

Electronic Supplementary Material

for

Deterioration mechanism of alkali-activated materials in sulfuric acid and the influence of Cu: a micro-to-nano structural, elemental and stable isotopic multi-proxy study

Cyrell Grengg^{a,*}, Gregor J.G. Gluth^{b,*}, Florian Mittermayr^c, Neven Ukrainczyk^d, Marko Bertmer^e, Ana Guilherme Buzanich^f, Martin Radtke^f, Albrecht Leis^g, Martin Dietzel^a

^a *Institute of Applied Geosciences, Graz University of Technology, Rechbauerstraße 12, 8010 Graz, Austria*

^b *Division 7.4 Technology of Construction Materials, Bundesanstalt für Materialforschung und -prüfung (BAM), Unter den Eichen 87, 12205 Berlin, Germany*

^c *Institute of Technology and Testing of Building Materials, Graz University of Technology, Inffeldgasse 24, 8010 Graz, Austria*

^d *Institute of Construction and Building Materials, Technical University of Darmstadt, Franziska-Braun-Strasse 3, 64 287, Darmstadt, Germany*

^e *Felix Bloch Institute for Solid State Physics, Leipzig University, Linnéstraße 5, 04103 Leipzig, Germany*

^f *Division 6.3 Structure Analysis, Bundesanstalt für Materialforschung und -prüfung (BAM), Richard-Willstätter-Straße 11, 12489 Berlin, Germany*

^g *JR-AquaConSol GmbH, Joanneum Research, Steyrergasse 21, 8010 Graz, Austria*

* *E-mail addresses: cyrill.grengg@tugraz.at (C. Grengg); gregor.gluth@bam.de (G.J.G. Gluth)*

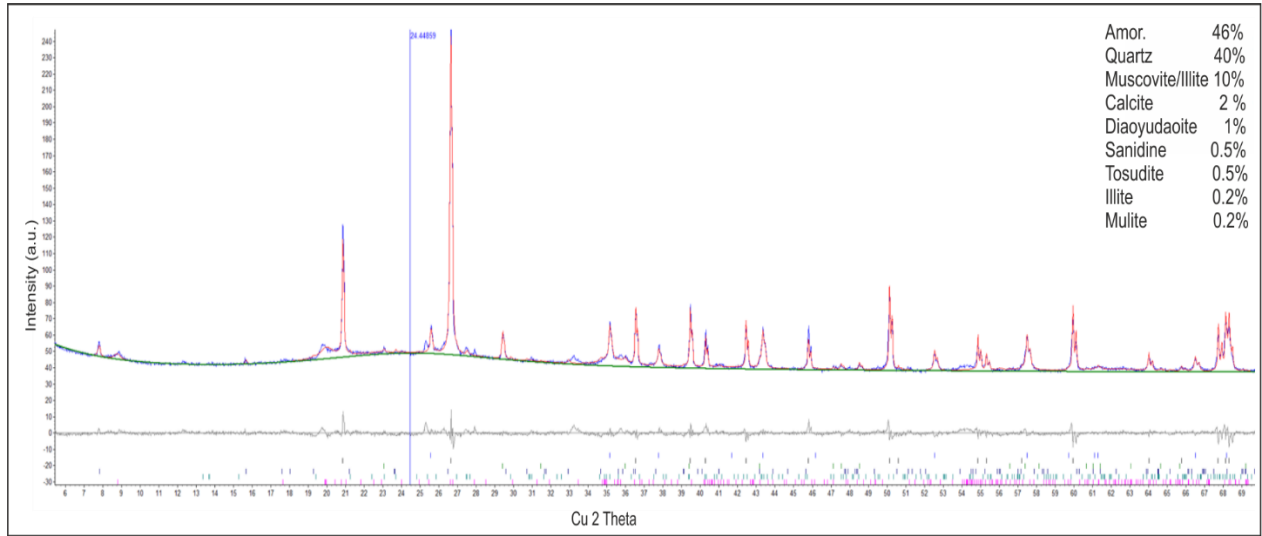


Fig. S1: Quantitative powder X-ray diffraction analysis (QXRD) of the raw metakaolin by means of Rietveld refinement (using Topas, Bruker).

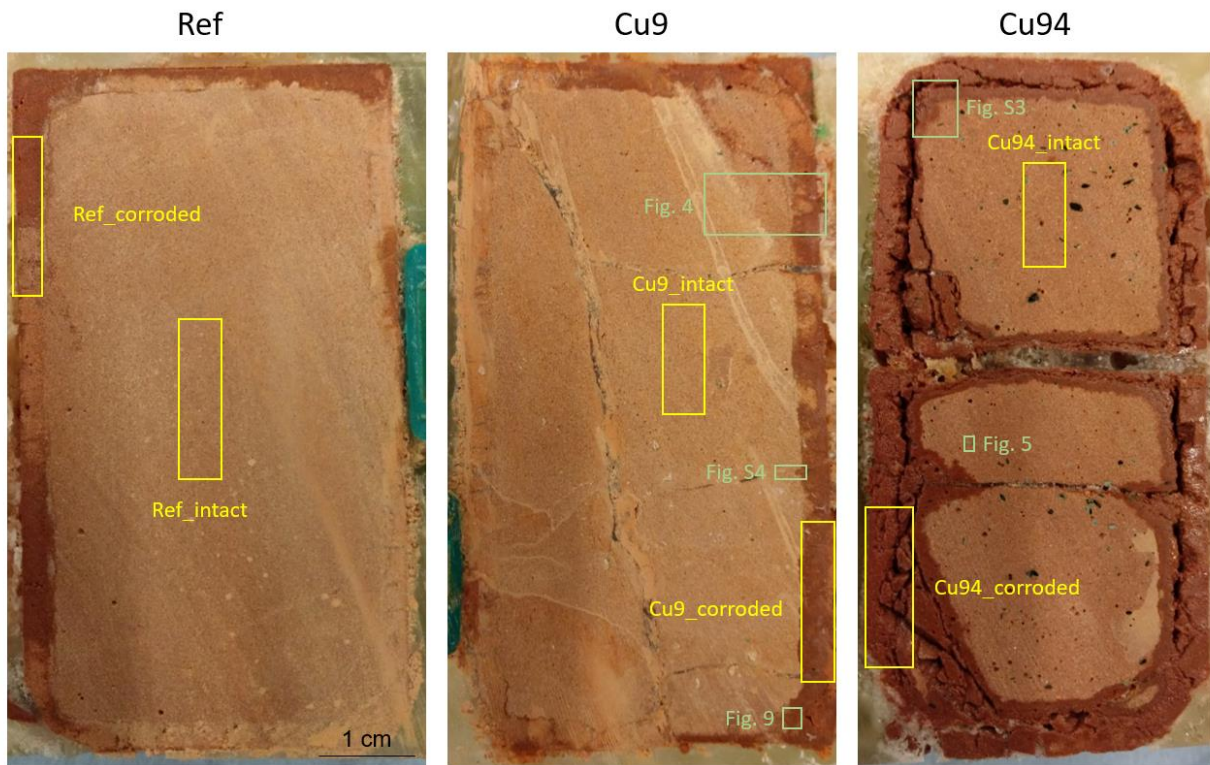


Fig. S2: Overview of the sampling locations for XRD, NMR and XANES analyses, extracted from cross sections of the mortar specimens after acid exposure, together with the areas on which the EPMA mappings were conducted.

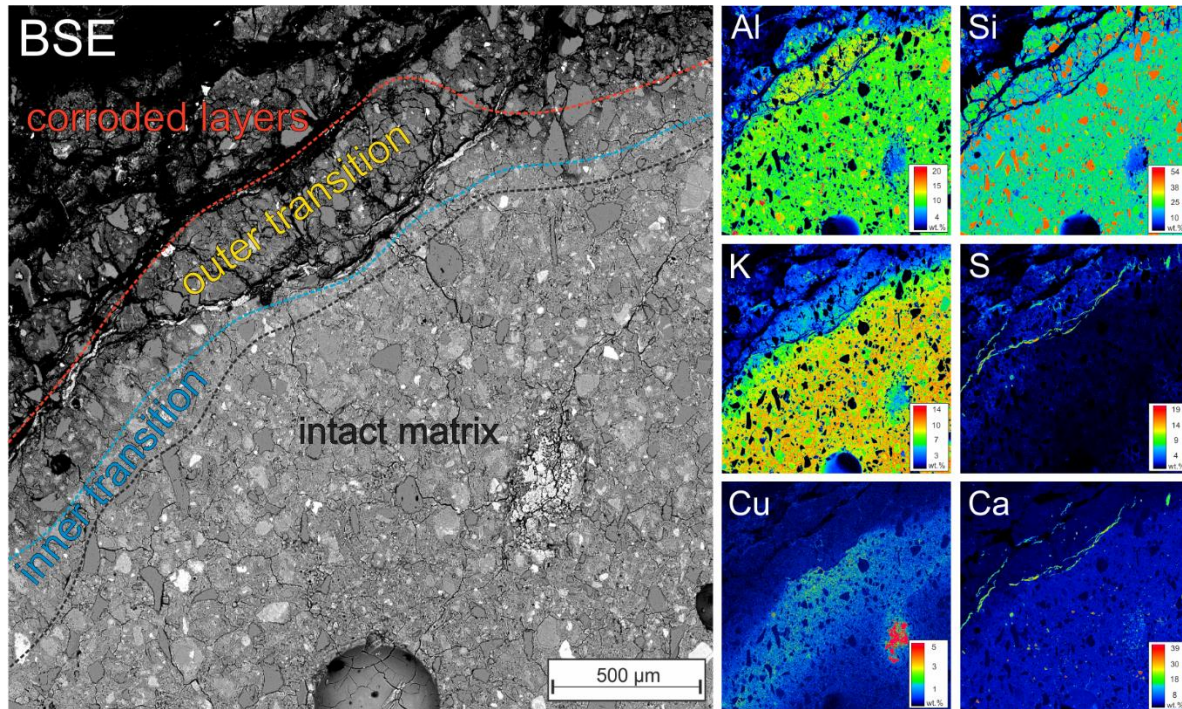


Fig. S3: BSE picture and elemental mapping of Al, Si, K, S and Ca displaying the transition (inner and outer zone) from intact to corroded microstructure of the Cu94 specimen.

