

This Supplementary Material accompanies the article:

Mick, E., Avar, G. and Stix, J. (2026) "The origin of fresh glass in phreatic eruptions at Rincón de la Vieja and Turrialba volcanoes, Costa Rica: Secondary hydration within hydrothermal systems", *Volcanica*, 9(1), pp. 417–433. doi: 10.30909/vol/jysr2288.

Supplementary Table 1. Unnormalized EMPA data for glass grains from Rincón de la Vieja. Oxides are *wt. %* values, Cl and S are in ppm.

	SiO ₂	TiO ₂	Al ₂ O ₃	Fe ₂ O ₃	MnO	MgO	CaO	Na ₂ O	K ₂ O	Cl	S	Total
RA-2-1	58.91	0.607	18.93	4.543	0.093	0.897	8.181	4.131	1.602	0.0934	0.0013	97.54
	63.70	0.938	13.73	7.535	0.151	1.467	4.768	3.425	2.638	0.1477	0.0007	97.74
	51.33	0.033	29.60	1.210	0.000	0.193	14.27	3.666	0.128	0.0000	0.0000	100.31
	52.87	0.038	28.46	1.333	0.011	0.182	12.85	4.185	0.242	0.0012	0.0007	100.04
	56.69	0.231	25.37	3.390	0.050	0.401	10.36	4.201	0.963	0.0114	0.0000	101.33
RA-2-2	64.60	1.072	13.17	7.308	0.205	1.337	3.823	3.485	3.359	0.1620	0.0001	97.80
	64.70	1.082	13.23	8.118	0.147	1.185	3.626	3.625	3.351	0.1820	0.0004	98.43
	62.97	0.972	14.43	7.119	0.203	1.154	4.717	3.624	3.142	0.1419	0.0015	97.77
	60.97	0.720	17.42	5.184	0.079	0.872	6.532	3.125	2.283	0.0906	0.0000	96.76
	52.09	0.022	28.41	1.538	0.000	0.223	13.49	3.896	0.219	0.0016	0.0000	99.73
RA-3-3	53.03	0.059	27.78	1.222	0.020	0.222	12.40	4.551	0.257	0.0030	0.0017	99.42
	65.17	0.784	15.59	4.515	0.098	0.490	4.845	4.813	2.338	0.1402	0.0049	98.34
	66.81	0.909	13.55	5.825	0.107	0.644	3.134	4.196	3.081	0.1529	0.0041	97.82
	57.45	0.731	13.19	4.492	0.116	0.627	1.823	4.187	3.453	0.1159	0.0000	85.74
	53.47	0.034	27.57	1.346	0.025	0.156	12.15	4.792	0.267	0.0015	0.0051	99.69
RA-3-9	70.22	0.760	12.92	4.772	0.105	0.666	2.200	3.421	4.133	0.1564	0.0054	98.88
	69.89	0.759	12.86	4.677	0.102	0.650	2.210	3.583	4.169	0.1596	0.0001	98.59
	67.28	0.583	15.31	3.623	0.091	0.555	4.097	4.198	2.954	0.0912	0.0032	98.43
	69.99	0.790	12.85	4.820	0.068	0.698	2.181	3.592	4.081	0.1598	0.0029	98.75
	69.29	0.824	12.38	5.097	0.109	0.789	2.237	3.578	4.028	0.1905	0.0035	98.02
RA-3-10	69.87	0.761	12.93	4.992	0.096	0.647	2.102	3.537	4.194	0.1477	0.0010	98.78
	69.79	0.779	12.96	4.588	0.083	0.584	2.260	3.668	3.948	0.1220	0.0027	98.33
	69.41	0.777	12.67	4.787	0.084	0.620	2.139	3.502	4.241	0.1519	0.0022	97.91
	69.70	0.854	13.07	4.380	0.108	0.438	2.226	3.637	4.296	0.1783	0.0044	98.45
	69.29	0.828	12.85	5.115	0.108	0.602	2.242	3.455	4.198	0.1760	0.0019	98.35
RA-3-11	53.79	0.097	28.19	1.093	0.000	0.132	12.38	4.434	0.315	0.0054	0.0009	100.32
	60.14	0.493	21.70	4.869	0.075	0.487	7.571	4.240	1.736	0.0524	0.0033	100.88
	55.43	0.207	25.92	1.841	0.041	0.271	10.76	4.903	0.690	0.0188	0.0023	99.89
	54.40	0.113	27.21	1.617	0.010	0.160	11.69	4.519	0.511	0.0057	0.0021	100.08
	64.95	1.114	14.11	6.698	0.165	1.152	4.330	3.896	3.240	0.1540	0.0028	99.14
RA-4-5	69.75	0.576	14.59	3.369	0.043	0.304	3.178	3.486	3.617	0.1554	0.0041	98.74
	60.76	0.169	22.94	1.897	0.023	0.160	7.997	5.140	1.435	0.0296	0.0023	100.36
	55.68	0.020	26.28	0.996	0.000	0.078	9.922	5.724	0.516	0.0037	0.0024	99.13
	55.57	0.089	25.27	1.389	0.003	0.104	10.08	5.136	0.727	0.0119	0.0032	98.24
	72.39	0.635	12.22	3.654	0.036	0.332	1.679	3.206	4.154	0.1619	0.0028	98.11
RA-4-11	69.84	0.656	13.73	4.481	0.080	0.451	2.815	3.982	3.513	0.1521	0.0024	99.26
	69.43	0.764	12.47	4.773	0.105	0.560	1.975	3.490	4.333	0.1814	0.0019	97.61
	69.29	0.756	12.39	4.931	0.104	0.601	2.065	3.546	4.296	0.1745	0.0027	97.67
	56.82	0.066	25.47	0.980	0.027	0.095	9.560	5.685	0.614	0.0018	0.0004	99.22
	64.99	0.380	19.54	3.379	0.038	0.251	5.260	4.631	2.495	0.0702	0.0010	100.70

