

Human Impact

Landscapes in the Anthropocene

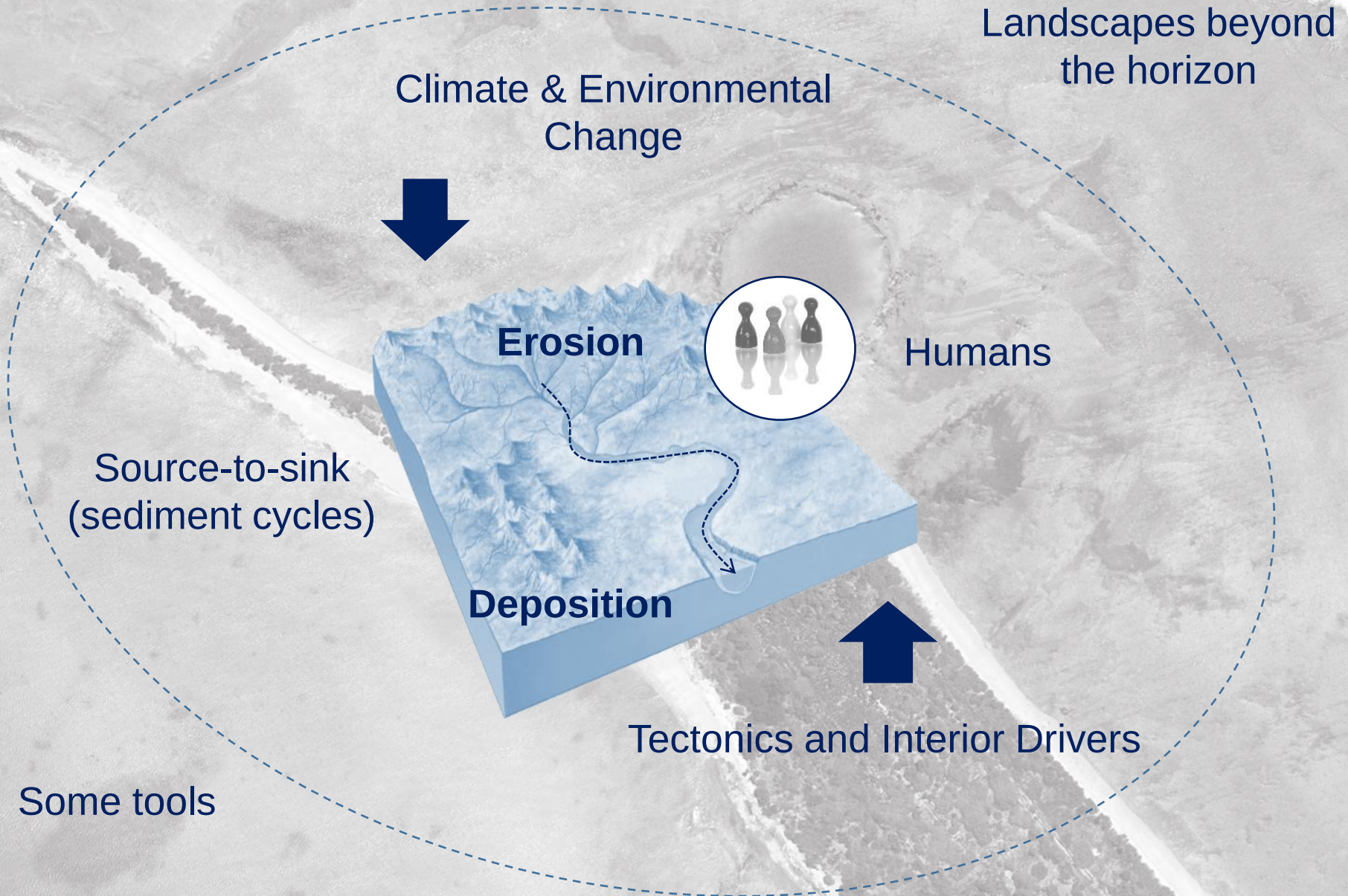


Prifysgol Cymru
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