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Phosphorite in drill cores off the Georgia shelf (USA): formation and multi-stage transformation of primary pellets formed within foraminiferal tests

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A series of shallow drill cores on the Georgia Coast revealed widespread occurrence of primary phosphorite pellets in the process of formation within silty to clayey (dominantly palygorskite), organic-rich sediments. These occurrences were observed in transgressive deposits ranging from Early Oligocene to Early Pliocene in age.

Primary phosphorite formation within microenvironments in foraminiferal tests was observed under the binocular microscope in various stages of formation. Its presence was confirmed by comparison of texture analysis for pellets and substrates, pellets or foram tests being the only larger particles in finer sediment matrix. The central tendency of phosphorite pellet sizes ($\sim$ 250 uM) corresponds closely to modal sizes of chambers of bolivinid benthic and globigerinid planktonic foraminifera. Sediments dominated by primary pellet occurrence usually had relatively low pellet concentrations (1-4%). Larger concentrations of pellets were accompanied by evidence of reworking and secondary phosphatization.

The petrographic observations, along with literature data from physicochemical studies of recent sediment environments, suggests that currently observed primary pellets precipitated within local microenvironments in chambers of foram tests in CFA-unsaturated zones of organic-rich sediments. As sea levels were lowered (regression) and water depths became shallower, higher-energy conditions promoted winnowing of finer sediments and enrichment of sediments in phosphorite pellets The local environment became oxygenated and supersaturated with CFA, presumably aided by

leaching and remobilization of finer preexisting CFA. Evidences of secondary phosphatization include oolitic apatite overgrowths on quartz or other nuclei, pseudomorphous replacement (phosphatization) of carbonate and other types of particles, and phosphorite particle aggregation.

Farther out on the Blake Plateau, under Gulf Stream current regimes, aggregation, breakup and recementation processes form phosphorite pebbles, cobbles and pavements that extend for thousands of square kilometers. As described in previous studies, the source of primary phosphate enrichment is interpreted to have been Tertiary sediments similar to those on the Georgia shelf, but whose finer detrital minerals were winnowed away by powerful currents of the Gulf Stream.

The microenvironmental mode of formation observed here may are consistent with pellet sizes in deposits from other geographic areas and geologic ages, suggesting possible wider applicability of the current formation models. Other organisms could also supply microenvironments for primary precipitation of pellets.