Supplementary Information

Accurate *in situ* oxygen isotopic analysis at high resolution by secondary ion mass spectrometry shows potential of aragonite as a reference material

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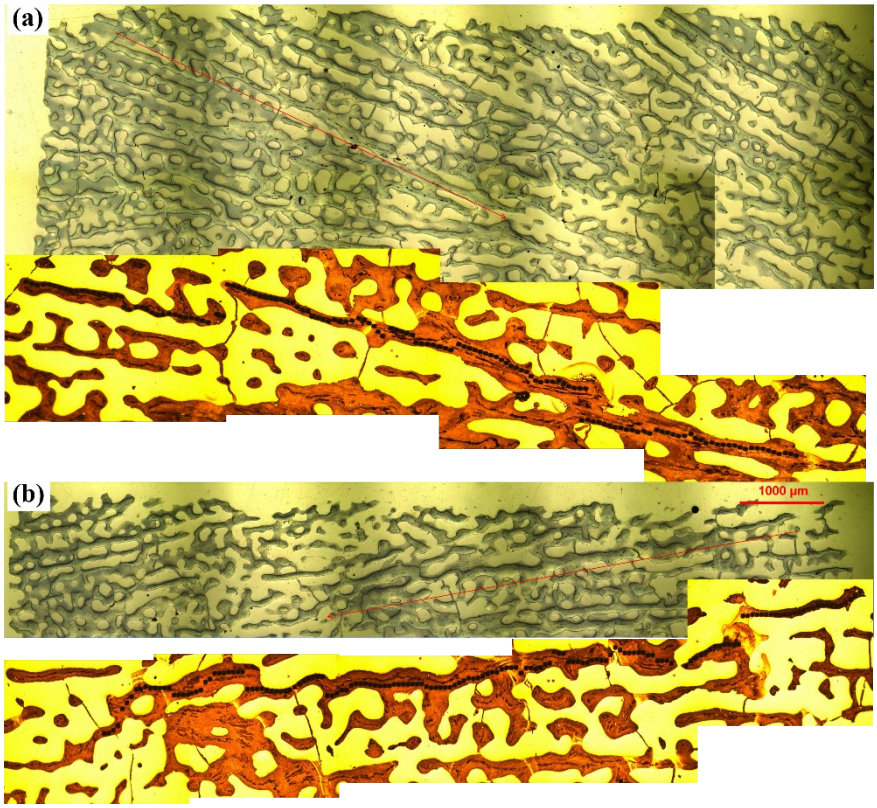
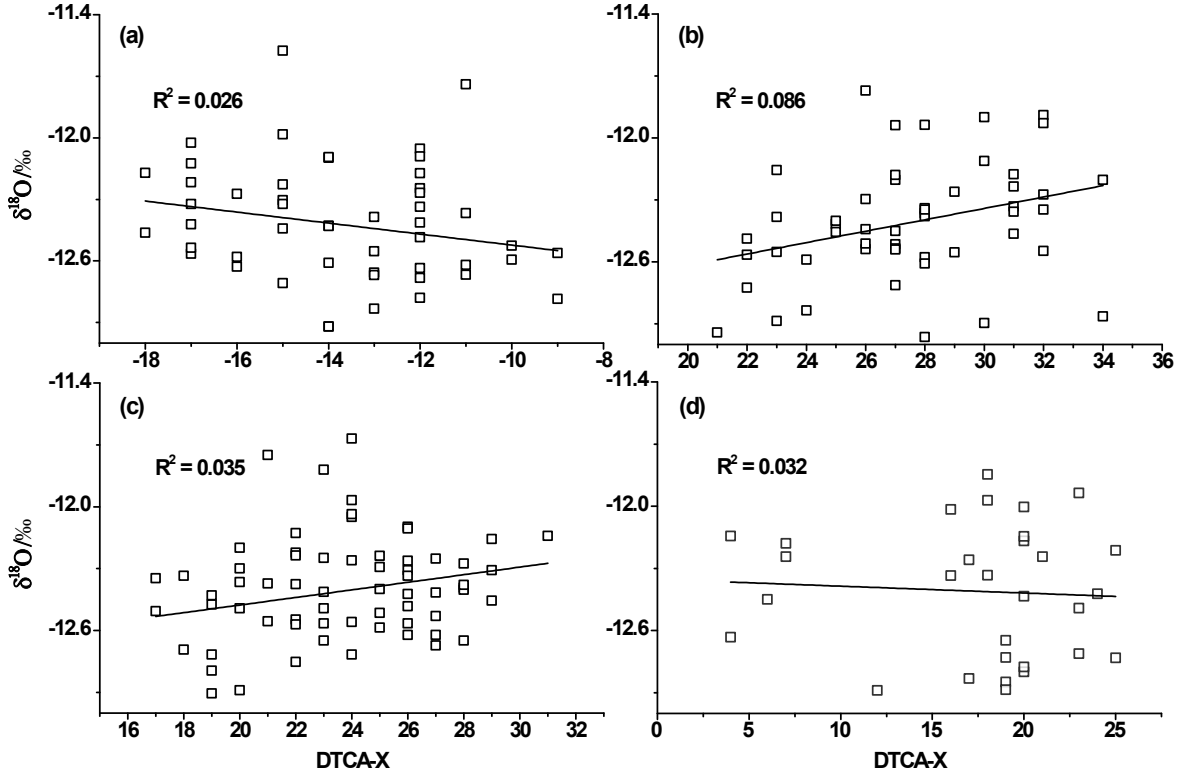


Supplementary Fig. 1 Photomicrograph in plane polarized reflected light of the corals sample before and after SIMS analysis. (a) Low-density skeleton and (b) high-density skeleton of coral.



Supplementary Fig. 2 The relationship between DTCA-X and δ18O for VS001/1-A standard in typical sessions. (a) Session 8, (b) Session 7, (c) Session 6, and (d) Session 5.

Supplementary Table 1 The SIMS data about the oxygen isotopic analyses on the new-developed reference material (VS001/1-A) ($\delta^{18}O_{uncorr.}$ defines the SIMS oxygen isotopic value without performing IMF corrected, and $\delta^{18}O_{corr.}$ defines the SIMS oxygen isotopic value performed IMF corrected)

	2018/11/25				2019/8/30				2019/8/31			
	$^{18}O/^{16}O$	SEM/%	$\delta^{18}O_{uncorr.}$ /‰	$\delta^{18}O_{corr.}$ /‰	$^{18}O/^{16}O$	SEM/%	$\delta^{18}O_{uncorr.}$ /‰	$\delta^{18}O_{corr.}$ /‰	$^{18}O/^{16}O$	SEM/%	$\delta^{18}O_{uncorr.}$ /‰	$\delta^{18}O_{corr.}$ /‰
VS001/1-A@1	2.045E-03	1.29E-02	-10.98	-12.83	2.032E-03	7.98E-03	-16.99	-12.96	2.034E-03	7.41E-03	-16.18	-11.97
VS001/1-A@2	2.045E-03	1.51E-02	-10.57	-12.43	2.032E-03	5.30E-03	-16.89	-12.86	2.032E-03	8.47E-03	-16.83	-12.62
VS001/1-A@3	2.045E-03	1.04E-02	-10.83	-12.68	2.033E-03	1.01E-02	-16.60	-12.58	2.033E-03	9.56E-03	-16.60	-12.39
VS001/1-A@4	2.045E-03	7.65E-03	-10.71	-12.56	2.032E-03	7.55E-03	-16.92	-12.90	2.033E-03	7.95E-03	-16.74	-12.53
VS001/1-A@5	2.045E-03	1.21E-02	-10.77	-12.62	2.033E-03	8.38E-03	-16.74	-12.71	2.033E-03	1.24E-02	-16.75	-12.55
