The consequence that is plastiglomerate

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First documented in 2014, plastiglomerate continues to proliferate across the Earth's surface. While these materials represent long-lasting symbols of anthropogenic impacts on the environment, they also highlight the need to address the global plastic crisis.

Plastiglomerate is a material that describes rock fragments, sand grains, plastic debris and organic materials (such as shells, wood and coral debris) held together in a matrix of once-molten plastic (FIG. 1a), and is one of very few examples of preservation of plastic debris in rock. Generated in beach locations by human-induced fires — either as a purposeful solution to remove trash or accidentally as a result of campfires — these anthropogenic 'stones' were first reported on Kamilo Beach, Hawai'i in 2014 (REF.[1]), but have since been identified in many coastal locations: from Bali, Indonesia, to California, USA, Madeira, Portugal and Ontario, Canada. As well as their geographic distribution, the range of plastiglomerate types has also expanded beyond their initial clastic and in situ classification[1]; the former describes loose fragments scattered across the beach surface and locally buried beneath the sand near the vegetation line, and the latter a part of rock outcrops with once molten plastic infilling vesicles, fractures, and indentations. In particular, plastiglomerate now includes pyroplastics[2], which have a larger plastic component and are less dense than typical plastiglomerate, and plasticrusts[3], which describe coatings of plastic formed by wave action on coastal rock outcrops.

Although mis-popularized as a new rock type, plastiglomerate is, by definition, not a rock; rocks are formed naturally, whereas plastiglomerate is composed of anthropogenic products (plastic) shaped by anthropogenic processes or actions (burning). Moreover, compared with natural sedimentary clasts, plastiglomerate is able to better withstand breakage due to a hardened plastic matrix. However, natural rocks and plastiglomerate may possess similar textural characteristics, for example, rounding as a result of sedimentary transport, the presence of vesicles in the plastic matrix, and/or plastic amygdules (infilling of vesicles with once molten plastic; FIG. 1b,c).

Regardless of the formation pathway and its classification, owing to the ease of creation in sedimentary environments, widespread distribution, resistance to chemical weathering and mechanical abrasion, and its high density, plastiglomerate (and its variants) have the potential to become buried, preserved, and form part of the rock record. Moreover, given their coastal occurrence, plastiglomerate might be washed out to sea during storm events and become part of the benthic sedimentary record. Thus, along with global deposition of combustion-related products (for example, fly ash), and collapse and burial of building materials (concrete and asphalt), plastiglomerate joins an ever-expanding group of long-lived human impacts. These remnants or casts of the initial plastic products will remain fused into the lithosphere as Earth's future rock record and can be used as a marker of the Anthropocene, when human activities began to rapidly alter the Earth and its atmosphere. Although its fate in the rock record remains unknown because of its youth in terms of geological time, plastiglomerate represents a powerful icon of human impacts.

Plastiglomerate is a symptom of the plastic pollution crisis. The popular press regularly reports on mismanaged plastic waste and patches of garbage in the ocean. Some of this waste inevitably ends up being transported by ocean currents, distributed globally, and deposited on land. It is local populations of island nations that disproportionately bear the burden of resultant beach clean-up efforts, adding to the load from local waste. In many cases, this waste ends up being burnt, resulting in plastiglomerate formation. In Bali, Indonesia, for example, abundant instances of plastiglomerate formation have been observed, including smouldering trash piles at tourist beaches. Unfortunately, these are not one-time occurrences. The constant supply of plastic waste drives continued disposal and thereby plastiglomerate production, representing a perpetual input of anthropogenic debris into the sedimentary column. At Kamilo Beach, for example, plastiglomerate was found again just three years after an extensive beach cleanup effort. Here, the sand has been so contaminated with plastic fragments that in places there appears to be more plastic than sand; like plastiglomerate, the synthetic and the organic become so fused together that separation becomes not only impractical, but probably impossible without further damage to the natural system.

