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GSA Proposal Study

Introduction: 1009/1000

The primary motivation for this study has been generated by Tobin et. al, 2012 which shows a precursor extinction linked to Deccan volcanism ~150 Kya before the K-Pg is reported and finds that benthic mollusks are more highly affected than at the K-Pg. Another event which was also the result of massive carbon input, the Paleocene-Eocene Thermal Maximum (PETM) is also thought to have occurred in two pulses (Bowen et al., 2014). Studying Paleogene marine sediments from Seymour Island (SI) may provide the chance to further understand both the PETM as well as the effects of Deccan volcanism at high latitudes. As there are well-preserved fossils on SI (Tatur et al., 2011), my first goal will be to document negative d13C ratios preserved in the calcite shells of benthic mollusks to identify both pulses of the PETM described in Bowen et al., 2014. My second goal is to identify changes in marine benthic biodiversity, if any, and my hypothesis is that the change should be negative for benthic organisms.

Justification: 2113/2500

Global warming events in the geologic past are of special interest to researchers today as the potential effects of artificial anthropogenic CO2 input are not yet fully understood. Understanding the earth's physical and geochemical responses to past CO2 input events is important for predicting future changes and guiding human response (Ciais et al., 2013; Caldeira et al., 2003, Hoegh-Guldberg and Bruno, 2010). Both the Cretaceous period which alternated between green-house and ice-house worlds (Hallam, 1985; MacLeod et al., 2005), and the Eocene which recorded CO2 levels similar to those of today (Bowen et al., 2014) provide good indicators of the type of climate and biotic response that could be expected as a result of anthropogenic CO2 input. Although the findings of Alavarez et. al, 1980 resulted in a flood of research into the triggers of the end-Cretaceous mass extinction, there is evidence that climate had been changing even prior to the impact.

The precise sequence and nature of events in the Late Cretaceous is not well constrained (Barrera et. al, 1994). Follmi (2012) shows that the Cretaceous alternated between ice-house and greenhouse conditions and that there are records for a cooling in Campanian bottom-waters from 12 C to 9 C in the Maastrichtian, although there is no evidence for glaciers (Huber et al., 2002). Tobin et al., 2012 examine very closely links with Deccan volcanism which occurred in three phases that coincide with a local extinction of benthic bivalves, but not of nektic ammonites. At the K-Pg, however, they show that the trend is the opposite: the nektic species become extinct but the benthic species remain intact. While they conclude that there must have been two different mechanisms at work causing both extinctions, they also state that both events occur too closely together in the rock record for their separate effects to be reliably determined. My investigation aims to provide a comparison case study of sediments from the same geologic setting as Tobin 2012 in order to provide insight into the behavior of the benthic community as a result of a negative carbon isotope excursion which signals warming.

Research Plan: 2382 /2500

Seymour Island is located off the Antarctic Peninsula in the James Ross Island Basin and was created as a result of extensional back-arc volcanism (Crame et al., 2004). It became tectonically inactive during the late Cretaceous and hosts well-preserved Mesozoic and Cenozoic marine sediments and fauna (Pirrie et al., 1991). All marine invertebrate fossils that are studied will come from the La Meseta Formation which is Eocene in age (Tatur et al., 2011). Two types of data will be obtained. Firstly, physical samples will be obtained from the British Antarctic Survey which has carried out many expeditions there, as well as from other individual collections. Since bivalves secrete calcite or aragonite shells in thermal equilibrium with sea-water (Grossman et al., 1986), it is possible to calculate past sea-surface temperature using d13C isotope ratios. Samples of bivalves will be micromilled by hand along growth bands and sent to a stable isotope laboratory for analysis of d13C and d18O ratios preserved within the original shell. Sea-surface temperatures will then be calculated using temperature equations after Kim and O'Neil, 2007 and plots of d13C to d18O will be created to aid in determining whether there are diagenetic effects. Secondly, this study will utilize fossil occurrence data downloaded from the Paleobiology Database in order to study extinction and diversity patterns. This data will be limited to marine benthic fossil occurrences that are Eocene in age which include oysters and brachiopods (Tatur et al., 2011; Ivanny et al., 2000). The data will be cleaned to remove rare all rare occurrences (>2) and the geographic range size of each species will be determined as far as is possible using the statistical program R as well as the Paleobiology Database. Alpha, Gamma and Beta diversities for each taxa will also be calculated. A problem that may occur here is error due to sampling and the Signor-Lipps effect which can cause an extinction to either seem much larger or smaller than it actually is because of the unlikelihood of sampling rarer taxa. To account for this the confidence intervals of 95% will be included for each dataset and the sample set will be sufficiently large to offset these effects. Calculating sea-surface temperatures will aid in understanding the climate at this time as well as help to identify the phases of the PETM, and biodiversity calculations will show the response of the fauna to these conditions.