VS001/1-A@6	2.046E-03	1.19E-02	-10.39	-12.25	2.033E-03	8.85E-03	-16.41	-12.38	2.033E-03	9.09E-03	-16.72	-12.51
VS001/1-A@7	2.045E-03	1.41E-02	-10.78	-12.64	2.033E-03	8.30E-03	-16.62	-12.59	2.033E-03	5.40E-03	-16.46	-12.25
VS001/1-A@8	2.046E-03	1.74E-02	-10.37	-12.23	2.032E-03	5.38E-03	-16.91	-12.89	2.033E-03	1.05E-02	-16.70	-12.49
VS001/1-A@9	2.045E-03	1.29E-02	-10.81	-12.67	2.033E-03	8.08E-03	-16.44	-12.42	2.032E-03	8.57E-03	-16.86	-12.65
VS001/1-A@10	2.047E-03	1.55E-02	-9.88	-11.74	2.033E-03	5.36E-03	-16.57	-12.54	2.033E-03	7.89E-03	-16.31	-12.10

VS001/1-A@11	2.046E-03	1.51E-02	-10.27	-12.13	2.033E-03	6.53E-03	-16.54	-12.52	2.033E-03	6.01E-03	-16.61	-12.40
VS001/1-A@12	2.045E-03	1.00E-02	-10.63	-12.48	2.033E-03	8.23E-03	-16.59	-12.57	2.033E-03	9.63E-03	-16.58	-12.38
VS001/1-A@13	2.045E-03	1.69E-02	-10.73	-12.58	2.034E-03	9.44E-03	-15.92	-11.89	2.033E-03	1.17E-02	-16.77	-12.56
VS001/1-A@14	2.044E-03	1.27E-02	-11.07	-12.92	2.033E-03	6.24E-03	-16.75	-12.73	2.032E-03	8.33E-03	-17.11	-12.91
VS001/1-A@15	2.045E-03	1.12E-02	-10.80	-12.66	2.032E-03	9.31E-03	-16.97	-12.94	2.033E-03	6.46E-03	-16.77	-12.57
VS001/1-A@16	2.045E-03	9.02E-03	-10.59	-12.44	2.034E-03	7.80E-03	-16.23	-12.20	2.033E-03	8.16E-03	-16.77	-12.57
VS001/1-A@17	2.047E-03	1.50E-02	-9.72	-11.58	2.033E-03	5.36E-03	-16.63	-12.61	2.031E-03	8.50E-03	-17.34	-13.13
VS001/1-A@18	2.046E-03	9.99E-03	-10.20	-12.05	2.033E-03	8.12E-03	-16.57	-12.55	2.033E-03	9.73E-03	-16.68	-12.47
VS001/1-A@19	2.045E-03	9.17E-03	-10.77	-12.63	2.033E-03	7.01E-03	-16.37	-12.34	2.033E-03	9.20E-03	-16.58	-12.37
VS001/1-A@20	2.046E-03	7.66E-03	-10.32	-12.17	2.034E-03	6.26E-03	-15.95	-11.93	2.033E-03	8.87E-03	-16.41	-12.20
VS001/1-A@21	2.045E-03	1.07E-02	-10.71	-12.57	2.032E-03	6.00E-03	-16.86	-12.84	2.033E-03	6.92E-03	-16.62	-12.41
VS001/1-A@22	2.045E-03	1.13E-02	-10.82	-12.67	2.034E-03	6.03E-03	-15.93	-11.90	2.033E-03	9.71E-03	-16.55	-12.35
