**Table 1. The abundance of organic material in samples from the Changling fault depression.**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| No | Well | Depth  m | Formation | Sample number | TOC | “A”  % | Cp  % | Pg（S1+S2） |
| % | mg.g-1 |
| 1 | F10 | 1860.0-2650.0 | K1*d* | 8 | 0.43 | — | — | 0.09 |
| 2 | F12 | 2777.0-2952.0 | K1*yc* | 2 | 2.01 | 0.1226 | 0.13 | 1.57 |
| 3 | CS2 | 2738.0-2746.0 | K1*d* | 2 | 0.44 | — | 0.02 | 0.21 |
| 4 | CS12 | 3085.0-3224.0 | K1*yc* | 2 | 0.97 | 0.0452 | 0.06 | 0.66 |
| 5 | CS5 | 5016.0-5193.0 | K1*yc* | 2 | 1.25 | 0.3946 | 0.34 | 4.09 |
| 6 | CS8 | 3975.0-3991.0 | K1*yc* | 2 | 1.37 | 0.4471 | 0.41 | 4.87 |
| 7 | TS1 | 2270.0-2272.2 | K1*d* | 1 | 2.62 | — | — | 2.82 |
| 8 | TS5 | 2871.0 | K1*yc* | 1 | 1.24 | 0.0877 | 0.09 | 1.08 |
| 9 | TS6 | 2962.5-3250.9 | K1*yc* | 3 | 1.14 | — | — | 0.71 |
| 3734.3-3738.0 | K1*sh* | 3 | 4.63 | — | — | 1.26 |
| 10 | TS8 | 2608.0 | K1*yc* | 1 | 1.48 | 0.2811 | 0.3 | 3.59 |
| 11 | LS1 | 2572.9 | K1*d* | 1 | 0.27 | — | — | 0.22 |
| 2858.0-2888.0 | K1*yc* | 3 | 1.14 | 0.0512 | 0.02 | 1.04 |
| 12 | LS14 | 2452.6-2454.0 | K1*d* | 1 | 1.13 | 0.0065 | — | 0.21 |
| 13 | XS1 | 3498.7-3677.6 | K1*d* | 2 | 0.21 | — | — | 0.21 |
| 4016.4-4502.0 | K1*yc* | 3 | 2.53 | — | — | 0.29 |

**Table 2. Physical properties of the Yingcheng Formation volcanic rocks**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Well | Well depth | Lithology | Permeability | Porosity | Rock density | Specific surface area | CH4 Diffusion coefficient | CO2 Diffusion coefficient | Date source |
| m | mD | % | g/cm3 | m2/g | cm2/s | cm2/s |
| CS1 | 3574.00 | Rhyolitic debris-crystal welded tuff | 0.011 | 5.4 | 2.48 | 0.9183 | 7.66E-06 | 7.20E-06 |  |
| CS103 | 3726.57 | Tuff | 9.25 | 29.3 | 1.92 | 1.20449 |  |  |  |
| CS105 | 3926.57 | Dacite | 0.0077 | 2.3 | 2.64 | 0.72726 | 7.78E-06 | 5.66E-06 |  |
| CS1-1 | 3727.90 | Rhyolite | 1.22 | 13.6 | 2.29 | 1.48609 |  |  |  |
| 3688.60 | Breccia | 0.086 | 8.0 |  |  |  |  | ▲ |
| 3749-3919 | Rhyolite | 1.89 | 7.34 |  |  |  |
| CS1-2 | 3671.15 | Rhyolitic crystal tuff | 0.0086 | 6.4 | 2.49 | 1.47609 | 5.48E-06 | 4.97E-06 |  |
| 3717.82-3831 | Rhyolite | 0.06 | 7.34 |  |  |  |  | ▲ |
| 3883-3690 | Rhyolite | 0.037 | 6.3 |  |  |  |  |
| CS3 | 3020.11 | Dacite | 0.0035 | 4.7 | 2.53 | 1.44722 |  |  |  |
| W21 | 1399.00 | Dacitic crystal tuff | 0.02 | 12.6 | 2.33 | 4.69497 | 1.51E-06 | 1.34E-06 |  |
| DS7 | 2435.50 | Dacite | 322 | 3.3 | 2.53 | 0.79501 |  |  |  |
| DS9 | 2010.60 | Andesite | 0.071 | 3.3 | 2.53 | 1.91823 | 4.81E-07 | 4.15E-07 |  |

