

Supplementary information

Table S1. Method Detection limits

Al	0.059 mg/L
Na	0.388 mg/L
Ca	0.112 mg/L
Mg	0.023 mg/L
Mn	0.023 mg/L
S	0.074 mg/L
P	0.038 mg/L

Sc	0.037 mg/L
Y	0.004 mg/L
La	0.003 mg/L
Ce	0.008 mg/L
Pr	0.003 mg/L
Nd	0.008 mg/L
Sm	0.004 mg/L
Eu	0.003 mg/L
Gd	0.003 mg/L
Tb	0.002 mg/L
Dy	0.004 mg/L
Ho	0.002 mg/L
Er	0.004 mg/L
Tm	0.002 mg/L
Yb	0.004 mg/L
Lu	0.002 mg/L
Th	0.007 mg/L
U	0.002 mg/L
Rb	0.005 mg/L
Nb	0.059 mg/L
Cs	0.004 mg/L
Hf	0.012 mg/L
Ta	0.003 mg/L
Re	0.002 mg/L
Os	0.057 mg/L
Pt	0.003 mg/L

Table S2: Cerium and Europium anomalies in the whole rock

ID	Ce/Ce*	Eu/Eu*
D1	1.00	1.15
D1	0.95	1.17
C3	0.94	1.12
C2	0.93	1.13
C1	0.98	1.23
B	0.95	1.31
B	0.91	1.19
A2	0.74	1.17
A2	0.74	1.13
A1	0.70	1.05

