

Reservoir formation and modification caused by multiple tectonic activities: Insight from calcite U-Pb geochronology in the Huangqiao area, Subei Basin

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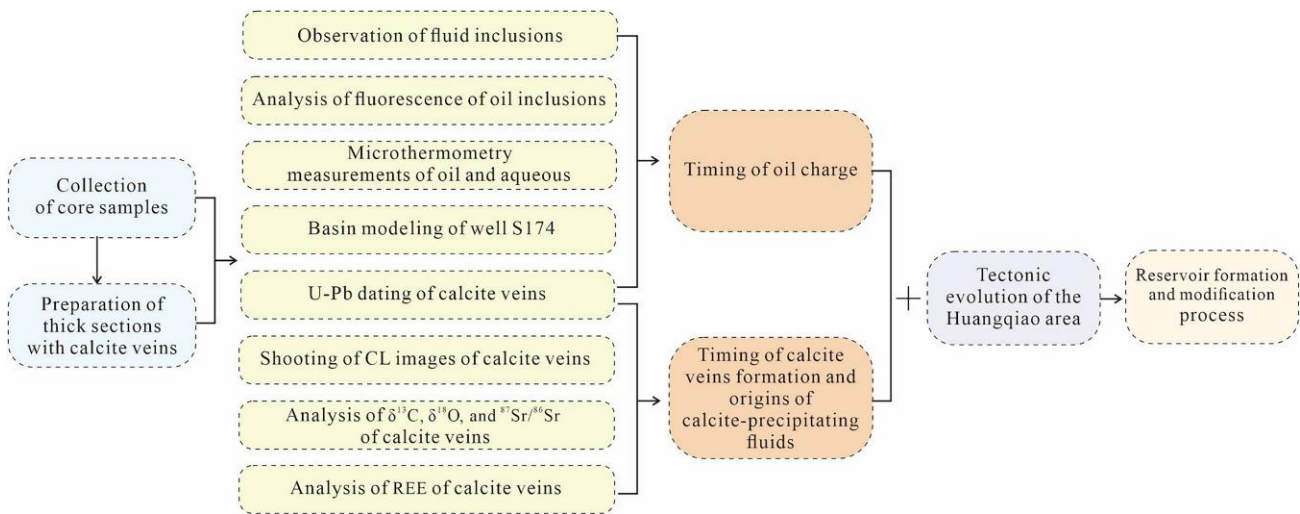


Figure S1. Flowchart of the research on reservoir formation and modification process in the Huangqiao area. CL = cathodoluminescence; REE = rare earth elements.

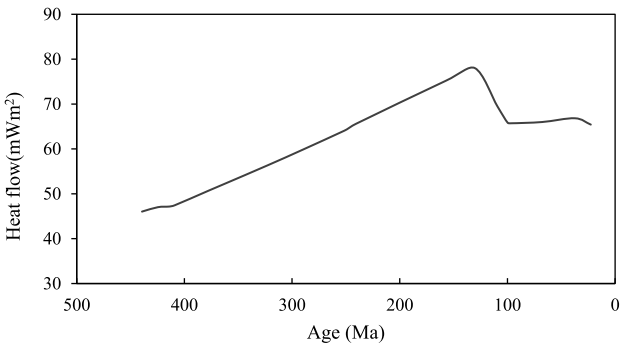


Figure S2. The heat flow model of the S174 well.