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Interest in plastiglomerate therefore extends beyond their documentation and impacts on the rock record. Having been displayed in numerous museums worldwide, and used in classroom-based and outreach teaching, plastiglomerate is no longer only a scientific find, but also an object of power that invokes an emotional reaction. It stirs an urgent recognition of the breadth of the global plastic pollution crisis and reinforces the need to address it. Thus, as well as providing a marker of the Anthropocene — and of vast, permanent damage to the sedimentary record — plastiglomerate, with its often vibrant colours and oddly shaped contortions, can act as a symbol of the powerful and undeniable human desire to rid the world of the pollution we ourselves have created, which in turn spurs action.

However, like the entanglement of natural sedimentary grains in ropes and lines (FIG. 1d), the formation of plastiglomerate results from the entanglements of consumerism, ease of access, and pollution. Without addressing these issues, it will be difficult to avoid continued plastic debris pollution and plastiglomerate formation. Public attitudes must be modified to reduce reliance on convenience products and thereby waste. Plastic must be adequately disposed of and recycled in all regions of the globe, both to reduce the volume entering the ocean, but to also prevent the need for burning on beaches. Support must be provided where facilities are not in place. With global interest in plastic pollution and environmental issues as a whole, now is the time to act, and plastiglomerate is a token reminder of our need to do so.

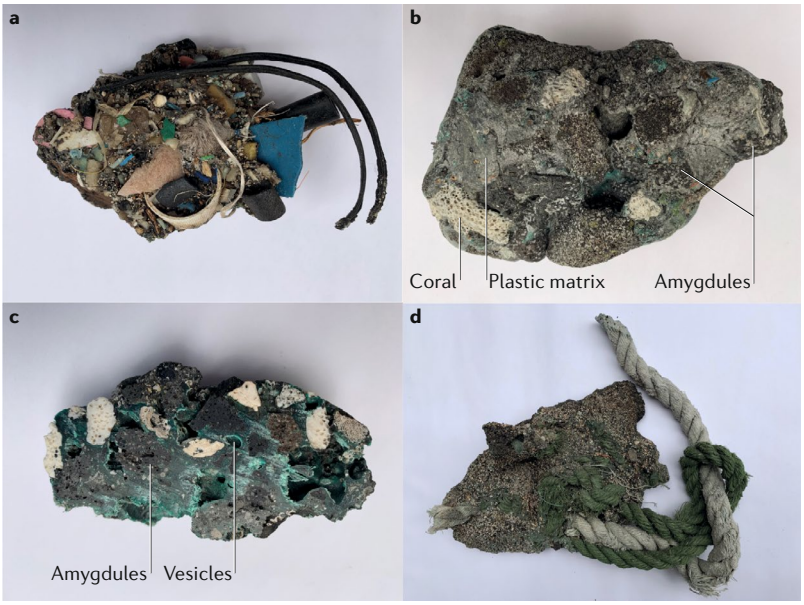

Fig. 1 | **Samples of Kamilo Beach plastiglomerate, exhibiting natural and human-made materials held together in a plastic matrix. a** | Approximately 11 cm long plastiglomerate composed of plastic fragments, nylon fishing line, sand, and woody debris. **b** | Rounded sample (~17 cm long) containing coral and basalt fragments with plastic amygdules. **c** | Cross section (~8.5 cm wide) showing coral and basalt fragments cemented in a green plastic matrix. **d** | Plastiglomerate (~29 cm long) containing beach sand, basalt fragments and ropes.

1. Corcoran, P. L., Moore, C. & Jazvac, K. An anthropogenic marker horizon in the future rock record. *GSA Today* **24**, 4–8 (2014).
2. Turner, A. et al. Marine pollution from pyroplastics. *Sci. Total Environ.* **694**, 1–8 (2019).
3. Gestoso, I. et al. Plasticrusts: a new potential threat in the Anthropocene's rocky shores. *Sci. Total Environ.* **687**, 413–415 (2019).

Competing interests
The authors declare no competing interests.