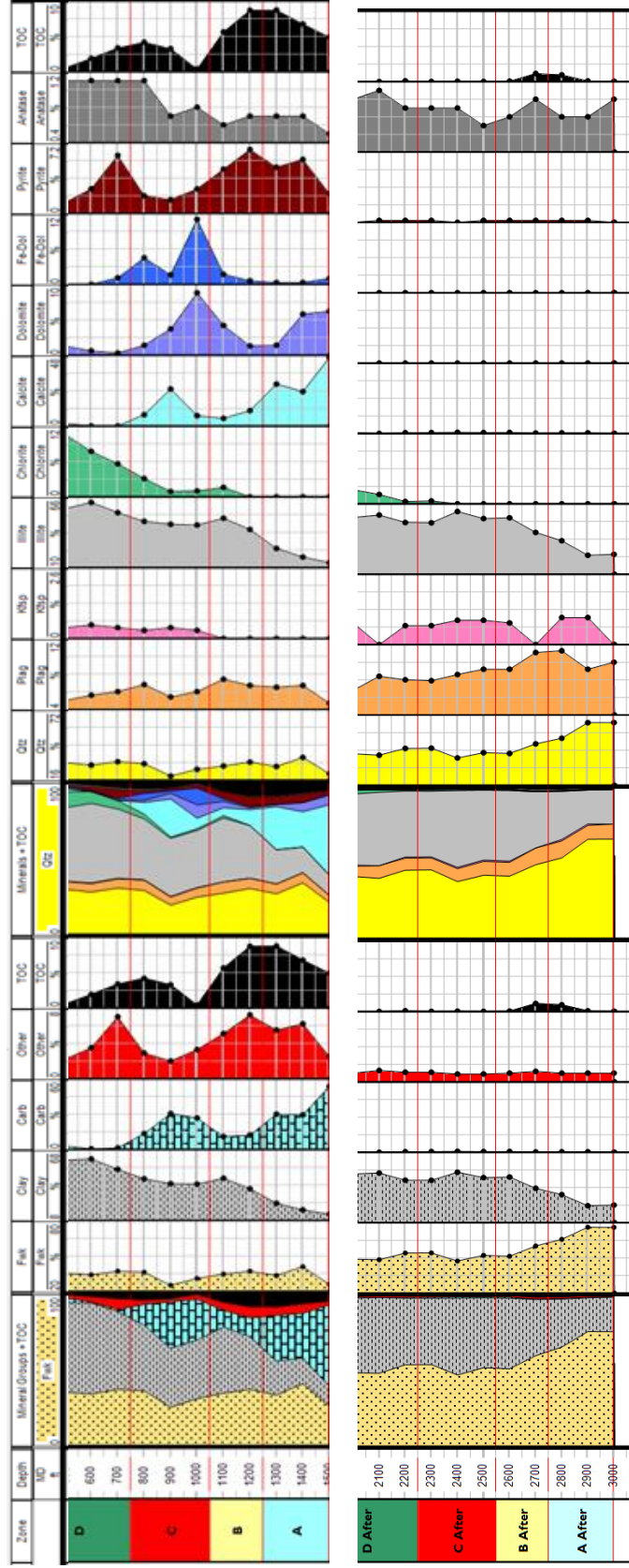
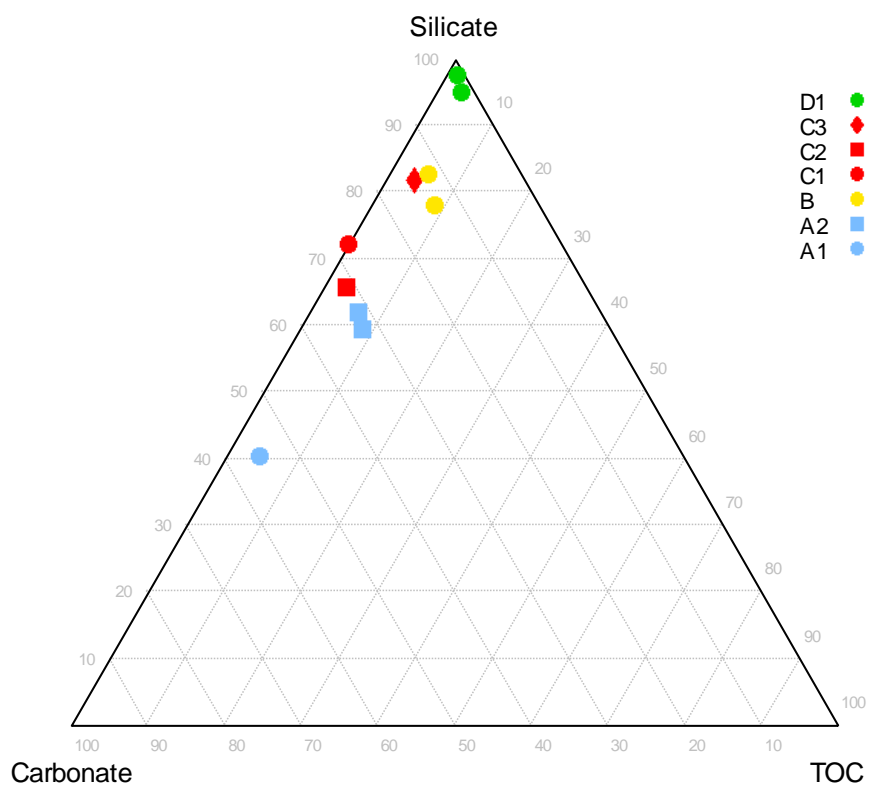
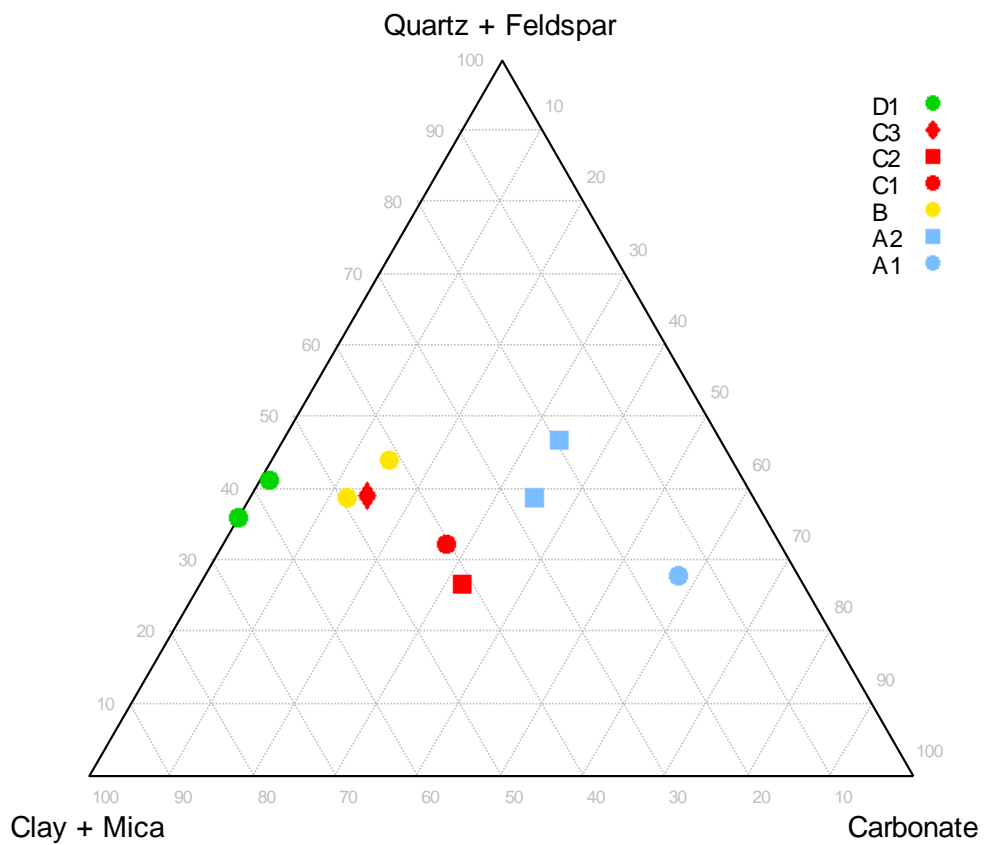


Figure S1. Comparative illustration to track the mineralogical changes in the residual samples after leaching. Calcite, dolomite, Fe-dolomite, and pyrite were completely removed using the traditional leaching chemicals. The TOC, which was measured via Leco Analyzer, recorded remnants in A1 sample and A2 samples. Chlorite dissolution was incomplete in the two uppermost samples from D1. The phases that did not dissolve were quartz, plagioclase, K-feldspar, illite, and anatase.