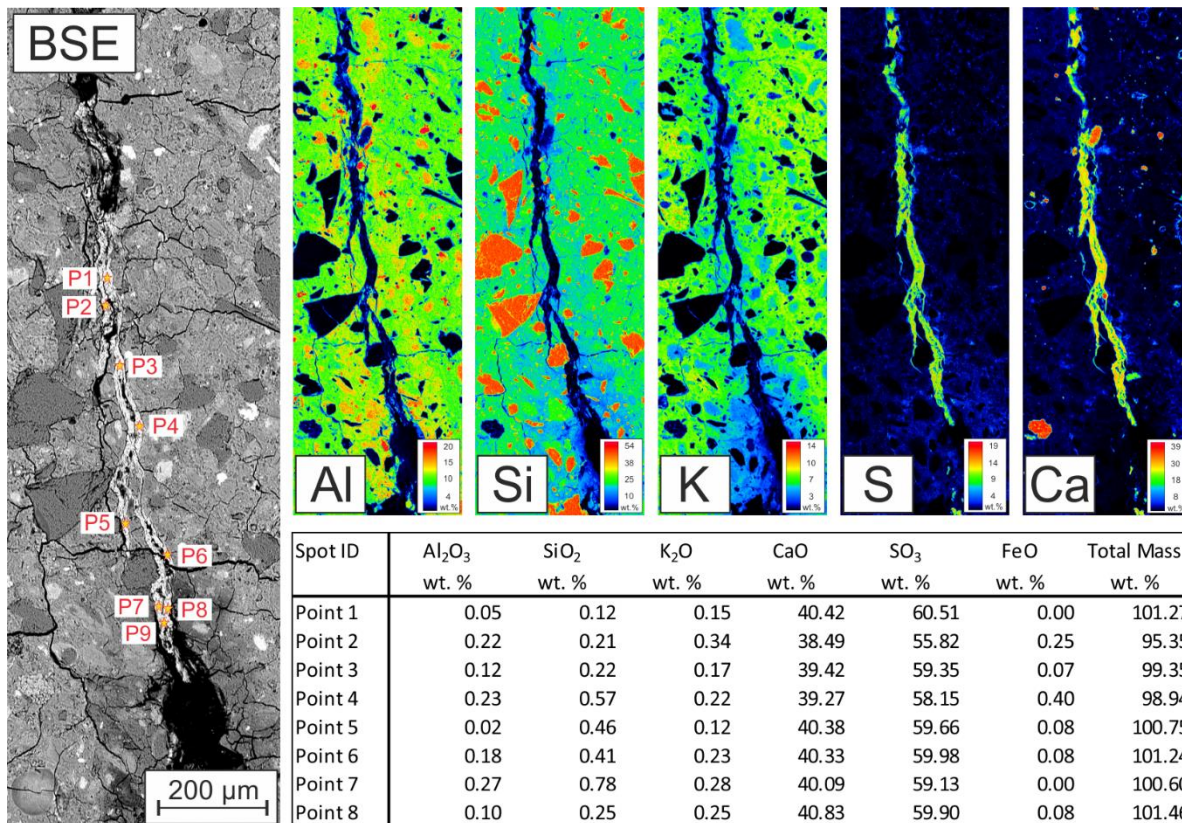


Fig. S4: BSE picture and elemental mappings of secondary Ca-sulfates, precipitating in a crack at the transition between intact and corroded matrix, with an average chemical composition of anhydrite.

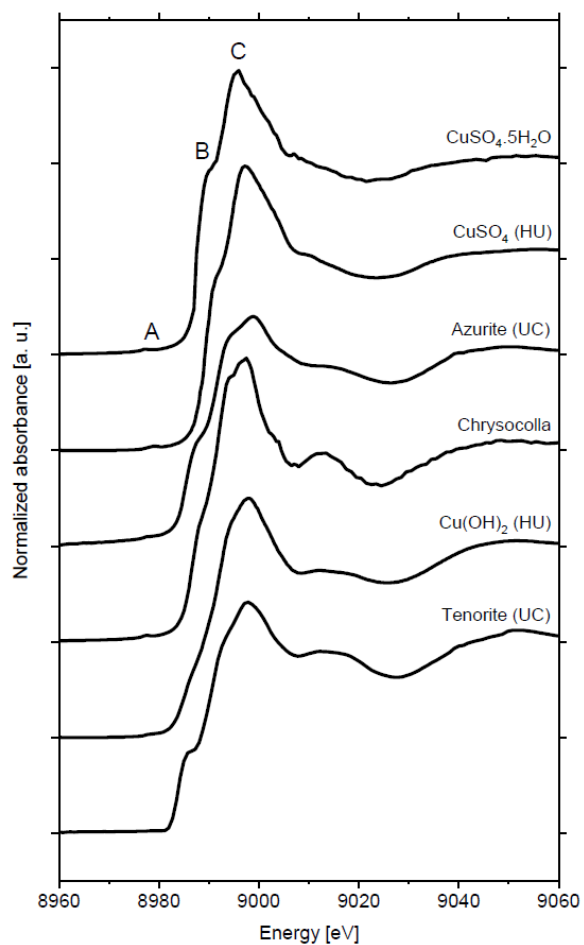


Fig. S5: Measured XANES spectra at the Cu K-edge of the reference compounds, and XANES spectra at the Cu K-edge obtained from databases (UC: University of Chicago [<http://cars.uchicago.edu/xaslib/search>]; HU: Hokkaido University [<https://www.cat.hokudai.ac.jp/catdb/>]).

Table S1: Mean oxide concentrations of quantitative FEG-EPMA spot measurements of the intact matrix, the transition zone and the corroded layers of the Ref, Cu9 and Cu94 specimens, together with the mean chemical compositions of the large and small Cu-grains in wt.%.

Sample ID	Al ₂ O ₃	Na ₂ O	SiO ₂	MgO	CuO	K ₂ O	CaO	SO ₃	FeO	total oxide mass
	wt. %	wt. %	wt. %	wt. %	wt. %	wt. %	wt. %	wt. %	wt. %	wt. %
Ref_intact	21.43	0.19	46.07	0.46	0.02	14.07	1.01	0.16	3.49	86.92
Ref_transition	20.30	0.14	45.60	0.43	0.01	14.07	0.65	1.09	2.23	84.57
Ref_corroded	5.67	0.08	70.74	0.22	0.01	1.99	0.10	2.16	2.78	83.77
Cu9_intact	21.08	0.18	45.53	0.54	0.03	13.68	1.36	0.27	3.30	86.14
Cu9_transition	19.63	0.17	45.55	0.45	0.29	11.78	2.13	2.28	3.58	85.90
Cu9_corroded	3.94	0.05	66.66	0.16	0.02	0.79	0.25	1.12	1.41	74.42
Cu94_intact	19.73	0.18	46.29	0.50	0.23	14.79	2.08	0.16	2.09	86.13
Cu94_transition	21.70	0.12	46.68	0.26	0.63	10.24	0.95	1.03	2.33	84.03
Cu94_corroded	3.60	0.04	66.32	0.27	0.06	0.61	0.15	1.54	1.19	73.83
Cu _{grain} _large_1_core	0.49	0.06	4.58	0.07	77.01	0.32	0.41	0.27	0.03	83.33
Cu _{grain} _large_1_inner_rim	3.39	0.09	21.12	0.13	45.56	1.04	0.33	0.20	0.05	71.99
Cu _{grain} _large_1_outer_rim	2.47	0.13	12.00	0.12	66.12	0.79	0.42	0.32	0.14	82.64
Cu _{grain} _large_2_core	3.94	0.25	24.42	0.23	51.24	2.00	0.83	0.86	0.09	83.94
Cu _{grain} _large_2_rim	2.41	0.18	11.99	0.23	76.70	1.02	0.60	0.17	0.37	93.75
Cu _{grain} _small_1	1.67	0.11	9.66	0.09	59.10	0.84	0.67	0.27	0.07	72.60
Cu _{grain} _small_2	4.21	0.06	26.64	0.26	43.31	2.80	1.15	0.37	0.25	79.15
Cu _{grain} _small_3	3.33	0.04	16.63	0.34	62.31	2.02	1.81	0.27	0.55	87.41

Table S2: Oxide concentrations of all quantitative FEG-EPMA spot measurements of the intact matrix, the transition zone and the corroded layers of the Ref, Cu9 and Cu94 specimens, together with all chemical compositions of the Cu-grains in wt.%.

