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COMMENT
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This article is a comment on *Seo et al.* [2014] doi:10.1002/2014JD022025.

Key Points:
- Seo et al. (2014) incorrectly reflects the dominant Asian dust transporter in the western Philippine Sea during the middle-late Quaternary
- The conclusion derived from their low-resolution clay mineral data conflicts with their Sr-Nd isotopic data
- Eastern Asian deserts are the major dust source in the western Philippine Sea during the middle-late Quaternary

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Comment on "Sr-Nd isotope composition and clay mineral assemblages in Eolian dust from the central Philippine Sea over the last 600 kyr: Implications for the transport mechanism of Asian dust" by Seo et al.

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1. Introduction

Each year, an estimated 2000 million tons of Eolian dust is emitted into the atmosphere, 75% of which is deposited on the land and 25% in the ocean [*Shao et al.*, 2011]. As the second largest dust source area on Earth, Asia contributes abundant Eolian dust southeastward to the Chinese Loess Plateau [e.g., *Porter and An*, 1995; *Guo et al.*, 2002; *Lu et al.*, 2004], the North Pacific [e.g., *Rea and Leinen*, 1988; *Pettke et al.*, 2000; *Nagashima et al.*, 2007], and the West Pacific [*Winckler et al.*, 2008; *Wan et al.*, 2012; *Xu et al.*, 2012, 2015; *Jiang et al.*, 2013; *Seo et al.*, 2014]. It is generally accepted that the Westerlies and the East Asian winter monsoon (EAWM) are the major drivers of Eolian transport from mainland Asia to the Pacific [*Clift and Plumb*, 2008; *Shao et al.*, 2011]. The central Asian deserts and the eastern Asian deserts are the most important Asian dust sources, although their respective fluxes are not always easy to resolve [*Chen and Li*, 2011]. Evidence from backward trajectories of air masses and dust observation analyses indicate that the Eolian dust derived from the central Asian continent is deposited largely over the North Pacific and less over the northwest Pacific [*Uno et al.*, 2009], while that from the eastern Asian continent can be transported southeastward to the northwest Pacific, including Taiwan [*Liu et al.*, 2009], the South China Sea [*Hsu et al.*, 2008], and the western Philippine Sea [*Jiang et al.*, 2013]. Based on analysis of just 17 samples spanning the last 600 ka, *Seo et al.* [2014] used Sr-Nd isotopic and clay mineral compositions in a sediment core from the central Philippine Sea (12°30′N, 134°60′E; Figure 1) to argue against the general view that Eolian dust transport in spring by the EAWM dominates the annual flux of Eolian dust to the northwest Pacific [e.g., *Wan et al.*, 2012; *Xu et al.*, 2012; *Ming et al.*, 2014]. In contrast, they highlighted the importance of long-range transport by zonal winds (i.e., the Westerlies) to the dust budget in the central Philippine Sea [*Seo et al.*, 2014].

2. Main Comment

Sr-Nd isotopes and clay mineralogy have been proven to be powerful proxies for characterizing Asian dust input to the Pacific [e.g., *Chen and Li*, 2011], especially at semiquantitative [e.g., *Wan et al.*, 2012; *Xu et al.*, 2012] or even quantitative levels [e.g., *Jiang et al.*, 2013; *Seo et al.*, 2014; *Serno et al.*, 2014; *Xu et al.*, 2015]. Of these proxies, Sr-Nd isotopes give the best resolution concerning sediment provenance [*Asahara et al.*, 1995; *Mahoney*, 2005; *Colin et al.*, 2006; *Chen et al.*, 2007; *Dou et al.*, 2012], especially when the grain-size effect over Sr isotopic compositions has been effectively excluded [*Feng et al.*, 2009]. *Seo et al.* [2014] deduced that Eolian dust from central Asian deserts (CADs) could be transported by the Westerlies and Trade winds and thus dominate the annual flux of Eolian dust to the central Philippine Sea. However, Sr-Nd isotopic compositions of the study Core PC631 sediments, as shown in Figure 5 of that paper, do not lie on the simple mixing line between Luzon volcanic and the CADs [*Seo et al.*, 2014]. These data actually plot between the two mixing lines drawn between the average end-member compositions of Luzon volcanic arc rocks and the eastern Asian deserts (EADs) except for the Ordos Desert (which is similar to the CADs) as well as between the average end-member compositions of Luzon volcanic arc rocks and the Ordos Desert [*Seo et al.*, 2014]. This indicates

