Supplementary information for

Microscale iron and sulphur isotopic compositions reveal pyritization pathways during early diagenesis

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Data S1 to S2
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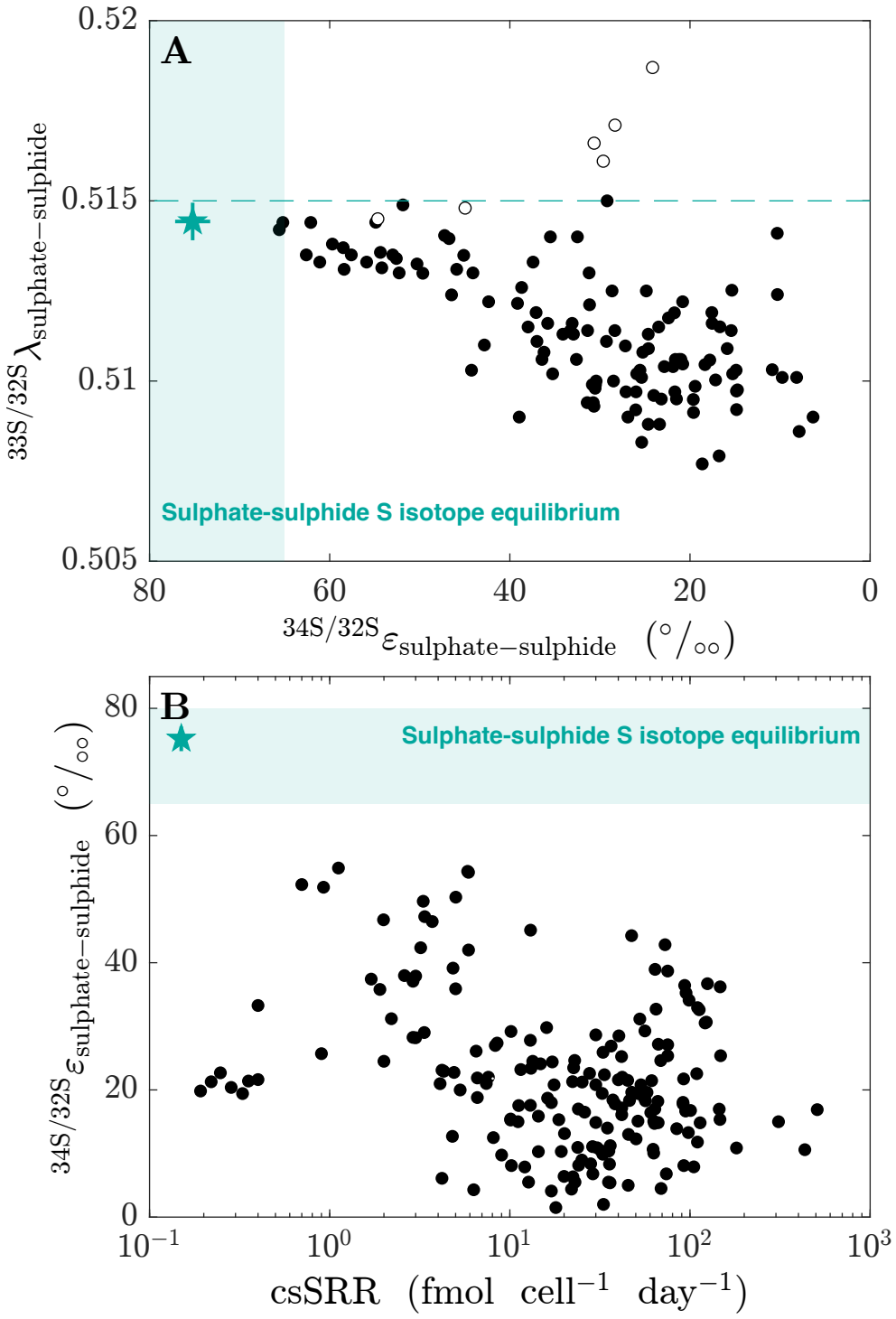
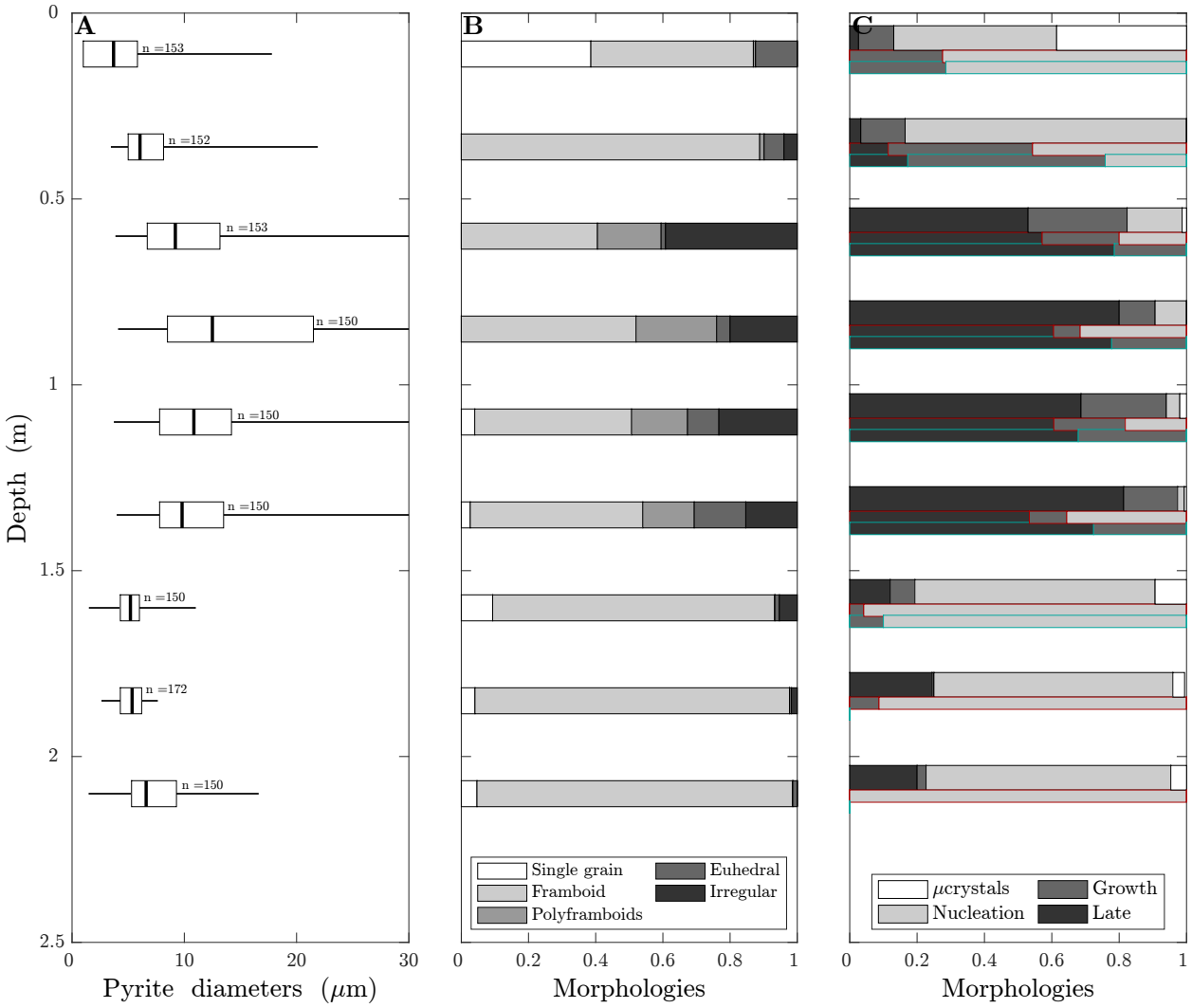
Other Supplementary Materials for this manuscript include the following:

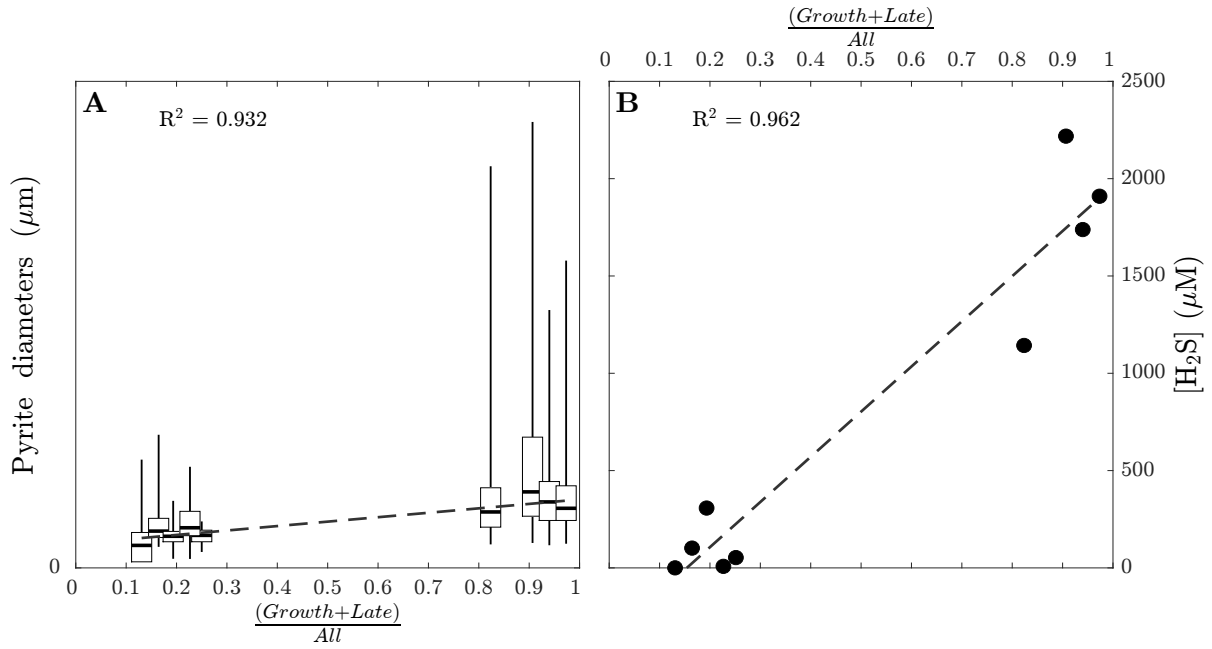
Data S1 to S3
Numerical model (matlab file).



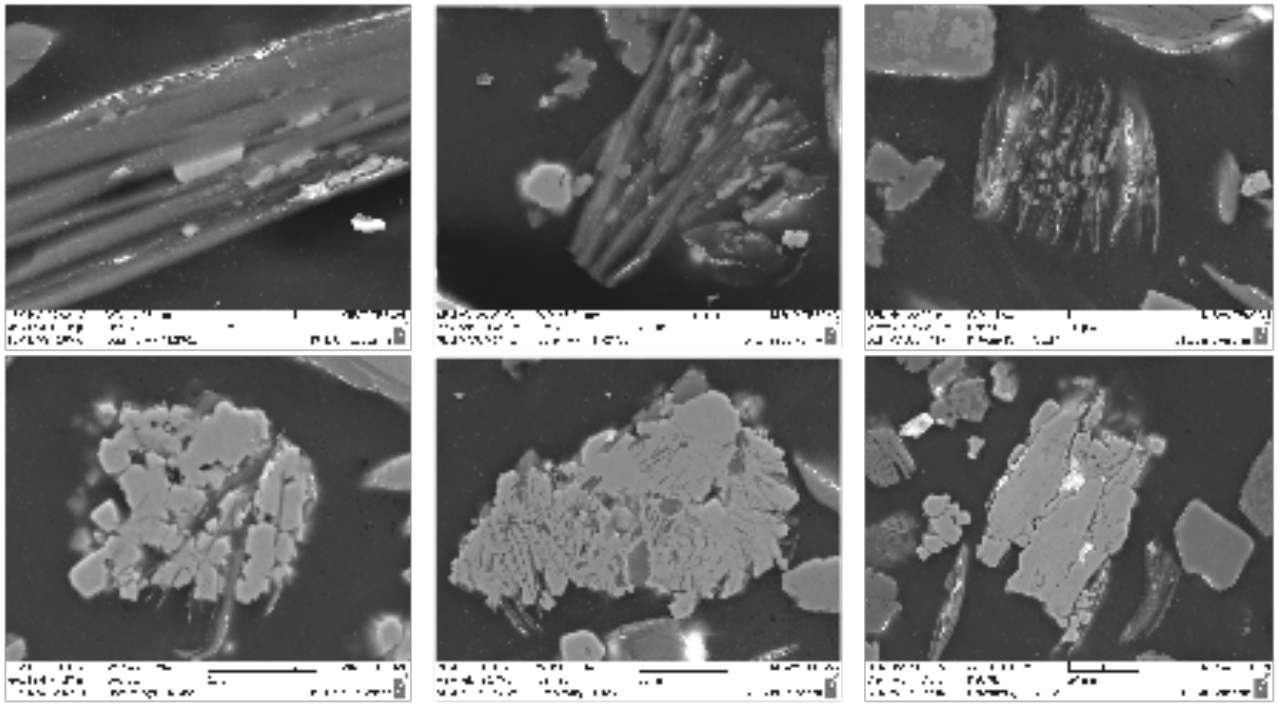
Supplementary Fig. 1: Microbial fractionation (teal star) reconstructed from our microscale pyrite S isotope measurements against laboratory pure culture experiments. Filled circles correspond to pure cultures of sulphate reducers (data from [1-5]), whereas open circles represent sulphur disproportionators (data from [1]). csSRR refers to the cell-specific sulphate reduction rate.