**Table 3. Geochemical characteristics of gas in the southern Songliao Basin.**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Well | Depth  m | Formation | Natural gas component carbon isotope（δ13C/‰） | | | | Isotope series | | (3He/4He)/10-6 | R/Ra |
| CH4 | C2H6 | C3H8 | CO2 |
| CS1▲ | 3753 | K1*yc* | -22.42 | -23.42 |  | -4.91 | C1>C2 | negative |  |  |
| 3350-3594 | -26.07 | -26.86 |  | -6.98 | C1>C2 | negative | 2.88±0.08 | 2.06 |
| CS1-2▲ | 3697-3704 | K1*yc* | -16.54 | -24.34 |  | -6.64 | C1>C2 | negative |  |  |
| 3838 | -18.30 | -25.00 |  | -11.60 | C1>C2 |  | 2.65±0.07 | 1.90 |
| 3697-3704 | -23.40 | -26.55 | -26.45 | -8.65 | C1>C2<C3 | mixed |  |  |
| CS2▲ |  | K1*yc* | -15.70 |  |  | -6.40 |  |  |  |  |
| CS103▲ | 3498-3511 | K1*d* | -19.78 | -28.16 | -30.74 | -10.60 | C1>C2>C3 | negative |  |  |
| CS1-1▲ | 3880 | K1*yc* | -22.40 | -27.00 |  | -11.90 | C1>C2 | negative | 2.94±0.08 | 2.10 |
| 3739 | -22.20 | -26.90 | -27.00 | -7.50 | C1>C2 | negative | 2.91±0.08 | 2.08 |
| CS6▲ |  | K1*yc* | -23.48 | -29.88 | -30.32 | -6.37 | C1>C2>C3 | negative |  |  |
| CS2▲ |  | K1*d* | -17.63 | -24.60 | -24.20 | -6.62 | C1>C2<C3 |  |  |  |
| YS1■ | 3466 | K1*d* | -20.40 |  |  | -14.30 |  |  |  |  |
| 3495 | -20.80 | -24.70 |  | -15.30 | C1>C2 | negative |  |  |
|  | K1*yc* | -23.02 | -25.90 | -26.55 | -6.85 | C1>C2>C3 | negative |  |  |

**Table 4. The compositions of natural gas from the Yingcheng and Denglouku formations**

**of the southern Songliao Basin.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Well | Formatiojn | Depth | CH**4** | CO2 |
| m | % | % |
| CS1-3 | K1*d* | 3471-3552 | 91.71 | 0.19 |
| 3528-3534 | 92.58 | 0.39 |
| K1*yc* | 3786 | 2.41 | 97.09 |
| 3787 | 1.98 | 97.56 |
| 3889 | 0.43 | 99.29 |
| CS1-2 | K1*yc* | 3697 | 69.44 | 21.95 |
| 3838 | 20.05 | 68.33 |
| CS103 | K**1***d* | 3511-3498 | 92.03 | 0.61 |
| K1*yc* | 3732.5 | 61.87 | 31.65 |
| 3733.5 | 62.10 | 31.63 |
| 3820.5 | 24.54 | 12.48 |
| CS1 | K1*d* |  |  | 0.54 |
| K1*yc* | 3594-3753 | 66.78 | 22.31 |
| CS1-1 | K1*yc* | 3880 | 22.89 | 58.23 |
| H5▲ | K1*d* | 1852.8-1941.2 | 80.70 | 0.30 |
| N102▲ | K1*d* | 1638-1665.4 | 93.99 | 0.12 |
| DS5■ | K1*yc* | 3102-3142.8 | 1.52 | 98.5 |