Table S1. The U-Pb Isotopic Compositions and Analytical Uncertainties for C1 Calcite Veins

$^{238}\text{U}/^{206}\text{Pb}$	$^{238}\text{U}/^{206}\text{Pb_Prop_2SE}$	$^{207}\text{Pb}/^{206}\text{Pb}$	$^{207}\text{Pb}/^{206}\text{Pb_Prop_2SE}$	U_PPM	Pb_PPM	U/Pb
26.38522	2.575866	0.492	0.097	0.047	0.0041	11.39
30.76923	2.177515	0.33	0.033	0.084	0.0064	13.05
45.80852	1.363973	0.0618	0.0044	0.793	0.0250	31.71
36.49635	2.131174	0.188	0.021	0.187	0.0088	21.30
40.16064	3.225754	0.199	0.026	0.216	0.0102	21.18
30.12048	2.358833	0.36	0.06	0.070	0.0049	14.29
41.15226	3.048316	0.249	0.031	0.096	0.0046	20.67
32.89474	2.705159	0.44	0.055	0.057	0.0042	13.58
36.10108	2.997563	0.321	0.042	0.085	0.0048	17.50
41.32231	2.5613	0.166	0.02	0.172	0.0070	24.60
43.91744	0.752209	0.0598	0.0026	2.300	0.0761	30.22
31.54574	2.487834	0.372	0.051	0.075	0.0050	15.03
39.52569	2.34342	0.263	0.031	0.146	0.0080	18.27
35.97122	2.458465	0.233	0.029	0.120	0.0063	19.20
29.49853	2.436456	0.478	0.067	0.072	0.0060	11.98
40.65041	2.148192	0.222	0.02	0.187	0.0090	20.80
39.37008	2.480005	0.175	0.021	0.154	0.0070	22.02
37.73585	2.56319	0.262	0.034	0.097	0.0052	18.67
30.95975	1.53361	0.34	0.027	0.143	0.0110	13.09
30.4878	2.230815	0.326	0.037	0.102	0.0079	12.88
43.10345	1.857907	0.0777	0.0068	0.515	0.0176	29.31
38.31418	2.348762	0.188	0.026	0.126	0.0060	20.88
41.49378	3.61564	0.114	0.012	0.272	0.0106	25.66
39.68254	2.362056	0.261	0.03	0.129	0.0066	19.56
40	2.72	0.123	0.011	0.365	0.0154	23.71
28.73563	2.312062	0.481	0.097	0.054	0.0050	10.82

Reported uncertainties are propagated 2σ (Prop_2SE), incorporating both internal counting statistics and external sources of error (e.g., calibration, instrumental drift, and decay constant uncertainties).

Table S2. The U-Pb Isotopic Compositions and Analytical Uncertainties for C2 Calcite Veins

$^{238}\text{U}/^{206}\text{Pb}$	$^{238}\text{U}/^{206}\text{Pb_Prop_2SE}$	$^{207}\text{Pb}/^{206}\text{Pb}$	$^{207}\text{Pb}/^{206}\text{Pb_Prop_2SE}$	U_PPM	Pb_PPM	U/Pb
40.48583	4.917308	0.296	0.028	0.158	0.0083	19.09
47.16981	4.89498	0.169	0.017	0.189	0.0070	26.83
47.16981	5.784976	0.157	0.021	0.150	0.0056	26.92
36.49635	4.262348	0.188	0.021	0.187	0.0088	21.30
40.16064	6.451508	0.199	0.026	0.216	0.0102	21.18
30.12048	4.717666	0.36	0.06	0.070	0.0049	14.29
41.15226	6.096632	0.249	0.031	0.096	0.0046	20.67
33.22259	3.311222	0.199	0.019	0.175	0.0096	18.13
30.76923	4.35503	0.33	0.033	0.084	0.0064	13.05
53.10674	2.651106	0.0611	0.0041	1.119	0.0307	36.45
55.86592	1.7478	0.0519	0.0021	5.083	0.1292	39.34
55.83473	1.62111	0.0518	0.0015	6.565	0.1665	39.43
46.70715	1.941586	0.18	0.015	0.743	0.0308	24.12
40.16064	2.419316	0.284	0.032	0.123	0.0062	19.94
49.75124	2.722705	0.151	0.016	0.307	0.0104	29.52
51.28205	2.314267	0.132	0.013	0.367	0.0119	30.76
50.99439	2.158355	0.0712	0.006	1.180	0.0312	37.82
45.45455	2.68595	0.165	0.018	0.695	0.0337	20.62
54.49591	2.316448	0.0741	0.0063	0.934	0.0243	38.44
36.76471	2.432958	0.257	0.034	0.113	0.0058	19.35
51.81347	4.026954	0.134	0.016	0.902	0.0302	29.87
52.30126	1.586544	0.0766	0.0055	0.780	0.0224	34.85
45.24887	1.883663	0.113	0.012	0.385	0.0136	28.37
51.65289	1.894295	0.0981	0.0086	0.519	0.0156	33.35
40	2.08	0.21	0.018	0.235	0.0108	21.69
34.24658	2.462939	0.322	0.038	0.090	0.0056	16.13
37.83585	5.12638	0.263	0.034	0.097	0.0052	18.67
31.05975	3.06722	0.341	0.027	0.143	0.0110	13.09
31.4778	4.46163	0.325	0.037	0.102	0.0079	12.88
38.41318	4.697524	0.187	0.026	0.126	0.0060	20.88
40.18254	4.724112	0.262	0.03	0.129	0.0066	19.56
40.27008	4.96001	0.176	0.021	0.154	0.0070	22.02

