GS32120 – Sedimentary Environments

Lecture 8 Anthropogenic Disruptors and Plastics

Prior tasks

1) Watch the pre-recorded Lecture 8a April 2021 that provides a short overview of the arguments for and against humans being the dominant geological agent, and briefly traces the history of the development of the Anthropocene concept.

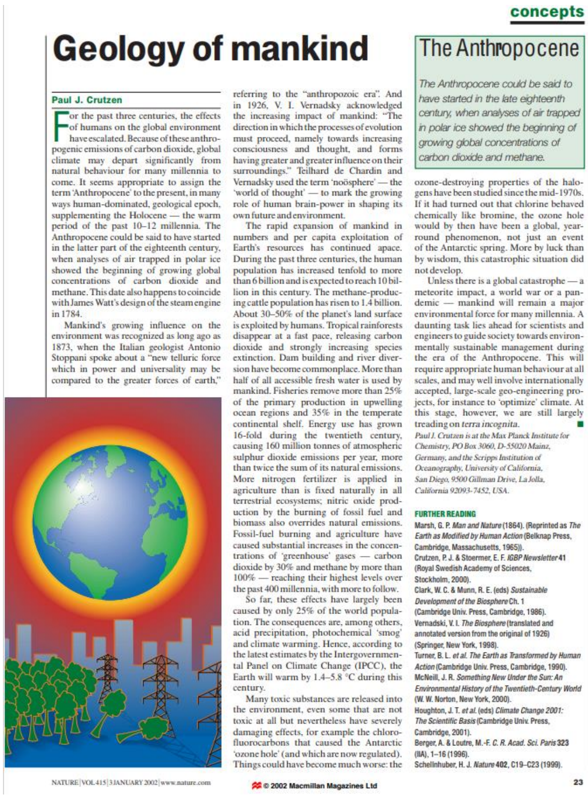
Active learning exercise 1 (~20 minutes)

1) Read the two short articles that brought the embryonic term 'Anthropocene' to wider attention (available on Blackboard), and then answer the associated questions:
   Crutzen, P.J. and Stoermer, E.F. 2000. The "Anthropocene". IGBP Newsletter 41: 17-18.
   Crutzen, P.J. 2002. Geology of mankind. Nature 415: 23.

The "Anthropocene"

by Paul J. Crutzen and Eugene F. Stoermer

IGBP NEWSLETTER 41



concepts

Geology of mankind

Paul J. Crutzen

The Anthropocene

NATURE | VOL 415 | 3 JANUARY 2002 | www.nature.com

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i) To what extent does consideration of human impacts on sedimentary environments, landforms/landscapes, and the geological record feature in these articles?;

ii) Why is consideration of these aspects a key part of any debate over a putative Anthropocene time interval?

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Prior tasks

1) Watch the pre-recorded Lecture 8b April 2021 that provides an overview of abiotic and biotic geological agents, and compares landscape shaping by natural and human agents.

Active learning exercise 2 (~20 minutes)

1) The oblique aerial view below (from Google Earth, centred on 25.045464°N, 55.317330°E) illustrates some of the distinctive urban developments in Dubai, United Arab Emirates, that are altering the Persian Gulf coastline. From this image and from your own browsing of the wider region, attempt to answer the following questions:

i) How do you think these developments are impacting on sedimentary environments, landforms/landscapes, and the geological record?;

ii) Do you think that humans are the dominant geological agent in this setting, at least in the present day? If so, why? If not, why not?;

iii) What do you think are the key factors that will determine the longevity of the impact of these developments on sedimentary environments, landforms/landscapes, and the geological record?

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Prior tasks

1) Watch the pre-recorded Lecture 8c April 2021 that puts human agency in perspective alongside other disruptors to sedimentary environments, outlines relevant space and time considerations, and also considers the distinctiveness of human sedimentary signatures.

Active learning exercise 3 (~15 minutes)

1) Read the following short article (available on Blackboard) that makes the case for managing and deliberately shaping landscapes to sequester carbon, and then answer the associated questions: Kelly, R. 2007. Carbon geomorphology. Geophemera, 101: 24-25.

