minerals

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SUPPLEMENTARY INFORMATION

Structural and geochemical assessment of the coralline alga *Tethysphytum antarcticum* from Terra Nova Bay, Ross Sea, Antarctica

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Thin sections

Complementary to the SEM investigations, a further sample slice was cut perpendicular to the rock and algal crust, to examine the skeletal mineralogy and crystal orientation. In an EPOVAC chamber, the dry sample was vacuum-embedded in a two-component epoxy resin (Biresin L48 resin and hardener, 4:1), cured 48 hours, cut with a water-cooled PRESI Mecatome precision rock saw and grinded on a PRESI Minitech 300 SPI using diamond discs with 125 µm, 75 µm, 54 µm, and 18 µm graining. The surface was then glued with BIRESIN epoxy resin to a glass slide and ground to 20 µm final thickness using a G&N MPS 2 R300. Sections were photographed in normal and polarized translucent light with a Zeiss Axio Zoom.V16, equipped with a Zeiss Plan-NEOFLUAR Z 1x/0.25 FWD 56 mm. The software Zeiss ZEN core 2.7.0 was used to produce high-resolution images via the tile stitching mode. All images were post-processed in Adobe Photoshop by means of sharpening, tonal value adjustment, and shadows/highlights adjustments.

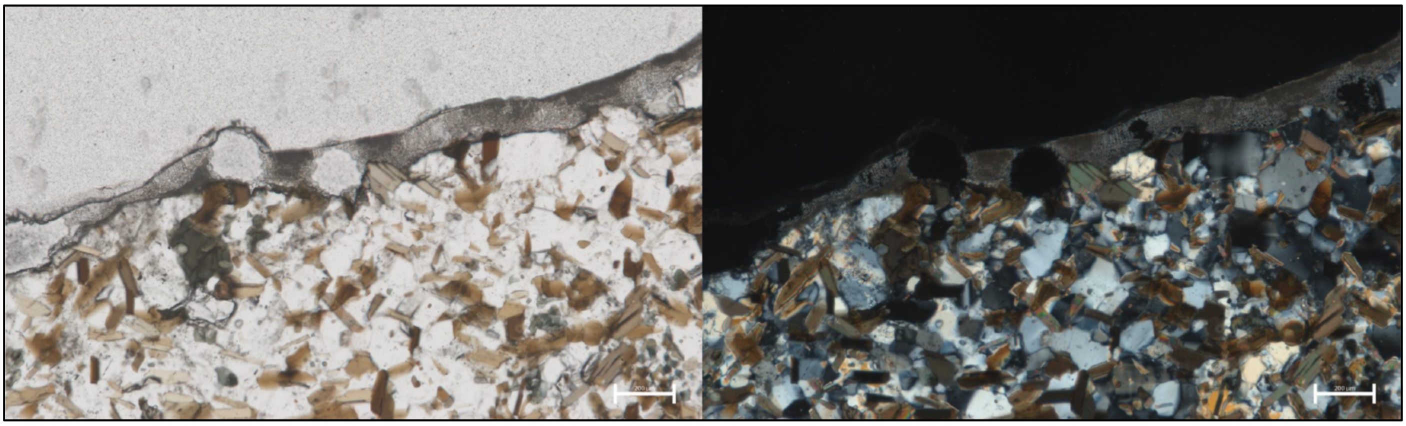

Figure S1. Thin section images with translucent light (left) and polarized light under crossed-nichols (right); the crystalline bedrock cobble is covered by a ~150 µm thin veneer of the calcareous coralline red alga *Thethysphytum antarcticum*. Two large conceptacles (sporangial cavities) in the center are embedded in the monomerous thallus. Electron-Microprobe map 3 is located between them. Scale bars: 200 µm.

µRaman spectroscopy

The rock thin section was examined for its principal mineral composition at the University of Padova (Organic Chemistry Institute) with a ThermoScientific micro-Raman Spectroscope. The monochromatic 532 nm DXR laser was run at 3 mW laser power, with a 25 µm aperture and a 50× LWD objective. Four replicates were taken for each spot measurement, with 30 s dwell time and Raman shift acquired between 50 and 3500 cm^{-1}, at 900 lines/mm grating. Data were processed, background corrected and visualized (Figure S2) with the OMNIC-software and compared to mineral reference spectra from the RRUFF-database (http://rruff.info). Principal peaks indicated orthoclase and phlogopite (Figure S2).