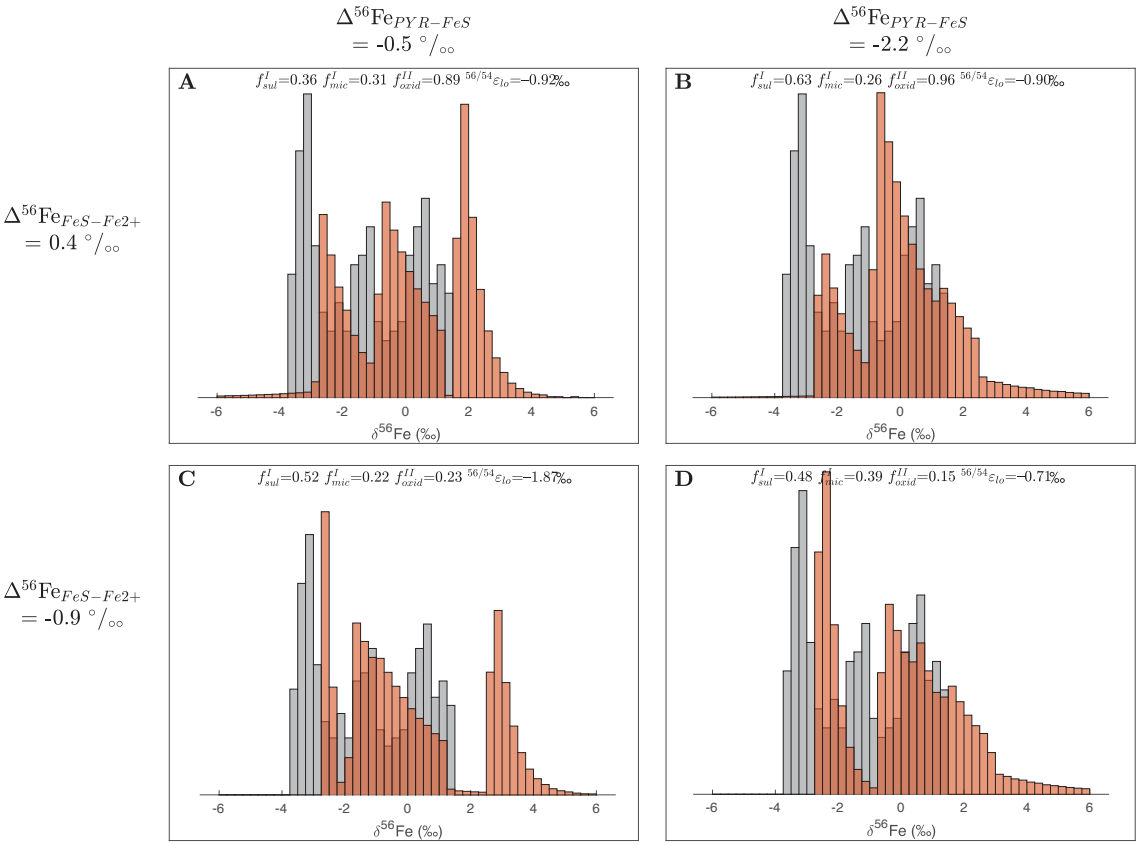
Supplementary Fig. 2: A. Box and whisker plots of pyrite grain size with depth in the core. The total number of grains analysed is shown above the right whisker. **B**. Stacked proportions of uninterpreted pyrite morphology (i.e., classification only). **C**. Stacked proportions of pyrite morphology according to the classification used in this study (i.e., microcrystal, nucleation, secondary, late). The upper stacked bars represent all grains sampled (≈150 grains). The stacked bars with green and red edges represent the subpopulations of grains for which microscale S and Fe isotopic compositions were measured, respectively.



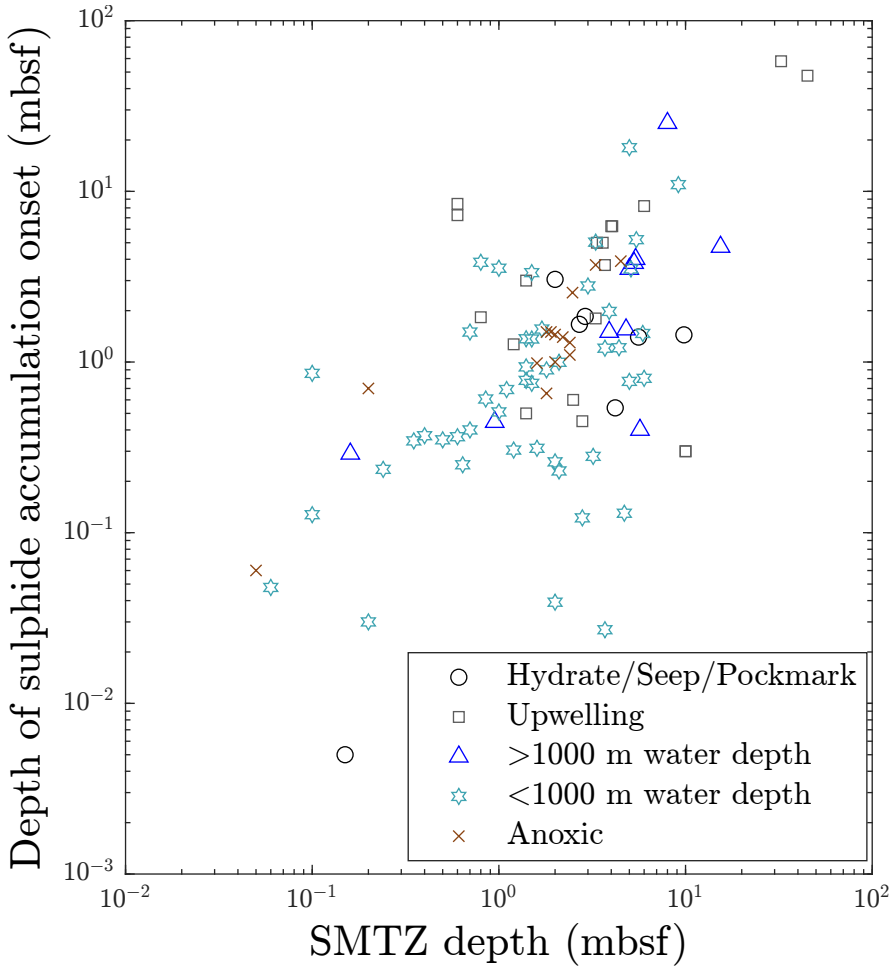
Supplementary Fig. 3: Cross plot of pyrite diameters and/or porewater sulphide concentration versus the relative proportion of growth and late morphologies out the total pyrite grain population. The dotted lines are linear regressions through the data and R^2 is the coefficient of determination.



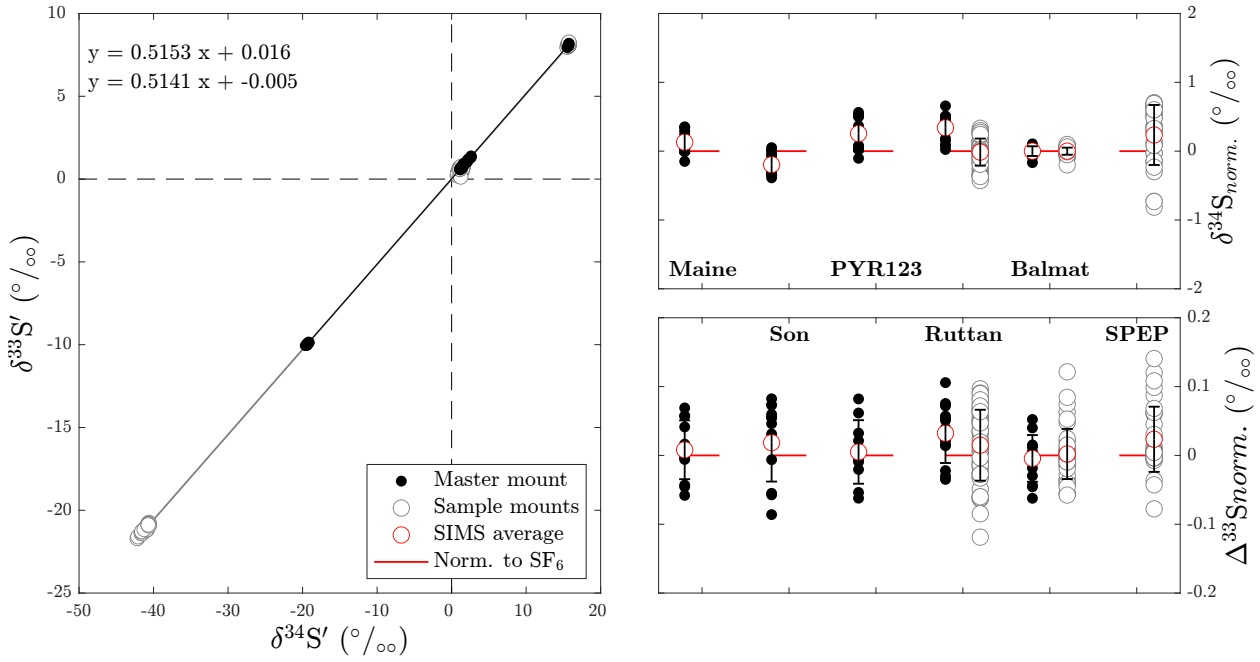
Supplementary Fig. 4: Examples of pyrite associated with sheet silicates, which are typically considered to be poorly reactive.



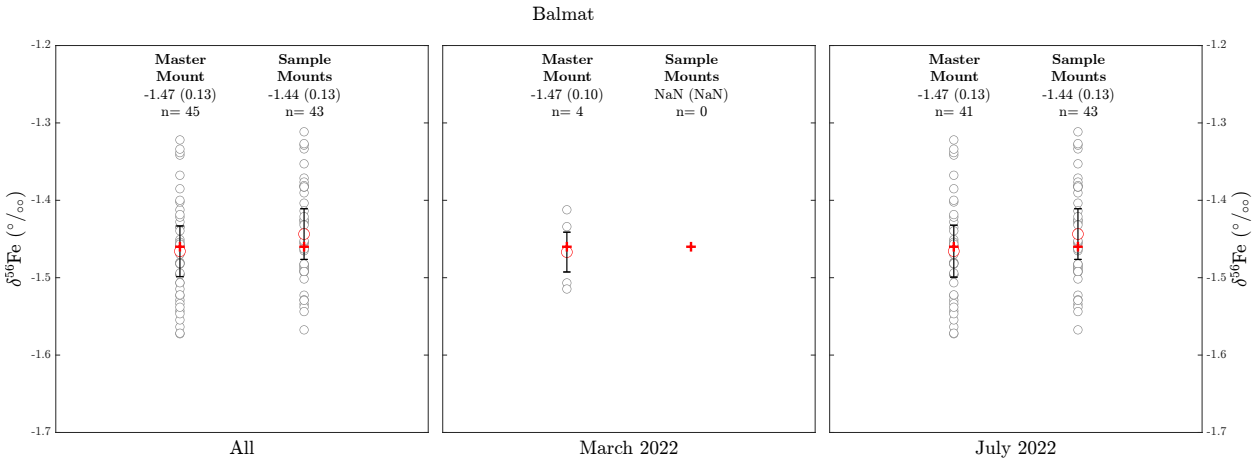
Supplementary Fig. 5: Observed (grey) and modelled (red) δ^{56}Fe distributions when using the Fe isotopic composition of riverine Fe(III) (oxyhydr)oxide (δ^{56}Fe = 0.08 ‰). Model distributions represent best-fit parameter combinations out of 1000 optimizations with randomly sampled initial parameter values. The four panels differ in the use of the EIE vs. KIE of FeS formation from Fe^{2+} (+0.4 vs. –0.9‰, respectively) and in the use of the fractionation associated with slow vs. rapid FeS transformation to pyrite (–0.5 vs. –2.2‰, respectively).



Supplementary Fig. 6: Cross plot of the depth in the sediment were sulphide starts to accumulate in porewater and the depth of the SMTZ.



Supplementary Fig. 7: Sulphur isotope internal standard results. The left panel shows $\delta^{34}S'$ vs. $\delta^{33}S'$ values. Black and grey lines and equations represent regression lines obtained in the SWISSIMS master mount and in our sample mounts, respectively. The right two panels show the $\delta^{34}S$ (top) and $\Delta^{33}S$ (bottom) values normalized to the bulk isotopic values obtained on our internal standards (Maine, Son, PYR123, Ruttan, Balmat and SPEP) in both the master and sample mounts.



Supplementary Fig. 8: Microscale $\delta^{56}Fe_{PYR}$ values obtained on our internal Balmat-UNIL pyrite standard, considering all analytical sessions (left panel) or individual analytical sessions. Master Mount refers to the SWISSIMS pyrite standard mount whereas Sample Mounts are fragment of Balmat-UNIL incorporated into the sample (unknown) mounts. The mean and 2σ uncertainty (in parentheses) in permil units and the number of analyses (n) are shown.