Sample ID	Al ₂ O ₃	Na ₂ O	SiO ₂	MgO	CuO	K ₂ O	CaO	SO ₃	FeO	total oxide mass
	wt.%	wt.%	wt.%	wt.%	wt.%	wt.%	wt.%	wt.%	wt.%	wt.%
Ref_intact_1	28.66	0.24	49.84	0.58	0.02	8.85	0.64	0.06	3.17	92.10
Ref_intact_2	27.15	0.28	50.73	0.56	0.00	9.69	0.58	0.06	2.91	92.00
Ref_intact_3	18.77	0.13	50.26	0.30	0.00	18.53	1.70	0.24	1.82	91.74
Ref_intact_4	20.12	0.16	44.06	0.16	0.08	18.76	1.20	0.16	0.74	85.45
Ref_intact_5	17.31	0.17	43.16	0.26	0.00	19.44	1.59	0.35	1.03	83.39
Ref_intact_6	22.15	0.17	48.24	0.89	0.02	11.26	0.82	0.19	6.56	90.35
Ref_intact_7	14.54	0.07	46.59	0.23	0.00	19.05	0.99	0.14	0.94	82.61
Ref_intact_8	18.77	0.17	49.05	0.35	0.08	19.00	1.54	0.20	1.21	90.41
Ref_intact_9	20.00	0.17	44.11	0.20	0.03	18.34	1.35	0.21	2.76	87.18
Ref_intact_10	19.45	0.21	44.04	0.51	0.00	16.53	1.12	0.22	2.94	85.03
Ref_intact_11	24.10	0.18	46.02	0.47	0.00	11.20	0.84	0.14	3.34	86.28
Ref_intact_12	19.87	0.19	39.70	0.19	0.03	11.79	0.87	0.08	16.74	89.52
Ref_intact_13	19.86	0.20	44.43	1.38	0.04	10.69	1.01	0.35	6.60	84.60
Ref_intact_14	19.49	0.13	41.78	0.29	0.00	16.20	1.16	0.16	3.49	82.74
Ref_intact_15	15.03	0.12	24.99	0.08	0.02	13.82	0.87	0.21	1.11	56.25
Ref_intact_16	18.24	0.12	33.49	0.12	0.00	13.65	1.04	0.07	19.33	86.08
Ref_intact_17	15.57	0.10	46.85	0.82	0.05	14.83	1.42	0.50	4.15	84.29
Ref_intact_18	21.38	0.26	50.47	0.25	0.00	17.80	1.39	0.26	1.39	93.19
Ref_intact_19	26.81	0.21	46.23	0.15	0.00	14.50	0.61	0.07	1.21	89.79
Ref_intact_20	14.71	0.13	33.94	0.33	0.01	13.56	0.83	0.18	4.89	68.58
Ref_intact_21	25.05	0.23	47.99	0.12	0.00	12.75	0.42	0.04	1.57	88.17
Ref_intact_22	16.96	0.16	44.12	1.38	0.00	12.25	1.17	0.24	7.13	83.41
Ref_intact_23	20.45	0.12	44.67	0.23	0.06	17.77	1.18	0.17	1.26	85.91
Ref_intact_24	19.43	0.17	48.01	0.71	0.00	12.62	1.00	0.28	5.17	87.39
Ref_intact_25	19.75	0.16	48.60	0.69	0.00	15.41	1.12	0.18	3.98	89.90
Ref_intact_26	21.89	0.21	46.49	0.42	0.00	14.90	2.06	0.10	3.35	89.42
Ref_intact_27	19.81	0.12	46.14	0.16	0.00	19.32	0.92	0.09	0.96	87.51
Ref_intact_28	26.35	0.14	46.07	0.90	0.00	8.61	0.82	0.06	3.07	86.08
Ref_intact_29	24.99	0.22	48.80	0.90	0.03	7.80	1.07	0.25	7.44	91.51
Ref_intact_30	22.66	0.21	41.46	0.30	0.00	17.67	1.25	0.05	1.77	85.41
Ref_intact_31	18.90	0.12	42.09	0.45	0.06	14.82	1.26	0.14	3.83	81.72
Ref_intact_32	27.83	0.28	49.62	0.83	0.04	9.65	0.54	0.03	3.34	92.25
Ref_intact_33	20.55	0.12	42.98	0.34	0.00	16.20	1.66	0.15	2.30	84.30
Ref_intact_34	19.45	0.20	46.46	0.81	0.00	11.25	1.01	0.37	7.01	86.58
Ref_intact_35	20.73	0.19	42.12	0.26	0.03	18.29	1.14	0.11	1.18	84.06
Ref_intact_36	19.31	0.16	44.86	0.79	0.00	13.42	0.95	0.36	5.90	85.74
Ref_intact_37	26.77	0.33	46.35	0.08	0.06	13.25	0.45	0.10	1.07	88.56

Ref_intact_38	22.61	0.17	50.19	0.73	0.01	10.67	0.75	0.14	4.87	90.14
Ref_intact_39	22.46	0.21	40.66	0.10	0.05	16.81	0.72	0.11	0.67	81.79
Ref_intact_40	20.13	0.20	46.00	0.20	0.00	19.24	1.15	0.15	1.23	88.30
Ref_intact_41	19.38	0.17	44.73	0.20	0.01	19.51	1.46	0.66	0.88	87.08
Ref_intact_42	20.31	0.15	45.85	0.28	0.05	18.27	1.04	0.18	2.55	88.71
Ref_intact_43	25.56	0.22	50.21	0.74	0.03	9.26	0.68	0.11	4.06	90.91
Ref_intact_44	23.37	0.20	54.06	0.50	0.00	10.43	0.54	0.07	1.54	90.72
Ref_intact_45	19.76	0.16	49.62	2.13	0.02	10.36	1.26	0.24	6.02	89.57
Ref_intact_46	26.09	0.26	48.13	0.45	0.00	11.28	0.54	0.06	4.73	91.62
Ref_intact_47	24.91	0.24	47.22	0.12	0.03	13.13	0.43	0.05	0.86	87.01
Ref_intact_48	19.17	0.12	44.37	0.13	0.00	17.92	0.79	0.27	0.87	83.70
Ref_intact_49	20.28	0.22	47.03	0.25	0.01	18.62	1.14	0.15	0.95	88.66
Ref_intact_50	25.43	0.29	47.63	0.16	0.02	12.52	0.43	0.04	1.62	88.16
Ref_intact_51	26.30	0.28	45.02	0.41	0.00	9.02	0.54	0.08	6.02	87.66
Ref_intact_52	23.72	0.23	49.19	1.18	0.07	10.06	0.89	0.14	3.78	89.37
Ref_intact_53	22.07	0.17	49.58	0.72	0.00	9.88	0.72	0.09	3.84	87.07
Ref_intact_54	23.84	0.20	45.71	0.46	0.00	9.26	0.66	0.14	4.74	85.07
Ref_intact_55	24.71	0.19	43.80	0.46	0.06	8.62	0.75	0.19	5.41	84.19
Ref_intact_56	23.98	0.18	48.53	0.46	0.00	11.34	0.73	0.06	3.63	88.98
Ref_intact_57	17.85	0.24	45.07	0.89	0.00	11.87	2.93	0.24	9.04	88.13
Ref_intact_58	26.91	0.26	47.27	0.39	0.00	9.87	0.69	0.08	3.92	89.40
Ref_intact_59	12.83	0.13	64.09	0.09	0.01	11.60	0.58	0.18	0.50	90.02
Ref_intact_60	17.62	0.16	45.48	0.28	0.00	19.95	1.99	0.09	0.92	86.54
Ref_intact_61	19.46	0.19	45.15	0.46	0.00	17.34	1.14	0.14	3.77	87.65
Ref_intact_62	14.12	0.22	64.01	0.27	0.01	11.86	1.01	0.19	1.34	93.09
Ref_intact_63	19.06	0.14	45.63	0.20	0.00	17.96	1.50	0.20	1.24	85.93
Ref_intact_64	20.86	0.20	46.34	0.25	0.00	19.01	1.35	0.15	1.21	89.39
Ref_intact_65	28.90	0.29	47.27	0.54	0.02	9.26	0.51	0.05	3.78	90.61
Ref_intact_66	21.10	0.28	42.39	0.33	0.01	18.13	1.11	0.14	2.14	85.63
Ref_intact_67	22.89	0.20	46.32	0.64	0.03	11.88	0.71	0.06	3.74	86.48
Ref_intact_68	21.97	0.25	39.51	0.34	0.00	12.86	0.77	0.13	8.14	83.96
Ref_intact_69	18.65	0.12	44.14	0.21	0.01	17.98	0.96	0.19	2.13	84.43
Ref_intact_70	21.52	0.32	45.93	0.19	0.00	18.69	1.27	0.21	0.69	88.82
Ref_intact_71	19.88	0.21	46.87	0.28	0.05	19.20	1.11	0.25	1.50	89.37
Ref_intact_72	26.82	0.25	49.46	0.59	0.00	10.39	0.57	0.08	2.58	90.74
Ref_intact_73	27.13	0.31	45.49	0.62	0.09	9.31	0.62	0.08	3.23	86.88
Ref_transition_1	14.75	0.06	46.37	0.31	0.00	14.83	0.39	0.47	0.80	78.01
Ref_transition_2	19.48	0.13	50.16	0.40	0.01	14.57	0.48	0.69	1.08	87.01
Ref_transition_3	18.27	0.17	42.24	0.29	0.00	17.00	0.39	0.61	0.79	79.76
Ref_transition_4	15.59	0.13	47.49	1.33	0.00	10.50	0.63	0.86	9.42	86.02
Ref_transition_5	17.56	0.14	42.65	0.26	0.00	15.99	2.95	3.70	1.21	84.46
Ref_transition_6	18.91	0.16	41.35	0.38	0.06	15.47	1.16	2.15	2.67	82.36