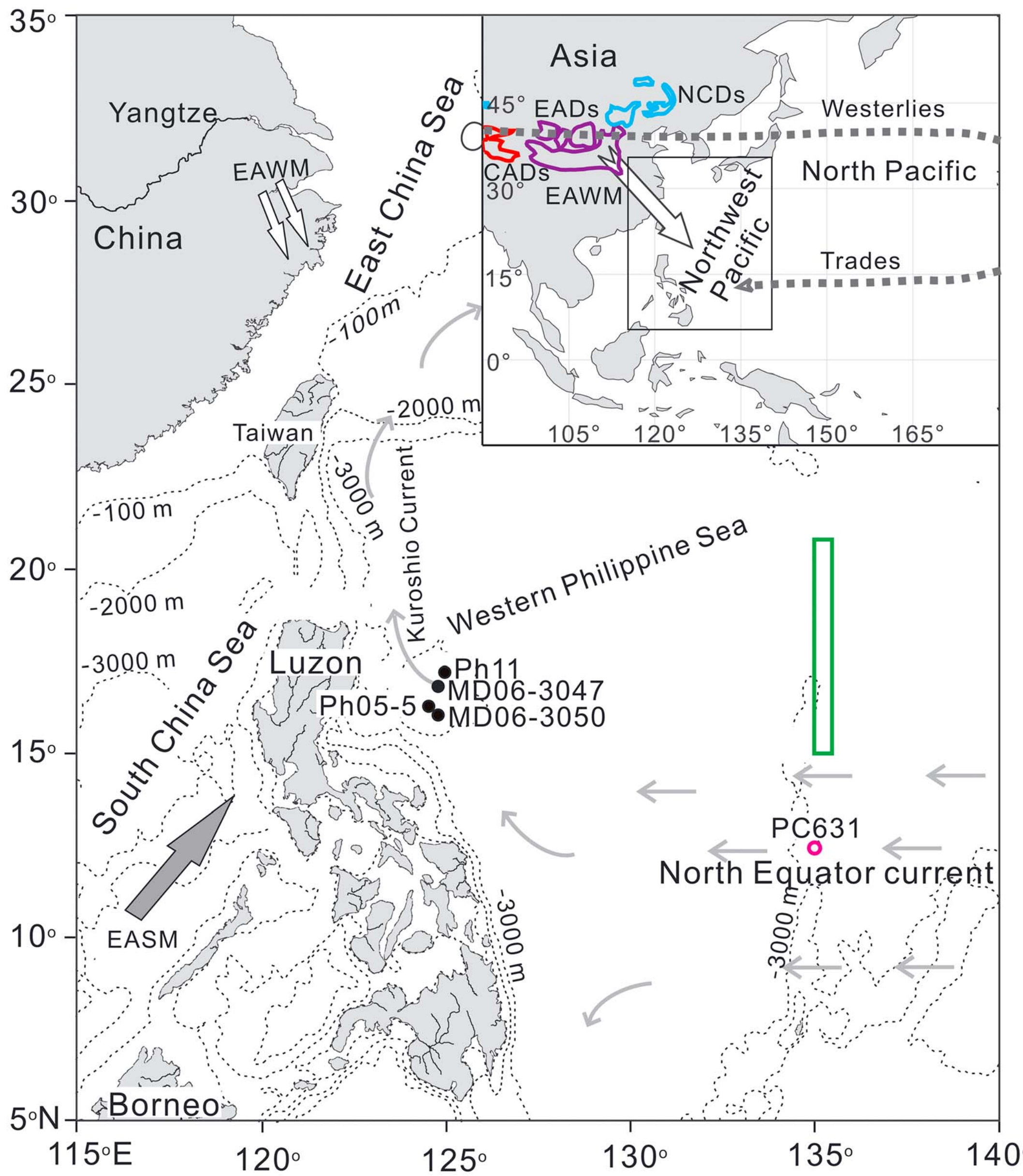

Figure 1. Bathymetric map showing the locations of Cores MD06-3047 [*Xu et al.,* 2012, 2015], MD06-3050 [*Wan et al.,* 2012], Ph05-5 [*Jiang et al.,* 2013], Ph11 [*Jiang et al.,* 2013], and PC631 [*Seo et al.,* 2014] as well as surface sediments (green rectangle) [*Jin et al.,* 2007] in the Philippine Sea. The −100, −2000, and −3000 m isobaths are shown by dotted line. Also shown are the major rivers, modern circulation, and monsoon directions. Note the two suggested major drivers of Eolian transport from mainland Asia to the northwest Pacific by the Westerlies and the East Asian winter monsoon (EAWM) [*Shao et al.,* 2011; *Seo et al.,* 2014]. EASM = East Asian summer monsoon. The northern Chinese deserts (NCDs), the east Asian deserts (EADs), and the central Asian deserts (CADs) are indicated by blue, purple, and red polygons.

dominant (or at least strong) supply of Eolian dust from the EADs to the central Philippine Sea over the last 600 ka (Figure 2). Similarly, Sr-Nd isotopic compositions of 64 sediments in Core MD06-3047 collected from the western Philippine Sea (17°00.44′N, 124°47.93′E; Figure 1) [*Xu et al.,* 2015], deposited over the last 200 ka, together with those of nine sediments in two short Cores Ph05-5 and Ph11 collected from the same basin (16°02.96′N, 124°20.69′E; 17°13.52′N, 125°00.47′E; Figure 1), deposited over the last 200–300 ka [*Jiang et al.,* 2013], also mostly lie between the above two mixing lines drawn between the average end-member compositions of Luzon volcanic arc rocks and two types of EADs (Figure 2), indicating contribution from the two types of EADs besides the CADs during the late Quaternary.