Supplementary Table 1: Depth and associated geochemical and pyrite grain information of samples from GC06. Pyrite grain size is given as the median with the 25th and 75th percentiles in square brackets. "Morphology 'sensu-stricto'" shows the percentage of single crystal/framboid/polyframboid/euhedral-cubic/irregular morphologies. "Morphology" shows the percentage of the morphologies used in this study: micro-crystal/nucleation/growth/late.

Geochemical and morphological result of GC06											
Depth	**SO_4^{2-}**	**ΣS(2-)**	**TS**	**PYR**	**%AVS**	**Fe_{HR}/Fe_T**	**Fe_{PYR}/Fe_{HR}**	**number of grains**	**Size**	**Morphology 'sensu-stricto'**	**Morphology**
mbsf	mmol/L	µmol/L	wt. %	wt. %	wt. %				µm	Cum. %	Cum. %
0.16	12.6	0.2	1.3	1.3	0.0	0.48	0.55	153	3.7[1/3.8]	39/48/1/12/0	39/48/10/3
0.41	8.9	101.8	1.7	1.7	0.0	0.57	0.62	152	6.0[5.0/8.1]	0/89/1/6/4	0/82/14/3
0.65	6.2	1143.0	2.0	1.7	0.1	0.74	0.72	153	9.2[3.9/13.2]	0/51/19/1/29	1/16/28/54
0.9	3.5	2218.5	2.3	2.0	0.1	0.75	0.77	150	12.5[8.5/21.5]	0/52/24/4/20	0/10/11/79
1.15	1.8	1738.5	1.9	1.7	0.1	0.68	0.74	150	10.8[7.8/14.2]	4/47/17/9/23	2/3/25/70
1.4	0.6	1909.8	2.1	1.6	0.3	0.74	0.80	150	9.8[7.8/13.5]	3/51/15/15/15	1/2/16/81
1.65	0.3	307.5	1.7	1.7	0.0	0.58	0.62	150	5.2[4.3/6.0]	9/84/0/1/5	9/74/7/10
1.9	0.3	53.0	1.8	1.8	0.0	0.53	0.59	172	5.3[4.3/6.2]	4/94/0/1/2	3/68/1/27
2.15	0.3	8.0	1.4	1.4	0.0	0.57	0.59	150	6.6[5.3/9.3]	5/95/0/1/0	5/76/2/18

Supplementary Table 2: Microscale $\delta^{56}Fe_{PYR}$ from GC06. Results are provided by core section (depth). The reported error on the $\delta^{56}Fe_{PYR}$ includes propagation of the internal and IMF 2σ errors. $\delta^{56}Fe$ values are reported against IRMM-014. The corresponding raw SIMS data are available on request.

Microscale Fe isotopes from GC06								
Core section	**Analyze name**	**Depth**	**Cr counts**	**Yield**	**$\delta^{56}Fe$**	**error $\delta^{56}Fe$**	**Morphology '*sensu-stricto*'**	**Morphology**
					‰ IRMM-014			
GC06_S01								
	d56Fe_090622_GC06-S01@1	0.1	7	0.96	-2.41	0.29	Framboid	Nucleation
	d56Fe_090622_GC06-S01@2	0.1	40	0.62	-3.23	0.34	Framboid	Nucleation
	d56Fe_090622_GC06-S01@3	0.1	25	0.82	-3.17	0.33	Framboid	Nucleation
	d56Fe_090622_GC06-S01@4	0.1	18	0.72	-2.96	0.33	Framboid	Nucleation
	d56Fe_090622_GC06-S01@7	0.1	29	0.92	-1.27	0.31	Framboid	Nucleation
	d56Fe_090622_GC06-S01@8	0.1	99	0.85	-2.53	0.30	Framboid	Nucleation
	d56Fe_090622_GC06-S01@9	0.1	9	0.98	-2.34	0.31	Framboid	Nucleation
	d56Fe_090622_GC06-S01@10	0.1	12	0.89	-2.95	0.32	Framboid	Nucleation
	d56Fe_090622_GC06-S01@11	0.1	8	0.94	-3.19	0.31	Framboid	Nucleation
	d56Fe_090622_GC06-S01@12	0.1	8	0.96	-3.35	0.31	Framboid	Nucleation
	d56Fe_090622_GC06-S01@13	0.1	36	0.94	-3.38	0.29	Euhedral	Growth
	d56Fe_090622_GC06-S01@14	0.1	66	0.68	-2.46	0.32	Euhedral	Growth
	d56Fe_090622_GC06-S01@15	0.1	32	0.71	-2.63	0.38	Framboid	Nucleation
	d56Fe_090622_GC06-S01@16	0.1	441	0.65	-3.29	0.45	Framboid	Nucleation
	d56Fe_090622_GC06-S01@17	0.1	237	0.71	-3.07	0.33	Euhedral	Growth
	d56Fe_090622_GC06-S01@18	0.1	63	0.97	-2.85	0.30	Euhedral	Growth
	d56Fe_090622_GC06-S01@19	0.1	78	0.81	-3.61	0.29	Euhedral	Growth
	d56Fe_090622_GC06-S01@20	0.1	53	0.63	-2.85	0.32	Euhedral	Growth
	d56Fe_090622_GC06-S01@21	0.1	84	0.67	-2.74	0.37	Euhedral	Growth
	d56Fe_090622_GC06-S01@22	0.1	291	0.71	-3.12	0.34	Framboid	Nucleation
	d56Fe_090622_GC06-S01@23	0.1	52	1.08	-2.38	0.29	Framboid	Nucleation
	d56Fe_090622_GC06-S01@24	0.1	73	0.77	-3.32	0.31	Framboid	Nucleation
	d56Fe_090622_GC06-S01@25	0.1	21	0.71	-2.00	0.32	Framboid	Nucleation
	d56Fe_090622_GC06-S01@26	0.1	433	0.70	-2.83	0.55	Framboid	Nucleation

	d56Fe_090622_GC06-S01@27	0.1	99	0.89	-3.25	0.30	Euhedral	Growth
	d56Fe_090622_GC06-S01@28	0.1	23	0.93	-3.49	0.30	Framboid	Nucleation
	d56Fe_090622_GC06-S01@29	0.1	26	0.67	-3.39	0.34	Framboid	Nucleation
	d56Fe_090622_GC06-S01@30	0.1	13	0.88	-3.50	0.31	Framboid	Nucleation
	d56Fe_090622_GC06-S01@31	0.1	4	0.99	-3.24	0.31	Framboid	Nucleation
GC06_S02								
	GC06-S02@02	0.37	41	0.95	-0.46	0.23	Euhedral	Growth
	GC06-S02@3	0.37	174	0.95	-2.76	0.27	Framboid	Nucleation
	GC06-S02@4	0.37	389	0.84	-3.30	0.23	Polyframboid	Nucleation
	GC06-S02@5	0.37	329	0.82	-0.99	0.22	Euhedral	Growth
	GC06-S02@6	0.37	11	0.92	-0.51	0.26	Euhedral	Growth
	d56Fe_100622_GC06-S02@01	0.37	125	0.85	-3.24	0.21	Polyframboid	Nucleation
	d56Fe_100622_GC06-S02@2	0.37	539	0.85	-1.79	0.23	Euhedral	Growth
	d56Fe_100622_GC06-S02@3	0.37	417	0.75	-0.67	0.24	Euhedral	Growth
	d56Fe_100622_GC06-S02@4	0.37	313	0.87	-3.34	0.21	Polyframboid	Nucleation
	d56Fe_100622_GC06-S02@5	0.37	3531	0.57	-3.50	0.39	Framboid	Nucleation
	d56Fe_100622_GC06-S02@6	0.37	258	0.85	-1.48	0.23	Euhedral	Growth
	d56Fe_100622_GC06-S02@7	0.37	370	0.83	-1.92	0.23	Framboid	Nucleation
	d56Fe_100622_GC06-S02@8	0.37	8307	0.67	-2.95	0.42	Framboid	Nucleation
	d56Fe_100622_GC06-S02@9	0.37	3719	0.45	-3.36	0.32	Framboid	Nucleation
	d56Fe_100622_GC06-S02@10	0.37	1514	0.86	-2.08	0.20	Euhedral	Growth
	d56Fe_100622_GC06-S02@11	0.37	67	0.83	-3.34	0.22	Euhedral	Growth
	d56Fe_100622_GC06-S02@12	0.37	1563	0.93	-3.17	0.24	Polyframboid	Nucleation
	d56Fe_100622_GC06-S02@14	0.37	436	0.78	-1.00	0.24	Framboid	Nucleation
	d56Fe_100622_GC06-S02@15	0.37	492	0.85	-2.25	0.23	Framboid	Nucleation
	d56Fe_100622_GC06-S02@16	0.37	2010	0.62	-1.76	0.45	Framboid	Nucleation
	d56Fe_100622_GC06-S02@17	0.37	1536	0.53	-3.06	0.33	Cubic	Growth
	d56Fe_100622_GC06-S02@18	0.37	317	0.80	0.24	0.25	Euhedral	Growth
	d56Fe_100622_GC06-S02@19	0.37	425	0.81	0.28	0.27	Euhedral	Growth
	d56Fe_100622_GC06-S02@20	0.37	579	0.71	0.44	0.28	Euhedral	Growth
	d56Fe_100622_GC06-S02@21	0.37	1374	0.61	-1.35	0.26	Framboid	Nucleation
	d56Fe_100622_GC06-S02@23	0.37	76	0.85	-2.14	0.23	Irregular	Late
	d56Fe_100622_GC06-S02@24	0.37	673	0.70	-3.51	0.25	Euhedral	Growth
	d56Fe_100622_GC06-S02@25	0.37	688	0.77	-1.70	0.23	Framboid	Nucleation
	d56Fe_100622_GC06-S02@26	0.37	1141	0.53	-1.80	0.35	Framboid	Nucleation

	d56Fe_100622_GC06-S02@27	0.37	95	0.91	-1.59	0.22	Irregular	Late
	d56Fe_100622_GC06-S02@28	0.37	1025	0.75	-2.90	0.24	Framboid	Nucleation
	d56Fe_100622_GC06-S02@29	0.37	550	0.91	-1.20	0.22	Polyframboid + overgrowth	Late
	d56Fe_100622_GC06-S02@30	0.37	554	0.66	-1.08	0.31	Euhedral	Growth
	d56Fe_100622_GC06-S02@31	0.37	551	0.70	-1.84	0.25	Framboid	Nucleation
	d56Fe_100622_GC06-S02@32	0.37	41	0.92	-1.61	0.22	Irregular	Growth
GC06_S03								
	d56Fe_100622_GC06-S03@01	0.62	0	0.90	-0.36	0.12	Irregular	Late
	d56Fe_100622_GC06-S03@2	0.62	0	0.84	0.35	0.15	Irregular	Late
	d56Fe_100622_GC06-S03@3	0.62	3	0.77	-1.73	0.14	Euhedral	Growth
	d56Fe_100622_GC06-S03@4	0.62	30	0.55	0.65	0.24	Euhedral	Growth
	d56Fe_100622_GC06-S03@5	0.62	1	0.55	0.21	0.18	Framboid	Late
	d56Fe_100622_GC06-S03@6	0.62	2	0.68	-1.45	0.21	Euhedral	Growth
	d56Fe_100622_GC06-S03@7	0.62	1	0.82	0.01	0.16	Irregular	Late
	d56Fe_100622_GC06-S03@8	0.62	2	0.84	0.52	0.15	Irregular	Late
	d56Fe_100622_GC06-S03@9	0.62	1	0.71	0.33	0.21	Irregular	Late
	d56Fe_100622_GC06-S03@10	0.62	1	0.78	-1.37	0.18	Euhedral	Growth
	d56Fe_100622_GC06-S03@11	0.62	1	0.69	0.43	0.16	Irregular	Late
	d56Fe_100622_GC06-S03@12	0.62	22	0.68	0.66	0.21	Irregular	Late
	d56Fe_100622_GC06-S03@13	0.62	0	0.83	0.22	0.17	Irregular	Late
	d56Fe_100622_GC06-S03@14	0.62	1	0.74	-0.24	0.17	Irregular	Late
	d56Fe_100622_GC06-S03@15	0.62	0	0.81	-1.08	0.18	Euhedral	Growth
	d56Fe_100622_GC06-S03@16	0.62	1	0.80	0.34	0.15	Irregular	Late
	d56Fe_100622_GC06-S03@17	0.62	14	0.54	-0.52	0.22	Irregular	Late
	d56Fe_100622_GC06-S03@18	0.62	32	0.60	0.39	0.20	Euhedral	Growth
	d56Fe_100622_GC06-S03@19	0.62	1	0.78	0.37	0.17	Irregular	Late
	d56Fe_100622_GC06-S03@20	0.62	2	0.83	0.46	0.18	Irregular	Late
	d56Fe_100622_GC06-S03@22	0.62	2	0.57	0.01	0.26	Irregular	Late
	d56Fe_100622_GC06-S03@23	0.62	0	0.84	0.59	0.15	Euhedral	Growth
	d56Fe_100622_GC06-S03@24	0.62	22	0.63	1.23	0.19	Irregular	Late
	d56Fe_100622_GC06-S03@25	0.62	1	0.75	-1.13	0.20	Irregular	Late
	d56Fe_100622_GC06-S03@26	0.62	0	0.66	-2.72	0.15	Framboid	Nucleation
	d56Fe_100622_GC06-S03@27	0.62	11	0.55	-0.14	0.19	Irregular	Late
	d56Fe_100622_GC06-S03@28	0.62	0	0.88	-0.66	0.12	Irregular	Late

