Table 3. Relationship between attenuation coefficient of gas drainage flow and degree of drainage difficulty

Categories	Easy to Drain Coal Seams	Drainable Coal Seams	Difficult to Drain Coal Seam
The attenuation coefficient of gas drainage flow d^{-1}	<0.003	0.003~0.05	>0.05
Coal seam permeability coefficient $m^3/Mpa^2 \cdot d$	>10	10~0.1	<0.1

Gas drainage flow attenuation coefficient calculation formula [4]:

$$q_t = q_0 e^{-\beta' t} \quad (1)$$

where: q_t represents the gas flow volume of the drainage hole after t-days drainage; q_0 represents the initial gas flow volume of the gas drainage hole; t is the gas drainage time; β' represents the attenuation coefficient of the gas drainage flow of the drainage hole flow volume. According to formula (1), the average single-hole CH_4 drainage pure flow volume was fitted, and the average single-hole gas pure flow attenuation coefficient can be obtained. It can be seen from Figure 9 that the average single-hole gas flow attenuation coefficient in the original area was 0.052, and the average single-hole gas flow attenuation coefficient in the test area was 0.01, which was reduced by 80.76%. After the coal seams are injected with liquid CO_2, the coal seams that were difficult to drain are converted into drainable coal seams.

The above analysis shows that: The liquid CO_2 fracturing coal seam CH_4 displacement technology can effectively increase the CH_4 drainage concentration and pure flow, the maximum CH_4 drainage concentration is increased by 1.78 times, the maximum CH_4 drainage pure flow is increased by 1.4 times, the average single-hole gas drainage concentration was increased by 2.15 times, the drainage pure flow volume was increased by 2.27 times. After the coal seams are injected with liquid CO_2, the average single-hole gas flow attenuation coefficient was reduced by 80.76%, and the coal seam in the test area was changed from difficult extraction to extractable coal seam.

6. CONCLUSION

(1) The permeability improvement effect of liquid CO_2 on coal seams mainly includes phase change permeability improvement, negative temperature damage and extrusion stress damage. When liquid CO_2 of a certain pressure is injected into the coal mass, after heating and phase change, CO_2 diffuses and permeates into the interior of the coal matrices, with its strong adsorption capacity, it replaces and drives out the CH_4 in the coal seam.

(2) In the injection process, liquid CO_2 first fills in the cracking holes and visible cracks with larger opening degree, then enters the original weak plane areas, and finally penetrates into the coal matrix pores, the pressure at the orifice of the injection borehole presents fluctuation characteristics. When CO_2 flows into the coal mass cracks, and diffuses into the pores of the coal matrices, it's affected by flow resistance and adsorption, and the coal mass permeability in the fracture zone, plastic zone and elastic zone decreases in turn.

(3) In this coal seam liquid CO_2 injection permeability improvement and displacement test, the effective influence radius was more than 30 meters, the average single-hole gas drainage concentration was increased by 2.15 times, the drainage pure flow volume was increased by 2.27 times, and the pure flow attenuation coefficient was reduced by 80.76%. The test indicated that the coal seam liquid CO_2 injection can improve the permeability and displacement of coal seam gas, thus improving the gas drainage effect of the coal seams.

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