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# Cenozoic trends in size and silica use in low and high latitude radiolarian faunas: evidence for co-evolution between diatoms and radiolarians, and increasing competition for dissolved silicia

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Harper and Knoll (1975) proposed that a Cenozoic trend towards lower shell weights in radiolarians documented by Moore (1969) reflected selective pressure to use less silica, due to increasing removal of dissolved silica in ocean water in the Cenozoic caused by the evolutionary rise of marine diatoms. More recently, Schmidt (2004) and Finkel et al. (2005, 2007) have documented Cenozoic changes in mean size in planktonic foraminifera, diatoms and dinoflagellates. These authors attribute size change in these groups instead to other factors, such as increasing water column stratification. Moore's data for radiolarians could thus reflect (water stratification driven) size change, diatom evolution driven change in silica efficiency, or both. To investigate which mechanism(s) are most likely responsible for Cenozoic trends in radiolarian shell weight, we have measured both size and silica use/unit cell volume in series of Ceonozic radiolarian populations from both low and high latitudes. Modern low latitude surface waters often have extremely low concentrations of dissolved silica due to efficient removal by planktonic diatoms. In high latitude oceans by contrast, deep mixing renews nutrients and surface water silica is often not fully removed by plankton growth, suggesting that in high latitudes, silica availability driven changes in radiolarian faunas should also be reduced. Our results are based on $>$5000 specimens, taken

from 26 low latitude samples ranging from 61 to 0 Ma from the Indian, Pacific and Atlantic Oceans, and 9 samples ranging from 60 to 1 Ma from the Southern Ocean. All samples were controlled for dissolution of shells which can bias results. Length, width; shell porosity and thickness were measured for each specimen when possible. We used simple geometric models of the two main groups of fossil radiolarians (Spumellaria -spheres, Nassellaria-cones) to calculate cell volume and silica use/unit volume. Our results show a clear unidirectional trend towards greater silica efficiency in low latitude radiolarian faunas over the Cenozoic, with however a significant shift occurring near the Eocene-Oligocene boundary. High latitude radiolarian faunas by contrast show only a minimal trend towards greater silica efficiency. Size shows no net change in radiolarian faunas over the Cenozoic and the one major feature ( a peak in the Early-Mid Eocene) is not correlated to size change records of other groups. These results support the hypothesis of Harper and Knoll that removal (by diatoms) of silica from Cenozoic oceans has influenced the evolution of radiolarians, driving a trend towards increased efficiency in the use of silica in radiolarian shells.