 | 50 | 2118 | 1085 | 0.51 | 0.02202 | 0.00021 | 0.16699 | 0.00361 | 0.05502 | 0.00104 | 140.43 | 1.34 | 156.80 | 2.49 |
| TW2323.30 | 37 | 335 | 222 | 0.66 | 0.09223 | 0.00222 | 0.93558 | 0.02904 | 0.07372 | 0.00158 | 568.69 | 2.59 | 670.57 | 3.34 |
| TW2323.31 | 67 | 2808 | 1699 | 0.61 | 0.02203 | 0.00038 | 0.15192 | 0.00330 | 0.05007 | 0.00071 | 140.50 | 1.96 | 143.61 | 2.50 |
| TW2323.32 | 25 | 1141 | 400 | 0.35 | 0.02211 | 0.00039 | 0.14019 | 0.00495 | 0.04605 | 0.00142 | 140.98 | 2.00 | 133.21 | 3.74 |
| TW2323.33 | 33 | 1443 | 645 | 0.45 | 0.02194 | 0.00026 | 0.14779 | 0.00425 | 0.04888 | 0.00125 | 139.89 | 1.53 | 139.96 | 3.13 |
| TW2323.34 | 40 | 1756 | 857 | 0.49 | 0.02187 | 0.00040 | 0.14874 | 0.00426 | 0.04940 | 0.00109 | 139.44 | 2.07 | 140.80 | 3.12 |
| TW2323.35 | 51 | 2002 | 1339 | 0.67 | 0.02288 | 0.00021 | 0.17344 | 0.00413 | 0.05502 | 0.00119 | 145.82 | 1.31 | 162.40 | 2.68 |
| TW2323.36 | 35 | 1517 | 686 | 0.45 | 0.02201 | 0.00030 | 0.14856 | 0.00399 | 0.04902 | 0.00117 | 140.33 | 1.64 | 140.64 | 2.96 |
| TW2323.37 | 46 | 1959 | 1081 | 0.55 | 0.02187 | 0.00028 | 0.14907 | 0.00377 | 0.04944 | 0.00099 | 139.47 | 1.59 | 141.09 | 2.82 |
| TW2323.38 | 7 | 246 | 209 | 0.85 | 0.02374 | 0.00062 | 0.16277 | 0.02158 | 0.04973 | 0.00644 | 151.23 | 2.77 | 153.12 | 13.32 |
| TW2323.39 | 5 | 192 | 146 | 0.76 | 0.02253 | 0.00042 | 0.20609 | 0.02885 | 0.06626 | 0.00917 | 143.65 | 2.09 | 190.27 | 14.05 |
| TW2329.1 | 90 | 3923 | 1307 | 0.33 | 0.02298 | 0.00017 | 0.15596 | 0.00181 | 0.04921 | 0.00029 | 146.47 | 1.19 | 147.16 | 1.70 |
| TW2329.2 | 34 | 1358 | 454 | 0.33 | 0.02413 | 0.00020 | 0.18955 | 0.00274 | 0.05727 | 0.00066 | 153.69 | 1.26 | 176.25 | 1.90 |
| TW2329.3 | 30 | 1260 | 460 | 0.37 | 0.02337 | 0.00017 | 0.15445 | 0.00212 | 0.04798 | 0.00048 | 148.91 | 1.19 | 145.83 | 1.85 |
| TW2329.4 | 26 | 1119 | 337 | 0.30 | 0.02325 | 0.00019 | 0.15486 | 0.00235 | 0.04835 | 0.00054 | 148.16 | 1.24 | 146.19 | 1.96 |
| TW2329.5 | 35 | 1489 | 600 | 0.40 | 0.02334 | 0.00020 | 0.16132 | 0.00222 | 0.05019 | 0.00045 | 148.73 | 1.26 | 151.86 | 1.85 |