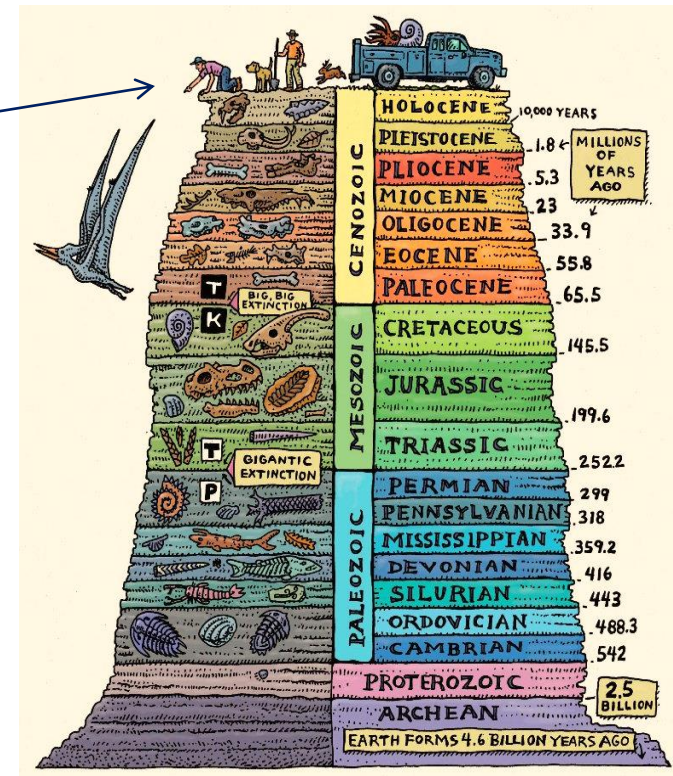
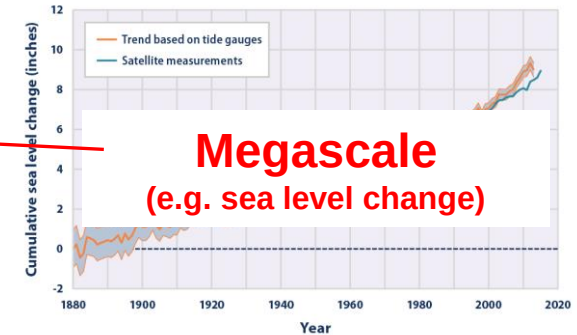
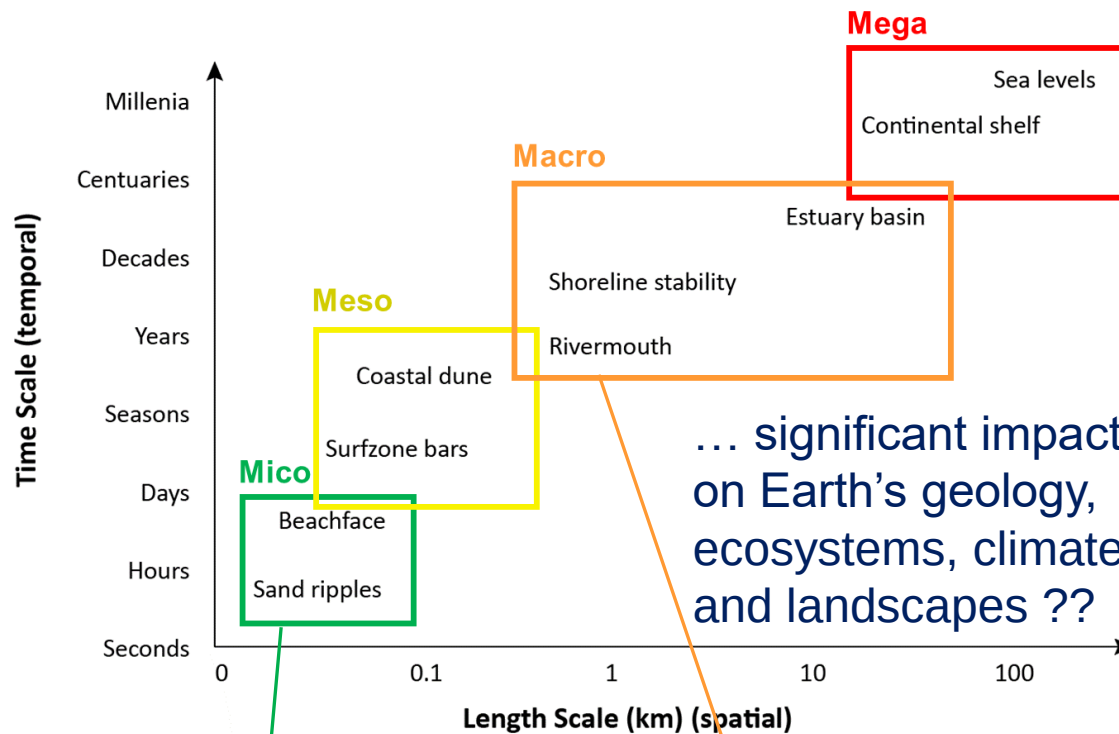
ACNA4007 – Physical Landscape and the Geosphere