ARTICLE: Carbon Geomorphology — Robert Kelly

Ever heard of 'carbon geomorphology'? Probably not: it's a new area, only now emerging from cross-disciplinary roots to form a coherent subject in its own right. But, in a few years' time, be assured that carbon mapping will be as commonplace as geological, landform and soil mapping are today, and that we'll be casually discussing the finer points of 'carbon landscapes'.

The driving force behind this nascent discipline has been the rapid development of the carbon market over the past few years. In an attempt to mitigate greenhouse gas emissions, and to sequester those that have already been released into the atmosphere, a number of market mechanisms have been established to generate and trade carbon credits. The best-known are the Clean Development Mechanism (CDM) and Joint Implementation (JI) mechanism of the Kyoto Protocol, but these are by no means alone.

Together, the various carbon markets are conservatively worth $30 billion and are growing rapidly – they tripled in value between 2005 and 2006. Over 700 carbon projects have been registered under the CDM, with a further 1,500 queuing up to join them. Over the next five years, the CDM is expected to generate 4 billion carbon credits, at an average market price of $10 per credit.

Geomorphology enters the picture because the carbon market is not restricted to industry, commerce and transport. Indeed, over one-third of the carbon credits generated in the so-called 'voluntary' (non-compliance) carbon market stem from forestry and land-use projects. The CDM is less kind to 'LULUCF' (Land Use, Land Use Change & Forestry), restricting it to afforestation and reforestation. But, together, the various carbon markets currently support a wide range of landscape-transforming projects, from soil rehabilitation projects in sub-Saharan Africa, anti-desertification shelterbelts in China, fire management programmes in Australia, peatland preservation in Indonesia and wetland restoration in Eastern Europe.

All of these projects owe their existence to the revenues they can claim for reducing greenhouse gas emissions – as in the case of restored wetlands, for instance, where re-wetting serves to reverse the carbon oxidation process associated with drainage – or for sequestering atmospheric carbon (as in the case of forestry and soil rehabilitation). In Ethiopia, where I am working, there is currently strong interest in rehabilitating highly degraded lands (the picture shows one site that is to be planted in the next month) with the oil-bearing tree, *Jatropha curcas*. This offers the (monetisable) carbon 'double hit' of sequestering atmospheric carbon through photosynthesis *and* also

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producing bio-diesel that displaces consumption of climate-unfriendly mineral diesel.

Right now, 'carbon landscaping' is a niche activity. Placed in a global context, the number of projects is a drop in the ocean; most are relatively small, occupying sites thousands of hectares in size and generating only localised geomorphological effects. Indeed, until recently geomorphologists have barely been involved: foresters, ecologists and soil scientists have done – literally and metaphorically – most of the groundwork.

Above and right: Site of proposed jatropha plantation, Ethiopia (© Robert Kelly)

But as the carbon markets grow and the price of carbon increases (which seems inevitable given the greenhouse mitigation challenge facing us over the coming century), so carbon land-use projects will multiply and spread. The expected entry of the United States into the market, and the anticipated relaxation of CDM LULUCF restrictions in the second phase of the Kyoto Protocol (after 2012), will only enhance the landscape-transforming potential of carbon finance.

Very quickly, the geomorphological effects will scale-up. 'Carbon landscapes' will span the whole range of geographical scales, from individual hillslopes and river valleys to entire mountain ranges and continental plains: the use of remote sensing and sophisticated statistical sampling offer the potential to monitor inaccessible carbon landscapes thousands of kilometres across at relatively little cost. The landscapes of the Sahel, the South American pampas and the Arctic taiga, to name but three, could be utterly transformed.

Geomorphological change *per se* is not the objective of carbon landscaping: it's merely the means employed to achieve carbon ends. But the geomorphological implications of carbon landscaping are inescapable, both in its effects (on denudation processes, on fluvial systems, on landforms and so on) and also in its implementation: there is likely to be growing demand for the services of geomorphologists who can 'geo-engineer' landscapes to maximise environmental carbon storage and minimise carbon translocation and loss. Of course, environmental carbon fluxes aren't divorced from geomorphology's traditional concerns: erosion acts to reduce terrestrial carbon sequestration just as it sculpts landforms; mass transport exports carbon just as it exports other minerals; biotic activity sequesters carbon just as it contributes to regolith weathering and physical stabilisation.