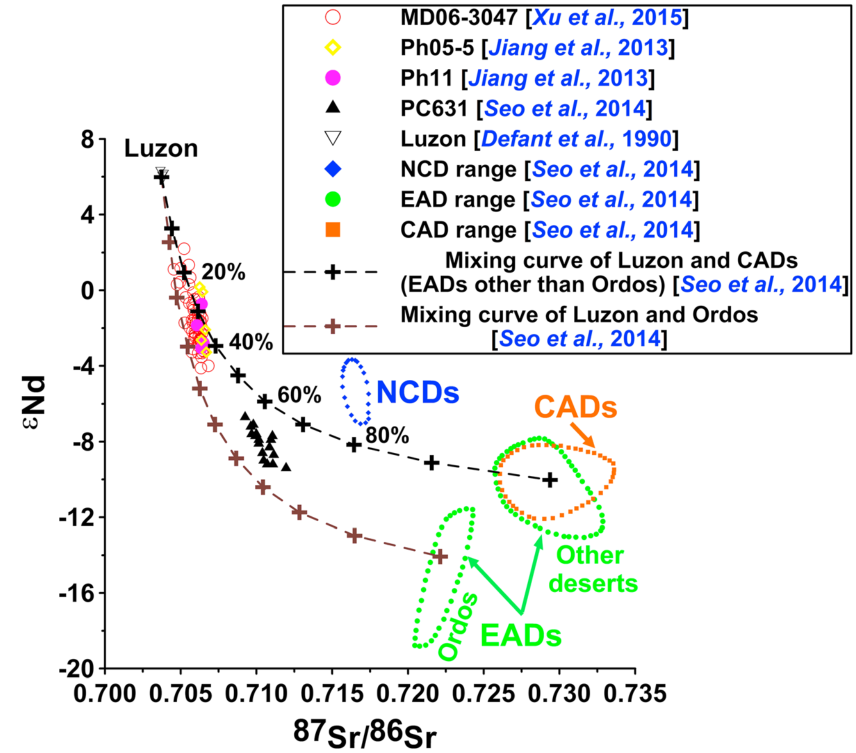

Figure 2. Discrimination plot showing variations in $^{87}Sr/^{86}Sr$ ratio and ε_{Nd} of Cores MD06-3047 [*Xu et al.,* 2015], Ph05-5 [*Jiang et al.,* 2013], Ph11 [*Jiang et al.,* 2013], and PC631 [*Seo et al.,* 2014] collected from the Philippine Sea. Sr-Nd isotopic data of potential source areas including Luzon [*Defant et al.,* 1990], the northern Chinese deserts (NCDs), the East Asian deserts (EADs), and the Central Asian deserts (CADs) [*Seo et al.,* 2014, and references therein] are also plotted for comparison. The mixing curves of Luzon and the CADs (similar to the EADs other than the Ordos Desert) as well as Luzon and the Ordos Desert are cited from *Seo et al.* [2014].

Clay mineral assemblages of 17 samples in Core PC631, as shown in Figure 6 of *Seo et al.* [2014], are the primary evidence for supporting their conclusion that Eolian dust input into the central Philippine Sea during the middle-late Quaternary might be dominantly derived from the CADs but not the EADs. However, we have to keep in mind that the analytical error (relative standard deviation) of the used X-ray diffraction semiquantitative method is generally as high as 5% [*Wan et al.,* 2012] and that clay mineral assemblages from stable sources also change through time as the environmental conditions change because rates of chemical weathering vary with both temperature and humidity. Considering the values of illite (average 46%), chlorite (average 19%), and kaolinite (average 10%) in Core PC631 as reported by *Seo et al.* [2014], this kind of analytical error (i.e., $\pm$5%) will lead to more significant shift (i.e., about $\pm$10%) of kaolinite/chlorite and illite/kaolinite values, from about 0.4 to 0.9 (on average 0.5) and from 2.9 to 6.9 (on average 4.6), respectively (Figure 3a). The above significant shift will certainly influence the discrimination result on Asian dust provenance, because kaolinite/chlorite ratio of about 0.5 is the boundary between the CADs and the EADs (Figure 3). Besides, a strong overlap between the CADs and the EADs end-members at low illite/kaolinite values hides the clear provenance discrimination on Cores PC631 and MD06-3047 (Figure 3). Furthermore, the potentially physical and chemical alteration during the long-distance transport and long-term deposition processes of Eolian dust might also influence the clay mineral assemblages and ratios [e.g., *Gibbs,* 1977; *Chen and Li,* 2011].

Even we accept the validity of the clay mineral plot developed by *Seo et al.* [2014] for discriminating Asian dust provenance, ignoring the analytical error of clay minerals, it is noteworthy that almost all the published clay mineral data for the upper sections (<600 ka) of Core MD06-3050 collected from the western Philippine Sea [*Wan et al.,* 2012] are most similar to the EADs but not the CADs (Figure 3a). Although some clay mineral data for the upper sections (<600 ka) of Core MD06-3047 collected from the same basin fall into the overlap zone between the CADs and the EADs, most of the clay mineral data for the upper sections of this core are more similar to the EADs, too. Surface sediments collected from the central Philippine Sea, with similar