	d56Fe_100622_GC06-S03@29	0.62	0	0.79	0.71	0.17	Irregular	Late
	d56Fe_100622_GC06-S03@30	0.62	1	0.80	-0.84	0.12	Euhedral	Growth
	d56Fe-20230504-GC06-S03@1	0.62	3	1.04	-1.44	0.22	Framboid	Nucleation
	d56Fe-20230504-GC06-S03@6	0.62	86	0.89	-3.22	0.23	Framboid	Nucleation
	d56Fe-20230504-GC06-S03@7	0.62	133	0.88	-3.11	0.27	Framboid	Nucleation
	d56Fe-20230504-GC06-S03@8	0.62	477	0.59	-3.43	0.38	Framboid	Nucleation
	d56Fe-20230504-GC06-S03@11	0.62	106	0.93	-3.18	0.27	Framboid	Nucleation
	d56Fe-20230504-GC06-S03@13	0.62	4	0.65	-2.91	0.26	Framboid	Nucleation
GC06_S04								
	GC06-S04@01	0.86	251	0.99	-0.82	0.22	Euhedral	Growth
	GC06-S04@2	0.86	2114	0.87	1.03	0.26	Framboid + cement + overgrowth	Late
	GC06-S04@3	0.86	2091	0.88	0.76	0.25	Framboid + cement + overgrowth	Late
	GC06-S04@6	0.86	722	0.91	0.99	0.23	Framboid + cement + overgrowth	Late
	GC06-S04@7	0.86	1987	0.98	0.07	0.25	Polyframboid + cement + overgrowth	Late
	GC06-S04@8	0.86	3972	0.89	1.18	0.27	Euhedral	Growth
	GC06-S04@9	0.86	5674	0.87	0.73	0.28	Irregular	Late
	GC06-S04@12	0.86	1301	0.94	-0.53	0.24	Framboid + cement + overgrowth	Late
	GC06-S04@13	0.86	2381	0.91	0.47	0.24	Framboid + cement + overgrowth	Late
	GC06-S04@14	0.86	4042	0.94	0.15	0.23	Irregular	Late
	GC06-S04@15	0.86	244	0.97	0.61	0.24	Euhedral	Growth
	GC06-S04@16	0.86	187	0.96	-1.71	0.23	Euhedral	Growth
	GC06-S04@17	0.86	8163	0.87	0.06	0.24	Framboid + cement + overgrowth	Late
	GC06-S04@18	0.86	2604	0.93	-1.52	0.24	Euhedral	Growth
	GC06-S04@19	0.86	1938	0.96	0.80	0.24	Framboid + cement + overgrowth	Late
	GC06-S04@20	0.86	1783	0.99	0.69	0.25	Irregular	Late
	GC06-S04@21	0.86	1612	0.97	0.28	0.23	Framboid + cement + overgrowth	Late
	GC06-S04@22	0.86	15039	0.95	0.06	0.26	Framboid + cement + overgrowth	Late
	GC06-S04@23	0.86	5611	0.87	0.64	0.25	Framboid + cement + overgrowth	Late
	GC06-S04@24	0.86	1465	0.94	1.09	0.23	Framboid + cement + overgrowth	Late
	GC06-S04@25	0.86	180	0.97	0.85	0.25	Framboid + cement + overgrowth	Late
	GC06-S04@26	0.86	5675	0.86	0.47	0.34	Euhedral	Growth
	GC06-S04@27	0.86	1009	0.94	0.39	0.25	Framboid + cement + overgrowth	Late
	GC06-S04@28	0.86	3701	0.89	0.64	0.26	Irregular	Late
	GC06-S04@29	0.86	235	0.97	0.03	0.23	Framboid + cement + overgrowth	Late
	GC06-S04@30	0.86	1494	0.96	0.41	0.22	Polyframboid + cement + overgrowth	Late

	d56Fe-20230506-GC06-S04@3	0.86	182	0.94	-2.71	0.29	Framboid	Nucleation
	d56Fe-20230506-GC06-S04@5	0.86	2824	0.67	-3.34	0.34	Framboid	Nucleation
	d56Fe-20230506-GC06-S04@6	0.86	2637	0.84	-3.08	0.30	Framboid	Nucleation
	d56Fe-20230506-GC06-S04@11	0.86	2060	0.63	-2.21	0.42	Framboid	Nucleation
	d56Fe-20230506-GC06-S04@12	0.86	777	0.80	-3.63	0.31	Framboid	Nucleation
	d56Fe-20230506-GC06-S04@14	0.86	5079	0.82	-0.49	0.31	Framboid	Nucleation
	d56Fe-20230506-GC06-S04@16	0.86	2465	0.69	0.98	0.32	Framboid	Nucleation
	d56Fe-20230506-GC06-S04@17	0.86	498	0.90	-3.41	0.29	Framboid	Nucleation
	d56Fe-20230506-GC06-S04@18	0.86	52	0.97	-1.69	0.30	Framboid	Nucleation
	d56Fe-20230506-GC06-S04@19	0.86	66	0.87	-1.60	0.30	Framboid	Nucleation
	d56Fe-20230506-GC06-S04@20	0.86	1730	0.73	-3.00	0.31	Framboid	Nucleation
	d56Fe-20230506-GC06-S04@21	0.86	149	0.94	-3.18	0.30	Framboid	Nucleation
GC06_S05								
	d56Fe_110622_GC06-S05@2	1.11	3167	0.78	1.30	0.15	Framboid + cement + overgrowth	Late
	d56Fe_110622_GC06-S05@3	1.11	1264	0.84	0.95	0.15	Polyframboid + cement + overgrowth	Late
	d56Fe_110622_GC06-S05@4	1.11	2330	0.82	0.47	0.12	Irregular	Late
	d56Fe_110622_GC06-S05@5	1.11	915	0.92	1.18	0.16	Irregular	Late
	d56Fe_110622_GC06-S05@6	1.11	1152	0.91	1.00	0.13	Irregular	Late
	d56Fe_110622_GC06-S05@7	1.11	1237	0.90	0.53	0.13	Irregular	Late
	d56Fe_110622_GC06-S05@8	1.11	2156	0.86	0.67	0.17	Framboid + cement + overgrowth	Late
	d56Fe_110622_GC06-S05@9	1.11	2162	0.77	-0.46	0.19	Polyframboid + cement + overgrowth	Late
	d56Fe_110622_GC06-S05@11	1.11	51067	0.64	-0.19	0.28	Euhedral	Growth
	d56Fe_110622_GC06-S05@13	1.11	6005	0.76	0.70	0.16	Polyframboid + cement + overgrowth	Late
	d56Fe_110622_GC06-S05@14	1.11	26547	0.60	1.31	0.28	Euhedral	Growth
	d56Fe_110622_GC06-S05@15	1.11	383	0.93	0.54	0.14	Framboid + cement + overgrowth	Late
	d56Fe_110622_GC06-S05@16	1.11	2663	0.79	1.23	0.15	Euhedral	Growth
	d56Fe_110622_GC06-S05@17	1.11	3352	0.84	0.69	0.22	Irregular	Late
	d56Fe_110622_GC06-S05@18	1.11	1261	0.88	1.06	0.12	Polyframboid + cement + overgrowth	Late
	d56Fe_110622_GC06-S05@19	1.11	4892	0.64	1.19	0.20	Euhedral	Growth
	d56Fe_110622_GC06-S05@20	1.11	1395	0.89	-0.24	0.14	Irregular	Late
	d56Fe_110622_GC06-S05@21	1.11	7945	0.84	1.32	0.14	Irregular	Late
	d56Fe_110622_GC06-S05@22	1.11	3195	0.76	0.73	0.15	Irregular	Late
	d56Fe_110622_GC06-S05@23	1.11	11481	0.81	1.01	0.18	Euhedral	Growth
	d56Fe_110622_GC06-S05@24	1.11	4500	0.63	1.45	0.24	Irregular	Late

	d56Fe_110622_GC06-S05@25	1.11	12116	0.81	-0.15	0.23	Euhedral	Growth
	d56Fe_110622_GC06-S05@26	1.11	1776	0.86	1.32	0.15	Irregular	Late
	d56Fe_110622_GC06-S05@27	1.11	2214	0.85	0.75	0.16	Framboid + cement + overgrowth	Late
	d56Fe_110622_GC06-S05@28	1.11	2513	0.78	1.15	0.21	Framboid + cement + overgrowth	Late
	d56Fe_110622_GC06-S05@29	1.11	3699	0.79	-0.92	0.14	Irregular	Late
	d56Fe_110622_GC06-S05@30	1.11	14948	0.74	0.57	0.18	Euhedral	Growth
	d56Fe-20230506-GC06-S05@4	1.11	2895	0.63	-3.21	0.31	Framboid	Nucleation
	d56Fe-20230506-GC06-S05@6	1.11	601	0.84	-2.20	0.34	Framboid	Nucleation
	d56Fe-20230506-GC06-S05@8	1.11	385	0.68	-2.64	0.31	Framboid	Nucleation
	d56Fe-20230506-GC06-S05@10	1.11	614	0.85	-2.22	0.31	Framboid	Nucleation
	d56Fe-20230506-GC06-S05@11	1.11	425	0.79	-3.29	0.54	Framboid	Nucleation
	d56Fe-20230506-GC06-S05@13	1.11	607	0.77	-3.51	0.45	Framboid	Nucleation
GC06_S06								
	d56Fe_110622_GC06-S06@1	1.36	1726	0.82	0.55	0.15	Irregular	Late
	d56Fe_110622_GC06-S06@3	1.36	2285	0.81	1.12	0.17	Framboid + cement + overgrowth	Late
	d56Fe_110622_GC06-S06@4	1.36	1927	0.82	1.23	0.12	Framboid + cement + overgrowth	Late
	d56Fe_110622_GC06-S06@5	1.36	49044	0.89	0.21	0.14	Euhedral	Growth
	d56Fe_110622_GC06-S06@7	1.36	2740	0.84	1.26	0.16	Irregular	Late
	d56Fe_110622_GC06-S06@8	1.36	5764	0.81	0.07	0.20	Irregular	Late
	d56Fe_110622_GC06-S06@9	1.36	2953	0.69	-1.06	0.23	Euhedral	Growth
	d56Fe_110622_GC06-S06@10	1.36	10803	0.85	1.29	0.14	Irregular	Late
	d56Fe_110622_GC06-S06@11	1.36	3147	0.82	0.80	0.14	Irregular	Late
	d56Fe_110622_GC06-S06@12	1.36	1177	0.87	0.32	0.16	Irregular	Late
	d56Fe_110622_GC06-S06@13	1.36	1788	0.84	0.02	0.15	Irregular	Late
	d56Fe_110622_GC06-S06@14	1.36	4129	0.77	0.79	0.21	Euhedral	Growth
	d56Fe_110622_GC06-S06@15	1.36	1318	0.86	1.32	0.14	Framboid + cement + overgrowth	Late
	d56Fe_110622_GC06-S06@16	1.36	3411	0.81	0.80	0.14	Irregular	Late
	d56Fe_110622_GC06-S06@17	1.36	1844	0.75	0.77	0.20	Irregular	Late
	d56Fe_110622_GC06-S06@18	1.36	2669	0.63	1.22	0.17	Irregular	Late
	d56Fe_110622_GC06-S06@19	1.36	4780	0.77	0.13	0.16	Polyframboid + cement + overgrowth	Late
	d56Fe_110622_GC06-S06@20	1.36	3327	0.57	-0.40	0.28	Irregular	Late
	d56Fe_110622_GC06-S06@21	1.36	2585	0.68	-0.12	0.15	Irregular	Late
	d56Fe_110622_GC06-S06@22	1.36	2795	0.89	-0.15	0.14	Irregular	Late
	d56Fe_110622_GC06-S06@23	1.36	1474	0.87	0.37	0.16	Irregular	Late