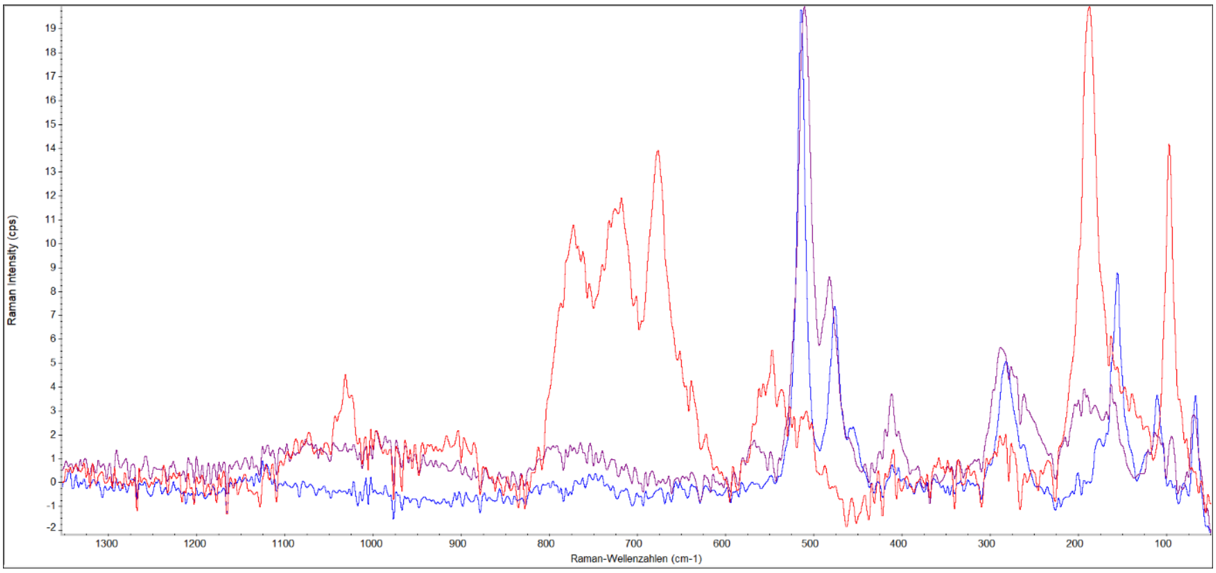

Figure S2. Raman spectra of two dominant minerals in the rock substrate beneath the algal crust are indicative of orthoclase (blue and purple) and phlogopite (red).

X-ray powder diffractometry (XRD)

The XRD-diffractograms showed characteristic peaks for the (*hkl*)-surfaces at the 2Θ Cu K_α angles as follows: (*012*) at 23.22°, (*104*) at 29.63°, (110) at 36.23°, (113) at 39.70°, (202) at 43.47°, (018) at 47.89°, (116) at 48.88°, (112) at 57.84°. Refined Rietfeld unit cell parameters a, c and cell volume are given along with calculated MgCO3 (mol%) in Table S1. Calculations are based on regressions provided by Titschack et al. 2011 [42].

Table S1. Summarized unit cell parameters from Rietfeld refinement and $MgCO_3$ (mol%).

Sample ID	*a* (Å)	*C* (Å)	Volume (Å³)	Mg occ refined	mol% $MgCO_3$ (*a* - based)	mol% $MgCO_3$ (volume - based)
Bulk powder 1	4.958	16.933	360.545	12.08	8.30	7.96
Bulk powder 2	4.958	16.930	360.390	11.28	8.47	8.13
Bulk powder 3	4.958	16.932	360.485	10.35	8.36	8.03
Average	4.958	16.932	360.473	11.24	8.38	8.04
Standard deviation	0.0003	0.0011	0.0637	0.0071	0.0007	0.0007

Table S2. Quantitative EMP-spot measurements.