| TW2329.6 | 34 | 1477 | 499 | 0.34 | 0.02318 | 0.00020 | 0.15391 | 0.00204 | 0.04825 | 0.00040 | 147.72 | 1.26 | 145.36 | 1.82 |
| TW2329.7 | 35 | 1424 | 582 | 0.41 | 0.02398 | 0.00019 | 0.15538 | 0.00215 | 0.04701 | 0.00044 | 152.74 | 1.22 | 146.65 | 1.86 |
| TW2329.8 | 28 | 1206 | 421 | 0.35 | 0.02353 | 0.00020 | 0.15190 | 0.00235 | 0.04683 | 0.00050 | 149.95 | 1.28 | 143.59 | 1.98 |
| TW2329.9 | 37 | 1598 | 652 | 0.41 | 0.02266 | 0.00017 | 0.15744 | 0.00206 | 0.05046 | 0.00042 | 144.45 | 1.22 | 148.46 | 1.80 |
| TW2329.10 | 34 | 1544 | 404 | 0.26 | 0.02273 | 0.00018 | 0.15415 | 0.00216 | 0.04929 | 0.00046 | 144.89 | 1.24 | 145.57 | 1.87 |
| TW2329.11 | 34 | 1510 | 579 | 0.38 | 0.02271 | 0.00017 | 0.15042 | 0.00200 | 0.04817 | 0.00044 | 144.76 | 1.21 | 142.28 | 1.82 |
| TW2329.12 | 65 | 2680 | 1794 | 0.67 | 0.02268 | 0.00018 | 0.17616 | 0.00221 | 0.05641 | 0.00041 | 144.58 | 1.22 | 164.75 | 1.76 |
| TW2329.13 | 29 | 1290 | 521 | 0.40 | 0.02249 | 0.00017 | 0.15602 | 0.00235 | 0.05026 | 0.00051 | 143.35 | 1.21 | 147.21 | 1.95 |
| TW2329.14 | 22 | 1021 | 304 | 0.30 | 0.02246 | 0.00018 | 0.14663 | 0.00231 | 0.04738 | 0.00056 | 143.16 | 1.22 | 138.94 | 2.00 |
| TW2329.15 | 28 | 1244 | 340 | 0.27 | 0.02295 | 0.00018 | 0.16853 | 0.00289 | 0.05309 | 0.00065 | 146.26 | 1.23 | 158.15 | 2.11 |
| TW2329.16 | 32 | 1397 | 759 | 0.54 | 0.02183 | 0.00017 | 0.16223 | 0.00204 | 0.05408 | 0.00049 | 139.23 | 1.21 | 152.65 | 1.77 |
| TW2329.17 | 38 | 1603 | 611 | 0.38 | 0.02359 | 0.00019 | 0.15736 | 0.00199 | 0.04846 | 0.00038 | 150.28 | 1.24 | 148.39 | 1.77 |
| TW2329.18 | 41 | 1759 | 750 | 0.43 | 0.02311 | 0.00018 | 0.15436 | 0.00203 | 0.04845 | 0.00039 | 147.29 | 1.23 | 145.76 | 1.81 |
| TW2329.19 | 33 | 1416 | 547 | 0.39 | 0.02295 | 0.00018 | 0.15721 | 0.00215 | 0.04964 | 0.00045 | 146.30 | 1.21 | 148.26 | 1.84 |
| TW2329.20 | 38 | 1592 | 569 | 0.36 | 0.02376 | 0.00020 | 0.16709 | 0.00234 | 0.05096 | 0.00044 | 151.39 | 1.27 | 156.89 | 1.87 |
| TW2329.21 | 30 | 1347 | 320 | 0.24 | 0.02293 | 0.00018 | 0.17841 | 0.00251 | 0.05641 | 0.00055 | 146.15 | 1.23 | 166.69 | 1.88 |