VS001/1-A@23	2.046E-03	1.02E-02	-10.24	-12.10	2.033E-03	7.98E-03	-16.32	-12.30	2.034E-03	6.51E-03	-16.26	-12.05
VS001/1-A@24	2.046E-03	1.00E-02	-10.45	-12.30	2.033E-03	9.02E-03	-16.39	-12.36	2.033E-03	5.41E-03	-16.52	-12.31
VS001/1-A@25	2.044E-03	1.60E-02	-11.25	-13.10	2.033E-03	8.40E-03	-16.48	-12.46	2.033E-03	7.11E-03	-16.36	-12.16
VS001/1-A@26	2.045E-03	7.81E-03	-10.76	-12.61	2.033E-03	6.70E-03	-16.54	-12.51	2.033E-03	1.02E-02	-16.71	-12.51
VS001/1-A@27	2.045E-03	1.12E-02	-10.57	-12.42	2.033E-03	9.01E-03	-16.58	-12.55	2.033E-03	8.48E-03	-16.78	-12.57
VS001/1-A@28	2.045E-03	1.38E-02	-10.61	-12.46	2.033E-03	5.96E-03	-16.41	-12.38	2.032E-03	1.15E-02	-16.88	-12.67
VS001/1-A@29	2.046E-03	1.44E-02	-10.17	-12.02	2.034E-03	7.43E-03	-16.18	-12.16	2.032E-03	7.60E-03	-17.00	-12.79
VS001/1-A@30	2.045E-03	1.19E-02	-10.93	-12.79	2.034E-03	9.28E-03	-16.23	-12.20	2.033E-03	1.15E-02	-16.61	-12.40
VS001/1-A@31	2.045E-03	1.48E-02	-10.67	-12.53	2.033E-03	7.75E-03	-16.36	-12.33	2.033E-03	6.56E-03	-16.43	-12.22
VS001/1-A@32	2.044E-03	1.13E-02	-11.07	-12.92	2.034E-03	9.58E-03	-16.29	-12.26	2.032E-03	7.74E-03	-16.96	-12.75
VS001/1-A@33	2.045E-03	1.51E-02	-10.56	-12.41	2.033E-03	6.81E-03	-16.37	-12.35	2.034E-03	6.59E-03	-16.03	-11.82
VS001/1-A@34	2.045E-03	1.47E-02	-10.74	-12.59	2.034E-03	5.87E-03	-16.26	-12.24	2.034E-03	8.29E-03	-16.24	-12.04
VS001/1-A@35	2.046E-03	1.68E-02	-10.13	-11.98	2.034E-03	7.65E-03	-16.14	-12.11	2.033E-03	1.03E-02	-16.70	-12.49
VS001/1-A@36	2.046E-03	1.57E-02	-10.48	-12.34	2.034E-03	5.28E-03	-15.97	-11.94	2.033E-03	9.47E-03	-16.44	-12.24
VS001/1-A@37	2.045E-03	1.41E-02	-10.70	-12.55	2.035E-03	6.24E-03	-15.80	-11.77	2.033E-03	7.85E-03	-16.54	-12.33
VS001/1-A@38	2.045E-03	1.51E-02	-10.93	-12.78	2.033E-03	8.45E-03	-16.51	-12.49	2.033E-03	7.65E-03	-16.51	-12.30
VS001/1-A@39	2.046E-03	1.07E-02	-10.47	-12.32	2.033E-03	8.80E-03	-16.56	-12.54	2.034E-03	8.55E-03	-15.88	-11.67