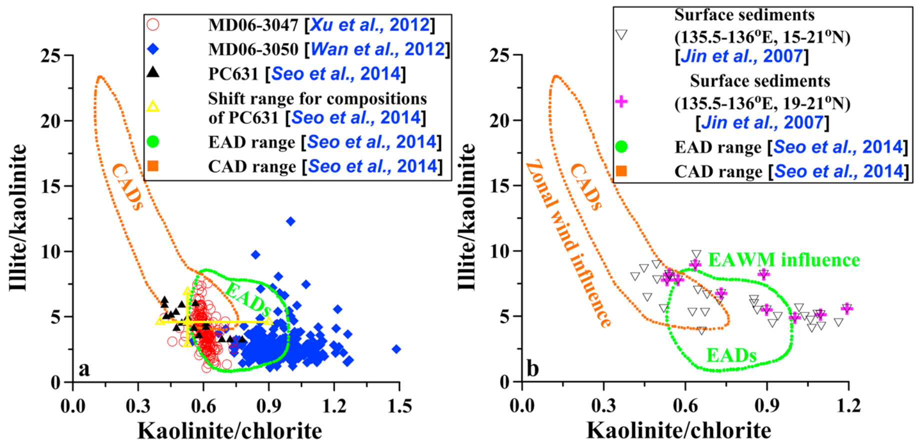

Figure 3. Discrimination plots showing (a) variations in kaolinite/chlorite and illite/kaolinite values of Cores MD06-3047 [*Xu et al.,* 2012], MD06-3050 [*Wan et al.,* 2012], and PC631 [*Seo et al.,* 2014] and (b) surface sediments [*Jin et al.,* 2007] in the Philippine Sea. Data of possible sources including the EADs and the CADs are cited from *Seo et al.* [2014]. Note the relatively wide maximum shift range for clay mineral compositions of Core PC631 that might result from the analytical error of the used X-ray diffraction method (i.e., ±5%).

longitude (135.5–136°E) to Core PC631 (134°60′E) also largely overlap with the EADs [*Jin et al.,* 2007] (Figure 3b). In particular, surface sediments collected from higher latitude parts of the central Philippine Sea (19–20°N) [*Jin et al.,* 2007] are also similar to the EADs (Figure 3b).

Consequently, Eolian dust deposited in the western Philippine Sea during the middle-late Quaternary, together with that in surface sediments collected from the northern central Philippine Sea (19–20°N, 135.5–136°E), appears to be mainly sourced from the EADs and not the CADs (Figures 2 and 3). It is well known that dust from the EADs is predominantly carried by northwesterly surface winds associated with the EAWM, while dust from the CADs is transported mainly via the prevailing Westerlies in the middle- to high-level troposphere [*Sun et al.,* 2001; *Uno et al.,* 2009; *Shao et al.,* 2011; *Shi and Liu,* 2011; *Seo et al.,* 2014]. Therefore, the dominant Asian dust transporter in the Philippine Sea is inferred to be the EAWM and not the Westerlies as suggested by *Seo et al.* [2014].

3. Concluding Remarks

The statement by *Seo et al.* [2014] that “the results of this study contradict the general perception that dust transport in spring by the EAWM dominates the annual flux of Eolian dust to the northwest Pacific [e.g., *Wan et al.,* 2012; *Xu et al.,* 2012; *Ming et al.,* 2014] and highlights the importance of long-range transport by zonal winds to the dust budget of the northwest Pacific” incorrectly reflects the dominant Asian dust transporter in the northwest Pacific, at least in the case of the western Philippine Sea, during the middle-late Quaternary. On the one hand, the conclusion derived from their low-resolution clay mineral data conflicts with their Sr-Nd isotopic data. In addition, Sr-Nd isotopic and clay mineral data from nearby cores and surface sediments with similar depositional ages in the Philippine Sea (Figure 1) also contradict this conclusion. As a result, we do not consider the conclusion of *Seo et al.* [2014] to be reliable. At the very least, they have pushed their data too far in placing too much emphasis on the provenance power of clay minerals alone, especially when this data set is only 17 samples spanning the last 600 ka. Looking at the wider region and using the more robust isotopic provenance proxies show that both the EADs and the CADs contribute dust to the region and that dust from the EADs dominates the wider Philippine Sea Basin via the EAWM.

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