Supplementary Material

Table S1. Clay mineral composition of the ore samples (%).

Sample ID	Montmorillonite	I/S	Illite	Kaolinite	Chlorite	C/S
Z1-Upper-13-3	71	/	4	4	4	17
Z1-Upper-14-2	76	/	4	2	3	15
Z1-Upper-15-3	64	/	5	4	4	23
Z1-Lower-8-2	57	/	5	7	7	24
Z1-Lower-9-2	/	8	14	78	/	/
Z1-Lower-19-3	62	/	4	5	6	23
Z1-Lower-29-1	75	/	3	5	2	15

I/S: mixed-layer illite/smectite; C/S: mixed-layer chlorite/smectite. The symbol "/" is retained as reported in the source data.

Table S2. Chemical composition of the original ore used in the leaching experiments.

Component	SiO_2	U	U^{6+}	Fe^{2+}	FeS_2	Total C	Inorganic C	S
Content (wt%)	61.0	0.082	0.041	0.95	0.87	2.04	1.58	0.68
Component	**Mg**	**Al**	**Fe**	**P**	**K**	**Na**	**U^{6+}/ΣU**	**LOI**
Content (wt%)	0.66	5.0	1.9	<0.5	2.25	1.24	50.0	10.9

LOI: loss on ignition; ΣU: total uranium. U^{6+}/ΣU is expressed as a percentage, not as wt%.

Table S3. Leachate pH, uranium concentration, and uranium recovery at different bicarbonate concentrations with hydrogen peroxide (reported dosage: 1 g/L; reagent concentration: 30%).

HCO_3^- concentration (g/L)	pH	U concentration (mg/L)	Uranium recovery (%)
0.3	8.54	12.7	7.7
0.5	8.48	15.3	9.3
1.0	8.27	18.9	11.5
1.5	8.16	23.8	14.5
2.0	8.15	27.7	16.9
3.0	8.06	29.0	17.7
5.0	8.08	33.9	20.7

Table S4. Results of the bicarbonate leaching kinetics test.

Leaching time (d)	Leachate pH	Leachate HCO_3^- (g/L)	Leachate U (mg/L)	Uranium recovery (%)	Increase (%)
2	8.16	1.07	23.8	14.5	0

Leaching time (d)	Leachate pH	Leachate HCO_3^- (g/L)	Leachate U (mg/L)	Uranium recovery (%)	Increase (%)
5	8.66	0.36	31.7	19.1	31.6

Table S5. Changes in bicarbonate concentration, uranium concentration, and uranium recovery during leaching at 0.6 MPa CO_2.

Leaching time	HCO_3^- concentration (g/L)	U concentration (mg/L)	Uranium recovery (%)
1 h	0.18	8.1	4.9
1 d	1.70	22.7	13.7
2 d	2.18	26.1	15.7
6 d	2.79	32.6	19.6

Table S6. Changes in bicarbonate concentration, uranium concentration, and uranium recovery during CO_2 + O_2 leaching at CO_2 pressures of 0.6 and 1.0 MPa.

(a) CO_2 pressure: 0.6 MPa

Leaching time (d)	CO_2 injection duration (h)	O_2 injection duration (h)	HCO_3^- (g/L)	U (mg/L)	Uranium recovery (%)
1	24	0	1.70	27.2	16.4
4	44	52	1.09	39.7	23.9
7	44	124	1.54	46.5	28.0
14	68	268	0.97	55.8	33.6
18	92	340	1.21	59.2	35.7
21	92	412	1.15	55.8	33.6

(b) CO_2 pressure: 1.0 MPa

Leaching time (d)	CO_2 injection duration (h)	O_2 injection duration (h)	HCO_3^- (g/L)	U (mg/L)	Uranium recovery (%)
2	43	0	2.39	31.7	19.3
5	91	29	2.16	45.0	28.2
8	127	74	1.48	75.7	49.3
11	180	96	1.42	75	51.85
15	120	120	2.33	87	59.35
19.5	144	144	1.42	87	61.39