Supplementary Table 1 Continued

	SiO ₂	TiO ₂	Al ₂ O ₃	Fe ₂ O ₃	MnO	MgO	CaO	Na ₂ O	K ₂ O	Cl	S	Total
RA-5-5	64.35	0.977	14.04	7.699	0.166	1.733	4.184	2.785	2.616	0.0422	0.0091	97.83
	64.58	0.964	14.16	7.020	0.153	1.670	5.379	4.267	0.929	0.0230	0.0042	98.45
	63.07	0.949	13.87	7.368	0.160	1.632	5.006	3.002	2.040	0.0544	0.0022	96.42
	64.94	0.945	14.00	6.801	0.142	1.541	4.186	2.745	2.499	0.0383	0.0027	97.16
	64.32	0.993	13.88	6.668	0.143	1.875	5.131	3.125	1.978	0.0814	0.0024	97.52
RA-6-1	69.65	0.599	13.19	3.567	0.054	0.492	2.182	3.634	3.963	0.1863	0.0043	97.17
	70.54	0.697	12.81	3.538	0.121	0.545	2.009	3.691	3.982	0.2041	0.0074	97.79
	69.17	0.552	13.41	3.430	0.083	0.501	2.614	3.996	3.767	0.1585	0.0054	97.35
	71.27	0.602	12.61	3.765	0.096	0.549	2.009	3.592	3.944	0.2013	0.0059	98.27
	70.61	0.642	12.69	3.750	0.121	0.569	1.993	3.522	4.043	0.2044	0.0064	97.78
RA-6-2	70.57	0.711	13.13	4.438	0.088	0.482	2.222	3.578	3.930	0.1850	0.0048	98.89
	55.52	0.000	26.68	0.900	0.014	0.083	7.920	5.374	0.025	0.0000	0.0000	96.44
	71.06	0.687	13.34	4.211	0.074	0.519	2.334	3.764	3.859	0.1731	0.0014	99.60
	55.58	0.069	27.17	1.088	0.009	0.103	11.07	5.307	0.426	0.0021	0.0009	100.73
	68.37	0.697	13.76	3.868	0.060	0.463	3.004	4.079	3.440	0.1844	0.0047	97.54
RA-6-3	72.90	0.901	12.08	3.620	0.022	0.171	1.085	3.389	5.063	0.2464	0.0037	99.12
	73.25	0.812	12.10	3.104	0.031	0.121	0.898	3.422	5.012	0.2298	0.0031	98.68
	59.85	0.240	22.34	1.691	0.013	0.096	8.063	5.652	1.115	0.0482	0.0025	98.93
	72.72	0.857	11.63	3.347	0.016	0.158	0.962	3.332	5.144	0.2383	0.0031	98.08
	60.64	0.234	22.01	1.711	0.000	0.114	7.579	5.708	1.329	0.0613	0.0014	99.22
RA-6-4	73.98	0.825	12.70	1.916	0.021	0.250	1.227	2.985	4.661	0.2373	0.0028	98.61
	72.54	0.954	12.24	2.357	0.086	0.475	1.366	2.809	4.369	0.2142	0.0026	97.18
	70.01	0.755	13.97	2.657	0.051	0.186	2.978	3.948	3.488	0.1838	0.0012	97.96
	71.95	0.846	12.40	4.063	0.089	0.393	1.343	3.604	4.907	0.1569	0.0049	99.35
	72.70	0.804	13.01	3.031	0.080	0.221	1.753	2.982	4.080	0.2359	0.0023	98.60
RA-6-6	67.29	0.748	14.54	3.999	0.069	0.453	3.431	4.046	3.403	0.1683	0.0050	97.75
	70.59	0.743	12.35	4.562	0.080	0.536	2.095	3.442	3.965	0.1891	0.0092	98.10
	70.30	0.800	12.49	4.575	0.082	0.549	2.030	3.331	4.020	0.1937	0.0063	97.92
	70.14	0.779	12.51	4.517	0.068	0.535	2.073	3.446	4.001	0.1904	0.0036	97.81
	70.33	0.757	12.45	4.426	0.032	0.566	2.100	3.377	4.129	0.2004	0.0052	97.93
RA-6-8	52.86	0.044	28.90	0.933	0.010	0.106	13.28	4.342	0.256	0.0031	0.0018	100.63
	63.48	0.519	17.57	2.961	0.073	0.425	6.414	4.346	2.208	0.1211	0.0032	97.82
	52.71	0.035	28.68	0.957	0.021	0.098	12.83	4.199	0.270	0.0031	0.0025	99.71
	70.20	0.716	12.50	4.350	0.085	0.585	2.096	3.628	4.047	0.1721	0.0038	97.95
	70.02	0.773	12.57	4.527	0.063	0.612	2.184	3.554	4.034	0.1778	0.0043	98.07

Supplementary Table 2. Unnormalized EMPA data for glass grains from Turrialba. Oxides are wt. % values, Cl and S are in ppm.