	d56Fe_110622_GC06-S06@24	1.36	2414	0.75	1.11	0.16	Irregular	Late
	d56Fe_110622_GC06-S06@25	1.36	2051	0.86	0.09	0.12	Irregular	Late
	d56Fe_110622_GC06-S06@26	1.36	834	0.92	1.30	0.17	Irregular	Late
	d56Fe_110622_GC06-S06@27	1.36	1111	0.87	-0.44	0.17	Irregular	Late
	d56Fe_110622_GC06-S06@28	1.36	1367	0.86	1.30	0.19	Euhedral	Growth
	d56Fe_110622_GC06-S06@29	1.36	1764	0.85	0.59	0.17	Framboid + cement + overgrowth	Late
	d56Fe_110622_GC06-S06@30	1.36	8453	0.75	-1.42	0.22	Euhedral	Growth
	d56Fe_110622_GC06-S06@31	1.36	5528	0.85	0.77	0.14	Framboid + cement + overgrowth	Late
	d56Fe-20230507-GC06-S06@1	1.36	442	0.75	-3.01	0.41	Framboid	Nucleation
	d56Fe-20230507-GC06-S06@4	1.36	783	0.67	-0.69	0.25	Framboid	Nucleation
	d56Fe-20230507-GC06-S06@5	1.36	218	0.75	-1.59	0.34	Framboid	Nucleation
	d56Fe-20230507-GC06-S06@6	1.36	695	0.76	-2.11	0.27	Framboid	Nucleation
	d56Fe-20230507-GC06-S06@7	1.36	728	0.54	-1.57	0.30	Framboid	Nucleation
	d56Fe-20230507-GC06-S06@8	1.36	1074	0.88	-3.08	0.24	Framboid	Nucleation
	d56Fe-20230507-GC06-S06@9	1.36	291	0.74	-3.40	0.28	Framboid	Nucleation
	d56Fe-20230507-GC06-S06@10	1.36	283	0.74	-2.11	0.26	Framboid	Nucleation
	d56Fe-20230507-GC06-S06@11	1.36	1764	0.85	-1.83	0.23	Framboid	Nucleation
	d56Fe-20230507-GC06-S06@12	1.36	1285	0.74	-1.21	0.36	Framboid	Nucleation
	d56Fe-20230507-GC06-S06@14	1.36	1332	0.92	-3.22	0.23	Framboid	Nucleation
	d56Fe-20230507-GC06-S06@16	1.36	2024	0.93	-1.40	0.23	Framboid	Nucleation
	d56Fe-20230507-GC06-S06@17	1.36	5622	0.90	0.37	0.28	Framboid	Nucleation
	d56Fe-20230507-GC06-S06@18	1.36	246	0.95	-3.17	0.23	Framboid	Nucleation
	d56Fe-20230507-GC06-S06@19	1.36	192	0.98	-0.27	0.23	Framboid	Nucleation
	d56Fe-20230507-GC06-S06@20	1.36	584	0.73	-1.75	0.27	Framboid	Nucleation
GC06_S07								
	d56Fe_120622_GC06-S07@1	1.61	1633	0.82	-3.18	0.16	Framboid	Nucleation
	d56Fe_120622_GC06-S07@2	1.61	4617	0.54	-3.45	0.33	Framboid	Nucleation
	d56Fe_120622_GC06-S07@3	1.61	1591	0.70	-1.28	0.22	Framboid	Nucleation
	d56Fe_120622_GC06-S07@4	1.61	4123	0.58	-1.24	0.33	Framboid	Nucleation
	d56Fe_120622_GC06-S07@5	1.61	3236	0.56	-3.54	0.28	Framboid	Nucleation
	d56Fe_120622_GC06-S07@6	1.61	2534	0.79	-1.10	0.18	Framboid	Nucleation
	d56Fe_120622_GC06-S07@7	1.61	650	0.65	-3.29	0.27	Framboid	Nucleation
	d56Fe_120622_GC06-S07@8	1.61	1195	0.77	-3.11	0.18	Framboid	Nucleation
	d56Fe_120622_GC06-S07@10	1.61	2032	0.63	-3.25	0.15	Framboid	Nucleation

	d56Fe_120622_GC06-S07@11	1.61	1004	0.92	-1.55	0.15	Framboid	Nucleation
	d56Fe_120622_GC06-S07@13	1.61	1975	0.69	-1.49	0.18	Framboid	Nucleation
	d56Fe_120622_GC06-S07@14	1.61	4491	0.61	-3.38	0.20	Framboid	Nucleation
	d56Fe_120622_GC06-S07@15	1.61	1684	1.03	-1.46	0.13	Framboid	Nucleation
	d56Fe_120622_GC06-S07@16	1.61	3637	0.87	-1.21	0.25	Framboid	Nucleation
	d56Fe_120622_GC06-S07@17	1.61	441	0.77	-1.51	0.16	Framboid	Nucleation
	d56Fe_120622_GC06-S07@18	1.61	3656	0.64	-1.17	0.22	Framboid	Nucleation
	d56Fe_120622_GC06-S07@19	1.61	1530	0.61	-1.13	0.20	Framboid	Nucleation
	d56Fe_120622_GC06-S07@20	1.61	1906	0.81	-2.83	0.17	Framboid	Nucleation
	d56Fe_120622_GC06-S07@21	1.61	23732	0.87	-1.07	0.15	Euhedral	Growth
	d56Fe_120622_GC06-S07@22	1.61	8067	0.73	-3.47	0.22	Framboid	Nucleation
	d56Fe_120622_GC06-S07@23	1.61	13076	0.80	-1.22	0.36	Framboid	Nucleation
	d56Fe_120622_GC06-S07@24	1.61	1420	0.81	-2.81	0.18	Framboid	Nucleation
	d56Fe_120622_GC06-S07@25	1.61	3349	0.82	-3.14	0.21	Framboid	Nucleation
	d56Fe_120622_GC06-S07@26	1.61	1374	0.85	-3.03	0.14	Framboid	Nucleation
GC06_S08								
	d56Fe_130622_GC06-S08@1	1.86	1000	0.90	-1.12	0.15	Framboid	Nucleation
	d56Fe_130622_GC06-S08@3	1.86	2177	0.71	-2.10	0.20	Framboid	Nucleation
	d56Fe_130622_GC06-S08@4	1.86	777	0.72	-3.51	0.30	Framboid	Nucleation
	d56Fe_130622_GC06-S08@5	1.86	450	0.68	-3.33	0.27	Framboid	Nucleation
	d56Fe_130622_GC06-S08@6	1.86	787	0.52	-3.12	0.28	Framboid	Nucleation
	d56Fe_130622_GC06-S08@7	1.86	6158	0.76	-1.07	0.20	Framboid	Nucleation
	d56Fe_130622_GC06-S08@8	1.86	1204	0.72	-1.24	0.25	Framboid	Nucleation
	d56Fe_130622_GC06-S08@9	1.86	19979	0.75	-1.34	0.21	Framboid	Nucleation
	d56Fe_130622_GC06-S08@10	1.86	361	0.77	-1.44	0.17	Framboid	Nucleation
	d56Fe_130622_GC06-S08@11	1.86	4682	0.70	-1.15	0.29	Framboid	Nucleation
	d56Fe_130622_GC06-S08@12	1.86	312	0.68	-0.79	0.27	Framboid	Nucleation
	d56Fe_130622_GC06-S08@13	1.86	7704	0.65	-3.41	0.19	Framboid	Nucleation
	d56Fe_130622_GC06-S08@14	1.86	4144	0.66	-3.66	0.25	Framboid	Nucleation
	d56Fe_130622_GC06-S08@15	1.86	7829	0.78	-1.11	0.21	Framboid	Nucleation
	d56Fe_130622_GC06-S08@16	1.86	1223	0.72	-3.72	0.16	Framboid	Nucleation
	d56Fe_130622_GC06-S08@17	1.86	2494	0.62	-0.04	0.99	Euhedral	Growth
	d56Fe_130622_GC06-S08@20	1.86	2710	0.70	-2.15	0.20	Framboid	Nucleation
	d56Fe_130622_GC06-S08@22	1.86	2794	0.63	-2.16	0.26	Euhedral	Growth

	d56Fe_130622_GC06-S08@24	1.86	22046	0.66	1.33	0.71	Framboid	Nucleation
	d56Fe_130622_GC06-S08@25	1.86	3263	0.61	-2.94	0.23	Framboid	Nucleation
	d56Fe_130622_GC06-S08@26	1.86	961	0.61	-3.20	0.48	Framboid	Nucleation
	d56Fe_130622_GC06-S08@28	1.86	2612	0.77	-3.09	0.13	Framboid	Nucleation
	d56Fe_130622_GC06-S08@29	1.86	629	0.77	-3.35	0.22	Framboid	Nucleation
GC06_S09								
	d56Fe_140622_GC06-S09@1	2.11	256	0.58	-3.01	0.32	Framboid	Nucleation
	d56Fe_140622_GC06-S09@2	2.11	411	0.76	-3.28	0.28	Framboid	Nucleation
	d56Fe_140622_GC06-S09@3	2.11	4769	0.63	-3.57	0.26	Framboid	Nucleation
	d56Fe_140622_GC06-S09@4	2.11	507	0.77	-3.31	0.19	Framboid	Nucleation
	d56Fe_140622_GC06-S09@5	2.11	2791	0.56	-2.33	0.30	Framboid	Nucleation
	d56Fe_140622_GC06-S09@6	2.11	671	0.79	-3.22	0.20	Framboid	Nucleation
	d56Fe_140622_GC06-S09@7	2.11	881	0.76	-0.87	0.23	Framboid	Nucleation
	d56Fe_140622_GC06-S09@8	2.11	822	0.77	-2.92	0.20	Framboid	Nucleation
	d56Fe_140622_GC06-S09@9	2.11	1146	0.66	-2.62	0.21	Framboid	Nucleation
	d56Fe_140622_GC06-S09@12	2.11	3074	0.85	-1.65	0.17	Framboid	Nucleation
	d56Fe_140622_GC06-S09@14	2.11	685	0.60	-3.16	0.25	Framboid	Nucleation
	d56Fe_140622_GC06-S09@15	2.11	252	0.86	-1.44	0.17	Framboid	Nucleation
	d56Fe_140622_GC06-S09@16	2.11	736	0.88	-0.83	0.18	Framboid	Nucleation
	d56Fe_140622_GC06-S09@17	2.11	2823	0.58	-2.86	0.31	Framboid	Nucleation
	d56Fe_140622_GC06-S09@18	2.11	749	0.72	-3.25	0.17	Framboid	Nucleation
	d56Fe_140622_GC06-S09@19	2.11	42267	0.50	-3.64	0.28	Framboid	Nucleation
	d56Fe_140622_GC06-S09@20	2.11	413	0.80	-3.62	0.18	Framboid	Nucleation
	d56Fe_140622_GC06-S09@21	2.11	617	0.78	-2.68	0.19	Framboid	Nucleation
	d56Fe_140622_GC06-S09@22	2.11	1266	0.68	0.59	0.19	Framboid	Nucleation
	d56Fe_140622_GC06-S09@23	2.11	733	0.65	-1.40	0.25	Framboid	Nucleation
	d56Fe_140622_GC06-S09@24	2.11	8056	0.74	-3.39	0.33	Framboid	Nucleation
	d56Fe_140622_GC06-S09@25	2.11	214	0.85	-2.71	0.18	Framboid	Nucleation
	d56Fe_140622_GC06-S09@26	2.11	226	0.41	-3.44	0.47	Framboid	Nucleation
	d56Fe_140622_GC06-S09@29	2.11	1745	0.61	-2.46	0.41	Framboid	Nucleation
	d56Fe_140622_GC06-S09@30	2.11	547	0.70	-2.77	0.19	Framboid	Nucleation

Supplementary Table 3: Microscale $\delta^{33}S_{PYR}$-$\delta^{34}S_{PYR}$-$\Delta^{33}S_{PYR}$ from GC06. Results are provided by core section (depth). The reported error on the $\delta^{33}S_{PYR}$-$\delta^{34}S_{PYR}$ includes propagation of the

internal and IMF 2σ errors. $\delta^{33}S_{PYR}$-$\delta^{34}S_{PYR}$-$\Delta^{33}S_{PYR}$ values are reported against VCDT. The raw SIMS data are available on request.

Microscale S isotopes from GC06										
Core section	**Analyze name**	**Depth**	**Yield**	**$\delta^{33}S$**	**err $\delta^{33}S$**	**$\delta^{34}S$**	**err $\delta^{34}S$**	**$\Delta^{33}S$**	**Morphology '*sensu-stricto*'**	**Morphology**
				‰ VCDT						
S01										
	d34S_220920_S01@1	0.1	0.73	-27.30	0.11	-52.42	0.10	0.051	Framboid	Nucleation
	d34S_220920_S01@2	0.1	0.42	-27.22	0.11	-52.36	0.10	0.096	Framboid	Nucleation
	d34S_220920_S01@3	0.1	0.61	-28.37	0.11	-54.45	0.10	0.050	Framboid	Nucleation
	d34S_220920_S01@5	0.1	0.50	-27.68	0.11	-53.20	0.10	0.080	Framboid	Nucleation
	d34S_220920_S01@6	0.1	0.59	-24.41	0.11	-47.07	0.10	0.111	Framboid	Nucleation
	d34S_220920_S01@8	0.1	0.47	-25.86	0.11	-49.78	0.10	0.092	Framboid	Nucleation
	d34S_220920_S01@9	0.1	0.49	-24.89	0.11	-47.92	0.10	0.084	Framboid	Nucleation
	d34S_220920_S01@10	0.1	0.70	-24.74	0.11	-47.67	0.10	0.094	Framboid	Nucleation
	d34S_220920_S01@11	0.1	0.74	-24.16	0.11	-46.66	0.10	0.148	Framboid	Nucleation
	d34S_220920_S01@12	0.1	0.64	-25.61	0.11	-49.36	0.10	0.120	Framboid	Nucleation
	d34S_220920_S01@13	0.1	0.68	-26.77	0.11	-51.50	0.10	0.097	Euhedral	Growth
	d34S_220920_S01@14	0.1	0.34	-27.17	0.11	-52.24	0.10	0.085	Euhedral	Growth
	d34S_220920_S01@15	0.1	0.53	-24.91	0.11	-47.95	0.10	0.084	Framboid	Nucleation
	d34S_220920_S01@16	0.1	0.66	-24.92	0.11	-47.98	0.10	0.083	Framboid	Nucleation
	d34S_220920_S01@17	0.1	0.49	-27.02	0.11	-51.96	0.10	0.079	Euhedral	Growth
	d34S_220920_S01@18	0.1	0.56	-26.43	0.11	-50.89	0.10	0.111	Euhedral	Growth
	d34S_220920_S01@19	0.1	0.57	-25.57	0.11	-49.29	0.10	0.126	Euhedral	Growth
	d34S_220920_S01@20	0.1	0.56	-23.22	0.11	-44.83	0.10	0.125	Euhedral	Growth
	d34S_220920_S01@21	0.1	0.57	-23.13	0.11	-44.67	0.10	0.126	Euhedral	Growth
	d34S_220920_S01@22	0.1	0.61	-24.12	0.11	-46.47	0.10	0.093	Framboid	Nucleation
	d34S_220920_S01@23	0.1	0.67	-25.07	0.11	-48.36	0.10	0.132	Framboid	Nucleation
	d34S_220920_S01@24	0.1	0.62	-26.38	0.11	-50.83	0.10	0.125	Framboid	Nucleation
	d34S_220920_S01@25	0.1	0.65	-24.54	0.11	-47.26	0.10	0.084	Framboid	Nucleation