| TW2329.22 | 40 | 1610 | 657 | 0.41 | 0.02389 | 0.00021 | 0.16261 | 0.00217 | 0.04942 | 0.00041 | 152.18 | 1.28 | 152.98 | 1.82 |
| TW2329.23 | 51 | 2070 | 982 | 0.47 | 0.02336 | 0.00019 | 0.16580 | 0.00210 | 0.05144 | 0.00036 | 148.85 | 1.23 | 155.76 | 1.77 |
| TW2329.24 | 37 | 1142 | 480 | 0.42 | 0.02645 | 0.00032 | 0.47756 | 0.01948 | 0.12121 | 0.00390 | 168.31 | 1.54 | 396.40 | 4.26 |
| TW2329.25 | 35 | 1471 | 590 | 0.40 | 0.02342 | 0.00017 | 0.16942 | 0.00217 | 0.05251 | 0.00047 | 149.22 | 1.18 | 158.91 | 1.78 |
| TW2329.26 | 52 | 2156 | 982 | 0.46 | 0.02316 | 0.00018 | 0.15646 | 0.00191 | 0.04900 | 0.00033 | 147.58 | 1.23 | 147.60 | 1.74 |
| TW2329.27 | 103 | 4009 | 1525 | 0.38 | 0.02492 | 0.00024 | 0.17813 | 0.00233 | 0.05182 | 0.00031 | 158.68 | 1.34 | 166.45 | 1.80 |
| TW2332.1 | 54 | 2479 | 1117 | 0.45 | 0.02126 | 0.00016 | 0.14064 | 0.00172 | 0.04797 | 0.00035 | 136 | 1.20 | 135.62 | 1.74 |
| TW2332.2 | 56 | 2541 | 1032 | 0.41 | 0.02128 | 0.00017 | 0.15230 | 0.00192 | 0.05188 | 0.00036 | 136 | 1.23 | 135.75 | 1.77 |
| TW2332.3 | 70 | 3169 | 1798 | 0.57 | 0.02086 | 0.00016 | 0.14227 | 0.00167 | 0.04948 | 0.00031 | 133 | 1.21 | 133.07 | 1.71 |
| TW2332.4 | 48 | 2117 | 936 | 0.44 | 0.02186 | 0.00017 | 0.14871 | 0.00183 | 0.04937 | 0.00036 | 139 | 1.22 | 139.38 | 1.75 |
| TW2332.5 | 30 | 1337 | 437 | 0.33 | 0.02214 | 0.00019 | 0.15172 | 0.00213 | 0.04974 | 0.00047 | 141 | 1.26 | 141.16 | 1.87 |
| TW2332.6 | 58 | 2502 | 1307 | 0.52 | 0.02202 | 0.00016 | 0.14763 | 0.00175 | 0.04863 | 0.00033 | 140 | 1.19 | 140.40 | 1.71 |
| TW2332.7 | 27 | 1248 | 424 | 0.34 | 0.02173 | 0.00017 | 0.15134 | 0.00221 | 0.05053 | 0.00055 | 139 | 1.22 | 138.56 | 1.92 |
| TW2332.8 | 45 | 1838 | 804 | 0.44 | 0.02197 | 0.00016 | 0.24039 | 0.00513 | 0.07980 | 0.00158 | 140 | 1.19 | 140.08 | 2.47 |
| TW2332.9 | 264 | 1737 | 926 | 0.53 | 0.06557 | 0.00107 | 5.20611 | 0.13738 | 0.55447 | 0.00658 | 409 | 1.88 | 409.42 | 2.92 |
| TW2332.10 | 48 | 2102 | 1353 | 0.64 | 0.02081 | 0.00023 | 0.17085 | 0.00200 | 0.06115 | 0.00085 | 133 | 1.44 | 132.79 | 1.71 |
| TW2332.11 | 43 | 1897 | 761 | 0.40 | 0.02169 | 0.00017 | 0.16811 | 0.00323 | 0.05579 | 0.00079 | 138 | 1.22 | 138.32 | 2.29 |