EMP-spot main-thallus	Distance (mm)	MgO (weight%)	CaO (weight%)	SrO (weight%)	SO_2 (weight%)	CO_2 (weight%)	Mg/Ca (mol/mol)	$MgCO_3$ (mol%)	Sr/Ca (mol/mol)	$SrCO_3$ (mol%)	$CaCO_3$ (mol%)
TNB-1	0	3.266	51.676	0.239	0.598	44.221	0.0879	8.06	0.0025	0.23	91.71
TNB-2	0.083	3.428	51.449	0.268	0.622	44.233	0.0927	8.46	0.0028	0.26	91.28
TNB-3	0.255	3.786	51.085	0.216	0.597	44.316	0.1031	9.33	0.0023	0.21	90.46
TNB-4	0.316	3.280	51.667	0.222	0.609	44.223	0.0883	8.10	0.0023	0.21	91.69
TNB-5	0.390	2.907	52.032	0.284	0.647	44.129	0.0777	7.19	0.0030	0.27	92.53
TNB-6	0.479	3.075	51.909	0.212	0.621	44.184	0.0824	7.60	0.0022	0.20	92.20
TNB-7	0.543	3.015	52.031	0.176	0.577	44.200	0.0806	7.45	0.0018	0.17	92.38
TNB-8	0.622	3.636	51.133	0.315	0.682	44.233	0.0990	8.98	0.0033	0.30	90.72
TNB-10	0.717	1.468	53.855	0.190	0.538	43.948	0.0379	3.65	0.0019	0.18	96.17
TNB-11	0.745	2.177	53.085	0.154	0.480	44.103	0.0571	5.39	0.0016	0.15	94.46
TNB-12	0.858	3.710	51.206	0.238	0.509	44.337	0.1008	9.14	0.0025	0.23	90.64
TNB-13	0.894	3.307	51.676	0.185	0.590	44.243	0.0890	8.16	0.0019	0.18	91.66
TNB-14	0.927	3.099	51.952	0.142	0.592	44.215	0.0830	7.65	0.0015	0.14	92.21
TNB-15	1.146	3.030	52.086	0.102	0.553	44.228	0.0809	7.48	0.0011	0.10	92.42
TNB-16	1.190	3.520	51.327	0.317	0.577	44.259	0.0954	8.68	0.0033	0.30	91.01
TNB-17	1.246	3.135	51.865	0.217	0.565	44.218	0.0841	7.74	0.0023	0.21	92.05
TNB-18	1.379	3.248	52.060	0.036	0.240	44.417	0.0868	7.98	0.0004	0.03	91.98
TNB-19	1.418	2.902	52.186	0.301	0.360	44.251	0.0774	7.16	0.0031	0.29	92.55
TNB-20	1.546	2.819	52.441	0.057	0.427	44.256	0.0748	6.95	0.0006	0.05	92.99
TNB-21	2.254	3.940	50.955	0.327	0.349	44.429	0.1076	9.68	0.0035	0.31	90.00
TNB-22	2.371	3.764	51.286	0.255	0.229	44.467	0.1021	9.24	0.0027	0.24	90.51
TNB-23	2.418	2.412	52.710	0.182	0.620	44.076	0.0637	5.98	0.0019	0.17	93.85
TNB-25	2.742	3.401	51.480	0.307	0.567	44.245	0.0919	8.39	0.0032	0.29	91.31
TNB-26	2.789	3.124	51.841	0.330	0.470	44.235	0.0839	7.71	0.0034	0.32	91.97
TNB-28	3.067	3.083	51.871	0.285	0.567	44.194	0.0827	7.62	0.0030	0.27	92.11
TNB-29	3.169	2.431	52.778	0.261	0.345	44.185	0.0641	6.01	0.0027	0.25	93.74
TNB-30	3.300	3.756	51.282	0.182	0.358	44.423	0.1019	9.23	0.0019	0.17	90.59
TNB-31	3.422	2.525	52.623	0.206	0.504	44.142	0.0668	6.25	0.0021	0.20	93.55
TNB-32	3.579	3.328	51.586	0.387	0.415	44.283	0.0898	8.21	0.0041	0.37	91.42
TNB-33	3.715	4.035	50.846	0.207	0.515	44.397	0.1104	9.92	0.0022	0.20	89.88
TNB-34	3.801	2.740	52.366	0.187	0.542	44.166	0.0728	6.77	0.0019	0.18	93.05
TNB-35	4.075	4.015	50.882	0.183	0.527	44.393	0.1098	9.88	0.0019	0.18	89.95
TNB-36	4.242	3.770	51.193	0.155	0.523	44.358	0.1025	9.28	0.0016	0.15	90.57
TNB-37	4.342	4.148	50.635	0.321	0.495	44.402	0.1140	10.20	0.0034	0.31	89.49
TNB-38	4.535	4.266	50.579	0.276	0.410	44.469	0.1174	10.48	0.0030	0.26	89.26
TNB-39	4.655	3.224	51.732	0.274	0.534	44.235	0.0867	7.96	0.0029	0.26	91.78
TNB-41	4.888	3.174	51.716	0.334	0.582	44.193	0.0854	7.84	0.0035	0.32	91.84
TNB-43	5.065	1.784	53.454	0.174	0.617	43.971	0.0464	4.43	0.0018	0.17	95.40
TNB-45	5.336	3.491	51.390	0.334	0.503	44.283	0.0945	8.61	0.0035	0.32	91.07
TNB-46	5.515	1.988	53.358	0.111	0.450	44.092	0.0518	4.92	0.0011	0.11	94.97
TNB-47	5.600	3.006	52.062	0.239	0.452	44.241	0.0803	7.42	0.0025	0.23	92.35
TNB-48	5.800	3.729	51.171	0.212	0.569	44.319	0.1014	9.19	0.0022	0.20	90.61
TNB-49	5.945	4.585	50.232	0.243	0.410	44.531	0.1270	11.24	0.0026	0.23	88.53
TNB-50	6.101	3.471	51.479	0.291	0.444	44.314	0.0938	8.55	0.0031	0.28	91.17
TNB-51	6.203	3.811	51.060	0.277	0.503	44.349	0.1038	9.38	0.0029	0.26	90.35
TNB-52	6.301	2.503	52.568	0.276	0.548	44.105	0.0663	6.20	0.0028	0.27	93.54
TNB-53	6.422	3.467	51.483	0.297	0.438	44.315	0.0937	8.54	0.0031	0.28	91.17
TNB-54	6.586	1.996	53.430	0.089	0.337	44.148	0.0520	4.94	0.0009	0.09	94.98
TNB-55	6.722	3.042	52.166	0.071	0.430	44.291	0.0811	7.50	0.0007	0.07	92.43
TNB-56	6.812	2.772	52.234	0.302	0.544	44.148	0.0738	6.86	0.0031	0.29	92.85
TNB-57	6.954	2.203	52.967	0.127	0.676	44.027	0.0579	5.46	0.0013	0.12	94.41
TNB-58	7.131	3.511	51.471	0.201	0.505	44.312	0.0949	8.65	0.0021	0.19	91.16
TNB-60	7.277	3.947	50.898	0.259	0.532	44.364	0.1079	9.72	0.0028	0.25	90.04
TNB-61	7.417	3.669	51.314	0.178	0.486	44.352	0.0995	9.03	0.0019	0.17	90.80
TNB-62	7.517	3.449	51.694	0.061	0.437	44.360	0.0928	8.49	0.0006	0.06	91.45
basal-thallus											
TNB-9	0.674	4.173	50.373	0.216	1.057	44.180	0.1153	10.31	0.0023	0.21	89.48
TNB-40	4.731	4.973	49.739	0.311	0.382	44.596	0.1391	12.18	0.0034	0.30	87.53