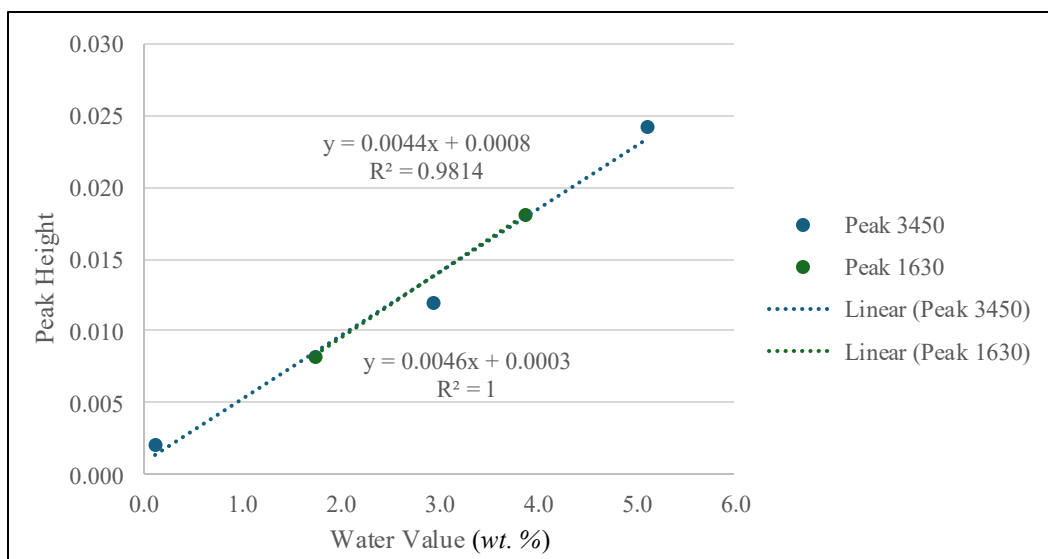
	SiO ₂	TiO ₂	Al ₂ O ₃	Fe ₂ O ₃	MnO	MgO	CaO	Na ₂ O	K ₂ O	Cl	S	Total
TA-1-3	57.28	1.980	14.05	9.242	0.046	3.141	3.706	2.758	4.815	0.0747	0.0019	96.17
	56.59	1.889	14.14	10.05	0.164	3.160	6.677	2.688	3.787	0.1201	0.0026	98.26
	58.96	1.981	14.25	8.668	0.107	2.346	4.868	2.906	4.374	0.0981	0.0148	97.70
	56.64	1.882	14.17	9.801	0.107	3.097	7.027	2.640	3.463	0.0876	0.0010	97.94
	55.33	1.817	13.74	10.03	0.191	3.020	8.171	2.773	3.224	0.1104	0.0028	97.41
TA-1-6	59.90	1.989	14.14	9.028	0.110	2.389	5.273	2.613	2.421	0.1011	0.0007	97.07
	57.86	1.891	13.90	9.348	0.141	2.690	5.523	3.042	2.655	0.1110	0.0007	96.23
	58.05	1.982	13.92	8.216	0.154	2.683	4.919	2.965	2.404	0.0896	0.0016	94.56
	60.62	1.969	14.21	9.392	0.167	2.447	4.813	2.374	2.381	0.0861	0.0228	97.54
	58.95	1.929	14.14	9.664	0.151	2.610	5.374	2.790	2.368	0.1076	0.0013	97.11
TA-1-7	57.03	1.969	14.18	10.91	0.207	3.435	6.403	2.271	1.706	0.0744	0.0020	97.10
	57.46	2.041	14.13	10.82	0.116	3.376	6.402	2.169	1.523	0.0658	0.0033	97.03
	57.24	1.982	14.09	10.84	0.177	3.373	6.312	2.286	1.542	0.0684	0.0030	96.83
	56.61	2.026	14.08	10.61	0.181	3.401	6.299	2.598	1.805	0.0693	0.0047	96.62
	57.04	2.036	14.18	10.90	0.188	3.455	6.587	2.460	1.479	0.0833	0.0049	97.32
TA-2-1	62.92	1.509	13.64	6.772	0.105	1.612	0.005	3.874	3.297	0.0956	0.0009	93.15
	62.27	1.569	13.89	7.093	0.102	1.566	3.622	4.128	3.237	0.1245	0.0302	96.93
	61.71	1.532	15.10	6.363	0.107	1.399	4.382	4.082	2.829	0.0958	0.0302	96.99
	61.85	1.564	13.72	7.119	0.187	1.556	3.575	4.089	3.152	0.1380	0.0326	96.27
	57.52	0.527	22.01	2.594	0.029	0.603	1.508	5.561	1.065	0.0226	0.0059	91.19
TA-2-2	54.93	0.079	26.80	1.133	0.006	0.129	11.24	4.770	0.354	0.0030	0.0003	99.32
	57.91	0.480	22.46	2.010	0.045	0.361	8.573	5.488	0.966	0.0195	0.0020	98.11
	60.20	1.289	16.82	4.440	0.077	0.901	5.380	5.538	2.182	0.1041	0.0020	96.49
	54.88	0.086	26.63	1.242	0.006	0.131	10.61	5.584	0.368	0.0038	0.0005	99.41
	53.12	0.089	27.66	1.137	0.000	0.157	11.96	4.781	0.265	0.0024	0.0035	99.07
TA-2-8	65.78	1.138	14.63	4.556	0.119	0.992	2.268	4.122	3.748	0.0690	0.0000	96.97
	66.83	1.359	13.91	4.732	0.052	1.041	2.193	3.864	3.784	0.0600	0.0006	97.35
	61.96	0.913	17.30	3.374	0.055	0.853	4.920	5.083	2.695	0.0322	0.0019	96.85
	62.09	0.586	20.73	2.420	0.035	0.455	5.852	5.723	1.934	0.0068	0.0000	99.59
	63.58	1.023	16.54	3.416	0.046	0.816	4.349	4.920	2.836	0.0652	0.0014	97.26
TA-3-7	64.41	1.579	13.99	6.135	0.088	1.279	3.672	3.311	3.742	0.0963	0.0025	97.70
	64.00	1.620	14.41	6.411	0.139	1.315	3.289	3.365	3.898	0.0923	0.0038	97.90
	63.22	1.436	13.58	6.107	0.098	1.536	4.339	3.500	3.604	0.1354	0.0016	96.95
	60.84	1.282	15.39	5.413	0.163	1.255	4.949	4.309	2.854	0.1485	0.0041	96.06
	63.51	1.578	13.79	6.588	0.152	1.392	4.274	3.240	3.572	0.1336	0.0035	97.58
TA-3-8	61.64	1.443	14.15	8.019	0.121	2.216	5.374	3.248	2.511	0.1422	0.0010	98.07
	62.12	1.478	14.30	7.702	0.143	2.104	4.713	3.296	2.629	0.1572	0.0144	97.89
	61.98	1.437	14.35	7.717	0.123	2.066	3.561	3.495	3.261	0.1427	0.0016	97.36
	61.34	1.523	14.02	7.709	0.159	2.135	5.135	3.339	2.650	0.1329	0.0000	97.38
	61.00	1.462	13.86	7.917	0.074	2.177	3.709	3.316	3.192	0.1424	0.0031	96.06
TA-3-12	52.52	2.690	13.83	10.74	0.106	4.699	8.157	3.670	1.337	0.0738	0.0014	96.75
	52.88	2.812	13.80	10.95	0.164	4.722	8.491	3.557	1.257	0.0760	0.0000	97.62
	52.45	2.780	13.71	10.67	0.139	4.779	8.546	3.403	1.266	0.0767	0.0013	96.75
	52.65	2.715	13.58	10.77	0.138	4.772	8.494	3.720	1.217	0.0777	0.0009	97.05
	52.69	2.845	13.88	10.51	0.143	4.824	8.550	3.471	1.344	0.0755	0.0000	97.28
TA-3-13	54.74	2.121	14.40	9.939	0.188	3.629	7.082	3.604	2.318	0.1251	0.0044	97.16
	55.04	2.213	14.69	9.934	0.098	3.660	6.820	3.519	2.130	0.1041	0.0041	97.22
	54.86	2.246	14.51	9.670	0.151	3.609	6.879	3.679	2.226	0.1057	0.0068	96.98
	53.78	2.133	14.05	9.757	0.134	3.721	7.051	3.551	2.223	0.1248	0.0068	95.55
	54.22	2.195	14.48	9.945	0.114	3.676	7.173	3.372	2.341	0.1211	0.0198	96.66

