INTRA-ANNUAL ISOTOPIC VARIATION IN *VENERICARDIA* BIVALVES: IMPLICATIONS FOR EARLY EOCENE TEMPERATURE, SEASONALITY, AND SALINITY ON THE U.S. GULF COAST

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ABSTRACT: Stable-isotope compositions were determined for 166 microsamples of aragonite from the bivalve *Venericardia hatcheplata* collected from the early Eocene Hatchetigbee Formation in southwestern Alabama. These were milled from two transects, one across the left valve hinge plate and one along the growth axis. Amplitude and spacing of about nine years of seasonal variation is very regular, with peaks and troughs occurring at equal intervals and reaching consistent compositions except for some attenuation in both parameters during the last three years of life. Assuming an ice-free world with an ocean $\delta^{18}O$ value of about --1.0‰, and using the aragonite--water fractionation equation of Grossman and Ku (1986), isotope-derived paleotemperatures are somewhat warmer (~ 31 °C) than temperatures presently recorded anywhere on the Earth's surface, and exhibit significantly greater seasonality (~ 12 °C) than regions with the warmest mean temperatures. It is therefore likely that these very negative and extremely seasonal $\delta^{18}O$ values reflect the influence of seasonal discharge of ^{18}O-depleted river water into the Eocene Gulf of Mexico.

Comparison of these data with (1) mean annual temperature versus seasonal temperature variation from modern climates, (2) isotopic compositions reported from coeval molluscs, and (3) isotopic compositions of global meteoric precipitation and United States rivers suggest that mean annual temperature along this portion of the Eocene Gulf coast was in fact about 26 °C, and varied seasonally from a winter low of about 25 °C to a summer high of 27 °C. Differences between these temperatures and those derived from direct conversion of oxygen isotope values reflect the influence of seasonal influx of fresh ($\delta^{18}O$ value of ~ --4.7‰) water. During deposition of this portion of the Hatchetigbee Formation, ambient water $\delta^{18}O$ values varied between winter values of about --1.0‰ to less than --3.5‰ during the summer. Freshwater discharge served to seasonally depress salinity to 10 to 16 ppt along this part of the Gulf coast. The early Eocene was perhaps the warmest time interval of the past 65 million years, primarily manifest as lower equator-to-pole temperature gradients. In this context, an Eocene mean annual temperature of ~ 26 °C is not much higher than modern surface water temperatures of about 24 °C at 29° 30' N, immediately off the modern Alabama coast. Seasonal temperature variation of ~ 2 to 3 °C about a mean of 26 °C, however, is significantly lower than that off coastal Alabama (19 to 30 °C), and occurs only along modern equatorial coasts at latitudes less than 19°. This implies that early Eocene tropical conditions extended well beyond modern latitudinal limits.