



**Topic:** The geology of Plastics and their utility to reveal the archaeology of the Anthropocene

**Keywords:** Anthropocene, Trindade Island, Brazil, Plastic pollution, The Ocean Decade

## Why do plastic debris forms matter for the Anthropocene?

Giovana Rebelo Diorio (1); Fernanda Avelar Santos (1); Gerson Fernandino (2)



(1) Programa de Pós-graduação em Geologia, Universidade Federal do Paraná (UFPR), PR, Brazil  
(2) Centro de Estudos Costeiros, Limnológicos e Marinhos, Departamento Interdisciplinar, Campus Litoral Norte, Universidade Federal do Rio Grande do Sul (UFRGS), RS, Brazil

### The Anthropocene

Anthropocene is still not formally included in the Geological Time Scale (Fig. 1), and the scientific community is discussing what it represents stratigraphically (Zalasiewicz et al., 2017; Gibbard et al., 2022). However, the Anthropocene is considered by many in the scientific community as currently happening and highlights humans as active global-scale geological agents. In this sense, geoscientists have the opportunity to understand how we influenced the past and are influencing the present, which is key to the future from an archaeological perspective.

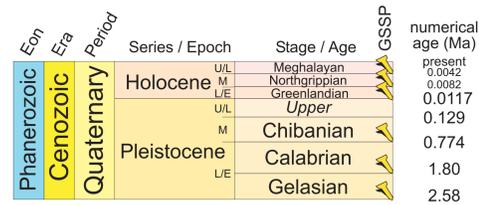


Figure 1: Last ca. 2.5 Ma in the Geological Time Scale (Cohen et al., 2013)

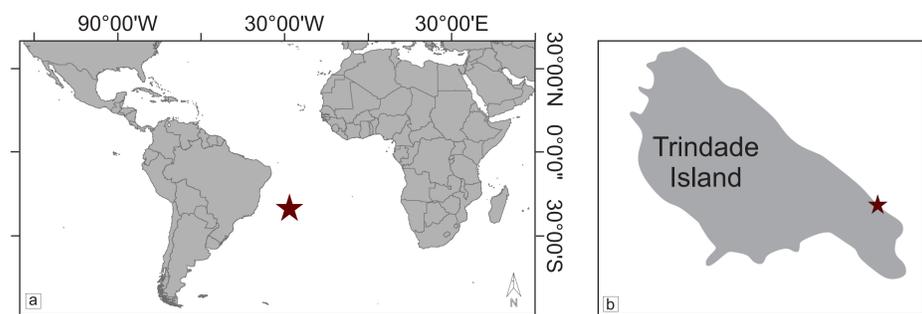


Figure 2: Location of the described plastic debris forms in Trindade Island, (a) a volcanic island located in the South Atlantic Ocean. The finding were in Trindade's (b) Tartarugas Beach.

### Plastic debris forms

In this scenario, plastic pollution stands out as plastic debris forms, i.e., materials containing plastic with a rock-like appearance (see Santos et al., 2022).

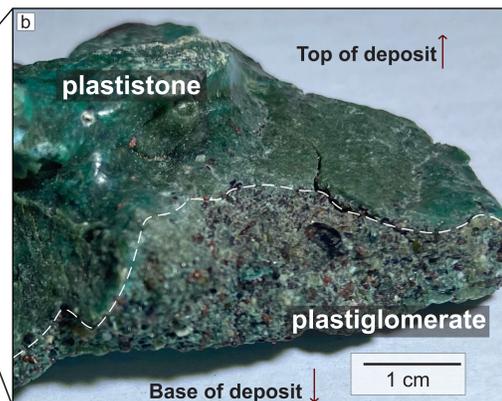


Figure 3: Outcrop of plastic debris forms on the foreshore of Parcel das Tartarugas. (a) In situ occurrences, on a wave-cut platform occupying at least part of the intertidal zone. The deposits cover massive nephelinites (seaward) and beach sediment (landward); (b) Sample varying vertically from plastiglomerate into plastistone towards the top of the deposits (after Santos et al., 2022).

### in situ plastic debris forms

We have described the first outcrop composed of plastic forms on a remote oceanic island (Tartarugas beach, Trindade Island, SE Atlantic Ocean, Fig. 2). We have identified (Fig. 3):

- **plastistones:** homogeneous composition of melted plastic;
- **plastiglomerates:** melted plastic cement, framework of volcanic lithoclasts, matrix ranging from fine to coarse sand (ca. 0.125 - 1 mm) of lithic fragments, heavy minerals, plastic, and bioclasts.