VS001/1-A@40	2.046E-03	7.27E-03	-10.24	-12.09	2.033E-03	7.82E-03	-16.37	-12.35	2.032E-03	5.94E-03	-16.79	-12.59
VS001/1-A@41	2.046E-03	1.11E-02	-10.32	-12.17	2.033E-03	8.56E-03	-16.58	-12.55	2.033E-03	6.30E-03	-16.47	-12.26
VS001/1-A@42	2.045E-03	1.08E-02	-10.68	-12.54	2.034E-03	8.53E-03	-16.21	-12.18	2.033E-03	1.09E-02	-16.64	-12.43
VS001/1-A@43	2.046E-03	1.35E-02	-10.42	-12.27	2.034E-03	8.78E-03	-16.30	-12.27	2.033E-03	9.06E-03	-16.69	-12.48
VS001/1-A@44	2.045E-03	1.47E-02	-10.86	-12.71	2.034E-03	8.93E-03	-15.96	-11.94	2.032E-03	9.31E-03	-17.26	-13.05
VS001/1-A@45	2.045E-03	1.02E-02	-10.58	-12.43	2.034E-03	5.78E-03	-16.20	-12.18	2.033E-03	5.64E-03	-16.45	-12.24
VS001/1-A@46	2.046E-03	1.18E-02	-10.47	-12.32	2.033E-03	6.88E-03	-16.38	-12.36	2.033E-03	9.61E-03	-16.57	-12.36
VS001/1-A@47	2.046E-03	1.22E-02	-10.36	-12.22	2.033E-03	9.27E-03	-16.49	-12.46	2.032E-03	5.91E-03	-16.92	-12.72
VS001/1-A@48	2.045E-03	1.26E-02	-10.51	-12.37	2.033E-03	5.45E-03	-16.47	-12.44	2.033E-03	7.90E-03	-16.63	-12.42
VS001/1-A@49	2.046E-03	1.59E-02	-10.41	-12.27	2.033E-03	5.46E-03	-16.48	-12.45	2.032E-03	1.28E-02	-16.92	-12.72
VS001/1-A@50	2.046E-03	1.10E-02	-10.24	-12.09	2.033E-03	1.02E-02	-16.57	-12.54	2.033E-03	5.63E-03	-16.66	-12.46
VS001/1-A@51	2.045E-03	9.21E-03	-10.53	-12.39	2.033E-03	7.24E-03	-16.43	-12.40	2.032E-03	1.05E-02	-16.90	-12.69

VS001/1-A@52									2.033E-03	8.70E-03	-16.50	-12.29
VS001/1-A@53									2.032E-03	7.08E-03	-16.86	-12.65
VS001/1-A@54									2.032E-03	7.19E-03	-16.83	-12.62
VS001/1-A@55									2.033E-03	1.16E-02	-16.52	-12.31
VS001/1-A@56									2.033E-03	8.87E-03	-16.62	-12.42
VS001/1-A@57									2.033E-03	1.02E-02	-16.35	-12.14
VS001/1-A@58									2.032E-03	7.91E-03	-17.10	-12.89
VS001/1-A@59									2.033E-03	7.46E-03	-16.47	-12.26
VS001/1-A@60									2.033E-03	5.94E-03	-16.34	-12.13