Ref_transition_7	20.35	0.20	48.80	0.37	0.00	17.19	1.13	2.01	0.80	90.88
Ref_transition_8	26.46	0.09	48.67	0.75	0.00	7.93	0.40	0.53	3.43	88.31
Ref_transition_9	18.29	0.14	42.50	0.22	0.00	16.92	0.30	0.82	1.45	80.64
Ref_transition_10	18.35	0.13	43.57	0.38	0.00	15.25	0.36	1.26	2.04	81.38
Ref_transition_11	30.43	0.18	46.79	0.33	0.03	8.82	0.27	0.28	1.03	88.21
Ref_transition_12	30.02	0.11	46.56	0.22	0.00	8.14	0.33	0.36	1.28	87.02
Ref_transition_13	17.78	0.14	51.98	0.22	0.00	14.72	0.24	0.61	0.69	86.46
Ref_transition_14	18.99	0.18	41.83	1.00	0.00	12.95	0.62	1.14	7.17	83.89
Ref_transition_15	19.26	0.22	46.65	0.22	0.06	17.86	0.37	0.76	0.92	86.32
Ref_transition_16	19.79	0.17	37.06	0.32	0.00	13.94	0.97	1.83	3.09	77.17
Ref_transition_17	20.10	0.13	44.51	0.69	0.00	13.30	0.49	0.83	2.66	82.78
Ref_transition_18	20.45	0.15	46.34	0.27	0.00	17.11	0.45	1.00	1.01	86.77
Ref_transition_19	20.78	0.08	50.97	0.29	0.06	14.87	0.41	0.86	0.85	89.30
Ref_corroded_1	5.69	0.08	74.12	0.24	0.01	1.99	0.16	1.84	2.46	86.64
Ref_corroded_2	9.55	0.08	68.65	0.09	0.02	1.95	0.05	1.67	0.41	82.51
Ref_corroded_3	8.99	0.11	73.27	0.22	0.00	2.24	0.08	2.46	0.68	88.09
Ref_corroded_4	7.40	0.12	46.54	0.47	0.00	2.97	0.22	2.23	25.80	85.76
Ref_corroded_5	9.21	0.07	69.78	0.55	0.00	1.65	0.23	2.20	2.51	86.20
Ref_corroded_6	6.29	0.07	70.90	0.29	0.01	2.49	0.08	2.47	1.15	83.76
Ref_corroded_7	4.83	0.05	71.92	0.15	0.00	2.02	0.06	2.13	1.32	82.49
Ref_corroded_8	3.18	0.06	69.64	0.23	0.05	1.57	0.08	2.71	1.18	78.70
Ref_corroded_9	3.41	0.09	74.51	0.23	0.00	1.75	0.05	2.37	1.25	83.65
Ref_corroded_10	3.19	0.05	82.80	0.17	0.02	1.47	0.07	2.38	0.33	90.53
Ref_corroded_11	3.53	0.06	78.13	0.16	0.00	2.24	0.05	2.60	0.51	87.32
Ref_corroded_12	6.96	0.10	75.15	0.30	0.00	2.60	0.11	1.81	2.46	89.52
Ref_corroded_13	9.99	0.11	69.35	0.14	0.00	2.41	0.07	2.07	0.79	84.94
Ref_corroded_14	3.11	0.07	68.04	0.06	0.00	1.08	0.05	1.14	0.24	73.83
Ref_corroded_15	7.94	0.09	64.30	0.33	0.00	2.41	0.13	2.48	8.03	85.71
Ref_corroded_16	3.28	0.05	64.84	0.09	0.00	2.02	0.08	2.40	0.59	73.35
Ref_corroded_17	3.84	0.04	64.88	0.20	0.00	1.79	0.08	2.25	2.02	75.13
Ref_corroded_18	4.37	0.14	77.65	0.15	0.02	1.67	0.15	1.59	0.67	86.49
Ref_corroded_19	3.02	0.06	79.60	0.15	0.00	1.43	0.05	2.24	0.45	86.99
Cu9_intact_1	15.55	n.a.	46.59	0.20	0.00	18.02	1.00	0.43	1.53	83.42
Cu9_intact_2	15.59	n.a.	43.47	0.49	0.00	16.67	1.31	0.50	3.05	81.75
Cu9_intact_3	17.75	n.a.	45.58	0.25	0.00	18.65	0.95	0.49	1.00	84.76
Cu9_intact_4	14.56	n.a.	40.06	0.60	0.06	15.30	8.07	0.69	0.65	80.03
Cu9_intact_5	20.20	n.a.	47.59	0.92	0.15	11.31	0.85	0.36	3.92	86.11
Cu9_intact_6	17.84	n.a.	45.87	0.33	0.05	17.29	1.05	0.27	2.17	85.65
Cu9_intact_7	16.25	n.a.	43.09	0.32	0.00	17.22	1.18	0.43	2.12	81.92
Cu9_intact_8	17.50	n.a.	44.81	0.25	0.07	17.13	1.06	0.42	2.03	84.46
Cu9_intact_9	20.32	n.a.	47.54	0.91	0.03	10.41	0.71	0.35	4.05	84.85
Cu9_intact_10	21.36	n.a.	46.16	0.59	0.04	10.87	0.67	0.43	5.59	86.30

Cu9_intact_11	19.30	n.a.	47.64	1.21	0.11	9.25	0.82	0.75	8.09	87.79
Cu9_intact_12	17.00	n.a.	46.31	0.38	0.09	18.58	1.15	0.78	1.31	88.05
Cu9_intact_13	23.36	n.a.	47.37	0.10	0.00	11.59	0.47	0.04	1.61	85.29
Cu9_intact_14	19.87	n.a.	44.31	0.27	0.00	14.57	0.70	0.11	1.02	81.07
Cu9_intact_15	17.45	n.a.	40.38	0.21	0.05	17.13	0.76	0.10	1.17	78.03
Cu9_intact_16	20.72	n.a.	47.27	1.31	0.08	10.82	0.81	0.10	5.40	87.76
Cu9_intact_17	26.60	0.20	42.82	0.24	0.05	10.91	0.53	0.10	3.97	85.41
Cu9_intact_18	18.16	0.09	39.73	0.40	0.00	17.06	1.03	0.24	4.10	80.84
Cu9_intact_19	19.11	0.13	49.31	0.38	0.03	17.84	0.96	0.16	1.66	89.60
Cu9_intact_20	19.44	0.10	41.92	0.41	0.06	17.30	3.99	0.15	1.22	84.61
Cu9_intact_21	20.95	0.20	48.24	1.59	0.00	11.76	0.72	0.54	3.44	87.47
Cu9_intact_22	19.52	0.10	47.06	0.52	0.05	15.24	6.76	0.25	0.95	90.50
Cu9_intact_23	18.97	0.12	36.14	0.23	0.10	16.99	0.74	0.22	1.77	75.29
Cu9_intact_24	25.38	0.20	43.06	0.66	0.00	9.94	0.74	0.19	3.09	83.27
Cu9_intact_25	19.90	0.16	44.75	0.39	0.00	16.69	3.85	0.36	1.41	87.52
Cu9_intact_26	24.23	0.41	54.14	0.63	0.00	9.57	0.71	0.19	2.17	92.11
Cu9_intact_27	26.37	0.20	47.07	0.34	0.12	12.19	0.61	0.10	2.75	89.82
Cu9_intact_28	27.03	0.24	46.48	0.51	0.01	10.95	0.66	0.09	4.12	90.11
Cu9_intact_29	16.24	0.17	41.74	0.88	0.00	13.14	1.91	0.34	8.23	82.70
Cu9_intact_30	17.57	0.08	48.10	1.05	0.00	8.63	1.13	0.31	4.35	81.26
Cu9_intact_31	24.94	0.15	47.95	0.71	0.00	11.40	0.49	0.06	2.58	88.30
Cu9_intact_32	17.96	0.13	43.10	0.22	0.00	18.05	0.98	0.19	1.44	82.13
Cu9_intact_33	19.33	0.16	47.32	1.18	0.03	13.42	1.02	0.36	6.11	88.93
Cu9_intact_34	18.31	0.10	43.10	0.37	0.00	17.67	2.02	0.28	0.77	82.71
Cu9_intact_35	18.41	0.15	44.46	0.39	0.00	17.85	3.41	0.33	1.43	86.45
Cu9_intact_36	26.82	0.32	42.98	0.26	0.02	8.88	0.45	0.11	7.70	87.56
Cu9_intact_37	24.16	0.24	46.82	0.48	0.04	12.64	0.80	0.26	5.04	90.52
Cu9_intact_38	28.69	0.17	44.38	0.10	0.05	9.74	0.47	0.08	2.74	86.42
Cu9_intact_39	26.25	0.21	47.85	0.43	0.00	10.04	0.69	0.15	2.89	88.53
Cu9_intact_40	24.50	0.22	49.20	1.04	0.05	7.98	1.05	0.42	6.97	91.43
Cu9_intact_41	23.12	0.15	49.32	0.96	0.01	9.34	0.93	0.57	6.29	90.69
Cu9_intact_42	20.16	0.16	40.31	0.43	0.05	15.60	1.10	0.27	2.26	80.34
Cu9_intact_43	17.91	0.14	41.97	0.46	0.05	17.43	4.28	0.27	1.56	84.15
Cu9_intact_44	19.94	0.12	49.02	0.48	0.03	10.99	0.61	0.26	10.08	91.60
Cu9_intact_45	25.02	0.25	49.48	0.47	0.01	10.35	0.62	0.09	4.57	90.92
Cu9_intact_46	28.16	0.26	47.72	0.20	0.05	11.95	0.53	0.02	1.20	90.10
Cu9_intact_47	26.11	0.27	46.92	0.18	0.12	13.09	0.45	0.03	1.07	88.24
Cu9_intact_48	19.48	0.15	43.52	0.43	0.00	14.96	0.81	0.23	3.42	83.07
Cu9_intact_49	19.58	0.19	43.05	0.45	0.02	15.80	3.10	0.23	2.94	85.36
Cu9_intact_50	19.05	0.16	47.63	0.66	0.08	16.69	0.87	0.41	3.86	89.40
Cu9_intact_51	18.87	0.10	45.49	0.30	0.00	17.78	2.58	0.33	1.42	86.88
Cu9_intact_52	21.29	0.21	43.43	0.77	0.07	9.94	0.80	0.23	4.27	81.06