Supplementary Table 2 Continued

	SiO ₂	TiO ₂	Al ₂ O ₃	Fe ₂ O ₃	MnO	MgO	CaO	Na ₂ O	K ₂ O	Cl	S	Total
TA-4-2	61.07	1.217	14.60	5.892	0.112	1.851	3.595	3.298	3.000	0.1325	0.0030	94.18
	61.74	1.204	14.32	6.466	0.095	2.035	3.976	1.567	2.821	0.1340	0.0043	93.71
	61.05	1.136	15.06	6.455	0.116	1.968	4.166	3.811	2.712	0.1419	0.0044	95.98
	60.41	1.258	14.28	6.475	0.135	2.005	3.885	2.571	2.792	0.1365	0.0018	93.30
	61.12	1.221	14.32	6.290	0.096	1.790	3.496	1.643	2.913	0.1385	0.0012	92.39
TA-4-10	59.55	1.834	13.75	9.039	0.152	2.533	5.016	2.154	2.366	0.0882	0.0009	95.57
	59.34	1.864	13.86	9.635	0.171	2.638	5.590	1.965	2.127	0.0861	0.0008	96.31
	59.72	1.820	14.04	9.179	0.181	2.507	4.948	2.078	2.343	0.0890	0.0000	95.98
	59.62	1.867	14.04	8.791	0.116	2.474	4.956	1.974	2.340	0.0801	0.0000	95.38
	59.57	1.824	13.88	9.241	0.161	2.533	4.913	2.186	2.384	0.0921	0.0005	95.86
TA-7-2	57.27	2.095	13.76	11.27	0.188	3.214	3.384	3.011	3.228	0.0879	0.0016	96.38
	56.26	2.020	13.54	11.15	0.131	3.182	6.214	3.767	2.020	0.0796	0.0009	97.24
	56.08	2.057	13.16	11.53	0.137	3.331	2.899	3.025	3.611	0.1719	0.0015	94.86
	55.98	2.114	13.41	11.64	0.147	2.972	4.261	3.090	3.016	0.1213	0.0000	95.60
	56.37	2.088	13.56	11.65	0.173	3.043	3.653	3.077	3.114	0.1041	0.0006	95.66
TA-7-4	53.11	0.498	1.186	18.21	0.480	26.70	1.830	0.047	0.003	0.0066	0.0016	100.25
	62.39	1.238	14.97	6.888	0.134	2.094	4.483	2.481	2.432	0.1368	0.0067	96.57
	61.14	1.331	14.87	8.047	0.179	2.601	4.297	2.534	2.655	0.1314	0.0051	96.99
	60.77	1.381	15.13	7.948	0.104	2.758	4.719	2.448	2.426	0.1286	0.0053	97.03
	61.59	1.331	15.02	7.658	0.165	2.593	4.548	2.380	2.771	0.1318	0.0025	97.42
TA-7-5	56.28	2.031	14.13	10.48	0.169	3.328	5.688	3.136	2.219	0.0806	0.0000	96.49
	56.06	2.053	13.96	10.31	0.144	3.186	6.478	2.949	2.005	0.0859	0.0000	96.20
	56.65	1.968	13.89	10.28	0.165	3.290	5.745	2.842	2.137	0.0856	0.0000	96.02
	57.27	1.953	14.23	10.35	0.188	3.274	6.114	3.134	2.091	0.0810	0.0000	97.65
	56.11	2.011	13.90	10.40	0.188	3.332	6.507	3.162	2.259	0.0829	0.0000	96.91
TA-8-1	63.87	1.407	14.50	5.756	0.117	1.204	3.306	4.151	3.328	0.0877	0.0027	97.15
	61.75	1.081	17.51	4.337	0.069	0.946	5.707	5.116	2.245	0.0894	0.0022	98.42
	53.87	0.061	27.54	1.043	0.034	0.089	11.29	5.151	0.360	0.0037	0.0000	99.34
	57.74	0.659	22.40	2.760	0.063	0.549	7.845	5.134	1.494	0.0269	0.0012	98.39
	63.73	1.543	13.77	6.812	0.154	1.514	3.217	3.855	3.243	0.1446	0.0020	97.30
TA-8-2	63.16	1.499	14.00	5.983	0.134	1.345	3.573	4.703	3.169	0.1015	0.0000	97.07
	63.51	1.568	13.87	6.578	0.172	1.403	3.306	4.410	3.310	0.0734	0.0006	97.54
	64.26	1.501	13.90	6.236	0.135	1.452	3.572	4.480	3.188	0.1077	0.0019	98.20
	58.74	0.285	24.17	2.112	0.067	0.267	8.447	5.754	0.921	0.0099	0.0000	100.57
	56.09	0.080	27.10	1.256	0.040	0.137	10.49	5.142	0.377	0.0030	0.0009	100.58
TA-8-3	63.16	1.575	13.92	6.988	0.129	1.553	3.535	4.202	3.235	0.1058	0.0009	97.70
	63.29	1.565	13.76	6.547	0.130	1.520	3.519	4.368	3.266	0.0512	0.0011	97.36
	61.67	1.546	14.04	6.525	0.129	1.554	3.826	4.597	3.041	0.1037	0.0046	96.39
	53.31	0.074	27.09	1.118	0.028	0.109	11.56	5.117	0.320	0.0019	0.0022	98.61
	59.22	0.883	17.88	5.252	0.115	2.898	6.352	5.023	1.676	0.0539	0.0007	98.82
TA-8-7	63.15	1.485	14.02	7.422	0.135	1.709	3.705	4.512	3.432	0.0888	0.0000	98.92
	61.45	1.428	15.21	6.955	0.080	1.656	4.303	5.040	2.712	0.1112	0.0018	98.24
	61.85	1.561	13.98	7.333	0.146	1.680	4.144	5.262	2.465	0.1272	0.0005	97.81
	61.83	1.583	13.72	7.609	0.154	1.864	3.769	4.545	3.200	0.1189	0.0012	97.63
	61.61	1.586	13.71	7.222	0.141	1.767	3.565	4.406	3.689	0.0936	0.0005	97.06
TA-8-9	53.24	0.059	28.03	0.984	0.013	0.088	12.21	4.843	0.273	0.0026	0.0028	99.66
	63.48	1.641	15.09	6.454	0.151	1.471	3.628	4.613	3.110	0.1452	0.0113	99.14
	60.61	0.768	20.15	3.919	0.064	0.754	6.242	5.511	1.850	0.0672	0.0075	99.55
	64.10	1.488	14.25	6.166	0.105	1.303	3.054	4.941	3.241	0.1293	0.0043	98.17
	54.84	0.214	25.98	1.555	0.015	0.218	10.39	5.472	0.499	0.0106	0.0022	99.04
TA-8-10	60.45	0.433	21.53	1.953	0.008	0.259	6.080	6.162	1.822	0.0153	0.0030	98.52
	55.71	0.105	26.40	1.236	0.012	0.081	10.03	5.755	0.491	0.0035	0.0066	99.71
	66.34	1.104	14.20	3.615	0.077	0.720	3.320	4.652	3.483	0.0421	0.0057	97.20
	54.81	0.100	26.26	1.204	0.034	0.097	10.40	5.492	0.443	0.0046	0.0045	98.73
	48.95	0.038	31.18	0.951	0.014	0.103	15.11	3.013	0.114	0.0041	0.0053	99.38