References 1951/2500

Alvarez, L.W., Alvarez, W., Asaro, F., and Michel, H.V., 1980, Extraterrestrial Cause for the Cretaceous-Tertiary Extinction: Science, v. 208, no. 4448, p. 1095–1108, doi: 10.1126/science.208.4448.1095.

Barrera, Enriqueta. "Global environmental changes preceding the Cretaceous-Tertiary boundary: Early-late Maastrichtian transition." *Geology* 22.10 (1994): 877-880.

Bowen, Gabriel J., et al. "Two massive, rapid releases of carbon during the onset of the Palaeocene-Eocene thermal maximum." *Nature Geoscience* 8.1 (2015): 44-47.

Caldeira, Ken, and Michael E. Wickett. "Oceanography: anthropogenic carbon and ocean pH." *Nature* 425.6956 (2003): 365-365.

Crame, Francis, Cantrill, and D Pirrie Maastrichtian stratigraphy of Antarctica: Cretaceous research., v. 25, no. 3, p. 411–423, doi: 10.1016/j.cretres.2004.02.002.

Föllmi, K. B. "Early Cretaceous life, climate and anoxia." *Cretaceous Research* 35 (2012): 230-257.

Grossman, E., and Ku, T., 1986, Oxygen and carbon isotope fractionation in biogenic aragonite: Temperature effects: Isotope geoscience., v. 59, p. 59–74, doi: 10.1016/0168-9622(86)90057-6.

Hallam, Anthony. "A review of Mesozoic climates." *Journal of the Geological Society* 142.3 (1985): 433-445.

Hoegh-Guldberg, Ove, and John F. Bruno. "The impact of climate change on the world's marine ecosystems." *Science* 328.5985 (2010): 1523-1528.

Huber, Brian T., Richard D. Norris, and Kenneth G. MacLeod. "Deep-sea paleotemperature record of extreme warmth during the Cretaceous." *Geology*30.2 (2002): 123-126.

MacLeod, Kenneth G., Brian T. Huber, and Carolina Isaza-Londoño. "North Atlantic warming during global cooling at the end of the Cretaceous."*Geology* 33.6 (2005): 437-440.

Pirrie, Duncan and Marshall, James. "Field relationships and stable isotope geochemistry of concretions from James Ross Island, Antarctica." *Sedimentary geology* 71.3 (2004):137–150.

Tatur, Andrzej Edward, Krzysztof Paweł Krajewski, and Rodolfo Alfredo DelValle. "The facies and biota of the oldest exposed strata of the Eocene La Meseta Formation (Seymour Island, Antarctica)." *Geological Quarterly*55.4 (2011): 345-360.

Tobin, Thomas S., et al. "Extinction patterns, δ 18 O trends, and magnetostratigraphy from a southern high-latitude Cretaceous–Paleogene section: links with Deccan volcanism." *Palaeogeography, Palaeoclimatology, Palaeoecology* 350 (2012): 180-188.