Waters south of the Polar Front become undersaturated with respect to aragonite and calcite, strongly limiting carbonate accumulation and preservation. Cold-water corals are the few calcifying organisms that can thrive in this corrosive environment and can, therefore, represent good candidates for the reconstruction of specific marine parameters at various temporal scales. Here we present an attempt to investigate the potential of the solitary deep-water coral *Flabellum* as reliable oceanographic archive using specimens sourced from contrasting habitats in the Southern Ocean ranging from tropical to truly polar settings in Antarctica and from the Atlantic Ocean. We used a laser ablation ICP-MS to analyse Li/Ca, B/Ca, Mg/Ca, Sr/Ca, Ba/Ca and U/Ca ratios along different coral microstructures. This high-resolution study revealed that most of the geochemical variations observed along the marginal thecal wall may be linked to the mixture of different microstructures (i.e. early mineralization zones and fibrous aragonite) having different minor and trace element compositions. The outer septal face displays a more homogeneous geochemical variation being composed only of fibrous aragonite and giving a good degree of reproducibility within and among septa. This coral portion is certainly the most suitable portion to derive paleoclimate information and part of the “vital effect” can be avoided using a careful sampling technique. Further studies on *Flabellum* will help in isolating environmental parameters, such as seawater temperature encoded in the coral aragonite, mainly using trace elements (e.g. Li/Mg) that show a more sensitive temperature dependence than others (e.g. Sr/Ca) at lower seawater temperatures.