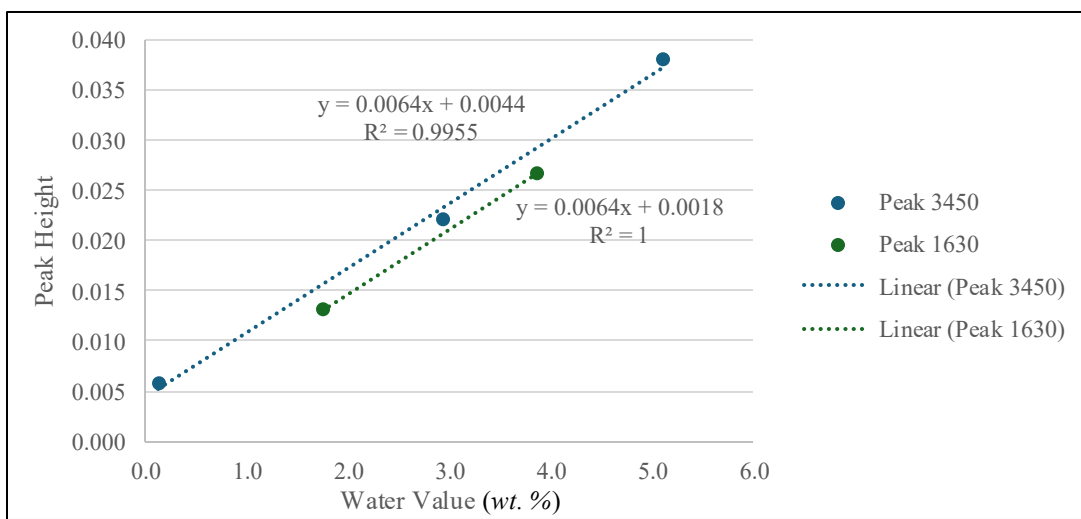
Supplementary Table 3. FTIR data for standards M6N, M3N and PCD.