	d34S_220920_S01@26	0.1	0.62	-26.55	0.11	-51.09	0.10	0.098	Framboid	Nucleation
	d34S_220920_S01@27	0.1	0.63	-25.92	0.11	-49.85	0.10	0.075	Euhedral	Growth
	d34S_220920_S01@28	0.1	0.45	-23.83	0.11	-45.97	0.10	0.111	Framboid	Nucleation
	d34S_220920_S01@29	0.1	0.63	-25.66	0.11	-49.34	0.10	0.065	Framboid	Nucleation
	d34S_220920_S01@30	0.1	0.56	-25.30	0.11	-48.84	0.10	0.153	Framboid	Nucleation
GC06-S02										
	d34S_220921_S02@1	0.37	0.73	-20.13	0.09	-39.04	0.06	0.169	Euhedral	Growth
	d34S_220921_S02@2	0.37	0.40	-17.87	0.09	-34.74	0.06	0.173	Euhedral	Growth
	d34S_220921_S02@3	0.37	0.61	-21.81	0.09	-42.21	0.06	0.157	Framboid	Nucleation
	d34S_220921_S02@4	0.37	0.67	-4.39	0.09	-8.92	0.06	0.216	Euhedral	Growth
	d34S_220921_S02@5	0.37	0.73	-15.86	0.09	-31.00	0.06	0.225	Euhedral	Growth
	d34S_220921_S02@6	0.37	0.75	-22.61	0.09	-43.75	0.06	0.163	Euhedral	Growth
	d34S_220921_S02@7	0.37	0.71	-27.79	0.09	-53.36	0.06	0.054	Framboid	Nucleation
	d34S_220921_S02@8	0.37	0.41	-7.75	0.09	-15.49	0.06	0.259	Euhedral	Growth
	d34S_220921_S02@9	0.37	0.47	-21.84	0.09	-42.21	0.06	0.131	Cubic	Growth
	d34S_220921_S02@10	0.37	0.69	-18.65	0.09	-36.25	0.06	0.184	Euhedral	Growth
	d34S_220921_S02@11	0.37	0.77	-28.41	0.09	-54.60	0.06	0.087	Framboid	Nucleation
	d34S_220921_S02@12	0.37	0.74	-18.09	0.09	-35.13	0.06	0.159	Euhedral	Growth
	d34S_220921_S02@14	0.37	0.49	-19.69	0.09	-38.24	0.06	0.191	Euhedral	Growth
	d34S_220921_S02@15	0.37	0.61	-18.10	0.09	-35.20	0.06	0.184	Polyframboids	Nucleation
	d34S_220921_S02@16	0.37	0.54	-19.30	0.09	-37.45	0.06	0.164	Euhedral	Growth
	d34S_220921_S02@17	0.37	0.45	-17.60	0.09	-34.29	0.06	0.213	Irregular	Late
	d34S_220921_S02@18	0.37	0.43	-19.24	0.09	-37.32	0.06	0.153	Irregular	Late
	d34S_220921_S02@19	0.37	0.53	-21.39	0.09	-41.37	0.06	0.137	Polyframboids	Nucleation
	d34S_220921_S02@20	0.37	0.55	-18.31	0.09	-35.61	0.06	0.186	Euhedral	Growth
	d34S_220921_S02@21	0.37	0.49	-19.21	0.09	-37.26	0.06	0.161	Euhedral	Growth
	d34S_220921_S02@22	0.37	0.65	-26.92	0.09	-51.74	0.06	0.065	Framboid	Nucleation
	d34S_220921_S02@23	0.37	0.63	-26.80	0.09	-51.54	0.06	0.087	Euhedral	Growth
	d34S_220921_S02@24	0.37	0.55	-20.88	0.09	-40.42	0.06	0.144	Euhedral	Growth
	d34S_220921_S02@25	0.37	0.68	-18.13	0.09	-35.22	0.06	0.167	Infilled framboid	Late

	d34S_220921_S02@26	0.37	0.74	-20.52	0.09	-39.81	0.06	0.182	Infilled polyframboids	Late
	d34S_220921_S02@27	0.37	0.64	-22.27	0.09	-43.12	0.06	0.175	Polyframboids	Nucleation
	d34S_220921_S02@28	0.37	0.43	-17.21	0.09	-33.57	0.06	0.220	Euhedral	Growth
	d34S_220921_S02@29	0.37	0.63	-18.62	0.09	-36.23	0.06	0.200	Euhedral	Growth
	d34S_220921_S02@30	0.37	0.52	-16.87	0.09	-32.87	0.06	0.188	Euhedral	Growth
GC06-S03										
	d34S_220921_S03@1	0.62	0.91	-9.97	0.09	-19.53	0.06	0.140	Irregular	Late
	d34S_220921_S03@2	0.62	0.91	-10.38	0.09	-20.38	0.06	0.163	Irregular	Late
	d34S_220921_S03@3	0.62	0.74	-6.57	0.09	-13.10	0.06	0.196	Euhedral	Growth
	d34S_220921_S03@4	0.62	0.55	-7.90	0.09	-15.63	0.06	0.181	Irregular	Late
	d34S_220921_S03@5	0.62	0.63	-5.91	0.09	-11.80	0.06	0.187	Euhedral	Growth
	d34S_220921_S03@6	0.62	0.50	-8.30	0.09	-16.42	0.06	0.190	Euhedral	Growth
	d34S_220921_S03@7	0.62	0.60	-7.78	0.09	-15.40	0.06	0.181	Irregular	Late
	d34S_220921_S03@8	0.62	0.52	-8.77	0.09	-17.22	0.06	0.135	Irregular	Late
	d34S_220921_S03@9	0.62	0.76	-9.15	0.09	-18.05	0.06	0.186	Irregular	Late
	d34S_220921_S03@10	0.62	0.97	-11.06	0.09	-21.72	0.06	0.188	Euhedral	Growth
	d34S_220921_S03@11	0.62	0.75	-11.52	0.09	-22.54	0.06	0.153	Irregular	Late
	d34S_220921_S03@12	0.62	0.62	-9.86	0.09	-19.32	0.06	0.139	Irregular	Late
	d34S_220921_S03@13	0.62	0.64	-8.68	0.09	-17.16	0.06	0.192	Irregular	Late
	d34S_220921_S03@14	0.62	0.68	-8.73	0.09	-17.26	0.06	0.199	Irregular	Late
	d34S_220921_S03@15	0.62	0.79	-11.39	0.09	-22.33	0.06	0.175	Euhedral	Growth
	d34S_220921_S03@17	0.62	0.54	-10.00	0.09	-19.70	0.06	0.190	Irregular	Late
	d34S_220921_S03@18	0.62	0.78	-9.62	0.09	-19.00	0.06	0.214	Irregular	Late
	d34S_220921_S03@19	0.62	0.75	-9.41	0.09	-18.53	0.06	0.177	Irregular	Late
	d34S_220921_S03@20	0.62	0.49	-9.19	0.09	-18.06	0.06	0.147	Irregular	Late
	d34S_220921_S03@21	0.62	0.89	-9.88	0.09	-19.39	0.06	0.152	Irregular	Late
	d34S_220921_S03@22	0.62	0.58	-7.25	0.09	-14.28	0.06	0.129	Irregular	Late
	d34S_220921_S03@23	0.62	0.65	-9.88	0.09	-19.50	0.06	0.211	Irregular	Late
	d34S_220921_S03@24	0.62	0.73	-6.31	0.09	-12.53	0.06	0.163	Irregular	Late
	d34S_220921_S03@25	0.62	0.47	-9.19	0.09	-18.05	0.06	0.147	Irregular	Late

	d34S_220921_S03@26	0.62	0.44	-9.06	0.09	-17.83	0.06	0.161	Irregular	Late
	d34S_220921_S03@28	0.62	0.53	-7.81	0.09	-15.44	0.06	0.171	Irregular	Late
	d34S_220921_S03@29	0.62	0.57	-9.27	0.09	-18.26	0.06	0.172	Irregular	Late
	d34S_220921_S03@30	0.62	0.84	-0.56	0.09	-1.49	0.06	0.205	Euhedral	Growth
GC06-S04										
	d34S_220922_S04@1	0.86	1.00	5.92	0.06	11.34	0.02	0.100	Euhedral	Growth
	d34S_220922_S04@2	0.86	0.55	6.13	0.06	11.67	0.02	0.142	Framboid + overgrowth	Late
	d34S_220922_S04@3	0.86	0.26	-2.13	0.06	-4.45	0.02	0.170	Framboid + overgrowth	Late
	d34S_220922_S04@4	0.86	0.82	7.28	0.06	14.07	0.02	0.064	Euhedral	Growth
	d34S_220922_S04@5	0.86	0.96	-4.37	0.06	-8.83	0.02	0.185	Euhedral	Growth
	d34S_220922_S04@6	0.86	0.61	-1.37	0.06	-2.90	0.02	0.122	Framboid + overgrowth	Late
	d34S_220922_S04@7	0.86	1.00	8.77	0.06	17.00	0.02	0.056	Framboid + overgrowth	Late
	d34S_220922_S04@8	0.86	0.97	2.70	0.06	5.01	0.02	0.126	Euhedral	Growth
	d34S_220922_S04@9	0.86	0.71	2.88	0.06	5.32	0.02	0.142	Framboid + overgrowth	Late
	d34S_220922_S04@10	0.86	0.57	-2.40	0.06	-5.02	0.02	0.195	Framboid + overgrowth + cement	Late
	d34S_220922_S04@11	0.86	0.92	10.81	0.06	21.00	0.02	0.047	Framboid + overgrowth + cement	Late
	d34S_220922_S04@12	0.86	0.93	8.23	0.06	15.86	0.02	0.095	Framboid + overgrowth + cement	Late
	d34S_220922_S04@13	0.86	0.79	6.10	0.06	11.72	0.02	0.080	Framboid + overgrowth	Late
	d34S_220922_S04@14	0.86	0.82	-1.34	0.06	-2.89	0.02	0.148	Framboid + overgrowth + cement	Late
	d34S_220922_S04@15	0.86	0.91	-6.40	0.06	-12.67	0.02	0.144	Euhedral	Growth
	d34S_220921_S04@16	0.86	0.91	3.91	0.06	7.31	0.02	0.153	Euhedral	Growth
	d34S_220921_S04@17	0.86	0.92	2.98	0.06	5.50	0.02	0.147	Irregular	Late
	d34S_220921_S04@18	0.86	0.46	-2.69	0.06	-5.49	0.02	0.137	Euhedral	Growth
	d34S_220921_S04@19	0.86	1.03	8.24	0.06	15.83	0.02	0.118	Irregular	Late
	d34S_220921_S04@20	0.86	0.39	-6.14	0.06	-12.30	0.02	0.208	Irregular	Late
	d34S_220921_S04@21	0.86	0.98	4.10	0.06	7.81	0.02	0.091	Framboid + overgrowth + cement	Late
	d34S_220921_S04@22	0.86	0.41	-5.21	0.06	-10.38	0.02	0.144	Framboid + overgrowth + cement	Late
	d34S_220921_S04@23	0.86	0.54	-0.68	0.06	-1.59	0.02	0.139	Framboid + overgrowth + cement	Late
	d34S_220921_S04@24	0.86	0.46	-2.12	0.06	-4.39	0.02	0.148	Framboid + overgrowth	Late
	d34S_220921_S04@25	0.86	0.92	-4.87	0.06	-9.79	0.02	0.189	Framboid + overgrowth + cement	Late