TNB-42	4.962	5.207	49.149	0.358	0.878	44.408	0.1474	12.80	0.0039	0.34	86.85
TNB-44	5.153	5.059	49.496	0.190	0.806	44.449	0.1422	12.43	0.0021	0.18	87.39
TNB-64	7.696	4.524	50.017	0.219	0.955	44.285	0.1259	11.16	0.0024	0.21	88.63
outliers											
TNB-24	2.652	0.170	55.435	0.123	0.530	43.742	0.0043	0.42	0.0012	0.12	99.46
TNB-27	2.982	0.354	55.293	0.078	0.462	43.812	0.0089	0.88	0.0008	0.08	99.04
TNB-59	7.210	0.242	55.652	0.045	0.104	43.957	0.0061	0.60	0.0004	0.04	99.36
TNB-63	7.664	0.239	54.350	1.267	0.694	43.451	0.0061	0.60	0.0126	1.24	98.16

Algal architecture

The vegetative plant tissue of the alga *Thetysphytum antarcticum* features a thallus, that is made up of a basal thallus that infills the uneven surface topography of the lithic substrate, and a main thallus above (Figure S3). Reproductive spore bearing chambers, called conceptacles occur within the main-thallus (Figure S3A). The basal layer is constructed by box-shaped cells, which can occur as pure organic to poorly calcified and as strongly calcified with the entire cell lumen filled by calcite. In EMP-maps (e.g., Figures 8 and 9), the organic parts contain high levels of sulfur, low levels of Ca, but no Mg. Instead, the blocky calcified part (Figure S3B) contains high levels of sulfur, high-levels of magnesium and high-levels of calcium (see EMP-map 1 in Figure 8).