VS001/1-A@61									2.033E-03	7.36E-03	-16.48	-12.27
VS001/1-A@62									2.033E-03	7.45E-03	-16.59	-12.38
VS001/1-A@63									2.033E-03	8.87E-03	-16.31	-12.11
VS001/1-A@64									2.033E-03	9.00E-03	-16.46	-12.25
VS001/1-A@65									2.034E-03	8.34E-03	-15.96	-11.75
VS001/1-A@66									2.033E-03	7.90E-03	-16.76	-12.56
VS001/1-A@67									2.033E-03	5.51E-03	-16.54	-12.33

	20200525				20200526				20200526			
	$^{18}O/^{16}O$	SEM/%	$\delta^{18}O_{uncorr.}$ /‰	$\delta^{18}O_{corr.}$ /‰	$^{18}O/^{16}O$	SEM/%	$\delta^{18}O_{uncorr.}$ /‰	$\delta^{18}O_{corr.}$ /‰	$^{18}O/^{16}O$	SEM/%	$\delta^{18}O_{uncorr.}$ /‰	$\delta^{18}O_{corr.}$ /‰
VS001/1-A@1	2.035E-03	7.76E-03	-15.51	-12.24	2.036E-03	5.29E-03	-14.95	-12.70	2.036E-03	8.06E-03	-14.89	-12.41
VS001/1-A@2	2.035E-03	7.75E-03	-15.45	-12.18	2.036E-03	8.35E-03	-15.00	-12.24	2.035E-03	8.75E-03	-15.35	-12.88
VS001/1-A@3	2.035E-03	8.44E-03	-15.72	-12.45	2.037E-03	1.03E-02	-14.37	-12.75	2.036E-03	5.70E-03	-14.94	-12.46
VS001/1-A@4	2.035E-03	6.28E-03	-15.41	-12.14	2.036E-03	1.01E-02	-14.60	-12.12	2.036E-03	6.11E-03	-15.12	-12.65
VS001/1-A@5	2.034E-03	5.24E-03	-15.90	-12.63	2.036E-03	5.29E-03	-14.78	-12.35	2.037E-03	5.33E-03	-14.74	-12.27
VS001/1-A@6	2.034E-03	8.90E-03	-16.16	-12.89	2.036E-03	8.21E-03	-14.74	-12.53	2.038E-03	9.73E-03	-14.33	-11.85
VS001/1-A@7	2.034E-03	1.05E-02	-16.10	-12.83	2.035E-03	6.63E-03	-14.77	-12.49	2.036E-03	1.02E-02	-15.27	-12.80
VS001/1-A@8	2.034E-03	9.51E-03	-16.00	-12.73	2.036E-03	9.40E-03	-14.66	-12.52	2.037E-03	6.92E-03	-14.73	-12.26
VS001/1-A@9	2.035E-03	6.76E-03	-15.53	-12.26	2.035E-03	8.30E-03	-14.68	-12.41	2.037E-03	6.81E-03	-14.60	-12.12
VS001/1-A@10	2.035E-03	6.71E-03	-15.44	-12.17	2.035E-03	1.15E-02	-14.56	-12.43	2.036E-03	7.15E-03	-15.28	-12.81
VS001/1-A@11	2.035E-03	8.70E-03	-15.51	-12.24	2.036E-03	6.79E-03	-14.46	-12.32	2.037E-03	6.43E-03	-14.74	-12.26