	d34S_220921_S04@26	0.86	0.85	5.30	0.06	10.15	0.02	0.081	Cubic	Growth
	d34S_220921_S04@27	0.86	0.95	2.08	0.06	3.78	0.02	0.128	Irregular	Late
	d34S_220921_S04@28	0.86	0.83	4.53	0.06	8.59	0.02	0.111	Irregular	Late
	d34S_220921_S04@29	0.86	1.03	28.44	0.06	55.60	0.02	0.177	Framboid + overgrowth + cement	Late
	d34S_220921_S04@30	0.86	1.06	13.11	0.06	25.19	0.02	0.216	Irregular	Late
	d34S_220923_S04@31	0.86	0.95	12.34	0.06	24.05	0.02	0.024	Irregular	Late
	d34S_220923_S04@32	0.86	0.75	1.43	0.06	2.46	0.02	0.161	Irregular	Late
	d34S_220923_S04@33	0.86	0.72	-1.26	0.06	-2.83	0.02	0.195	Irregular	Late
	d34S_220923_S04@34	0.86	1.00	-3.10	0.06	-6.38	0.02	0.195	Irregular	Late
	d34S_220923_S04@35	0.86	0.83	5.87	0.06	11.24	0.02	0.102	Framboid + overgrowth + cement	Late
	d34S_220923_S04@36	0.86	0.89	2.47	0.06	4.57	0.02	0.120	Irregular	Late
	d34S_220923_S04@37	0.86	0.99	2.61	0.06	4.86	0.02	0.111	Irregular	Late
	d34S_220923_S04@38	0.86	0.77	1.00	0.06	1.65	0.02	0.149	Irregular	Late
	d34S_220923_S04@39	0.86	1.00	4.26	0.06	8.12	0.02	0.084	Irregular	Late
	d34S_220923_S04@40	0.86	0.69	3.52	0.06	6.56	0.02	0.144	Framboid + overgrowth + cement	Late
	d34S_220923_S04@41	0.86	0.86	-5.58	0.06	-11.13	0.02	0.170	Irregular	Late
	d34S_220923_S04@42	0.86	0.98	-6.57	0.06	-13.09	0.02	0.191	Euhedral	Growth
	d34S_220923_S04@43	0.86	0.93	8.33	0.06	16.04	0.02	0.103	Euhedral	Growth
	d34S_220923_S04@44	0.86	0.68	-1.81	0.06	-3.84	0.02	0.170	Irregular	Late
	d34S_220923_S04@45	0.86	0.92	-5.94	0.06	-11.92	0.02	0.215	Euhedral	Growth
GC06-S05										
	d34S_220922_S05@2	1.11	0.84	12.36	0.10	24.08	0.11	0.031	Euhedral	Growth
	d34S_220922_S05@3	1.11	0.89	16.23	0.10	31.76	0.11	-0.003	Framboid + overgrowth + cement	Late
	d34S_220922_S05@4	1.11	0.93	12.19	0.10	23.81	0.11	-0.005	Irregular	Growth
	d34S_220922_S05@5	1.11	0.70	12.49	0.10	24.32	0.11	0.039	Irregular	Late
	d34S_220922_S05@6	1.11	0.75	13.38	0.10	26.13	0.11	0.005	Framboid + overgrowth + cement	Late
	d34S_220922_S05@7	1.11	0.67	14.67	0.10	28.66	0.11	0.008	Irregular	Late
	d34S_220922_S05@8	1.11	0.88	16.80	0.10	32.95	0.11	-0.040	Irregular	Growth
	d34S_220922_S05@9	1.11	0.90	12.84	0.10	25.06	0.11	0.016	Framboid + overgrowth + cement	Late
	d34S_220922_S05@10	1.11	0.75	15.98	0.10	31.31	0.11	-0.024	Framboid + overgrowth + cement	Late

	d34S_220922_S05@12	1.11	0.76	13.66	0.10	26.71	0.11	-0.006	Framboid + overgrowth + cement	Growth
	d34S_220922_S05@13	1.11	0.65	12.15	0.10	23.71	0.11	0.010	Irregular	Growth
	d34S_220922_S05@14	1.11	0.90	14.50	0.10	28.38	0.11	-0.016	Polyframboid cemented	Late
	d34S_220922_S05@15	1.11	0.82	12.01	0.10	23.48	0.11	-0.012	Irregular	Late
	d34S_220922_S05@16	1.11	0.79	16.46	0.10	32.18	0.11	0.016	Polyframboid cemented	Late
	d34S_220922_S05@17	1.11	0.74	13.54	0.10	26.47	0.11	-0.005	Irregular	Late
	d34S_220922_S05@18	1.11	0.77	9.90	0.10	19.25	0.11	0.029	Polyframboid cemented	Growth
	d34S_220922_S05@19	1.11	0.55	9.48	0.10	18.37	0.11	0.065	Framboid + overgrowth + cement	Growth
	d34S_220922_S05@20	1.11	0.63	12.68	0.10	24.79	0.11	-0.013	Framboid + overgrowth + cement	Growth
	d34S_220922_S05@21	1.11	0.49	9.57	0.10	18.56	0.11	0.059	Framboid + overgrowth + cement	Late
	d34S_220922_S05@22	1.11	0.73	10.28	0.10	19.99	0.11	0.036	Irregular	Growth
	d34S_220922_S05@23	1.11	0.57	14.39	0.10	28.10	0.11	0.017	Polyframboid cemented	Late
	d34S_220922_S05@24	1.11	0.71	15.38	0.10	30.16	0.11	-0.037	Framboid + overgrowth + cement	Late
	d34S_220922_S05@25	1.11	0.91	16.94	0.10	33.20	0.11	-0.025	Polyframboid cemented	Late
	d34S_220922_S05@26	1.11	0.89	16.66	0.10	32.59	0.11	0.005	Polyframboid cemented	Late
	d34S_220922_S05@27	1.11	0.56	15.76	0.10	30.81	0.11	0.011	Framboid + overgrowth + cement	Late
	d34S_220922_S05@28	1.11	0.86	16.51	0.10	32.41	0.11	-0.052	Polyframboid cemented	Late
	d34S_220922_S05@29	1.11	0.92	16.83	0.10	32.98	0.11	-0.019	Irregular	Late
	d34S_220922_S05@30	1.11	0.87	9.82	0.10	19.04	0.11	0.060	Framboid + cement	Late
GC06-S06										
	d34S_220923_S06@1	1.36	0.56	10.38	0.10	20.12	0.03	0.066	Irregular	Late
	d34S_220923_S06@2	1.36	0.51	9.46	0.10	18.35	0.03	0.049	Irregular	Late
	d34S_220923_S06@3	1.36	0.74	10.87	0.10	21.07	0.03	0.070	Euhedral	Growth
	d34S_220923_S06@4	1.36	0.78	11.26	0.10	21.88	0.03	0.046	Irregular	Late
	d34S_220923_S06@5	1.36	0.90	11.89	0.10	23.13	0.03	0.043	Euhedral	Growth
	d34S_220923_S06@6	1.36	0.91	-0.57	0.10	-1.42	0.03	0.158	Irregular	Late
	d34S_220923_S06@7	1.36	0.87	11.39	0.10	22.20	0.03	0.019	Polyframboid + overgrowth + cement	Growth
	d34S_220923_S06@8	1.36	0.75	11.03	0.10	21.44	0.03	0.041	Framboid + overgrowth + cement	Late
	d34S_220923_S06@9	1.36	0.72	10.54	0.10	20.51	0.03	0.028	Euhedral	Growth
	d34S_220923_S06@10	1.36	0.58	9.61	0.10	18.60	0.03	0.071	Irregular	Late

	d34S_220923_S06@11	1.36	0.90	11.83	0.10	23.01	0.03	0.044	Euhedral	Growth
	d34S_220923_S06@12	1.36	0.80	11.47	0.10	22.29	0.03	0.053	Polyframboid + overgrowth + cement	Late
	d34S_220923_S06@13	1.36	0.83	9.95	0.10	19.33	0.03	0.035	Euhedral	Growth
	d34S_220923_S06@14	1.36	0.86	10.49	0.10	20.33	0.03	0.073	Polyframboid + overgrowth + cement	Late
	d34S_220923_S06@15	1.36	0.66	10.78	0.10	20.99	0.03	0.025	Irregular	Late
	d34S_220923_S06@16	1.36	0.79	9.79	0.10	19.05	0.03	0.029	Framboid + overgrowth + cement	Late
	d34S_220923_S06@17	1.36	0.65	10.50	0.10	20.46	0.03	0.017	Irregular	Late
	d34S_220923_S06@19	1.36	0.66	11.31	0.10	22.00	0.03	0.037	Irregular	Late
	d34S_220923_S06@20	1.36	0.66	9.93	0.10	19.28	0.03	0.047	Framboid + overgrowth + cement	Late
	d34S_220923_S06@21	1.36	0.77	11.34	0.10	22.08	0.03	0.032	Irregular	Late
	d34S_220923_S06@22	1.36	0.66	10.88	0.10	21.19	0.03	0.024	Irregular	Late
	d34S_220923_S06@23	1.36	0.55	10.31	0.10	19.95	0.03	0.088	Irregular	Late
	d34S_220923_S06@24	1.36	0.88	10.96	0.10	21.34	0.03	0.024	Irregular	Late
	d34S_220923_S06@25	1.36	0.86	10.66	0.10	20.68	0.03	0.066	Irregular	Late
	d34S_220923_S06@26	1.36	0.76	11.65	0.10	22.61	0.03	0.066	Euhedral	Growth
	d34S_220923_S06@27	1.36	0.88	-0.48	0.10	-1.23	0.03	0.147	Euhedral	Late
	d34S_220923_S06@28	1.36	0.82	11.38	0.10	22.15	0.03	0.035	Polyframboids	Growth
	d34S_220923_S06@29	1.36	0.66	10.49	0.10	20.33	0.03	0.071	Framboid + overgrowth + cement	Late
	d34S_220923_S06@30	1.36	0.86	8.75	0.10	16.95	0.03	0.063	Irregular	Late
GC06-S07										
	d34S_220923_S07@1	1.61	0.53	-2.09	0.06	-4.28	0.06	0.117	Framboid	Nucleation
	d34S_220923_S07@2	1.61	0.28	-4.07	0.06	-8.19	0.07	0.160	Euhedral	Growth
	d34S_220923_S07@3	1.61	0.34	0.63	0.06	0.88	0.06	0.175	Framboid	Nucleation
	d34S_220923_S07@4	1.61	0.56	5.77	0.06	10.96	0.06	0.139	Framboid	Nucleation
	d34S_220923_S07@5	1.61	0.38	-6.83	0.06	-13.53	0.06	0.156	Framboid	Nucleation
	d34S_220923_S07@6	1.61	0.54	-0.69	0.06	-1.70	0.06	0.186	Framboid	Nucleation
	d34S_220923_S07@7	1.61	0.39	5.60	0.06	10.74	0.07	0.089	Framboid	Nucleation
	d34S_220923_S07@8	1.61	0.41	-5.98	0.06	-12.00	0.06	0.220	Framboid	Nucleation
	d34S_220923_S07@9	1.61	0.32	-1.12	0.06	-2.57	0.07	0.204	Framboid	Nucleation
	d34S_220923_S07@10	1.61	0.45	13.92	0.06	27.12	0.06	0.042	Framboid	Nucleation

Supplementary Table 4: Co-located (i.e., same grain) microscale $\delta^{56}Fe_{PYR}$-$\delta^{34}S_{PYR}$-$\Delta^{33}S_{PYR}$ from GC06. Results are provided by core section (depth). $\delta^{56}Fe$ values are reported against IRMM-014. $\delta^{34}S_{PYR}$-$\Delta^{33}S_{PYR}$ values are reported against VCDT. The corresponding raw SIMS data are available on request.

Corresponding microscale pyrite Fe and S isotopes from GC06							
Core section	**Fe analyze name**	**Depth**	**$\delta^{56}Fe$**	**S analyze name**	**$\delta^{34}S$**	**$\Delta^{33}S$**	**Morphology**
			‰ IRMM-014		‰ VCDT		
GC06_S01							
	d56Fe_090622_GC06-S01@1	0.1	-2.41	d34S_220920_S01@1	-52.42	0.051	Nucleation
	d56Fe_090622_GC06-S01@2	0.1	-3.23	d34S_220920_S01@2	-52.36	0.096	Nucleation
	d56Fe_090622_GC06-S01@3	0.1	-3.17	d34S_220920_S01@3	-54.45	0.050	Nucleation
	d56Fe_090622_GC06-S01@4	0.1	-2.96	d34S_220920_S01@5	-53.20	0.080	Nucleation
	d56Fe_090622_GC06-S01@7	0.1	-1.27	d34S_220920_S01@6	-47.07	0.111	Nucleation
	d56Fe_090622_GC06-S01@8	0.1	-2.53	d34S_220920_S01@8	-49.78	0.092	Nucleation
	d56Fe_090622_GC06-S01@9	0.1	-2.34	d34S_220920_S01@9	-47.92	0.084	Nucleation
	d56Fe_090622_GC06-S01@10	0.1	-2.95	d34S_220920_S01@10	-47.67	0.094	Nucleation
	d56Fe_090622_GC06-S01@11	0.1	-3.19	d34S_220920_S01@11	-46.66	0.148	Nucleation
	d56Fe_090622_GC06-S01@12	0.1	-3.35	d34S_220920_S01@12	-49.36	0.120	Nucleation
	d56Fe_090622_GC06-S01@13	0.1	-3.38	d34S_220920_S01@13	-51.50	0.097	Growth
	d56Fe_090622_GC06-S01@14	0.1	-2.46	d34S_220920_S01@14	-52.24	0.085	Growth
	d56Fe_090622_GC06-S01@15	0.1	-2.63	d34S_220920_S01@15	-47.95	0.084	Nucleation
	d56Fe_090622_GC06-S01@16	0.1	-3.29	d34S_220920_S01@16	-47.98	0.083	Nucleation
	d56Fe_090622_GC06-S01@17	0.1	-3.07	d34S_220920_S01@17	-51.96	0.079	Growth
	d56Fe_090622_GC06-S01@18	0.1	-2.85	d34S_220920_S01@18	-50.89	0.111	Growth
	d56Fe_090622_GC06-S01@19	0.1	-3.61	d34S_220920_S01@19	-49.29	0.126	Growth
	d56Fe_090622_GC06-S01@20	0.1	-2.85	d34S_220920_S01@20	-44.83	0.125	Growth
	d56Fe_090622_GC06-S01@21	0.1	-2.74	d34S_220920_S01@21	-44.67	0.126	Growth
	d56Fe_090622_GC06-S01@22	0.1	-3.12	d34S_220920_S01@22	-46.47	0.093	Nucleation
	d56Fe_090622_GC06-S01@23	0.1	-2.38	d34S_220920_S01@23	-48.36	0.132	Nucleation
	d56Fe_090622_GC06-S01@24	0.1	-3.32	d34S_220920_S01@24	-50.83	0.125	Nucleation

