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Contrasting contributions of lithogenic particles to cross-shelf iron transport in eastern boundary upwelling regimes

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Iron (Fe) transport from continental margins to ocean basins has been described as a step-wise “shelf-to-basin shuttle”. A critical step is the mobilization of dissolved and particulate Fe under reducing conditions at the sediment water interface and overlying benthic nepheloid layer. Reduction of Fe(III) to the mobile Fe(II) valence and subsequent re-oxidation and precipitation has been thought to be the main driver of this process. Here, we report an additional process that is associated with reducing conditions – the resuspension of buoyant, Fe bearing particles from reducing sediments. Buoyancy enhancement affects both lithogenic and non-lithogenic particles and is decoupled from Fe redox reactions. Previous work suggests that organic matter accumulating under hypoxic or anaerobic conditions may have structural properties that enhance buoyancy. One consequence of this process is the westward extension of particle-rich plumes from eastern boundaries containing high levels of Fe and lithogenic elements like aluminum (Al) and titanium. We observed such features off the Oregon coast, where particle resuspension within hypoxic zones is coupled to offshore transport by subsurface eddies. A coupled Regional Ocean Modeling System-Biogeochemical Elemental Cycling (ROMS-BEC) model suggests that particles within these plumes have exceptionally low sinking velocities. Plumes rich in particulate Fe are also observed off the Peruvian margin. However, particulate Al is low relative to Fe there, suggesting that lithogenic particles are not mobilized to the same extent as Oregon. There are key differences in these regimes, but we don’t know enough about the mechanisms of particle suspension to determine which factors are critical. For instance, the Peruvian shelf is reducing enough to be nitrogenous, whereas the Oregon shelf is merely hypoxic. But we also observed offshore transport of particles from the nitrogenous shelf off Southern Mexico, where the relative concentrations of Fe and Al were similar to Oregon. Shelf regions off Mexico and Oregon are strongly influenced by rivers, in contrast to Peru. Perhaps sedimentary terrestrial organic matter derived from rivers has a strong influence on particle buoyancy. However, many other factors, such as current velocities in the benthic boundary and seafloor topography must also play a role.