M6N			M3N			PCD		
Spectrum	A-3450	A-1630	Spectrum	A-3450	A-1630	Spectrum	A-3450	A-1630
1	0.0244	0.0194	1	0.0129	0.0089	1	0.00267	0.00107
2	0.0256	0.0197	2	0.0118	0.0083	2	0.00259	0.00096
3	0.0287	0.0201	3	0.0121	0.0066	3	0.00289	0.0012
4	0.0223	0.0176	4	0.0122	0.0086	4	0.00303	0.00113
5	0.0229	0.0173	5	0.0113	0.008	5	0.0029	0.00112
6	0.024	0.0172	6	0.0109	0.0075	6	0.0028	0.0011
7	0.0211	0.0171	7	0.0105	0.0077	7	0.00282	0.001
8	0.0204	0.0161	8	0.0105	0.0076	8	0.00289	0.00117
9	0.0215	0.0159	9	0.0103	0.007	9	0.00278	0.00125
1	0.0227	0.018	1	0.0131	0.009	1	0.00161	0.00078
2	0.0232	0.0183	2	0.0126	0.0087	2	0.00151	0.0008
3	0.0214	0.017	3	0.0124	0.0082	3	0.00095	0.00066
4	0.0243	0.017	4	0.0134	0.0092	4	0.00172	0.00091
5	0.027	0.0175	5	0.013	0.0088	5	0.00168	0.00105
6	0.0273	0.02	6	0.0127	0.0088	6	0.00122	0.00076
7	0.0258	0.0187	7	0.0126	0.0088	7	0.00183	0.00099
8	0.0266	0.0194	8	0.0123	0.0087	8	0.00127	0.00078
9	0.0283	0.0192	9	0.0119	0.0084	9	0.00153	0.00088
Day 1	0.0243	0.0181	Day 1	0.0120	0.0083	Day 1	0.0021	0.0010
1	0.04	0.027	1	0.024	0.013	1	0.007	0.001
2	0.041	0.026	2	0.025	0.015	2	0.007	0.001
3	0.04	0.027	3	0.026	0.015	3	0.007	0.001
4	0.04	0.027	4	0.025	0.013	4	0.006	0.001
5	0.041	0.027	5	0.025	0.014	5	0.006	0.001
6	0.041	0.027	6	0.024	0.014	6	0.006	0.001
7	0.04	0.028	7	0.025	0.013	7	0.006	0.001
8	0.04	0.028	8	0.025	0.013	8	0.006	0.001
9	0.04	0.027	9	0.025	0.014	9	0.006	0.002
1	0.032	0.024	1	0.019	0.011	1	0.005	0.001
2	0.035	0.026	2	0.018	0.01	2	0.005	0.001
3	0.039	0.027	3	0.019	0.011	3	0.005	0.001
4	0.034	0.025	4	0.019	0.011	4	0.005	0.001
5	0.035	0.026	5	0.019	0.011	5	0.005	0.001
6	0.037	0.028	6	0.02	0.012	6	0.005	0.001
7	0.034	0.026	7	0.019	0.011	7	0.005	0.001
8	0.036	0.027	8	0.02	0.012	8	0.005	0.001
9	0.038	0.027	9	0.021	0.012	9	0.005	0.001
Day 2	0.0379	0.0267	Day 2	0.022	0.013	Day 2	0.0057	0.0011
1	0.027	0.021	1	0.02	0.012	1	0.006	0.002
2	0.029	0.021	2	0.02	0.012	2	0.005	0.001
3	0.031	0.023	3	0.02	0.011	3	0.006	0.001
4	0.027	0.021	4	0.02	0.012	4	0.006	0.002
5	0.028	0.022	5	0.02	0.012	5	0.006	0.002
6	0.029	0.023	6	0.02	0.012	6	0.006	0.001
7	0.027	0.02	7	0.019	0.011	7	0.006	0.001
8	0.028	0.021	8	0.02	0.011	8	0.006	0.002
9	0.029	0.022	9	0.02	0.012	9	0.006	0.001
Day 3	0.0283	0.0216	Day 3	0.020	0.012	Day 3	0.0059	0.0014
Average	0.0306	0.0222	Average	0.0176	0.0106	Average	0.0043	0.0011



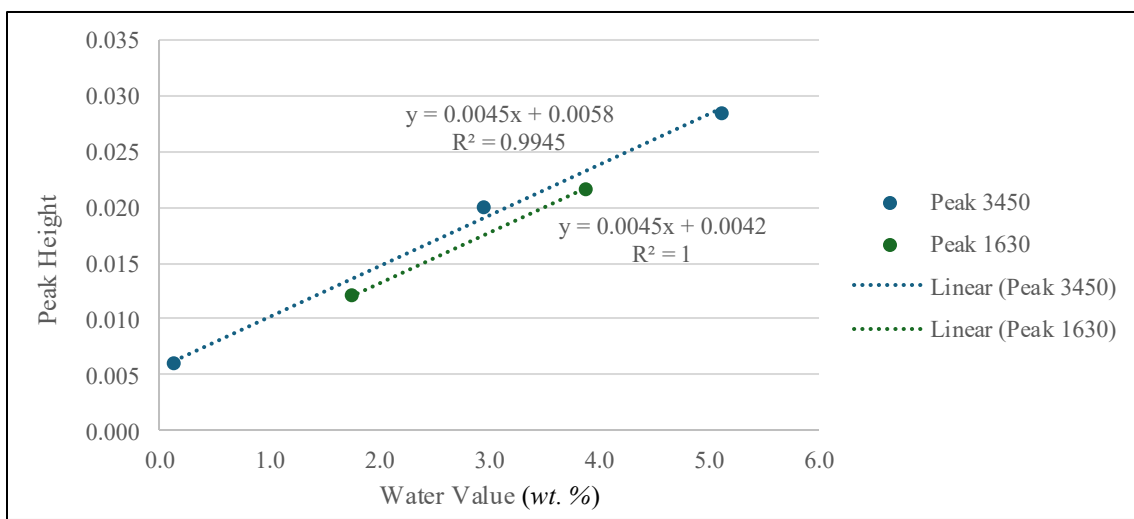
	A-3450	A-1630	H ₂ O _{total} (wt. %)	H ₂ O _{mol} (wt. %)
M6N	0.0243	0.0181	5.1110	3.8700
M3N	0.0120	0.0083	2.9400	1.7400
PCD	0.0021	0.0010	0.1250	

Supplementary Figure 1. Calibration line for FTIR analysis conducted Day 1. Green points and line correspond to A-1630 peak and H₂O_{mol}. Blue points and line correspond to A-3450 peak and H₂O_{total}.