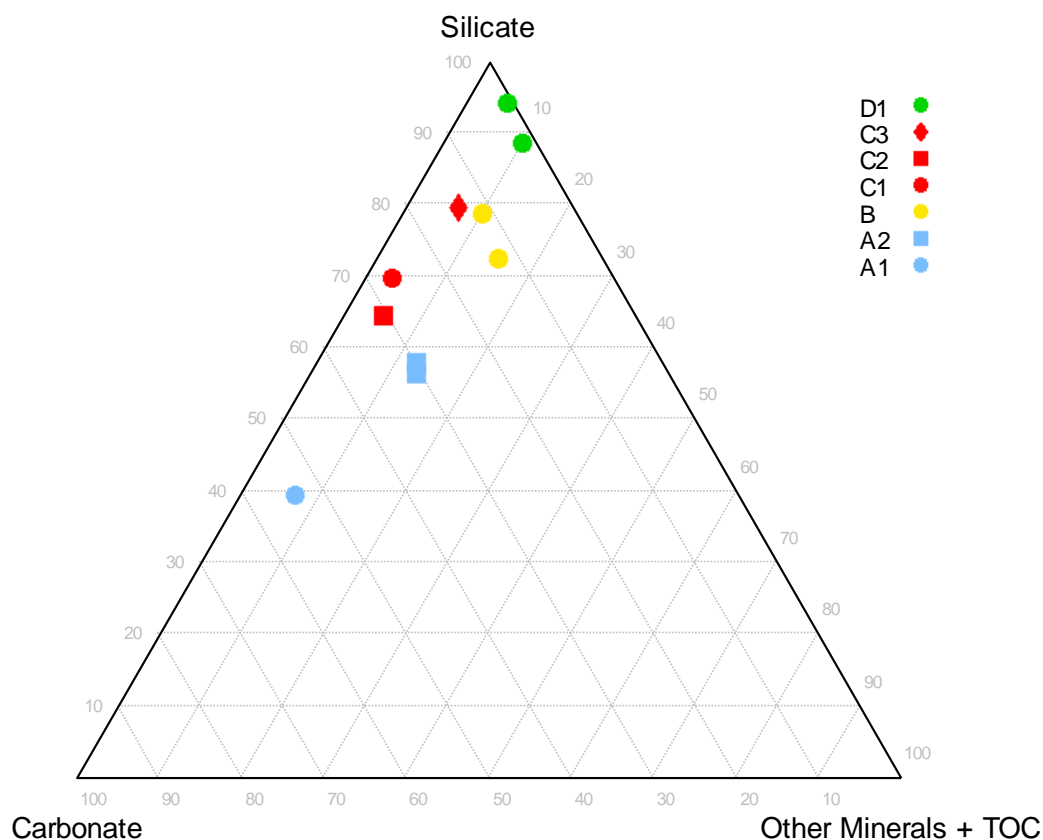


Figure S2 Ternary plots for mineralogical proportions of the samples

$Fwk = Quartz + Feldspar$; $Clay = Total\ Clay\ Minerals + Mica$; $Carb = Calcite + Dolomite + Fe-Dolomite$

Table S3. Formation location of global oil shales

Sample ID	Formation	Country	Mineralogy	Age (System or Series)
GR	Green River Formation	United States	Carbonate-quartz/feldspar	Eocene
TM	Timahdit oil shale	Morocco	Mixed layer clays-carbonate	Late Cretaceous
GI	Ghareb Formation	Israel	Carbonate	Late Cretaceous
GJ	Ghareb Formation	Jordan	Carbonate-clay	Late Cretaceous
KB	Kimmeridgian Blackstone	United Kingdom	Claystone	Jurassic
IF	Irati Formation	Brazil	Quartz-illite	Permian
GD	Glen Davis torbanite	Australia	Quartz	Permian
PR	Phosphoria Formation	United States	Quartz-ML clays	Permian
PO	Pumpherston Torbanite	United Kingdom	Quartz-kaolinite	Carboniferous
NA	New Albany Shale	United States	Quartz-illite	Mississippian-Devonian
EK	Narva-E mine kukersite	Estonia	Carbonate-clay	Ordovician
AS	Alum Shale Formation	Sweden	Quartz-illite	Cambrian