S1 Collection and processing of seepage experiment samples

Cut and process the irregular oil shale blocks extracted in parallel to the bedding direction into oil shale cylindrical specimens with a diameter of 50mm and a length of 100mm, and seal them with cling film to prevent weathering and deterioration. Heating to 100 ℃, 200 ℃, 300 ℃, 400 ℃, and 500 ℃ in an air atmosphere using a muffle furnace for subsequent infiltration experiments; The heating rate is 5 ℃/min, and after pyrolysis, it is cooled to room temperature and stored in a dryer.

The experiment used a self-designed oil shale pyrolysis core seepage device to simulate small-scale oil shale under certain formation pressure conditions in the target layer, and explored the groundwater permeability and pollutant release behavior at the water rock interface of the oil shale after pyrolysis at five temperatures. The burial depth of the oil shale collection area is 0-200m. To simulate in-situ mining, a confining pressure of 3MPa is set based on the formation pressure gradient of 0.025MPa/100m, and the pore pressure difference is maintained at 1MPa. The specific experimental steps are: (1) Place the pyrolysis core specimen into the core holder for seepage testing; (2) Through a computer data acquisition system, the medium water is used to provide a constant annular pressure and axial pressure at the inlet end. The computer simultaneously controls a separate channel to provide axial back pressure at the outlet end, in order to achieve the setting of pore pressure difference at the inlet and outlet; (3) Using a high-precision quality collection system, real-time measurement of the water flow rate through the specimen is carried out. (4) Observing the trend of the permeability coefficient of the computer window over time, the reading displayed after it stabilizes is the permeability coefficient of the oil shale specimen under the set pressure conditions; (5) After the test is completed, the pressure control system is closed in a stepped manner and the oil shale specimen is taken out. Perform flow statistics every 24 hours of seepage, and conduct short-term seepage experiments for a total of 15 days for each group of samples. The core gripper maintains a sealed state during seepage to restore the closed state of groundwater. Conduct three parallel experiments under each operating condition. After summarizing the seepage data, the evolution laws of various parameters of oil shale can be formed under certain pressure conditions and

temperature gradient fields.

S2 Comparative Analysis of Leaching and Percolation Experiments

The results of seepage and leaching experiments indicate that the overall concentrations of inorganic sulfate and heavy metal Mn are relatively low at a pyrolysis temperature of 100 ℃; When the pyrolysis temperature is at 300 ℃, the sulfate concentration slightly increases; As the pyrolysis temperature increases to 400 ℃ and 500 ℃, the release concentration of sulfate and Mn rapidly increases; Overall, the concentration trends of sulfate and Mn within this temperature range are relatively obvious, and the results of the two experiments are similar.

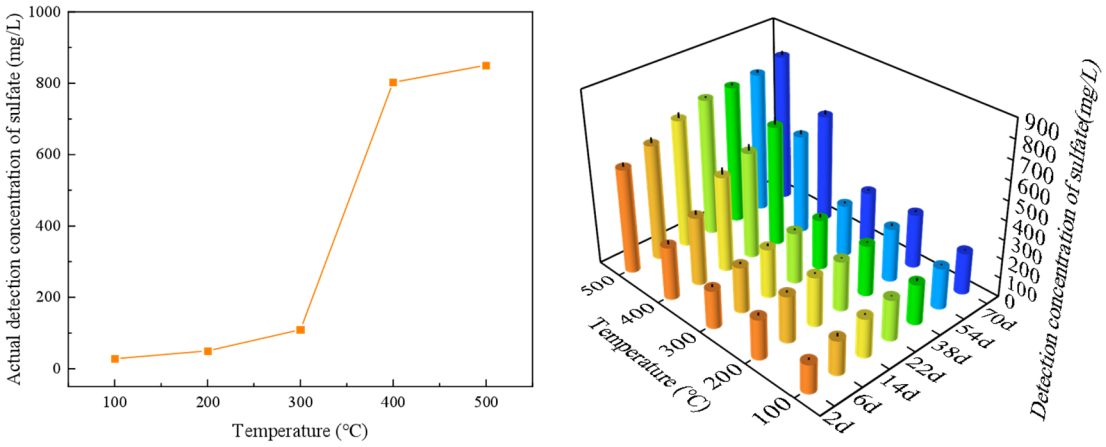

Figure S1 Seepage experiment (left) and leaching experiment (right) Actual detection concentration of sulfate

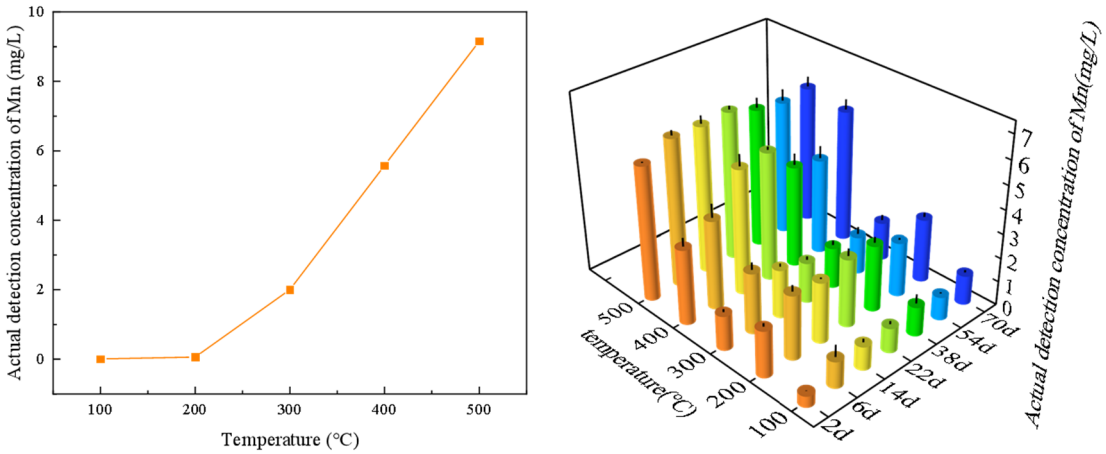

Figure S2 Percolation experiment (left) and leaching experiment (right) Actual detection concentration of Mn

S3 Correlation analysis between leaching experiment and seepage experiment

Pearson correlation analysis was conducted on the sulfate and heavy metal Mn in

the infiltration and leaching experiments, and the analysis results are shown in Table S1. There is a significant positive correlation (P<0.01) between sulfate in the infiltration and leaching experiments, with a correlation coefficient of 0.882. There is a significant positive correlation (P<0.01) between heavy metal Mn in the infiltration and leaching experiments, with a correlation coefficient of 0.952.

Table S1 Correlation analysis

		seepage experiment	leaching experiment
sulfate	seepage experiment	1	
	leaching experiment	0.882**	1
Mn	seepage experiment	1	
	leaching experiment	0.952**	1

Note: * * indicates a significant correlation at the 0.01 level.

In summary, there is a strong correlation between seepage experiment and leaching experiment, and using leaching experiment instead of seepage experiment is established.