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Basinal marl-limestone cycles in the Upper Cenomanian of Langre, northern Spain - a multi-proxy approach

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In the Cenomanian of the North Cantabrian Basin (northern Spain), a cyclic succession of marls and marly limestones was deposited in the eastern parts of the basin (Langre section). A 18 m thick segment of this hemipelagic marl-limestone alternation from the Upper Cenomanian Calycoceras naviculare Zone comprising 14 couplets was logged in great lithological detail, measured in the field with a gamma-ray spectrometer, and sampled for macrofossils, thin-section analysis, stable isotope analysis, inorganic geochemistry, total organic carbon (TOC) and magnetic susceptibility (with a total of 58 samples). The aim of this high-resolution multi-proxy approach was to elucidate the controlling factors for the formation of these presumably orbitally forced marl-limestone rhythmites. Mean cycle thickness is 1.25 m and carbonate contents range from 31-77 %. According to number of couplets and geochronologic constrains of the investigated interval, the cycles are inferred to reflect the precession signal of the Milankovitch band. Accepting a precession-controlled deposition, mean accumulation rates are around 62.5 m/ma. Natural gamma ray values are between 350 and 1,250 cts/sec with maxima clearly indicating marly beds and minima limestones. The magnetic susceptibility (MS) even better picks out the cycles and can be used as a reliable indicator of lithology (i.e., variations in clay content). MS values range from 2.1 in limestone to >5 x 10-6 SI in marls. Total organic carbon (TOC) values range between zero and 1.5 % but are commonly between 0.15 and 0.4 % with higher values usually in marls. d13C values show a relatively flat signature typical for the naviculare Zone with values around 2.5-2.6 permil V-PDB. In the upper part of the section (cycles 13-14), towards the summit of the naviculare Zone, d13C values show more pronounced shifts from 1.5-2.7 permil, indicating the onset of perturbations of the car-

bon cycle related to the latest Cenomanian oceanic anoxic event (OAE) II. The d18O values show a strong, presumably diagenetically induced scatter, ranging from -3 to -4.9 permil V-PDB. The microfacies analysis indicates systematic variations between marls and limestones: marls are more silty, containing pyrite and abundant sponge spicules; limestones contain small glauconite pellets and more and larger calcispheres as well as other skeletal grains (such as ostracods, foraminifera, and bioclasts). Macrofossils are rare and comprise ammonites (Eucalycoceras rowei, Thomelites sornayi, Thomelites sp.), inoceramid (Inoceramus ex gr. pictus) and non-inoceramid bivalves (Euthymipecten beaveri, Entolium sp.), irregular echinoids (Sternotaxis) as well as indeterminate siliceous sponges. Irregular echinoids and sponges tend to be more common in marls whereas the bivalves are commonly found in limestones. Trace fossils are represented by Thalassinoides isp., Zoophycos isp. and Chondrites isp., the two fist being common in limestones. Manganese content is very low (62-180 ppm) whereas Sr/Ca ratios are very high (2-4.6 x 10-3), indicating little diagenetic alteration. Lower K/Al ratios (= lower illite/smectite ratios) in limestones indicate more semiarid conditions combined with wet and dry seasonal changes favouring physical weathering and the development of smectite. K/Al ratios are decreasing throughout cycles 1-8 followed by an increase in cycles 9-14. This long-term cycle is mirrored by the mean CaCO3 contents which increase up to cycle 8 followed by a general fall. Ba and TOC values are mostly higher in marls and lower in limestones, suggesting that limestone deposition was not connected with enhanced productivity. Since limestones are usually thinner as marls and contain authigenic glauconite, lower accumulation rates must be assumed for their deposition. Higher accumulation rates in marls may also explain their higher TOC contents. The marl-limestone cycles of the NCB are interpreted as dilution cycles that were triggered by terrigenous, probably fluvial input (direct evidence of deltaic input of siliciclastics into the NCB is known from the Early to Middle Cenomanian). Increased input of suspended clay and silt as well as nutrient in response to variations in humidity in northern subtropical latitudes caused more rapid deposition (marl beds) and increased primary productivity. During dryer conditions, terrigenous input decreased and limestone beds accumulated.