Cu9_intact_53	25.40	0.26	50.04	0.72	0.02	9.66	0.74	0.21	4.36	91.41
Cu9_intact_54	26.44	0.22	47.85	0.67	0.02	9.95	0.72	0.11	4.08	90.08
Cu9_intact_55	25.44	0.15	49.82	0.72	0.05	9.00	0.75	0.10	4.91	90.99
Cu9_intact_56	26.24	0.24	49.17	0.58	0.05	9.98	0.56	0.10	3.61	90.52
Cu9_intact_57	19.01	0.15	42.64	0.33	0.00	18.59	2.56	0.16	1.17	84.62
Cu9_intact_58	19.24	0.14	46.86	0.69	0.07	16.42	1.17	0.29	3.46	88.34
Cu9_intact_59	19.59	0.16	40.82	0.27	0.01	17.35	1.31	0.22	2.47	82.20
Cu9_intact_60	20.00	0.24	43.12	0.79	0.04	13.84	1.51	0.34	7.55	87.42
Cu9_intact_61	18.27	0.10	42.49	0.31	0.00	15.77	0.78	0.21	3.57	81.51
Cu9_intact_62	18.78	0.09	44.16	0.26	0.06	18.34	1.46	0.25	1.62	85.06
Cu9_intact_63	23.76	0.21	48.85	0.59	0.02	11.74	0.76	0.20	3.49	89.68
Cu9_intact_64	24.85	0.17	48.76	0.96	0.01	10.55	0.68	0.15	2.53	88.72
Cu9_transition_1	21.52	0.61	50.15	0.39	0.12	14.64	2.38	2.50	0.87	93.18
Cu9_transition_2	16.49	0.10	42.90	0.41	0.26	10.89	2.69	3.35	1.61	78.74
Cu9_transition_3	23.92	0.13	41.33	0.92	0.34	8.31	1.99	3.22	4.42	84.61
Cu9_transition_4	16.90	0.21	37.02	0.27	0.21	14.71	6.59	5.26	1.83	83.07
Cu9_transition_5	19.26	0.12	42.24	0.41	0.27	13.95	0.59	1.27	1.60	79.71
Cu9_transition_6	17.58	0.10	46.85	0.72	0.42	10.03	0.76	1.58	8.06	86.19
Cu9_transition_7	20.01	0.17	45.41	0.40	0.31	18.11	1.11	2.08	1.33	88.99
Cu9_transition_8	32.46	0.13	49.00	0.13	0.07	5.15	0.28	0.18	0.98	88.40
Cu9_transition_9	18.62	0.21	47.66	0.37	0.15	17.93	3.40	3.25	0.72	92.43
Cu9_transition_10	19.89	0.17	46.09	0.84	0.52	9.88	2.45	2.66	3.81	86.30
Cu9_transition_11	19.78	0.23	39.29	0.51	0.30	12.60	4.42	4.15	3.00	84.35
Cu9_transition_12	25.03	0.16	44.46	0.66	0.33	9.78	0.47	1.04	1.93	83.86
Cu9_transition_13	19.10	0.14	46.29	0.22	0.20	18.50	2.40	2.44	0.68	90.07
Cu9_transition_14	14.05	0.07	33.43	0.87	0.66	6.98	0.81	1.34	27.11	85.38
Cu9_transition_15	18.35	0.17	45.65	0.24	0.33	16.54	4.09	3.39	1.15	89.97
Cu9_transition_16	19.22	0.10	42.14	0.23	0.63	11.65	3.05	2.88	2.85	82.78
Cu9_transition_17	18.46	0.21	44.72	0.27	0.14	14.65	4.90	4.26	1.19	88.89
Cu9_transition_18	2.16	0.04	71.68	0.12	0.13	1.07	0.27	0.19	2.32	77.98
Cu9_transition_19	24.35	0.18	47.84	0.45	0.17	10.32	0.65	0.71	3.23	87.91
Cu9_transition_20	21.93	0.14	46.99	0.54	0.20	11.62	0.80	1.28	3.32	86.89
Cu9_transition_21	23.20	0.11	45.35	0.39	0.24	10.17	0.65	0.86	3.21	84.27
Cu9_corroded_1	2.43	0.13	59.49	0.05	0.00	0.79	0.69	1.18	0.73	65.50
Cu9_corroded_2	9.38	0.06	62.35	0.59	0.00	1.54	0.44	0.22	3.62	78.24
Cu9_corroded_3	2.83	0.02	66.54	0.08	0.01	0.87	0.28	0.86	0.74	72.23
Cu9_corroded_4	3.06	0.02	64.12	0.07	0.00	0.71	0.27	0.43	0.48	69.18
Cu9_corroded_5	1.88	0.06	65.74	0.03	0.00	0.77	0.27	0.51	0.18	69.43
Cu9_corroded_6	5.36	0.07	63.05	0.30	0.02	0.93	0.31	0.43	2.18	72.69
Cu9_corroded_7	3.10	0.02	67.28	0.03	0.01	0.76	0.26	0.43	1.13	73.03
Cu9_corroded_8	7.13	0.04	56.11	0.07	0.00	0.89	0.31	0.34	7.12	72.01
Cu9_corroded_9	7.67	0.02	63.79	1.35	0.04	1.91	0.45	0.44	3.44	79.12

Cu9_corroded_10	2.25	0.08	65.31	0.06	0.05	0.70	0.24	0.56	1.10	70.36
Cu9_corroded_11	8.29	0.07	63.78	0.19	0.05	1.31	0.30	0.41	2.63	77.02
Cu9_corroded_12	4.48	0.08	75.26	0.10	0.00	0.71	0.30	0.58	1.08	82.60
Cu9_corroded_13	2.42	0.04	72.28	0.12	0.00	0.59	0.20	0.56	0.45	76.69
Cu9_corroded_14	2.52	0.08	70.36	0.08	0.00	0.63	0.22	0.63	0.42	74.94
Cu9_corroded_15	3.83	0.07	68.81	0.08	0.04	0.88	0.34	0.81	1.79	76.65
Cu9_corroded_16	2.29	0.02	81.92	0.07	0.00	0.63	0.28	0.68	0.26	86.17
Cu9_corroded_17	3.02	0.04	69.64	0.08	0.04	0.60	0.22	1.75	0.52	75.90
Cu9_corroded_18	2.94	0.05	69.86	0.12	0.00	0.71	0.25	1.46	0.88	76.26
Cu9_corroded_19	4.76	0.01	68.86	0.22	0.00	0.92	0.28	1.30	0.84	77.20
Cu9_corroded_20	3.11	0.06	73.55	0.17	0.00	0.76	0.24	1.39	1.18	80.51
Cu9_corroded_21	6.56	0.03	69.31	0.09	0.00	0.68	0.18	1.31	0.54	78.70
Cu9_corroded_22	2.81	0.04	70.28	0.09	0.03	0.52	0.14	2.05	1.08	77.09
Cu9_corroded_23	3.62	0.03	60.67	0.18	0.00	0.79	0.12	2.51	0.87	68.79
Cu9_corroded_24	2.95	0.01	66.09	0.04	0.01	0.58	0.08	1.48	1.56	72.81
Cu9_corroded_25	2.71	0.04	67.58	0.06	0.09	0.69	0.09	3.09	1.60	75.94
Cu9_corroded_26	1.98	0.02	64.54	0.05	0.00	0.36	0.08	1.44	0.41	68.91
Cu9_corroded_27	2.15	0.01	64.00	0.07	0.00	0.46	0.03	1.43	1.20	69.34
Cu9_corroded_28	4.90	0.04	55.86	0.16	0.07	0.50	0.12	3.21	1.48	66.34
Cu94_intact_1	19.80	0.18	42.47	0.38	0.21	16.27	2.51	0.13	1.75	83.72
Cu94_intact_2	18.13	0.13	44.83	0.44	0.15	16.48	2.29	0.23	1.58	84.28
Cu94_intact_3	20.72	0.18	42.35	0.51	0.21	11.33	1.08	0.29	3.64	80.35
Cu94_intact_4	20.35	0.15	47.20	0.41	0.18	16.62	2.25	0.12	1.13	88.43
Cu94_intact_5	21.46	0.21	50.57	0.44	0.09	16.09	2.38	0.17	0.90	92.40
Cu94_intact_6	20.08	0.18	51.05	0.39	0.15	15.43	2.47	0.15	1.26	91.17
Cu94_intact_7	18.75	0.19	49.44	0.50	0.16	14.83	2.50	0.07	1.52	87.96
Cu94_intact_8	19.43	0.11	42.98	0.31	0.17	15.35	2.28	0.11	1.42	82.20
Cu94_intact_9	19.51	0.18	46.58	0.50	0.20	15.60	3.03	0.18	2.06	87.85
Cu94_intact_10	21.49	0.24	48.38	0.54	0.31	15.46	2.14	0.11	2.45	91.23
Cu94_intact_11	18.30	0.17	43.87	0.38	0.21	15.84	2.51	0.10	2.45	83.99
Cu94_intact_12	17.77	0.08	40.54	0.78	0.40	10.32	1.12	0.27	3.25	74.65
Cu94_intact_13	19.00	0.13	43.57	0.40	0.16	16.83	2.24	0.14	1.10	83.66
Cu94_intact_14	19.80	0.15	43.15	0.44	0.20	15.64	2.27	0.14	1.76	83.64
Cu94_intact_15	21.98	0.28	51.88	0.43	0.21	15.75	2.15	0.08	1.12	94.05
Cu94_intact_16	16.34	0.56	60.17	0.94	0.26	7.15	1.03	0.23	6.34	93.31
Cu94_intact_17	16.37	0.10	45.17	0.38	0.18	17.03	2.26	0.15	0.98	82.70
Cu94_intact_18	17.80	0.09	43.61	0.47	0.12	16.13	2.15	0.09	3.64	84.09
Cu94_intact_19	19.36	0.15	42.49	0.46	0.28	15.99	2.16	0.13	1.51	82.62
Cu94_intact_20	27.61	0.21	50.11	0.71	0.21	7.70	0.57	0.29	3.01	90.41
Cu94_intact_21	15.89	0.12	40.42	0.29	0.19	16.75	2.25	0.21	1.52	77.64
Cu94_intact_22	20.06	0.19	47.38	0.67	0.36	14.66	2.24	0.14	4.30	90.00
Cu94_intact_23	17.95	0.13	50.04	0.32	0.16	14.70	1.97	0.13	0.99	86.46