A look back...



People and Geomorphology

- Physical processes happen over a range of scales - where do people fit in?



An Anthropocene...?

- Have humans become the dominant geological (ecological, geomorphic etc.) agent (driver / process) on Earth?

Informal term... ? **concepts**

Geology of mankind

Paul J. Crutzen

For the past three centuries, the effects of humans on the global environment

referring to the "anthropozoic era". And in 1926, V. I. Vernadsky acknowledged the increasing impact of mankind: "The direction in which the processes of evolution

The Anthropocene

The Anthropocene could be said to have started in the late eighteenth century, when analyses of air trapped in polar ice showed the beginning of

Is the Anthropocene an issue of stratigraphy or pop culture?

Whitney J. Autin, Dept. of Earth Sciences, SUNY College at Brockport, Brockport, New York 14420, USA, dirtguy@esc.brockport.edu; and John M. Holbrook, School of Geology, Energy & the Environment, Texas Christian University, Fort Worth, Texas 76129, USA

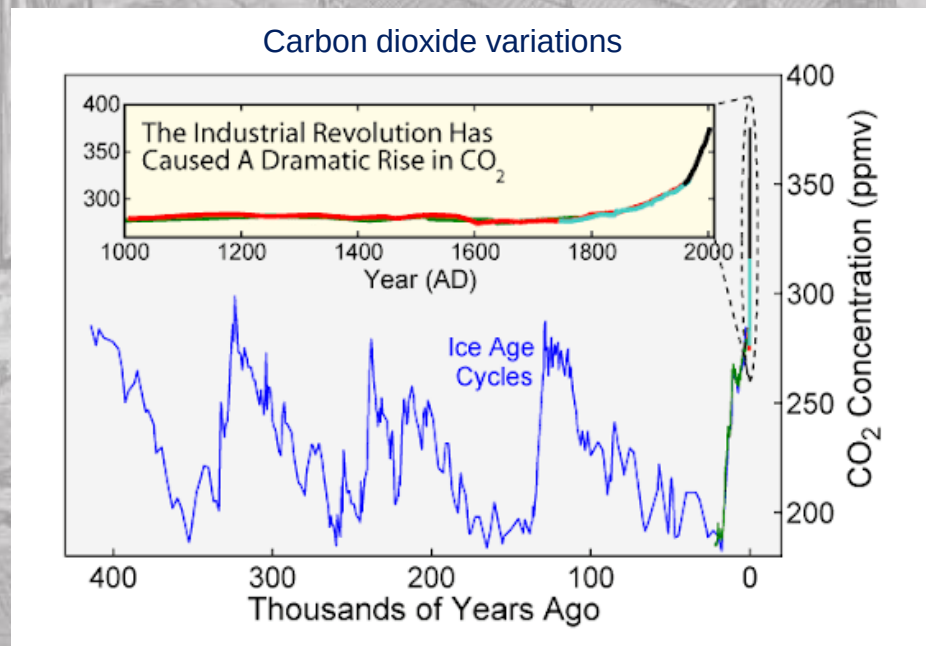
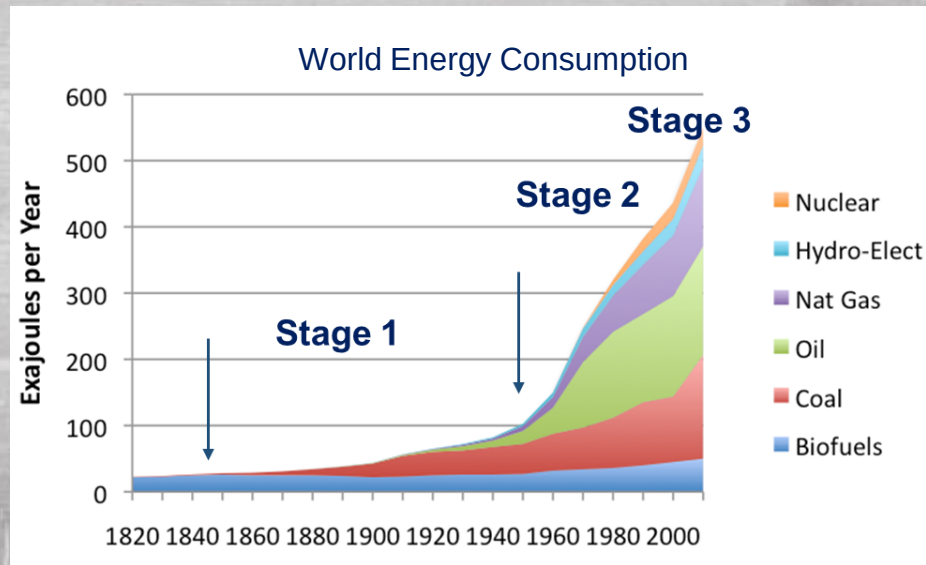