	A-3450	A-1630	H ₂ O _{total} (wt. %)	H ₂ O _{mol} (wt. %)
M6N	0.0379	0.0267	5.1110	3.8700
M3N	0.0220	0.0130	2.9400	1.7400
PCD	0.0057	0.0011	0.1250	

Supplementary Figure 2. Calibration line for FTIR analysis conducted Day 2. Green points and line correspond to A-1630 peak and H₂O_{mol}. Blue points and line correspond to A-3450 peak and H₂O_{total}.



	A-3450	A-1630	H ₂ O _{total} (wt. %)	H ₂ O _{mol} (wt. %)
M6N	0.0283	0.0216	5.1110	3.8700
M3N	0.0200	0.0120	2.9400	1.7400
PCD	0.0059	0.0014	0.1250	

Supplementary Figure 3. Calibration line for FTIR analysis conducted Day 3. Green points and line correspond to A-1630 peak and H₂O_{mol}. Blue points and line correspond to A-3450 peak and H₂O_{total}.

Supplementary Table 4. FTIR data for samples from Rincón de la Vieja (RA) and Turrialba (TA).

Sample	A-3450	A-1630	H ₂ O (wt.%)	H ₂ O _{mol} (wt.%)	OH (wt.%)
RA-2-1	0.00790	0.00230	0.55	0.08	0.47
RA-3-9	0.00740	0.00300	0.47	0.19	0.28
RA-3-10	0.00750	0.00470	0.48	0.45	0.03
	0.00740	0.00410	0.47	0.36	0.11
RA-4-5	0.00590	0.00260	0.23	0.13	0.11
	0.00700	0.00290	0.41	0.17	0.23
	0.00750	0.00290	0.48	0.17	0.31
	0.00880	0.00480	0.69	0.47	0.22
RA-5-5	0.00850	0.00220	0.64	0.06	0.58
RA-6-1	0.00140	0.00070	0.14	0.09	0.05
	0.00180	0.00110	0.23	0.17	0.05
RA-6-2	0.00146	0.00031	0.15	0.00	0.15
	0.00300	0.00050	0.50	0.04	0.46
RA-6-4	0.00150	0.00060	0.16	0.07	0.09
	0.00620	0.00250	1.23	0.48	0.75
	0.00420	0.00080	0.77	0.11	0.66
	0.00380	0.00170	0.68	0.30	0.38
RA-6-6	0.00590	0.00110	1.16	0.17	0.99
	0.00570	0.00130	1.11	0.22	0.90
	0.00470	0.00140	0.89	0.24	0.65
	0.00290	0.00110	0.48	0.17	0.30
	0.00150	0.00040	0.16	0.02	0.14
	0.00260	0.00080	0.41	0.11	0.30
	0.00280	0.00100	0.45	0.15	0.30
	0.00390	0.00120	0.70	0.20	0.51
	0.00360	0.00100	0.64	0.15	0.48
TA-1-3	0.0077	0.0025	0.52	0.11	0.41
TA-1-6	0.0142	0.0021	1.53	0.05	1.48
	0.0049	0.0019	0.08	0.02	0.06
TA-1-7	0.0127	0.0049	1.30	0.48	0.81
TA-3-12	0.0135	0.0046	1.71	0.09	1.62
	0.0189	0.0099	2.91	1.27	1.64
TA-4-2	0.0129	0.0104	1.58	1.38	0.20
TA-4-5	0.0172	0.0071	2.53	0.64	1.89
TA-4-10	0.0114	0.0044	1.24	0.04	1.20
TA-7-2	0.0056	0.0020	0.19	0.03	0.16
TA-7-5	0.0183	0.0094	2.17	1.19	0.98
	0.0198	0.0058	2.41	0.63	1.78
TA-8-1	0.0118	0.0032	1.16	0.22	0.94
TA-8-2	0.0064	0.0021	0.31	0.05	0.27
TA-8-3	0.0113	0.0028	1.08	0.16	0.92
	0.0101	0.0028	0.89	0.16	0.73
	0.0216	0.0047	2.69	0.45	2.23
	0.0101	0.0031	0.89	0.20	0.69
TA-8-7	0.0093	0.0019	0.77	0.02	0.75
TA-8-9	0.0067	0.0019	0.36	0.02	0.34
	0.0169	0.0029	1.95	0.17	1.78
TA-8-10	0.0166	0.0032	1.91	0.22	1.69
	0.0105	0.0028	0.95	0.16	0.80

Supplementary Table 5. SIMS standard data for standards D52-5, MCR1, MCR2 and MCR4.

