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Carbonate Compensation Depth and Carbonate Carbon Flux in the Pacific Ocean over the Cenozoic

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The Pacific Ocean, the largest ocean basin, plays a critical role in the global carbon cycle, where a massive quantity of deep-sea sediment is sequestered on the seafloor and ultimately transferred into the mantle through its extensive subduction zones. However, the fluxes of carbonate carbon to the seafloor, and the volume stored and subducted in the Pacific remains relatively unknown over the Cenozoic. Here we estimate the carbonate carbon flux to the Pacific seafloor since the early Cenozoic by modelling the evolution of the carbonate compensation depth (CCD), defined as the water depth where carbonate supply from the surface equals its dissolution at depth. This results in a lack of carbonate sediments below the CCD. Except for the eastern equatorial region, the CCD is poorly constrained or unknown in other regions of the Pacific. Given the regional and latitudinal variations in oceanographic parameters affecting carbonate sedimentation (e.g., water chemistry, surface productivity) across the Pacific basin, the Cenozoic CCD is modelled for six regions of the western and eastern North Pacific, western tropical Pacific, eastern equatorial Pacific, and western and eastern South Pacific. We utilize 110 deep-sea drill sites from DSDP, ODP and IODP expeditions to reconstruct the paleo-water depth through time at each location using pyBacktrack software. We carry out a linear reduced major-axis regression of the carbonate accumulation rate (CAR) versus paleo-water depth to compute the CCD in 0.5 My time intervals, incorporating dynamic topography and eustatic sea-level in our computations. We find that the CCD has fluctuated over the Cenozoic by ~1–1.2 km and shows distinct variabilities within the six regions of the Pacific. For example, a relatively shallow CCD (~2.8–4 km) across the western North and eastern South Pacific versus a deep CCD (~4–4.7 km) in the eastern equatorial region, and highly fluctuating western tropical CCD over the late Cenozoic, suggest substantial latitude-longitude control on the carbonate flux. The results indicate that the total carbonate carbon flux is primarily dominated by the eastern equatorial region between the early Oligocene and the middle Miocene (to maximum 55 Mt C/yr), due to enhanced nutrient concentration and higher primary productivity rate, as reflected by a deeper CCD. This contrasts with minimal carbonate carbon flux in the eastern and western North Pacific ranging between 0 and 5 Mt C/yr over the Cenozoic. Additionally, the Pacific total carbonate carbon mass has experienced a modest rise from the early Eocene (55 Ma) to the early Oligocene at ~34 Ma (from 3000 to 3500 Mt), followed by a gradual increase, reaching 4400 Mt at the present day. This recorded progressive rise since the early Oligocene coincides with the initiation of the Antarctic ice-sheet growth and intensified continental silicate weathering and alkalinity input to the oceans. Our new modelling of the CCD to assess the evolution of the Pacific deep-sea carbonate carbon reservoir during the Cenozoic improves

constraints on deep carbon computations in the context of the global carbon cycle.