Cu94_intact_24	20.29	0.22	45.05	0.45	0.22	16.29	2.43	0.13	1.46	86.57
Cu94_intact_25	20.44	0.20	47.80	0.41	0.26	15.05	2.09	0.10	2.01	88.40
Cu94_intact_26	18.59	0.15	47.18	0.41	0.18	16.96	2.47	0.15	1.21	87.33
Cu94_intact_27	20.18	0.16	42.14	1.01	0.40	14.01	2.27	0.20	2.49	82.89
Cu94_intact_28	19.89	0.19	45.99	0.50	0.35	15.80	1.98	0.25	2.26	87.30
Cu94_intact_29	24.72	0.17	45.95	0.82	0.44	9.31	0.62	0.13	3.63	85.90
Cu94_intact_30	19.90	0.17	48.21	0.40	0.24	16.29	2.30	0.23	1.08	88.84
Cu94_intact_31	19.81	0.17	44.54	0.39	0.27	16.93	2.59	0.18	0.87	85.82
Cu94_transition_1	21.38	0.05	47.13	0.21	0.16	5.97	0.41	1.76	0.88	78.06
Cu94_transition_2	23.67	0.07	40.25	0.15	0.36	6.13	0.46	2.08	0.94	74.24
Cu94_transition_3	17.96	0.11	59.33	0.34	0.41	4.46	0.25	0.52	5.21	88.65
Cu94_transition_4	19.84	0.08	39.57	0.17	0.38	7.65	0.89	1.74	1.77	72.18
Cu94_transition_5	25.39	0.13	46.05	0.31	0.44	6.35	0.36	0.43	9.37	88.93
Cu94_transition_6	21.78	0.06	47.13	0.08	0.31	8.82	0.50	0.91	0.66	80.40
Cu94_transition_7	24.50	0.08	47.35	0.36	0.56	8.40	0.67	0.66	2.00	84.62
Cu94_transition_8	16.46	0.11	46.30	0.86	0.81	5.88	0.52	0.89	12.73	84.65
Cu94_transition_9	22.53	0.10	48.06	0.22	0.64	11.68	0.96	0.89	1.33	86.47
Cu94_transition_10	23.09	0.14	46.43	0.23	0.84	12.50	1.04	1.10	1.97	87.34
Cu94_transition_11	23.37	0.14	47.82	0.21	0.58	12.53	1.13	1.20	1.43	88.48
Cu94_transition_12	23.27	0.12	47.42	0.18	0.70	12.39	1.01	1.08	1.23	87.51
Cu94_transition_13	24.67	0.14	49.86	0.22	0.56	13.19	1.16	1.12	0.85	91.86
Cu94_transition_14	22.52	0.19	44.46	0.24	0.78	13.38	1.29	1.11	1.06	85.08
Cu94_transition_15	21.85	0.15	47.70	0.31	0.75	13.23	1.54	0.78	1.12	87.49
Cu94_transition_16	22.53	0.17	44.63	0.23	0.89	12.60	2.09	1.22	1.82	86.21
Cu94_transition_17	20.43	0.07	41.26	0.10	0.76	10.31	0.66	1.57	1.11	76.29
Cu94_transition_18	18.93	0.09	43.69	0.12	0.48	7.44	0.43	1.97	1.04	74.26
Cu94_transition_19	20.53	0.14	48.77	0.36	0.78	14.07	1.40	0.49	1.14	87.71
Cu94_transition_20	21.60	0.14	49.24	0.28	0.54	13.44	1.41	0.47	1.19	88.42
Cu94_transition_21	20.71	0.18	48.37	0.24	0.71	13.51	1.60	0.30	1.22	86.94
Cu94_transition_22	20.44	0.16	46.13	0.27	1.45	11.41	1.22	0.43	1.11	82.91
Cu94_corroded_1	2.78	0.06	66.15	0.06	0.11	0.73	1.15	2.39	0.68	74.23
Cu94_corroded_2	2.68	0.04	70.91	0.01	0.02	0.63	0.10	0.95	0.50	75.85
Cu94_corroded_3	2.45	0.03	83.27	0.03	0.05	0.57	0.08	0.40	0.57	87.52
Cu94_corroded_4	5.32	0.05	68.10	0.01	0.12	0.70	0.13	1.18	0.44	76.08
Cu94_corroded_5	7.85	0.10	63.47	0.18	0.16	1.65	0.21	1.78	1.65	77.13
Cu94_corroded_6	5.72	0.09	65.34	0.05	0.07	1.07	0.28	1.69	1.30	75.73
Cu94_corroded_7	7.39	0.05	66.64	0.07	0.00	0.64	0.07	1.22	0.80	77.01
Cu94_corroded_8	2.09	0.00	76.65	0.03	0.03	0.31	0.06	1.84	0.58	81.59
Cu94_corroded_9	2.28	0.03	68.20	0.03	0.06	0.60	0.29	2.15	1.20	74.94
Cu94_corroded_10	3.29	0.04	71.16	0.18	0.04	1.04	0.11	1.69	0.77	78.32
Cu94_corroded_11	1.50	0.01	73.38	0.10	0.07	0.21	0.04	2.19	1.11	78.60
Cu94_corroded_12	4.35	0.02	62.63	0.03	0.02	0.22	0.03	2.43	0.81	70.62

Cu94_corroded_13	6.39	0.09	64.36	0.29	0.04	1.05	0.27	1.87	5.98	80.37
Cu94_corroded_14	1.84	0.02	68.97	0.02	0.08	0.31	0.04	2.79	0.24	74.32
Cu94_corroded_15	1.82	0.00	60.09	0.04	0.00	0.24	0.01	2.63	0.44	65.27
Cu94_corroded_16	1.72	0.00	67.09	0.04	0.02	0.34	0.04	1.48	0.47	71.20
Cu94_corroded_17	2.59	0.02	57.45	0.03	0.06	0.30	0.05	1.27	0.58	62.42
Cu94_corroded_18	5.64	0.05	67.48	0.03	0.01	0.55	0.03	1.27	0.74	75.81
Cu94_corroded_19	4.04	0.04	57.76	5.39	0.23	0.65	0.05	1.11	3.39	72.70
Cu94_corroded_20	2.08	0.05	56.46	0.07	0.03	0.44	0.25	0.69	0.71	60.89
Cu94_corroded_21	1.62	0.04	64.34	0.07	0.04	0.44	0.03	1.21	0.57	68.38
Cu94_corroded_22	5.94	0.05	55.49	0.02	0.00	0.48	0.05	0.91	0.81	63.77
Cu94_corroded_23	2.90	0.03	65.29	0.05	0.07	0.69	0.07	1.44	1.87	72.48
Cu94_corroded_24	3.35	0.09	67.10	0.04	0.16	0.72	0.09	0.70	2.36	74.59
Cu94_corroded_25	2.46	0.00	70.11	0.02	0.00	0.73	0.11	1.23	1.30	75.95
Cu _{grain} _large_1_core_1	0.68	0.06	9.09	0.10	72.15	0.73	0.49	0.27	0.07	83.72
Cu _{grain} _large_1_core_2	0.68	0.06	8.05	0.13	76.41	0.47	0.58	0.35	0.08	86.83
Cu _{grain} _large_1_core_3	0.30	0.00	3.79	0.02	84.40	0.14	0.46	0.26	0.00	89.38
Cu _{grain} _large_1_core_4	1.53	0.00	12.36	0.16	86.96	0.92	0.52	0.27	0.02	102.83
Cu _{grain} _large_1_core_5	0.16	0.01	2.70	0.06	85.68	0.25	0.38	0.06	0.00	89.43
Cu _{grain} _large_1_core_6	0.32	0.03	3.07	0.05	85.52	0.35	0.40	0.23	0.00	89.98
Cu _{grain} _large_1_core_7	0.23	0.01	1.67	0.05	83.84	0.33	0.42	0.14	0.13	86.84
Cu _{grain} _large_1_core_8	0.90	0.21	4.29	0.10	76.86	0.42	0.37	0.09	0.00	83.42
Cu _{grain} _large_1_core_9	0.31	0.06	3.59	0.00	84.06	0.24	0.33	0.08	0.00	88.76
Cu _{grain} _large_1_core_10	0.30	0.06	3.42	0.07	85.19	0.13	0.44	0.15	0.00	89.79
Cu _{grain} _large_1_core_11	0.30	0.07	4.18	0.06	84.34	0.10	0.39	0.23	0.00	89.83
Cu _{grain} _large_1_core_12	0.38	0.10	3.95	0.05	88.55	0.09	0.48	0.18	0.07	94.03
Cu _{grain} _large_1_inner_rim_1	3.96	0.09	22.78	0.12	41.55	1.20	0.30	0.20	0.06	70.26
Cu _{grain} _large_1_inner_rim_2	3.45	0.07	22.36	0.08	48.01	1.10	0.31	0.11	0.06	75.58
Cu _{grain} _large_1_inner_rim_3	3.64	0.11	22.63	0.13	42.89	1.19	0.30	0.18	0.03	71.16
Cu _{grain} _large_1_inner_rim_4	2.97	0.00	19.04	0.08	50.22	1.02	0.44	0.15	0.03	73.95
Cu _{grain} _large_1_inner_rim_5	3.64	0.05	22.72	0.11	43.81	1.10	0.31	0.14	0.02	71.97
Cu _{grain} _large_1_inner_rim_6	3.25	0.13	19.46	0.13	52.91	0.90	0.28	0.18	0.01	77.38
Cu _{grain} _large_1_inner_rim_7	3.56	0.12	23.40	0.11	42.68	1.08	0.32	0.25	0.01	71.54
Cu _{grain} _large_1_inner_rim_8	3.30	0.08	22.52	0.17	44.54	0.93	0.25	0.24	0.07	72.18
Cu _{grain} _large_1_inner_rim_9	3.45	0.10	22.21	0.11	39.11	0.82	0.31	0.15	0.00	66.34
Cu _{grain} _large_1_inner_rim_10	3.62	0.08	20.50	0.10	40.05	1.12	0.28	0.27	0.01	66.06
Cu _{grain} _large_1_inner_rim_11	2.79	0.03	18.95	0.12	56.31	1.04	0.37	0.22	0.00	79.84
Cu _{grain} _large_1_inner_rim_12	4.26	0.19	23.31	0.09	44.03	1.58	0.53	0.18	0.09	74.43
Cu _{grain} _large_1_inner_rim_13	3.42	0.11	16.88	0.06	53.32	0.97	0.26	0.19	0.00	75.25
Cu _{grain} _large_1_inner_rim_14	3.82	0.18	22.24	0.09	46.84	1.08	0.29	0.18	0.05	74.89
Cu _{grain} _large_1_inner_rim_15	3.96	0.14	21.87	0.10	44.57	1.01	0.37	0.17	0.00	72.31
Cu _{grain} _large_1_inner_rim_16	3.38	0.11	20.09	0.08	46.19	0.95	0.42	0.23	0.02	71.57
Cu _{grain} _large_1_outer_rim_1	1.84	0.12	11.10	0.03	67.52	0.46	0.29	0.36	0.05	81.84