| TW2332.12 | 65 | 2592 | 1834 | 0.71 | 0.02155 | 0.00017 | 0.27653 | 0.00585 | 0.09178 | 0.00144 | 137 | 1.22 | 137.47 | 2.45 |
| TW2332.13 | 42 | 1715 | 687 | 0.40 | 0.02240 | 0.00018 | 0.24207 | 0.00349 | 0.07840 | 0.00081 | 143 | 1.23 | 142.81 | 1.90 |
| TW2332.14 | 52 | 2421 | 1157 | 0.48 | 0.02059 | 0.00016 | 0.14077 | 0.00171 | 0.04959 | 0.00035 | 131 | 1.21 | 131.41 | 1.73 |
| TW2332.15 | 26 | 1281 | 349 | 0.27 | 0.02104 | 0.00016 | 0.13914 | 0.00194 | 0.04798 | 0.00048 | 134 | 1.20 | 134.21 | 1.87 |
| TW2332.16 | 28 | 1258 | 445 | 0.35 | 0.02172 | 0.00018 | 0.14943 | 0.00231 | 0.04985 | 0.00055 | 138 | 1.25 | 138.49 | 1.98 |
| TW2332.17 | 46 | 2052 | 956 | 0.47 | 0.02137 | 0.00016 | 0.14252 | 0.00173 | 0.04842 | 0.00036 | 136 | 1.22 | 136.32 | 1.73 |
| TW2332.18 | 46 | 2099 | 880 | 0.42 | 0.02117 | 0.00016 | 0.14263 | 0.00173 | 0.04889 | 0.00036 | 135 | 1.20 | 135.04 | 1.74 |
| TW2332.19 | 36 | 1699 | 654 | 0.38 | 0.02101 | 0.00016 | 0.14312 | 0.00192 | 0.04937 | 0.00043 | 134 | 1.21 | 134.04 | 1.83 |
| TW2332.20 | 61 | 2736 | 1405 | 0.51 | 0.02085 | 0.00015 | 0.15499 | 0.00180 | 0.05393 | 0.00037 | 133 | 1.17 | 133.02 | 1.70 |
| TW2332.21 | 44 | 1992 | 871 | 0.44 | 0.02117 | 0.00016 | 0.14187 | 0.00180 | 0.04862 | 0.00040 | 135 | 1.21 | 135.06 | 1.77 |
| TW2332.22 | 26 | 1206 | 401 | 0.33 | 0.02132 | 0.00017 | 0.14385 | 0.00215 | 0.04891 | 0.00052 | 136 | 1.22 | 135.99 | 1.94 |
| TW2332.23 | 22 | 1024 | 281 | 0.27 | 0.02136 | 0.00016 | 0.14016 | 0.00228 | 0.04767 | 0.00064 | 136 | 1.20 | 136.24 | 2.04 |
| TW2332.24 | 39 | 1593 | 697 | 0.44 | 0.02207 | 0.00018 | 0.24292 | 0.00590 | 0.07873 | 0.00138 | 141 | 1.26 | 140.71 | 2.73 |
| TW2332.25 | 26 | 1266 | 389 | 0.31 | 0.02102 | 0.00016 | 0.13387 | 0.00202 | 0.04617 | 0.00051 | 134 | 1.22 | 134.11 | 1.95 |
| TW2332.26 | 71 | 3081 | 1901 | 0.62 | 0.02127 | 0.00016 | 0.14334 | 0.00168 | 0.04887 | 0.00030 | 136 | 1.20 | 135.67 | 1.71 |
| TW2332.27 | 28 | 1291 | 455 | 0.35 | 0.02145 | 0.00017 | 0.14743 | 0.00210 | 0.04983 | 0.00049 | 137 | 1.23 | 136.82 | 1.89 |