Reported uncertainties are propagated 2σ (Prop_2SE), incorporating both internal counting statistics and external sources of error (e.g., calibration, instrumental drift, and decay constant uncertainties).

Table S3. The U-Pb Isotopic Compositions and Analytical Uncertainties for C3 Calcite Veins

$^{238}\text{U}/^{206}\text{Pb}$	$^{238}\text{U}/^{206}\text{Pb_Prop_2SE}$	$^{207}\text{Pb}/^{206}\text{Pb}$	$^{207}\text{Pb}/^{206}\text{Pb_Prop_2SE}$	U_PPM	Pb_PPM	U/Pb
57.20824	1.309113	0.1579	0.0069	1.794	0.0549	32.68
47.16981	2.44749	0.246	0.02	0.850	0.0375	22.67
58.44535	1.229709	0.1104	0.0056	1.747	0.0488	35.80
57.77008	2.002429	0.141	0.013	2.017	0.0604	33.39
50.02501	2.152152	0.195	0.017	2.554	0.0953	26.80
61.05006	1.34176	0.095	0.0062	2.430	0.0625	38.88
60.71645	1.364	0.1164	0.007	1.876	0.0506	37.08
62.53909	1.095118	0.0884	0.0042	2.495	0.0613	40.70
53.4188	1.341177	0.174	0.012	2.064	0.0693	29.78
62.89308	1.107551	0.0709	0.0036	2.711	0.0637	42.56
61.46281	1.322187	0.0819	0.0039	2.218	0.0547	40.55
63.85696	1.100982	0.0802	0.0045	2.671	0.0632	42.26
60.45949	1.498694	0.1407	0.0088	1.472	0.0412	35.73
55.06608	1.121941	0.1396	0.0068	2.290	0.0713	32.12
48.54369	1.861627	0.245	0.017	1.113	0.0473	23.53
60.90134	1.37232	0.095	0.0058	1.969	0.0503	39.15
61.61429	1.17686	0.1062	0.0077	3.676	0.0982	37.43
55.77245	1.524177	0.1822	0.0087	1.046	0.0345	30.32
57.33945	1.676784	0.148	0.013	1.134	0.0350	32.40
64.97726	1.139952	0.0713	0.0033	2.926	0.0666	43.93
48.1232	1.806357	0.215	0.014	2.871	0.1159	24.77
57.73672	2.2668	0.176	0.015	0.835	0.0260	32.12
59.55926	1.454395	0.1526	0.0085	1.690	0.0496	34.07
58.24112	1.288971	0.15	0.038	1.957	0.0551	35.52
56.33803	2.126562	0.163	0.019	1.146	0.0371	30.89
62.77464	1.655075	0.0668	0.0049	1.259	0.0297	42.44
57.20824	1.309113	0.1579	0.0069	1.794	0.0549	32.68

Reported uncertainties are propagated 2σ (Prop_2SE), incorporating both internal counting statistics and external sources of error (e.g., calibration, instrumental drift, and decay constant uncertainties).

