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Organic matter preservation in a bypass-dominated ancient, exhumed submarine canyon, Magallanes Basin, Chile

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Summary

Continental shelf-margins and submarine canyons are key pathways for organic carbon transfer from land to deep basins, yet the controls on organic matter (OM) preservation within these linked elements remain poorly constrained. Here we integrate geochemical, petrographic, and stratigraphic data from an ancient system outcropping in the Cretaceous Magallanes Basin to evaluate how OM is routed and preserved across shelf-margin clinoforms, an exhumed submarine canyon, and associated submarine channels. OM quantity and composition vary systematically across five facies associations and four stratigraphic phases. Phase 1, representing initial progradation, contains the highest total organic carbon (TOC) values (up to 2.2 wt.%) where high sedimentation rates and mixed terrestrial-marine input favored OM retention. Biomarker ratios (e.g., Pr/Ph >4.5, TAR_{HC} >3.0) and organic petrography indicate dominant terrestrial sourcing. Phase 2 records shelf and upper-slope canyon incision and fill, with marked transverse variability: canyon-axis deposits show higher TOC (0.57 wt.%), while off-axis and margin deposits have lower TOC (both 0.29 wt.%). Systematic increase in $\delta^{13}C_{org}$ through the stratigraphic succession reflects increasing marine influence during canyon evolution. Phase 3, dominated by high-energy, proximal deltaic deposits, is characterized by low TOC (avg. 0.41 wt.%), enriched $\delta^{13}C_{org}$, and vitrinite-dominated assemblages, consistent with bypass and OM oxidation. Distal Phase slope channels >40 km downslope, have similar TOC proportions as Phase 2 but more readily preserves mineralized, thermally mature OM, as indicated by elevated vitrinite reflectance values (up to 0.91%). By linking geochemical signals to sedimentological facies associations, we show that depositional energy, flow confinement, and stratigraphic position exert first-order controls on OM preservation in shelf-margin and canyon systems, and that even broadly bypass-prone margins can preserve discrete, spatially predictable intervals of relative OM enrichment.