Cu _{grain_large_1_outer_rim_2}	1.91	0.13	11.96	0.13	68.24	0.58	0.40	0.27	0.06	83.83
Cu _{grain_large_1_outer_rim_3}	4.29	0.14	16.11	0.12	51.78	0.98	0.52	0.25	0.30	74.58
Cu _{grain_large_1_outer_rim_4}	2.91	0.18	12.45	0.04	63.96	0.92	0.29	0.30	0.12	81.34
Cu _{grain_large_1_outer_rim_5}	2.14	0.24	12.46	0.17	66.21	0.70	0.70	0.27	0.10	83.00
Cu _{grain_large_1_outer_rim_6}	1.98	0.10	11.72	0.19	69.58	0.59	0.35	0.39	0.03	84.99
Cu _{grain_large_1_outer_rim_7}	1.89	0.09	11.55	0.14	70.91	0.53	0.35	0.35	0.07	85.88
Cu _{grain_large_1_outer_rim_8}	1.65	0.15	8.84	0.09	75.79	0.47	0.37	0.34	0.02	87.88
Cu _{grain_large_1_outer_rim_9}	1.86	0.06	10.55	0.11	71.21	0.59	0.53	0.30	0.00	85.30
Cu _{grain_large_1_outer_rim_10}	1.75	0.02	10.77	0.08	70.27	0.74	0.41	0.35	0.09	84.69
Cu _{grain_large_1_outer_rim_11}	1.70	0.04	10.92	0.08	71.66	0.84	0.30	0.25	0.11	86.08
Cu _{grain_large_1_outer_rim_12}	2.18	0.06	12.19	0.15	70.03	0.97	0.30	0.24	0.11	86.38
Cu _{grain_large_1_outer_rim_13}	2.50	0.23	11.97	0.15	69.72	0.92	0.33	0.37	0.23	86.49
Cu _{grain_large_1_outer_rim_14}	2.33	0.12	11.43	0.14	69.07	1.10	0.49	0.41	0.36	85.64
Cu _{grain_large_2_core_1}	4.48	0.16	30.25	0.28	45.33	2.33	1.30	1.08	0.08	85.38
Cu _{grain_large_2_core_2}	3.37	0.13	23.66	0.13	49.11	2.36	0.87	0.68	0.00	80.39
Cu _{grain_large_2_core_3}	3.77	0.25	22.90	0.11	55.66	2.08	0.49	1.10	0.07	86.44
Cu _{grain_large_2_core_4}	1.39	0.07	26.98	0.31	39.91	2.26	0.57	0.56	0.29	72.38
Cu _{grain_large_2_core_5}	5.04	0.23	30.76	0.22	41.42	2.21	0.48	1.11	0.05	81.57
Cu _{grain_large_2_core_6}	4.53	0.20	30.90	0.24	46.55	2.35	0.48	1.05	0.13	86.49
Cu _{grain_large_2_core_7}	3.26	0.13	22.79	0.15	50.80	2.20	0.49	0.91	0.04	80.78
Cu _{grain_large_2_core_8}	2.02	0.12	11.74	0.28	75.57	0.99	0.46	0.09	0.34	91.84
Cu _{grain_large_2_core_9}	3.62	0.18	11.52	0.17	57.56	1.72	0.48	0.56	0.10	75.94
Cu _{grain_large_2_core_10}	2.56	0.14	30.48	0.38	48.18	1.92	1.18	0.73	0.07	85.82
Cu _{grain_large_2_core_11}	3.36	0.26	23.52	0.18	56.71	1.98	0.80	0.94	0.05	87.81
Cu _{grain_large_2_core_12}	4.71	0.34	29.04	0.25	45.13	2.33	1.05	1.09	0.01	84.07
Cu _{grain_large_2_core_13}	4.89	0.38	29.92	0.35	48.53	1.97	1.28	1.11	0.07	88.57
Cu _{grain_large_2_core_14}	4.93	0.33	23.52	0.25	52.02	1.79	1.22	1.05	0.03	85.21
Cu _{grain_large_2_core_15}	4.68	0.34	27.70	0.26	53.02	1.97	1.01	0.80	0.00	89.88
Cu _{grain_large_2_core_16}	5.14	0.54	19.77	0.16	52.21	1.68	0.93	0.77	0.10	81.32
Cu _{grain_large_2_core_17}	5.22	0.53	19.77	0.19	53.36	1.93	1.06	0.95	0.09	83.13
Cu _{grain_large_2_rim_1}	1.93	0.10	8.85	0.21	81.56	0.58	0.45	0.12	0.24	94.06
Cu _{grain_large_2_rim_2}	1.55	0.10	8.09	0.16	82.98	0.54	0.36	0.06	0.28	94.18
Cu _{grain_large_2_rim_3}	2.44	0.16	11.41	0.28	77.11	0.82	0.38	0.14	0.34	93.13
Cu _{grain_large_2_rim_4}	2.13	0.16	11.85	0.17	78.52	0.99	0.40	0.14	0.38	94.83
Cu _{grain_large_2_rim_5}	2.11	0.15	12.46	0.13	76.71	1.15	0.52	0.30	0.42	93.97
Cu _{grain_large_2_rim_6}	2.34	0.23	14.24	0.22	73.96	1.55	0.83	0.26	0.46	94.09
Cu _{grain_large_2_rim_7}	2.25	0.16	15.35	0.15	71.13	1.84	1.18	0.27	0.69	93.12
Cu _{grain_large_2_rim_8}	2.41	0.13	13.01	0.23	76.22	1.32	0.64	0.21	0.34	94.67
Cu _{grain_large_2_rim_9}	2.37	0.18	10.93	0.23	77.58	0.97	0.46	0.12	0.27	93.15
Cu _{grain_large_2_rim_10}	3.80	0.26	15.32	0.43	70.75	0.97	0.77	0.09	0.48	93.20
Cu _{grain_large_2_rim_11}	3.08	0.22	11.54	0.29	74.65	0.88	0.44	0.27	0.35	91.73
Cu _{grain_large_2_rim_12}	2.43	0.17	12.64	0.25	77.29	0.97	0.78	0.20	0.30	95.06