VS001/1-A@12	2.035E-03	6.59E-03	-15.60	-12.33	2.034E-03	8.81E-03	-14.94	-12.21	2.036E-03	5.93E-03	-15.16	-12.69
VS001/1-A@13	2.036E-03	7.67E-03	-15.20	-11.94	2.035E-03	8.90E-03	-14.73	-12.69	2.037E-03	8.80E-03	-14.71	-12.24
VS001/1-A@14	2.036E-03	6.51E-03	-15.27	-12.00	2.035E-03	7.88E-03	-14.55	-12.48	2.037E-03	8.15E-03	-14.57	-12.10
VS001/1-A@15	2.035E-03	7.01E-03	-15.48	-12.21	2.035E-03	1.10E-02	-14.39	-12.30	2.037E-03	7.51E-03	-14.66	-12.19
VS001/1-A@16	2.034E-03	8.75E-03	-16.07	-12.80	2.037E-03	8.44E-03	-14.49	-12.14	2.038E-03	6.96E-03	-14.41	-11.94
VS001/1-A@17	2.035E-03	9.29E-03	-15.41	-12.14	2.034E-03	5.61E-03	-14.81	-12.56	2.036E-03	9.79E-03	-15.20	-12.73
VS001/1-A@18	2.034E-03	9.16E-03	-16.12	-12.85	2.034E-03	7.33E-03	-14.62	-12.37	2.036E-03	9.77E-03	-15.33	-12.86
VS001/1-A@19	2.035E-03	7.21E-03	-15.69	-12.42	2.035E-03	7.85E-03	-14.39	-12.15	2.036E-03	1.22E-02	-15.07	-12.60
VS001/1-A@20	2.034E-03	1.27E-02	-16.15	-12.88					2.037E-03	6.57E-03	-14.64	-12.16
VS001/1-A@21	2.036E-03	7.00E-03	-15.24	-11.97					2.037E-03	6.41E-03	-15.03	-12.56

VS001/1-A@22	2.034E-03	7.63E-03	-15.98	-12.71					2.037E-03	9.45E-03	-14.57	-12.09
VS001/1-A@23	2.036E-03	1.12E-02	-15.11	-11.85					2.036E-03	6.33E-03	-15.25	-12.77
VS001/1-A@24	2.034E-03	5.22E-03	-16.00	-12.73					2.037E-03	8.10E-03	-14.63	-12.15
VS001/1-A@25	2.034E-03	6.82E-03	-16.04	-12.77								
VS001/1-A@26	2.035E-03	7.93E-03	-15.70	-12.43								
VS001/1-A@27	2.036E-03	1.02E-02	-15.28	-12.01								
VS001/1-A@28	2.034E-03	7.09E-03	-15.92	-12.65								
VS001/1-A@29	2.035E-03	6.98E-03	-15.76	-12.49								
VS001/1-A@30	2.035E-03	1.01E-02	-15.60	-12.33								

	20200706				2020/12/21				2021/4/19			
	$^{18}O/^{16}O$	SEM/%	$\delta^{18}O_{uncorr.}$ /‰	$\delta^{18}O_{corr.}$ /‰	$^{18}O/^{16}O$	SEM/%	$\delta^{18}O_{uncorr.}$ /‰	$\delta^{18}O_{corr.}$ /‰	$^{18}O/^{16}O$	SEM/%	$\delta^{18}O_{uncorr.}$ /‰	$\delta^{18}O_{corr.}$ /‰