| TW2332.28 | 28 | 1251 | 480 | 0.38 | 0.02168 | 0.00016 | 0.15388 | 0.00232 | 0.05143 | 0.00056 | 138 | 1.21 | 138.26 | 1.95 |
| TW2332.29 | 23 | 1038 | 288 | 0.28 | 0.02211 | 0.00019 | 0.14196 | 0.00227 | 0.04674 | 0.00060 | 141 | 1.26 | 140.95 | 2.03 |
| TW2332.30 | 36 | 1634 | 664 | 0.41 | 0.02097 | 0.00016 | 0.16616 | 0.00210 | 0.05755 | 0.00047 | 134 | 1.22 | 133.76 | 1.77 |
| TW2332.31 | 26 | 1191 | 374 | 0.31 | 0.02216 | 0.00018 | 0.15185 | 0.00221 | 0.04974 | 0.00051 | 141 | 1.26 | 141.29 | 1.91 |
| TW2332.32 | 49 | 2142 | 963 | 0.45 | 0.02236 | 0.00019 | 0.15023 | 0.00194 | 0.04877 | 0.00036 | 143 | 1.27 | 142.57 | 1.79 |
| TW2332.33 | 23 | 1029 | 273 | 0.27 | 0.02282 | 0.00020 | 0.15108 | 0.00235 | 0.04802 | 0.00053 | 145 | 1.28 | 145.48 | 1.99 |
| TW2332.34 | 29 | 1327 | 438 | 0.33 | 0.02167 | 0.00017 | 0.14261 | 0.00206 | 0.04778 | 0.00050 | 138 | 1.22 | 138.19 | 1.90 |
| TW2332.35 | 41 | 1803 | 782 | 0.43 | 0.02187 | 0.00018 | 0.14547 | 0.00192 | 0.04829 | 0.00039 | 139 | 1.25 | 139.45 | 1.81 |
| TW2332.36 | 53 | 2368 | 1058 | 0.45 | 0.02178 | 0.00017 | 0.15260 | 0.00222 | 0.05060 | 0.00042 | 139 | 1.23 | 138.89 | 1.91 |
| TW2332.37 | 74 | 3287 | 1735 | 0.53 | 0.02133 | 0.00016 | 0.14063 | 0.00161 | 0.04784 | 0.00028 | 136 | 1.20 | 136.04 | 1.69 |
| TW2332.38 | 32 | 1451 | 509 | 0.35 | 0.02169 | 0.00017 | 0.14432 | 0.00209 | 0.04820 | 0.00046 | 138 | 1.24 | 138.34 | 1.91 |
| TW2332.39 | 46 | 1996 | 894 | 0.45 | 0.02222 | 0.00018 | 0.15026 | 0.00190 | 0.04905 | 0.00037 | 142 | 1.23 | 141.68 | 1.77 |
| TW2332.40 | 25 | 1163 | 320 | 0.28 | 0.02160 | 0.00022 | 0.14815 | 0.00289 | 0.04969 | 0.00070 | 138 | 1.38 | 137.74 | 2.31 |

表4 满克头鄂博组同位素年龄按阶统计表

Table 4 Isotope statics by Stage of Manketuoebo Formation

|  |  |
| --- | --- |
| 晚侏罗世 | 早白垩世 |
| 卡洛维阶 | 牛津阶 | 基默里奇阶 | 提塘阶 | 贝里阿斯阶 | 凡兰吟阶 | 欧特里沃阶 | 巴列姆阶 | 阿普特阶 |
|  |  |  |  | 冀北阶 | 热河阶 |
| 166.1±1.2-163.5±1.0Ma | 163.5±1.0-157.3±1.0 Ma | 157.3±1.0-152.1±0.9 Ma | 152.1±0.9-145.0±0.8Ma | 145.0±0.8-139.8Ma | 139.8-132.9Ma | 132.9-129.4Ma | 129.4-125.0Ma | 125.0-113.0 Ma |
| 9 | 38 | 23 | 11 | 10 | 10 | 1 | 2 | 4 |