Anthropocene = Global Climate Change?

- **Stage 1:** 1800 – 1945 – Deforestation, industrial revolution (steam engines) and increase in greenhouse effect (global warming)

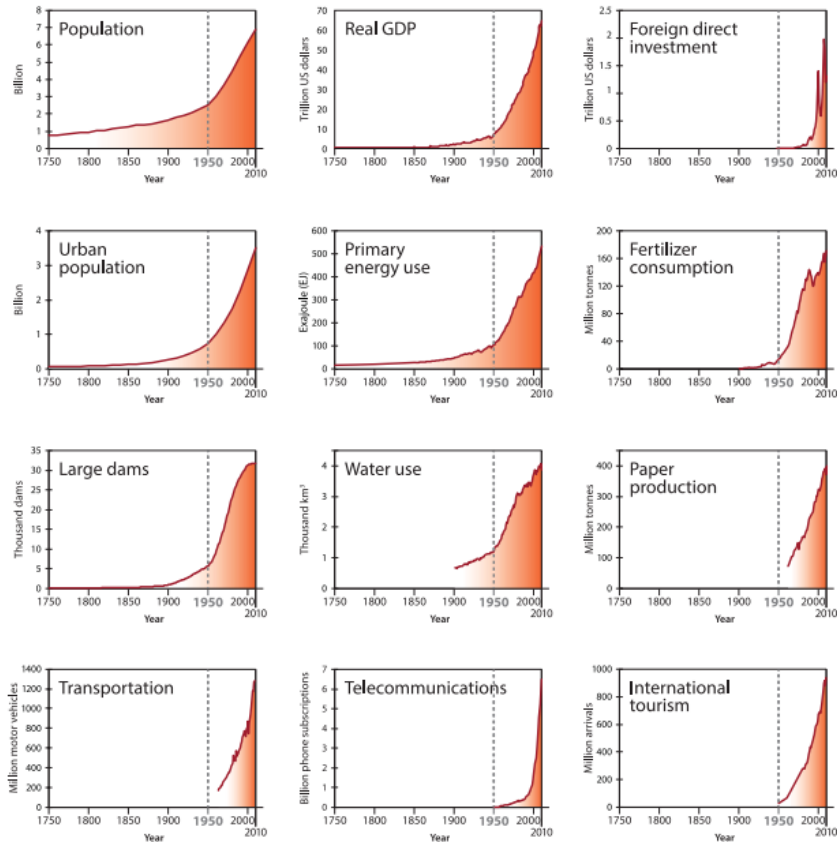


- **Stage 2:** 1945 – 2010/2015 – The “Great Acceleration” (global networks, politics and society)
- **Stage 3:** What brings the future, increased vulnerability... ??