VS001/1-A@1	2.042E-03	5.40E-03	-12.39	-12.68	2.040E-03	8.51E-03	-13.16	-12.71	2.030E-03	7.28E-03	-18.20	-12.22
VS001/1-A@2	2.042E-03	8.71E-03	-12.15	-12.44	2.040E-03	8.49E-03	-13.31	-12.86	2.029E-03	5.60E-03	-18.51	-12.52
VS001/1-A@3	2.043E-03	9.32E-03	-11.92	-12.21	2.040E-03	7.22E-03	-12.94	-12.49	2.030E-03	7.36E-03	-17.98	-11.99
VS001/1-A@4	2.042E-03	7.91E-03	-12.04	-12.32	2.041E-03	1.07E-02	-12.57	-12.12	2.029E-03	5.30E-03	-18.36	-12.37
VS001/1-A@5	2.043E-03	1.08E-02	-11.81	-12.09	2.041E-03	8.69E-03	-12.52	-12.07	2.030E-03	7.39E-03	-18.15	-12.16
VS001/1-A@6	2.041E-03	1.18E-02	-12.51	-12.80	2.040E-03	7.94E-03	-12.98	-12.53	2.030E-03	8.62E-03	-18.11	-12.12
VS001/1-A@7	2.043E-03	9.63E-03	-11.93	-12.22	2.040E-03	8.95E-03	-12.92	-12.47	2.029E-03	7.56E-03	-18.49	-12.50
VS001/1-A@8	2.042E-03	9.67E-03	-12.24	-12.53	2.041E-03	9.89E-03	-12.56	-12.11	2.029E-03	5.83E-03	-18.50	-12.52
VS001/1-A@9					2.042E-03	1.10E-02	-12.34	-11.89	2.029E-03	7.14E-03	-18.32	-12.33
VS001/1-A@10					2.040E-03	5.77E-03	-13.08	-12.63	2.030E-03	8.89E-03	-18.15	-12.16
VS001/1-A@11					2.040E-03	6.20E-03	-12.95	-12.50	2.029E-03	7.44E-03	-18.41	-12.43
VS001/1-A@12					2.040E-03	6.67E-03	-12.99	-12.54	2.030E-03	9.56E-03	-17.96	-11.98
VS001/1-A@13					2.041E-03	1.12E-02	-12.58	-12.13	2.029E-03	7.53E-03	-18.56	-12.58
VS001/1-A@14					2.040E-03	1.32E-02	-13.08	-12.63	2.028E-03	5.03E-03	-18.90	-12.92
VS001/1-A@15									2.029E-03	7.46E-03	-18.55	-12.56
VS001/1-A@16									2.029E-03	5.77E-03	-18.68	-12.69
VS001/1-A@17									2.028E-03	6.11E-03	-18.78	-12.79
VS001/1-A@18									2.028E-03	6.31E-03	-19.04	-13.05
VS001/1-A@19									2.030E-03	8.90E-03	-18.03	-12.04
VS001/1-A@20									2.029E-03	7.72E-03	-18.36	-12.37
VS001/1-A@21									2.030E-03	7.86E-03	-18.17	-12.18
VS001/1-A@22									2.029E-03	6.33E-03	-18.52	-12.53