But carbon landscaping has the potential to fundamentally re-orient the study and practice of geomorphology. First, the sheer volume of the financial investments flowing into carbon mitigation/sequestration projects cannot but divert our research and consulting activities – a trend that will be reinforced by the growing emphasis in government research funding on climate change issues. And, second, carbon landscaping is very much a surface-based activity: while geologists may monopolise the study and extraction of minerals and fossil fuels, so geomorphologists should come to dominate the task of capturing, storing and monitoring environmental carbon.

So, take note: a lot more of us may be describing ourselves as 'carbon geomorphologists' in the not-too-distant future!

Robert Kelly *works on carbon landscaping issues in sub-Saharan Africa.*

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If you would like to comment on or debate this issue please send your emails and letters to the Editor and the best will be published in the next issue of Geophemera — Editor.

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i) Nearly 15 years on, to what extent have the predictions made by Kelly come true?;

ii) Do you think increased landsurface shaping (for carbon sequestration or other environmental management purposes) is a good development, a bad development, or something in between? Why do you think this?

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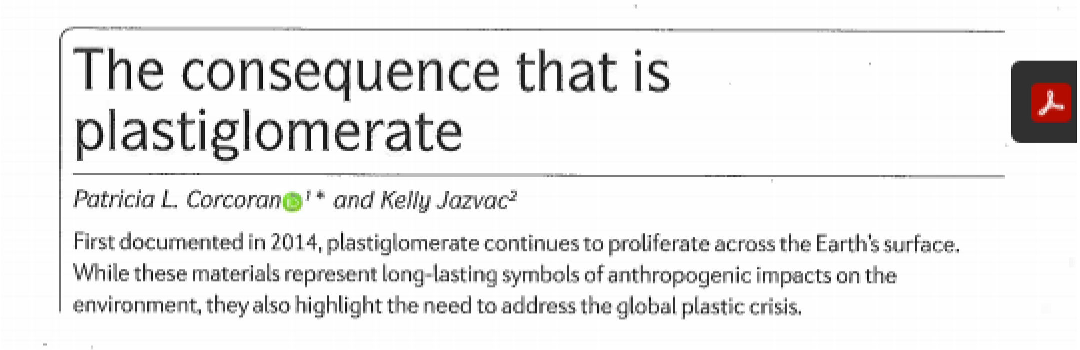
Prior tasks

1) Watch the pre-recorded Lecture 8d April 2021 that provides an overview of human-made ('novel') materials in sedimentary environments, with a particular focus on the transport of plastics from source to sink.

Active learning exercise 4 (~20 minutes)

Read the following short articles (available on Blackboard or online) that address different aspects of plastics in sedimentary environments, and then attempt to answer the associated questions:

1) Corcoran, P.L. and Jazvac, K. 2020. The consequence that is plastiglomerate. Nature Reviews 1: 6-7.


The consequence that is plastiglomerate

Patricia L. Corcoran[1] and Kelly Jazvac[2]*

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.

Note the statement that: "plastiglomerate represents a powerful icon of human impacts …. no longer only a scientific find, but also an object of power that involves an emotional reaction".

i) Do you agree that plastiglomerate is a powerful icon of human impacts?;
ii) Can you think of other sedimentary environment-related icons of human impacts?;
iii) Do you think emotional reaction to plastic pollution and other forms of environmental degradation is helpful or unhelpful for addressing environmental management challenges?

2) The following online, non-specialist article considers the fate of disposable face masks and gloves – plastics-based, durable materials – that are now working their into the geological cycle, particularly during the COVID-19 pandemic:
Holmes, R., Fugagnoli, A. and Zalasiewicz, J. 2020. What will COVID-19 look like to geologists in the far future? The Conversation, July 28th 2020. Available at: https://theconversation.com/what-will-covid-19-look-like-to-geologists-in-the-far-future-143085

i) One of the reader's comments asked: "And what exactly is the problem with countless billions of microplastic fragments ending up in deep sea muds? It sounds like effective carbon sequestration, however inadvertent."

What would you say in response to this question?