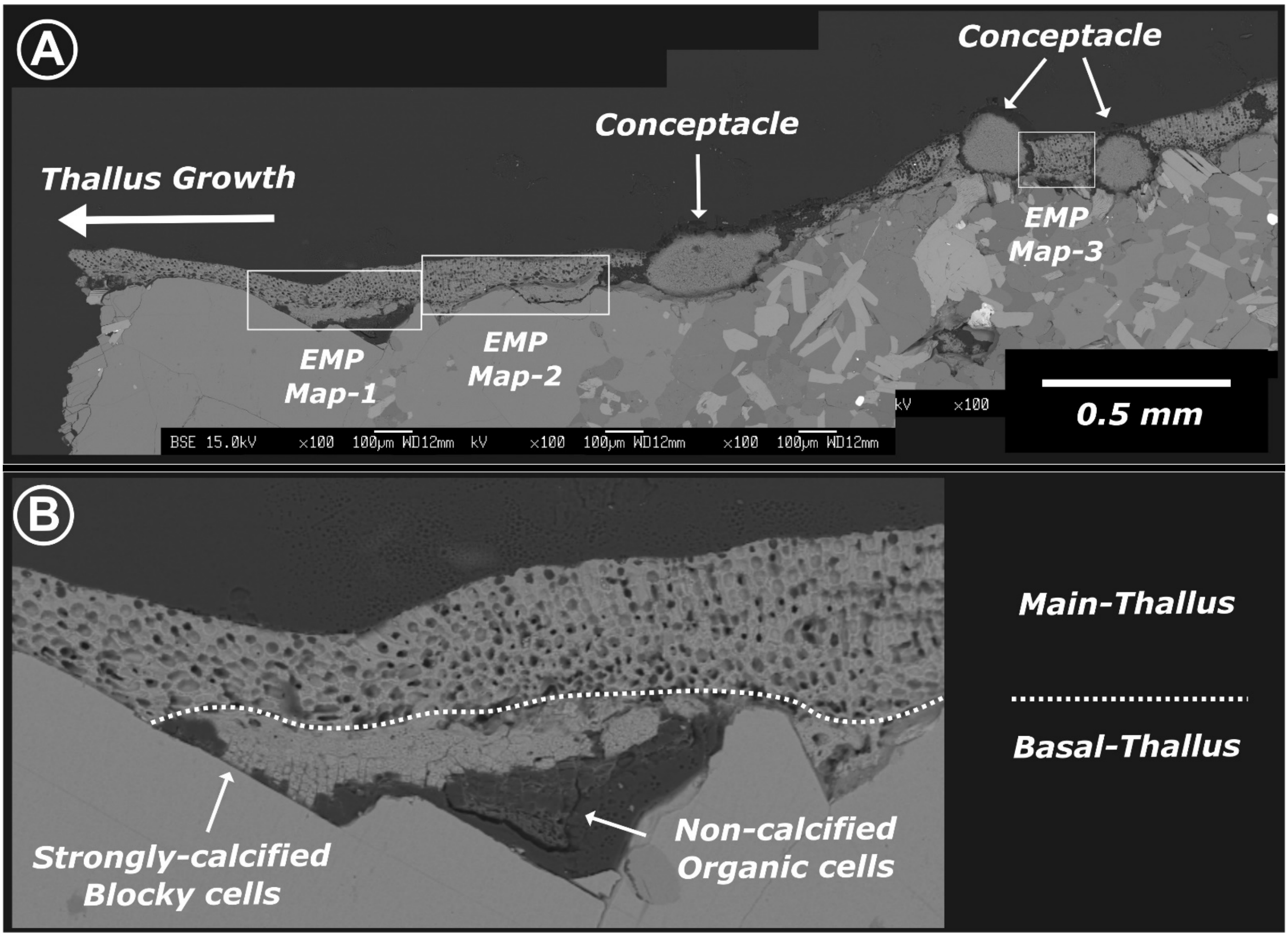

Figure S3. Basic architecture of the calcareous coralline alga *Thetysphytum antarcticum* with conceptacles interspersed within the thallus (**A**), and a clear separation of a basal thallus and the main-thallus above (**B**). The basal layer consists of box shaped organic cells with varying degrees of high-Mg calcite infilling.