	d56Fe_090622_GC06-S01@25	0.1	-2.00	d34S_220920_S01@25	-47.26	0.084	Nucleation
	d56Fe_090622_GC06-S01@26	0.1	-2.83	d34S_220920_S01@26	-51.09	0.098	Nucleation
	d56Fe_090622_GC06-S01@27	0.1	-3.25	d34S_220920_S01@27	-49.85	0.075	Growth
	d56Fe_090622_GC06-S01@28	0.1	-3.49	d34S_220920_S01@28	-45.97	0.111	Nucleation
	d56Fe_090622_GC06-S01@29	0.1	-3.39	d34S_220920_S01@29	-49.34	0.065	Nucleation
	d56Fe_090622_GC06-S01@30	0.1	-3.50	d34S_220920_S01@30	-48.84	0.153	Nucleation
GC06_S02							
	d56Fe_100622_GC06-S02@01	0.37	-3.24	d34S_220921_S02@22	-51.74	0.065	Nucleation
	d56Fe_100622_GC06-S02@2	0.37	-1.79	d34S_220921_S02@4	-8.92	0.216	Late
	d56Fe_100622_GC06-S02@3	0.37	-0.67	d34S_220921_S02@6	-43.75	0.163	Growth
	d56Fe_100622_GC06-S02@4	0.37	-3.34	d34S_220921_S02@11	-54.60	0.087	Nucleation
	d56Fe_100622_GC06-S02@5	0.37	-3.50	d34S_220921_S02@7	-53.36	0.054	Nucleation
	d56Fe_100622_GC06-S02@6	0.37	-1.48	d34S_220921_S02@5	-31.00	0.225	Growth
	d56Fe_100622_GC06-S02@11	0.37	-3.34	d34S_220921_S02@23	-51.54	0.087	Growth
	d56Fe_100622_GC06-S02@12	0.37	-3.17	d34S_220921_S02@3	-42.21	0.157	Nucleation
	d56Fe_100622_GC06-S02@14	0.37	-1.00	d34S_220921_S02@19	-41.37	0.137	Nucleation
	d56Fe_100622_GC06-S02@16	0.37	-1.76	d34S_220921_S02@15	-35.20	0.184	Nucleation
	d56Fe_100622_GC06-S02@18	0.37	0.24	d34S_220921_S02@16	-37.45	0.164	Growth
	d56Fe_100622_GC06-S02@19	0.37	0.28	d34S_220921_S02@14	-38.24	0.191	Growth
	d56Fe_100622_GC06-S02@20	0.37	0.44	d34S_220921_S02@8	-15.49	0.259	Growth
	d56Fe_100622_GC06-S02@24	0.37	-3.51	d34S_220921_S02@9	-42.21	0.131	Growth
GC06_S03							
	d56Fe_100622_GC06-S03@01	0.62	-0.36	d34S_220921_S03@1	-19.53	0.140	Late
	d56Fe_100622_GC06-S03@2	0.62	0.35	d34S_220921_S03@2	-20.38	0.163	Late
	d56Fe_100622_GC06-S03@3	0.62	-1.73	d34S_220921_S03@3	-13.10	0.196	Late
	d56Fe_100622_GC06-S03@5	0.62	0.21	d34S_220921_S03@4	-15.63	0.181	Late
	d56Fe_100622_GC06-S03@6	0.62	-1.45	d34S_220921_S03@5	-11.80	0.187	Late
	d56Fe_100622_GC06-S03@10	0.62	-1.37	d34S_220921_S03@6	-16.42	0.190	Late
	d56Fe_100622_GC06-S03@11	0.62	0.43	d34S_220921_S03@7	-15.40	0.181	Late
	d56Fe_100622_GC06-S03@12	0.62	0.66	d34S_220921_S03@8	-17.22	0.135	Late

	d56Fe_100622_GC06-S03@13	0.62	0.22	d34S_220921_S03@9	-18.05	0.186	Late
	d56Fe_100622_GC06-S03@15	0.62	-1.08	d34S_220921_S03@10	-21.72	0.188	Late
	d56Fe_100622_GC06-S03@16	0.62	0.34	d34S_220921_S03@11	-22.54	0.153	Late
	d56Fe_100622_GC06-S03@17	0.62	-0.52	d34S_220921_S03@12	-19.32	0.139	Late
	d56Fe_100622_GC06-S03@19	0.62	0.37	d34S_220921_S03@13	-17.16	0.192	Late
	d56Fe_100622_GC06-S03@20	0.62	0.46	d34S_220921_S03@14	-17.26	0.199	Late
	d56Fe_100622_GC06-S03@23	0.62	0.59	d34S_220921_S03@15	-22.33	0.175	Late
	d56Fe_100622_GC06-S03@25	0.62	-1.13	d34S_220921_S03@17	-19.70	0.190	Late
	d56Fe_100622_GC06-S03@28	0.62	-0.66	d34S_220921_S03@18	-19.00	0.214	Late
	d56Fe_100622_GC06-S03@29	0.62	0.71	d34S_220921_S03@19	-18.53	0.177	Late
	d56Fe_100622_GC06-S03@30	0.62	-0.84	d34S_220921_S03@30	-1.49	0.205	Growth
GC06_S04							
	GC06-S04@01	0.86	-0.82	d34S_220922_S04@1	11.34	0.100	Growth
	GC06-S04@2	0.86	1.03	d34S_220922_S04@2	11.67	0.142	Late
	GC06-S04@3	0.86	0.76	d34S_220922_S04@3	-4.45	0.170	Late
	GC06-S04@6	0.86	0.99	d34S_220922_S04@6	-2.90	0.122	Late
	GC06-S04@7	0.86	0.07	d34S_220922_S04@7	17.00	0.056	Late
	GC06-S04@8	0.86	1.18	d34S_220922_S04@8	5.01	0.126	Growth
	GC06-S04@9	0.86	0.73	d34S_220922_S04@9	5.32	0.142	Late
	GC06-S04@12	0.86	-0.53	d34S_220922_S04@12	15.86	0.095	Late
	GC06-S04@13	0.86	0.47	d34S_220922_S04@13	11.72	0.080	Late
	GC06-S04@14	0.86	0.15	d34S_220922_S04@14	-2.89	0.148	Late
	GC06-S04@15	0.86	0.61	d34S_220922_S04@15	-12.67	0.144	Growth
	GC06-S04@16	0.86	-1.71	d34S_220921_S04@16	7.31	0.153	Late
	GC06-S04@17	0.86	0.06	d34S_220921_S04@17	5.50	0.147	Late
	GC06-S04@18	0.86	-1.52	d34S_220921_S04@18	-5.49	0.137	Late
	GC06-S04@19	0.86	0.80	d34S_220921_S04@19	15.83	0.118	Late
	GC06-S04@20	0.86	0.69	d34S_220921_S04@20	-12.30	0.208	Late
	GC06-S04@21	0.86	0.28	d34S_220921_S04@21	7.81	0.091	Late
	GC06-S04@22	0.86	0.06	d34S_220921_S04@22	-10.38	0.144	Late
	GC06-S04@23	0.86	0.64	d34S_220921_S04@23	-1.59	0.139	Late
	GC06-S04@24	0.86	1.09	d34S_220921_S04@24	-4.39	0.148	Late
	GC06-S04@25	0.86	0.85	d34S_220921_S04@25	-9.79	0.189	Late
	GC06-S04@26	0.86	0.47	d34S_220921_S04@26	10.15	0.081	Growth
	GC06-S04@27	0.86	0.39	d34S_220921_S04@27	3.78	0.128	Late
	GC06-S04@28	0.86	0.64	d34S_220921_S04@28	8.59	0.111	Late

	GC06-S04@29	0.86	0.03	d34S_220921_S04@29	55.60	0.177	Late
	GC06-S04@30	0.86	0.41	d34S_220921_S04@30	25.19	0.216	Late
GC06_S05							
	d56Fe_110622_GC06-S05@8	1.11	0.67	d34S_220922_S05@10	31.31	-0.024	Late
	d56Fe_110622_GC06-S05@11	1.11	-0.19	d34S_220922_S05@12	26.71	-0.006	Growth
	d56Fe_110622_GC06-S05@14	1.11	1.31	d34S_220922_S05@13	23.71	0.010	Growth
	d56Fe_110622_GC06-S05@18	1.11	1.06	d34S_220922_S05@23	28.10	0.017	Late
	d56Fe_110622_GC06-S05@19	1.11	1.19	d34S_220922_S05@22	19.99	0.036	Growth
	d56Fe_110622_GC06-S05@21	1.11	1.32	d34S_220922_S05@16	32.18	0.016	Late
	d56Fe_110622_GC06-S05@22	1.11	0.73	d34S_220922_S05@17	26.47	-0.005	Late
	d56Fe_110622_GC06-S05@23	1.11	1.01	d34S_220922_S05@19	18.37	0.065	Growth
	d56Fe_110622_GC06-S05@25	1.11	-0.15	d34S_220922_S05@20	24.79	-0.013	Growth
	d56Fe_110622_GC06-S05@26	1.11	1.32	d34S_220922_S05@21	18.56	0.059	Late
	d56Fe_110622_GC06-S05@28	1.11	1.15	d34S_220922_S05@25	33.20	-0.025	Late
GC06_S06							
	d56Fe_110622_GC06-S06@1	1.36	0.55	d34S_220923_S06@1	20.12	0.066	Late
	d56Fe_110622_GC06-S06@3	1.36	1.12	d34S_220923_S06@2	18.35	0.049	Late
	d56Fe_110622_GC06-S06@5	1.36	0.21	d34S_220923_S06@3	21.07	0.070	Growth
	d56Fe_110622_GC06-S06@7	1.36	1.26	d34S_220923_S06@10	18.60	0.071	Late
	d56Fe_110622_GC06-S06@8	1.36	0.07	d34S_220923_S06@15	20.99	0.025	Late
	d56Fe_110622_GC06-S06@9	1.36	-1.06	d34S_220923_S06@13	19.33	0.035	Late
	d56Fe_110622_GC06-S06@10	1.36	1.29	d34S_220923_S06@14	20.33	0.073	Late
	d56Fe_110622_GC06-S06@19	1.36	0.13	d34S_220923_S06@16	19.05	0.029	Late
	d56Fe_110622_GC06-S06@20	1.36	-0.40	d34S_220923_S06@19	22.00	0.037	Late
	d56Fe_110622_GC06-S06@22	1.36	-0.15	d34S_220923_S06@21	22.08	0.032	Late
	d56Fe_110622_GC06-S06@23	1.36	0.37	d34S_220923_S06@22	21.19	0.024	Late
	d56Fe_110622_GC06-S06@24	1.36	1.11	d34S_220923_S06@23	19.95	0.088	Late
	d56Fe_110622_GC06-S06@25	1.36	0.09	d34S_220923_S06@24	21.34	0.024	Late
	d56Fe_110622_GC06-S06@27	1.36	-0.44	d34S_220923_S06@25	20.68	0.066	Late
	d56Fe_110622_GC06-S06@28	1.36	1.30	d34S_220923_S06@26	22.61	0.066	Growth
	d56Fe_110622_GC06-S06@29	1.36	0.59	d34S_220923_S06@27	-1.23	0.147	Late

	d56Fe_110622_GC06-S06@30	1.36	-1.42	d34S_220923_S06@28	22.15	0.035	Growth
	d56Fe_110622_GC06-S06@31	1.36	0.77	d34S_220923_S06@29	20.33	0.071	Late
GC06_S07							
	d56Fe_120622_GC06-S07@6	1.61	-1.10	d34S_220923_S07@1	-4.28	0.117	Nucleation
	d56Fe_120622_GC06-S07@3	1.61	-1.28	d34S_220923_S07@3	0.88	0.175	Nucleation
	d56Fe_120622_GC06-S07@15	1.61	-1.46	d34S_220923_S07@4	10.96	0.139	Nucleation

Supplementary Table 5: Model parameters. The code uses the isotope effects $\alpha = \exp(\varepsilon/1000)$ calculated from the Fe isotope fractionations provided in this table.

Parameter	**Value**	**Source**
Free model parameters		
f^{I}_{mic}	$0 \leq f^{I}_{mic} \leq 1$	Free
f^{I}_{sulph}	$0 \leq f^{I}_{sulph} \leq 1 - f^{I}_{mic}$	Free
f^{II}_{oxid}	$0 \leq f^{II}_{oxid} \leq 1$	Free
$^{56/54}\varepsilon_{lo}$	$-2 \leq {}^{56/54}\alpha_{lo} \leq 2$	6
Fixed isotopic fractionation		
$^{56/54}\varepsilon_{mic}$	–3.0 ‰	7,8
$^{56/54}\varepsilon_{oxid}$	2.5 ‰	9
$^{56/54}\varepsilon_{aq}$	–0.9 or +0.4‰	10-13
$^{56/54}\varepsilon_{FeS\text{-}Pyr}$	–2.2 or –0.5‰	14-16

Supplementary Data 1. (separate file)

Reference list of existing porewater sulphate and sulphide $\delta^{34}S$-$\Delta^{33}S$ (fig. 3A). Data available on request.

Supplementary Data 2. (separate file)

Reference list of porewater chemistry collected in marine sediments (fig. S6). Data available on request.

Supplementary Model. (separate file)

Matlab™ code of pyrite formation and Fe isotope fractionation model.

Supplementary References

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