Cu _{grain_large_2_rim_13}	2.33	0.22	11.82	0.15	78.00	0.91	0.56	0.16	0.20	94.44
Cu _{grain_large_2_rim_14}	2.61	0.26	10.87	0.35	77.60	0.88	0.57	0.14	0.25	93.62
Cu _{grain_large_2_rim_15}	2.32	0.19	11.43	0.28	76.43	0.96	0.73	0.15	0.50	93.07
Cu _{grain_small_1_1}	1.03	0.08	11.11	0.07	54.36	0.77	0.68	0.30	0.03	68.60
Cu _{grain_small_1_2}	0.89	0.07	8.25	0.04	63.52	0.26	0.61	0.30	0.00	74.02
Cu _{grain_small_1_3}	1.16	0.08	6.13	0.07	65.30	0.67	0.46	0.17	0.14	74.36
Cu _{grain_small_1_4}	1.42	0.07	7.79	0.08	54.01	0.37	0.63	0.35	0.05	64.84
Cu _{grain_small_1_5}	1.09	0.03	10.04	0.07	58.73	0.51	0.53	0.20	0.08	71.35
Cu _{grain_small_1_6}	1.64	0.04	11.85	0.10	59.59	0.31	1.04	0.22	0.01	74.94
Cu _{grain_small_1_7}	2.94	0.06	7.47	0.05	48.79	1.29	0.97	0.18	0.02	61.93
Cu _{grain_small_1_8}	1.58	0.16	11.03	0.15	65.26	1.13	0.79	0.37	0.08	80.67
Cu _{grain_small_1_9}	2.71	0.28	10.60	0.10	53.86	1.09	0.64	0.29	0.03	69.70
Cu _{grain_small_1_10}	2.01	0.04	9.92	0.11	63.02	0.65	0.47	0.23	0.02	76.53
Cu _{grain_small_1_11}	1.82	0.14	11.19	0.05	57.43	1.35	0.71	0.07	0.10	72.99
Cu _{grain_small_1_12}	1.51	0.10	11.79	0.12	58.65	1.25	0.58	0.37	0.16	74.73
Cu _{grain_small_1_13}	1.79	0.27	8.98	0.12	61.06	1.03	0.64	0.38	0.09	74.50
Cu _{grain_small_1_14}	1.81	0.08	9.07	0.10	63.78	1.11	0.60	0.34	0.21	77.17
Cu _{grain_small_2_1}	3.04	0.10	23.61	0.27	58.64	2.47	1.23	0.70	0.15	90.31
Cu _{grain_small_2_2}	6.42	0.14	13.97	0.04	39.71	2.31	1.02	0.63	0.02	64.36
Cu _{grain_small_2_3}	3.33	0.02	31.66	0.23	45.16	2.76	0.86	0.55	0.00	84.67
Cu _{grain_small_2_4}	4.01	0.05	30.54	0.24	38.57	2.92	1.21	0.29	0.07	77.98
Cu _{grain_small_2_5}	4.52	0.08	33.41	0.39	40.37	3.27	1.15	0.26	0.07	83.73
Cu _{grain_small_2_6}	5.64	0.00	36.40	0.50	37.79	4.07	1.20	0.34	1.85	87.82
Cu _{grain_small_2_7}	5.83	0.12	25.95	0.25	39.14	2.62	1.25	0.28	0.03	75.60
Cu _{grain_small_2_8}	2.46	0.02	22.07	0.07	43.34	2.90	0.66	0.23	0.09	71.90
Cu _{grain_small_2_9}	2.77	0.02	23.39	0.32	58.94	2.24	1.24	0.25	0.15	89.38
Cu _{grain_small_2_10}	3.84	0.02	13.47	0.14	36.55	2.35	1.36	0.24	0.24	58.37
Cu _{grain_small_2_11}	4.43	0.06	38.58	0.44	38.16	2.92	1.51	0.26	0.13	86.49
Cu _{grain_small_3_1}	3.02	0.02	16.60	0.37	69.00	1.71	0.69	0.09	0.34	91.92
Cu _{grain_small_3_2}	3.35	0.07	14.73	0.32	70.27	1.81	0.81	0.32	0.42	92.21
Cu _{grain_small_3_3}	3.13	0.01	13.12	0.38	44.82	2.15	12.59	0.19	0.23	76.62
Cu _{grain_small_3_4}	2.03	0.01	11.56	0.15	78.41	1.51	0.72	0.16	0.27	94.98
Cu _{grain_small_3_5}	4.93	0.03	20.49	0.47	57.69	2.56	1.22	0.40	0.86	88.76
Cu _{grain_small_3_6}	3.24	0.03	17.86	0.41	64.23	1.60	0.61	0.25	0.71	89.09
Cu _{grain_small_3_7}	3.07	0.05	16.38	0.37	67.62	1.45	0.61	0.23	0.64	90.66
Cu _{grain_small_3_8}	2.96	0.00	21.89	0.35	58.34	2.84	0.87	0.64	0.62	88.65
Cu _{grain_small_3_9}	3.42	0.08	16.77	0.20	64.57	2.30	0.80	0.24	0.59	89.03
Cu _{grain_small_3_10}	2.76	0.00	13.85	0.23	61.64	2.05	1.19	0.25	0.52	82.64
Cu _{grain_small_3_11}	3.48	0.06	13.14	0.22	57.47	2.21	0.63	0.21	0.76	78.36
Cu _{grain_small_3_12}	4.51	0.08	23.21	0.56	53.61	1.99	0.99	0.30	0.64	85.99

Table S3: Evolution of the saturation indices (SI) of relevant mineral phases with time.

Sample ID	Time [d]	SiO ₂ (am)	K-Alum	alunite	jurbanite	AlOHSO ₄	gypsum	bassanite	anhydrite	cuprite	chrysocolla
Ref	0.007	0.20	-4.62	-6.28	-1.36	-1.63	-1.25	-2.07	-1.47	-10.97	-11.94
	0.042	0.87	-3.30	-4.05	-0.65	-0.92	-0.94	-1.77	-1.16	-11.23	-11.40
	0.167	1.34	-2.23	-2.55	-0.19	-0.46	-0.63	-1.46	-0.85	-11.52	-11.07
	0.333	1.50	-1.81	-1.98	-0.02	-0.28	-0.45	-1.27	-0.67	-11.65	-10.98
	0.667	1.60	-1.44	-1.42	0.14	-0.11	-0.32	-1.14	-0.53	-11.76	-10.93
	1	1.62	-1.26	-1.18	0.21	-0.03	-0.26	-1.08	-0.47	-11.81	-10.95
	2	1.60	-1.00	-0.86	0.30	0.06	-0.14	-0.96	-0.36	-11.90	-11.00
	4	1.57	-0.76	-0.62	0.36	0.13	-0.05	-0.87	-0.26	-11.99	-11.08
	7	1.53	-0.57	-0.36	0.44	0.21	0.04	-0.78	-0.17	-12.05	-11.16
	14	1.47	-0.33	0.06	0.55	0.33	0.14	-0.68	-0.08	-12.10	-11.24
	21	1.41	-0.19	0.24	0.61	0.39	0.19	-0.63	-0.02	-12.16	-11.33
	28	1.39	-0.22	0.19	0.59	0.37	0.19	-0.63	-0.02	-12.15	-11.35
	35	1.33	-0.26	-0.26	0.51	0.30	0.19	-0.62	-0.02	-12.28	-11.48
Cu9	0.007	0.29	-4.40	-5.96	-1.25	-1.52	-1.23	-2.06	-1.45	-6.96	-9.84
	0.042	0.95	-3.17	-3.89	-0.59	-0.86	-0.84	-1.67	-1.06	-5.87	-8.64
	0.167	1.39	-2.12	-2.44	-0.16	-0.42	-0.56	-1.38	-0.78	-4.79	-7.66
	0.333	1.53	-1.71	-1.87	0.01	-0.25	-0.41	-1.24	-0.63	-4.46	-7.36
	0.667	1.62	-1.34	-1.36	0.16	-0.09	-0.27	-1.10	-0.49	-4.25	-7.17
	1	1.63	-1.16	-1.12	0.22	-0.02	-0.21	-1.03	-0.43	-4.17	-7.12
	2	1.62	-0.90	-0.83	0.30	0.06	-0.08	-0.90	-0.30	-4.12	-7.10
	4	1.58	-0.64	-0.51	0.39	0.16	-0.02	-0.84	-0.24	-4.08	-7.12
	7	1.54	-0.46	-0.21	0.47	0.25	0.09	-0.73	-0.13	-4.02	-7.13
	14	1.47	-0.24	0.09	0.56	0.34	0.20	-0.62	-0.01	-4.00	-7.19
	21	1.42	-0.10	0.42	0.65	0.43	0.20	-0.61	-0.01	-3.99	-7.24
	28	1.40	-0.22	0.02	0.53	0.32	0.24	-0.58	0.03	-3.95	-7.24
	35	1.28	-0.21	-0.02	0.52	0.31	0.24	-0.58	0.02	-3.95	-7.36
Cu94	0.007	0.23	-4.14	-6.13	-1.36	-11.48	-0.92	-1.74	-1.13	-6.68	-9.76
	0.042	1.00	-2.80	-3.67	-0.57	-0.84	-0.84	-1.66	-1.06	-5.34	-8.33
	0.167	1.42	-1.97	-2.33	-0.15	-0.41	-0.51	-1.34	-0.73	-4.46	-7.47
	0.333	1.55	-1.62	-1.81	0.02	-0.24	-0.33	-1.15	-0.54	-4.08	-7.15
	0.667	1.62	-1.28	-1.35	0.15	-0.09	-0.24	-1.06	-0.45	-3.83	-6.96
	1	1.63	-1.10	-1.11	0.22	-0.02	-0.16	-0.98	-0.38	-3.73	-6.90
	2	1.61	-0.85	-0.83	0.30	0.07	-0.08	-0.90	-0.30	-3.54	-6.82
	4	1.57	-0.59	-0.47	0.40	0.18	0.02	-0.80	-0.20	-3.38	-6.78
	7	1.53	-0.40	-0.17	0.48	0.26	0.11	-0.71	-0.10	-3.24	-6.75
	14	1.48	-0.18	-0.16	0.48	0.27	0.21	-0.61	0.00	-3.02	-6.70
	21	1.42	-0.19	0.10	0.56	0.35	0.23	-0.58	0.02	-2.93	-6.71
	28	1.39	-0.08	0.00	0.53	0.32	0.24	-0.58	0.03	-2.86	-6.71