Table S4. The U-Pb Isotopic Compositions and Analytical Uncertainties for C4 Calcite Veins

$^{238}\text{U}/^{206}\text{Pb}$	$^{238}\text{U}/^{206}\text{Pb_Prop_2SE}$	$^{207}\text{Pb}/^{206}\text{Pb}$	$^{207}\text{Pb}/^{206}\text{Pb_Prop_2SE}$	U_PPM	Pb_PPM	U/Pb
13.88889	3.858025	0.66	0.068	0.072	0.0172	4.21
17.7305	1.320356	0.675	0.056	0.067	0.0123	5.44
30.30303	2.387511	0.481	0.051	0.071	0.0059	12.09
32.25806	1.873049	0.502	0.032	0.232	0.0202	11.50
33.0033	2.614123	0.559	0.066	0.073	0.0062	11.82
42.37288	2.693192	0.39	0.029	0.296	0.0177	16.72
43.29004	3.37325	0.347	0.04	0.148	0.0082	18.12
43.66812	2.860357	0.379	0.052	0.137	0.0081	16.96
44.44444	2.962963	0.374	0.034	0.198	0.0110	18.06
47.61905	2.721088	0.348	0.028	0.284	0.0148	19.27
50.25126	3.030227	0.306	0.027	0.176	0.0081	21.85
52.35602	3.289384	0.33	0.032	0.175	0.0074	23.56
54.34783	3.249055	0.299	0.031	0.188	0.0087	21.53
54.82456	2.043898	0.242	0.017	0.494	0.0191	25.82
55.55556	3.395062	0.311	0.03	0.192	0.0084	22.75
55.55556	3.703704	0.336	0.033	0.283	0.0114	24.84
57.50431	2.612329	0.264	0.019	0.386	0.0146	26.38
57.80347	2.238631	0.215	0.016	0.496	0.0183	27.15
58.78895	1.278772	0.1744	0.0067	2.450	0.0763	32.11
58.82353	2.249135	0.222	0.016	0.495	0.0168	29.39
58.82353	2.214533	0.184	0.013	0.527	0.0174	30.24
61.50062	2.950214	0.168	0.019	0.325	0.0096	33.74
62.1504	2.703871	0.188	0.018	0.330	0.0099	33.21
66.357	1.585171	0.133	0.0067	1.527	0.0409	37.33
67.61325	1.828621	0.1115	0.0075	1.206	0.0300	40.24
71.42857	1.22449	0.1028	0.0052	3.463	0.0788	43.95
71.42857	1.27551	0.0632	0.0031	3.730	0.0778	47.94
71.68459	2.055472	0.0937	0.0072	0.964	0.0219	44.12
72.72727	1.004959	0.0506	0.0016	8.670	0.1757	49.35
72.7802	1.853935	0.0891	0.0068	1.097	0.0244	45.03
73.80074	1.68843	0.0817	0.0045	1.732	0.0389	44.58
74.34944	1.71363	0.0688	0.0037	1.944	0.0402	48.31
74.79432	1.957966	0.0678	0.0041	1.810	0.0382	47.38
76.14986	0.811832	0.04838	0.00085	3.750	0.7079	5.30

Reported uncertainties are propagated 2σ (Prop_2SE), incorporating both internal counting statistics and external sources of error (e.g., calibration, instrumental drift, and decay constant uncertainties).