★ We verified that occurrences were compatible with that of pure polyethylene (PE) and polypropylene (PP) via Fourier Transform Infrared Spectroscopy (FTIR).

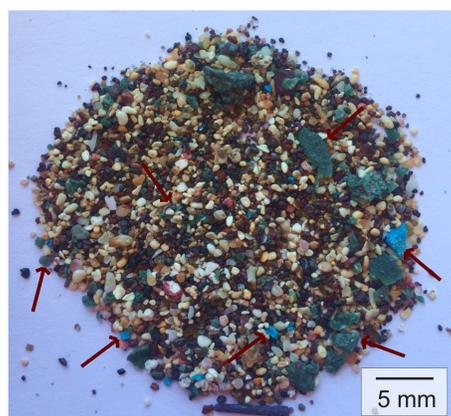


Figure 4: Beach sediments composed of natural and human-made components (plastic fragments, red arrows) (after Santos et al., 2022).

### clastic plastic debris forms

As it is a dynamic beach environment, the deposits have been submitted to natural mechanical reworking processes (e.g. waves), and clastic occurrences were found, i.e. preexisting fragments separated of their original deposition places and transported by purely mechanical agents. The highlights were pyroplastics (see Fig. 5), i.e. fragments from the weathering and erosion of older plastic debris forms, that may be clastic plastiglomerates or clastic plastistone. We have also found microplastics in the beach sediment, which is mainly composed of lithic fragments, heavy minerals (predominantly olivine), green and blue plastics (Fig. 4), and bioclasts.

### And what's next?

Trindade Island's eastern coast has been dominated by beach erosion and aeolian deflation (Angulo et al., 2018) and Parcel das Tartarugas is characterized as a storm-beach deposit with upstream alluvial fans. Therefore, there were both in situ and clastic findings (Fig. 5) that may become a sediment supply for the beach.

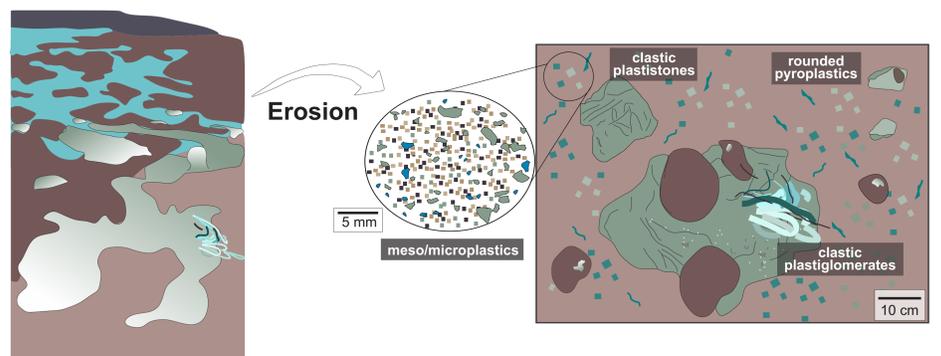


Figure 5: Conceptual model of how in situ plastic debris forms, after eroded, can be a supply for different types of clastic sediments (after Santos et al., 2022).

Due to Trindade Island's location in a region with intense carbonate precipitation and beachrock formation, these plastic fragments – as well as other marine litter items – have the potential to be preserved among the natural material during these rocks formation (e.g., Zalasiewicz et al., 2016; Angulo et al., 2018). In addition, this outcrop site is subject to the possibility of burial either by gravitational mass movements induced in the upstream alluvial fans by episodic ocean storms or by intertidal and eventually sub-tidal deposits in response to ongoing rising sea level associated with the effect of island subsidence (e.g., Angulo et al., 2018).



Figure 6: Photo of Parcel das Tartarugas (taken by Julia Figueiredo de Arouca Monteiro), highlighting the outcrop's location and different mechanisms that can help preserving these occurrences.

This affects – in terms of composition – the sediment cycle in several ways, because these scenarios (Fig. 6) suggest that these human-influenced rock-like materials show a high fossilization susceptibility (e.g., ichnofossils, anthroquinones), and may present a long-term preservation once buried in geological strata (e.g., Zalasiewicz et al., 2016). In this sense, plastic debris forms are relevant in the Anthropocene background. The Earth Sciences should increasingly deal with these novel sedimentary scenarios, where plastic and other types of marine pollution are the main components in deposits.

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