	Primary Current	$^{16}\text{O}2\text{H}/^{16}\text{O}1\text{H}$	$^{16}\text{O}1\text{H}/\text{Coeff}$	Alpha
D52-5	0.663484	0.000225	588443.3	1.524585
	0.684191	0.000225	586288	1.520318
	0.615529	0.000225	557315.2	1.520381
	0.601857	0.000225	554878.3	1.522165
	0.561072	0.000225	518679.4	1.521469
	0.505347	0.000224	513301.1	1.518298
	0.852505	0.000226	651511.1	1.530286
	0.802049	0.000223	638745.6	1.509742
	0.740844	0.000225	592921.7	1.519262
	0.673728	0.000224	569722.7	1.518541
	0.748356	0.000224	641214.3	1.517006
	0.829376	0.000224	642376.5	1.517677
	0.685244	0.000225	569767.8	1.525009
	0.626346	0.000223	573343.6	1.511281
	0.663464	0.000224	608734.7	1.514515
	0.673623	0.000224	541481.6	1.51619
	0.590977	0.000225	530656.6	1.524842
	0.694353	0.000225	624790.1	1.520823
	0.632182	0.000224	539388.4	1.518672
	0.625153	0.000225	502067.7	1.52103
MCR2	0.641062	0.000211	843069	1.438577
	0.629492	0.000212	573471.7	1.443809
MCR4	0.671024	0.000201	927329.2	1.448041
	0.710933	0.000202	678748.8	1.459105
MCR1	0.660473	0.000201	605002.9	1.465656
	0.668306	0.000199	637266.9	1.44932
	0.666473	0.000200	602538.5	1.456082
	0.695569	0.000212	833941.5	1.445363
	0.698081	0.000211	815988.8	1.437512
	0.696308	0.000204	855376	1.470825
	0.675579	0.0002	895737.4	1.445267
	0.664184	0.000199	626473.7	1.44876
	0.665182	0.000199	639458.3	1.450866
	0.694311	0.000199	616653.2	1.452931
	0.707299	0.000201	636186.3	1.464009
	0.758658	0.000199	674231.7	1.449016
	0.745924	0.0002	658098.8	1.461927
	0.776512	0.0002	685453.6	1.458717
	0.780102	0.000198	661215.5	1.44513
	0.845623	0.000201	664649	1.465421
	0.810489	0.000199	700697.8	1.452966
	0.806429	0.0002	704103.4	1.458514
	0.828108	0.000197	692758.1	1.439713

Supplementary Table 6. SIMS data for Turrialba (TA) and Rincón de la Vieja (RA) glass samples. Alpha values were 1.52 for Turrialba samples and 1.45 for Rincón de la Vieja samples.

	Measured OD/OH	rSE of Mean	Standard Error	Sample Ratio	1 σ	Delta (‰)	Delta 1 σ
TA-1-6	0.000210	0.828947	0.000002	0.000138	0.000001	-112.32	8.86
	0.000213	0.649141	0.000001	0.000140	0.000001	-98.02	7.20
	0.000214	0.763519	0.000002	0.000141	0.000001	-94.42	8.25
TA-8-2	0.000222	1.055001	0.000002	0.000146	0.000002	-62.32	11.00
	0.000223	1.040594	0.000002	0.000147	0.000002	-57.27	10.87
	0.000222	0.907509	0.000002	0.000146	0.000001	-62.29	9.60
TA-8-3	0.000218	0.898485	0.000002	0.000144	0.000001	-77.51	9.51
	0.000218	0.750030	0.000002	0.000143	0.000001	-79.97	8.13
	0.000222	0.866264	0.000002	0.000146	0.000001	-61.78	9.21
TA-8-10	0.000218	1.052863	0.000002	0.000144	0.000002	-78.42	10.98
	0.000226	1.365537	0.000003	0.000149	0.000002	-45.91	14.01
	0.000225	1.287658	0.000003	0.000148	0.000002	-49.80	13.25
TA-8-9	0.000221	1.031118	0.000002	0.000145	0.000002	-66.05	10.77
	0.000223	0.869433	0.000002	0.000147	0.000001	-58.43	9.24
	0.000222	1.075375	0.000002	0.000146	0.000002	-62.86	11.20
TA-1-7	0.000212	0.547849	0.000001	0.000140	0.000001	-103.57	6.31
	0.000210	0.587362	0.000001	0.000139	0.000001	-110.77	6.65
	0.000217	1.173467	0.000003	0.000143	0.000002	-83.75	12.14
TA-7-5	0.000213	0.439568	0.000001	0.000140	0.000001	-100.51	5.39
	0.000211	0.448488	0.000001	0.000139	0.000001	-107.62	5.47
TA-7-2	0.000217	0.565953	0.000001	0.000143	0.000001	-81.55	6.47
	0.000215	0.449277	0.000001	0.000141	0.000001	-93.71	5.47
	0.000214	0.433822	0.000001	0.000141	0.000001	-97.08	5.35
TA-1-3	0.000214	0.689838	0.000001	0.000141	0.000001	-94.40	7.57
	0.000214	0.598881	0.000001	0.000141	0.000001	-95.98	6.76
	0.000215	0.684023	0.000001	0.000141	0.000001	-91.77	7.52
RA-3-9	0.000224	0.772733	0.000002	0.000154	0.000001	-11.29	9.38
	0.000225	0.834251	0.000002	0.000155	0.000002	-6.58	9.90
	0.000229	0.845664	0.000002	0.000157	0.000002	9.61	9.99
RA-4-5	0.000226	0.749162	0.000002	0.000155	0.000001	-3.47	9.19
	0.000225	0.896264	0.000002	0.000155	0.000002	-7.39	10.43
	0.000226	0.895478	0.000002	0.000156	0.000002	-0.31	10.42
RA-2-1	0.000222	0.459374	0.000001	0.000153	0.000001	-19.76	7.03
	0.000227	0.542289	0.000001	0.000156	0.000001	3.75	7.60
RA-6-6	0.000223	0.549406	0.000001	0.000153	0.000001	-16.43	7.65
	0.000218	0.575848	0.000001	0.000150	0.000001	-38.24	7.84
	0.000220	0.555764	0.000001	0.000151	0.000001	-27.43	7.70
RA-6-2	0.000225	0.692441	0.000002	0.000155	0.000001	-7.04	8.74
	0.000228	0.824394	0.000002	0.000157	0.000002	8.20	9.81
	0.000224	0.738084	0.000002	0.000154	0.000001	-12.58	9.10
RA-6-1	0.000222	0.426498	0.000001	0.000153	0.000001	-20.61	6.82
	0.000224	0.435072	0.000001	0.000154	0.000001	-12.89	6.88
	0.000218	0.466491	0.000001	0.000150	0.000001	-37.66	7.08