Table S5. The Input Parameters for Basin Modeling of the Well S174

Formation	Type	Begin Age, Ma	Top Depth, m	Present Thick, m	Eroded Thick, m	Lithology	Kerogen
Q	F	2.6	0	168		Q	
N	F	22	168	225.4		N	
K _{2p} .E	E	38			−984		
K _{2p}	F	99	393.4	846.6		K	
J.E	E	164			−953		
J	D	201			953	J	
T.E	E	223			−129		
T _{1q} ²	F	238	1240	141		T	
T _{1q} ¹	F	252	1381	228		T	
P _{2d}	F	258	1609	47.6		P _{2d}	
P _{2l}	F	264	1656.6	142.4		P _{2l}	Type II (Burnham '89)
P _{1g}	F	270	1799	35		P _{1g}	
P _{1q}	F	298	1834	190.5		P _{1q}	
C	F	354	2024.5	223		C	
D _{3w} .E	E	407			−289.5		
D _{3w} .D	D	413			289.5	D	
D _{3w} .F	F	415	2247.5	146		D	
S _{2f}	F	427	2393.5	539		S _{2f}	
S _{1g}	F	432	2932.5	307.13		S _{1g}	Type II (Burnham '89)

Abbreviations: C = Carboniferous; D = deposition (marked as a normal sedimentary interval); D_{3w}.D. = Upper Devonian Wutong Formation with deposition; D_{3w}.E. = Upper Devonian Wutong Formation with erosion; D_{3w}.F. = Upper Devonian Wutong Formation; E = erosion surface/hiatus; F = Formation (used when no erosion/deposition emphasis is needed); J = Jurassic; J.E = Jurassic with erosion; K_{2p} = Upper Cretaceous Pakou Formation; K_{2p}.E. = Upper Cretaceous Pukou Formation with erosion; N = Neogene; P_{1g} = upper Permian Gufeng Formation; P_{1q} = upper Permian Qixia Formation; P_{2d} = upper Permian Dalong Formation; P_{2l} = upper Permian Longtan Formation; Q = Quaternary; T_{1q}¹ = Lower Triassic Qinglong Formation first member; T_{1q}² = Lower Triassic Qinglong Formation second member; S_{1g} = middle Silurian Gaojiabian Formation; S_{2f} = middle Silurian Fentou Formation; T.E. = Triassic with erosion.

Table S6. The Lithology of Formations of the Well S174

Formation	Lithology Pattern	Sandstone, %	Siltstone, %	Shale, %	Limestone, %	Dolomite, %	Evaporite, %	Kerogen, %	Igneous, %	Total, %
Q	Sandstone	95	5	0	0	0	0	0	0	100
N	Sandstone	65	35	0	0	0	0	0	0	100
K	Sandstone	30	60	10	0	0	0	0	0	100
J	Sandstone	50	40	10	0	0	0	0	0	100
T	Limestone	0	10	20	70	0	0	0	0	100
P _{2d}	Siltstone	0	65	20	5	10	0	0	0	100
P _{2l}	Siltstone	10	80	5	0	5	0	0	0	100
P _{1g}	Siltstone	0	75	10	0	15	0	0	0	100
P _{1q}	Limestone	0	0	10	90	0	0	0	0	100
C	Limestone	30	0	0	70	0	0	0	0	100
D	Sandstone	60	40	0	0	0	0	0	0	100
S _{2f}	Sandstone	50	50	0	0	0	0	0	0	100
S _{1g}	Siltstone	20	80	0	0	0	0	0	0	100

Abbreviations: C = Carboniferous; D = deposition (marked as a normal sedimentary interval); J = Jurassic; K = Cretaceous; N = Neogene; P_{1g} = upper Permian Gufeng Formation; P_{1q} = upper Permian Qixia Formation; P_{2d} = upper Permian Dalong Formation; P_{2l} = upper Permian Longtan Formation; Q = Quaternary; T = Triassic; S_{1g} = middle Silurian Gaojiabian Formation; S_{2f} = middle Silurian Fentou Formation.