

## Broad region of no sediment in the southwest Pacific Basin: COMMENT AND REPLY

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In their recent paper, Rea et al. (2006) claim to have discovered an area covering  $\sim 2 \times 10^6$  km<sup>2</sup> located between  $\sim 28^\circ\text{S}$  and  $42.5^\circ\text{S}$  in the central South Pacific that has been devoid of sediment since the Late Cretaceous (or covered by less than 7 m of sediment—the maximum thickness of sediment not detectable by the seismic-reflection profiling system used by Rea et al.). They named this area the South Pacific bare zone. This conclusion is based mainly on the interpretation of one N-S seismic-reflection profile, plus three gravity cores within this area. However, if we define a bare zone as being totally devoid of sediment, then the seismic-reflection profiling system deployed by these authors is clearly inadequate to test this hypothesis. Instead, there is abundant evidence to support the occurrence of an appreciable sediment cover within this supposedly bare zone.

The area studied by Rea et al. lies beneath the subtropical anticyclonic gyre, is characterized by very low productivity of the surface waters (Glasby, 1976a), and is one of the most remote areas in the world ocean (Stoffers et al., 1985). As such, it is characterized by low sedimentation rates and high abundances of manganese nodules. Previous studies have shown that the sediments in this region are dominantly pelagic clays, with sedimentation rates  $< 1$  mm/10<sup>3</sup> yr (Piper et al., 1985, 1987), and that almost the whole area south of  $36^\circ\text{S}$  is covered by manganese nodules with surface densities of up to 75%–100%, with some massive manganese crusts observed locally (Glasby, 1976b; Plüger et al., 1985; Plüger, 1989, personal commun.; Skornyakova et al., 1990). Berger et al. (1976) have estimated the Carbonate Compensation Depth (CCD) in this region to be  $\sim 4,200$  m.

The age of the seafloor on which the nodules form in this region lies between  $\sim 25$ – $70$  Ma (Müller et al., 1997). Assuming that the sediment thickness in this area is 7 m (the maximum thickness of sediment not detectable by Rea et al.), then it can be calculated that the average rate of sedimentation in this region is in the range of  $\sim 0.1$ – $0.3$  mm/10<sup>3</sup> yr. This rate is much lower than the sedimentation rate previously estimated for this region (0.4 mm/10<sup>3</sup> yr; Glasby, 1991) and is about an order of magnitude lower than the actual sedimentation rates determined by <sup>230</sup>Th/<sup>231</sup>Pa dating on sediment cores taken on a W-E transect across this region at  $42^\circ\text{S}$  during cruise SO-14 of R/V *Sonne* in 1980 (Schmitz et al., 1986). These low sedimentation rates reflect the extremely low input of aeolian dust from the deserts of Australia in this remote area (Prospero et al., 1989; Rea, 1994).

If we now take the thickest layers of manganese oxides in the manganese nodules collected during the *Sonne* cruise to be  $\sim 15$ – $30$  mm (based on photographs of nodule sections) and assume that these hydrogenous nodules have grown at rates of  $\sim 3.5$ – $3.8$  mm/10<sup>6</sup> yr since their formation (Plüger, 1989, personal commun.), then it can be calculated that these nodules formed over the period from  $\sim 3.9$ – $8.6$  Ma to the present. Nodule formation in this region is therefore quite recent. However, these age data are not sufficiently well constrained to permit paleoceanographic interpretation. In some nodules, the outer layer of the nodules consists of two discrete horizons of manganese oxides, each  $\sim 15$  mm thick, implying an abrupt increase in ocean bottom current velocities at some stage (Glasby, 2006).

The area investigated by Rea et al. is one of five areas in the Pacific with the most abundant coverage of manganese nodules (Piper et al., 1987). The results presented here show unambiguously that this area is not a bare zone but is most likely characterized by sediment thicknesses somewhat less than 7 m. In order to validate this conclusion, it is suggested that one or two latitudinal transects be undertaken across the basin using systematic box coring, bottom photography, piston coring, and a deep-towed high-frequency seismic system. Provisional calculations suggest that more than a billion tonnes of deep-sea nodules occur within this poorly surveyed region, and that more detailed studies of the distribution and mode of formation of the nodules and their relation to the sedimentation regime are in order.

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We thank Glasby (2007) for his comments regarding the sedimentary history of the southwest Pacific Basin. Our definition of this region of extremely low deposition, which we termed a bare zone, was based largely on our two (not one, as noted by Glasby) north-south transects of the region, and on information gathered from the associated survey and coring sites (Rea et al., 2006, Fig. 2). Glasby has pointed out additional information about the bare zone, including information regarding very low sedimentation rates and the nature and implications of the manganese nodule fields that cover much of that part of the deep sea floor.

It should be noted that the 1980 cruise of the *R/V Sonne* reported by Schmitz et al. (1986) and mentioned by Glasby recovered cores only from the periphery of the bare zone. Finally, in his Comment, Glasby redefined the bare zone to be truly bare—not with our conservative estimate of less than 7 m of sediment—and then noted that such a completely bare area was unlikely to exist. We agree that there is almost certainly a minimal amount of sediment within the bare zone, and concur with Glasby's call

for more marine geology–geophysics cruises to the region to better understand the sediment distribution and the relationships between sediment accumulation and manganese nodule distribution.

An example of such a cruise was conducted aboard the *R/V Revelle* in December and January of 2006–2007. That cruise, also a site survey cruise for the Integrated Ocean Drilling Program, included a west-to-east trackline at ~28°S, and a west-southwest–trending trackline that crossed the very southeastern corner of the bare zone as shown on our map (Rea et al., 2006, Fig. 2). Seismic profiles from those tracks show very thin sediment at 28°S, and ~20 m of sediment at the southeastern extreme of the bare zone. A core from the 28° south transect on 70 Ma crust recovered a total of 5 m of brown clay over basalt (S. D'Hondt, 2007, personal commun.), demonstrating the very thin sediment cover there.

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