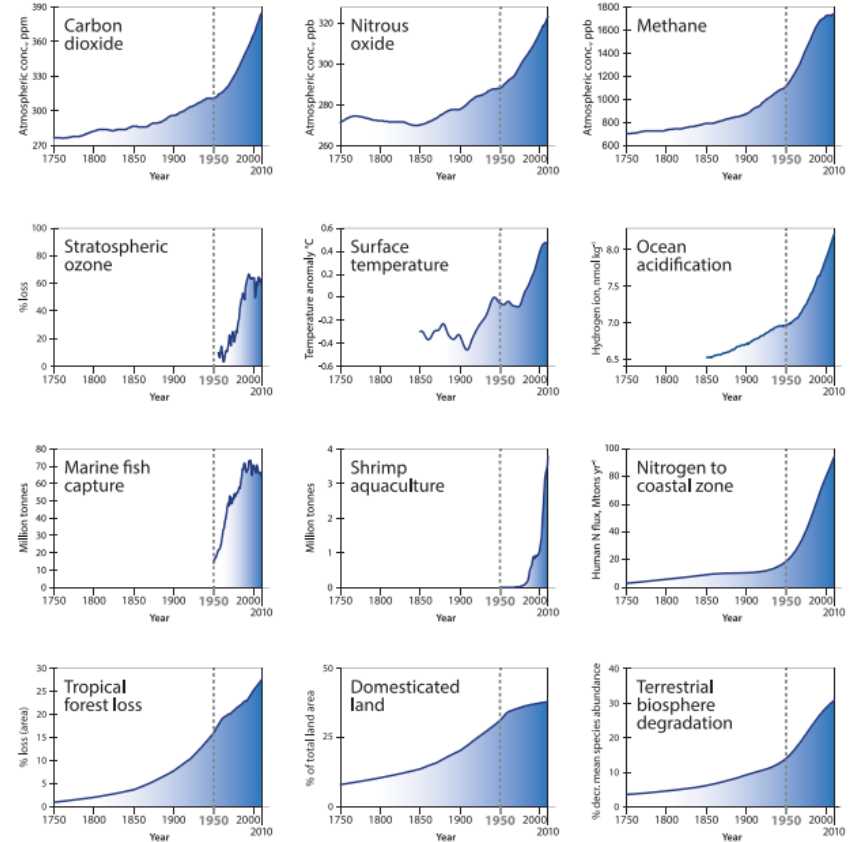


The Great Acceleration

Socio-economic trends



Earth system trends



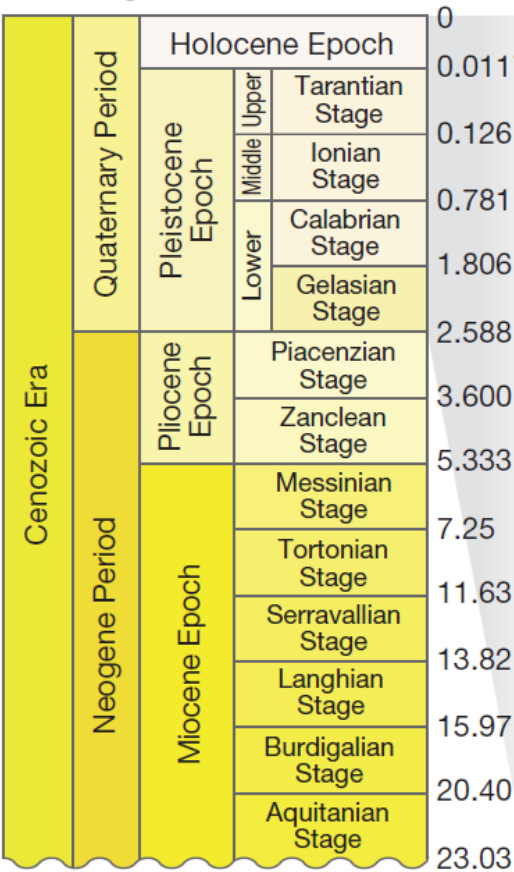
- Post-1950 acceleration of the human imprint on the Earth System

Scientists on the International Geosphere-Biosphere Programme
have said that Earth is now operating in a “no analogue” state

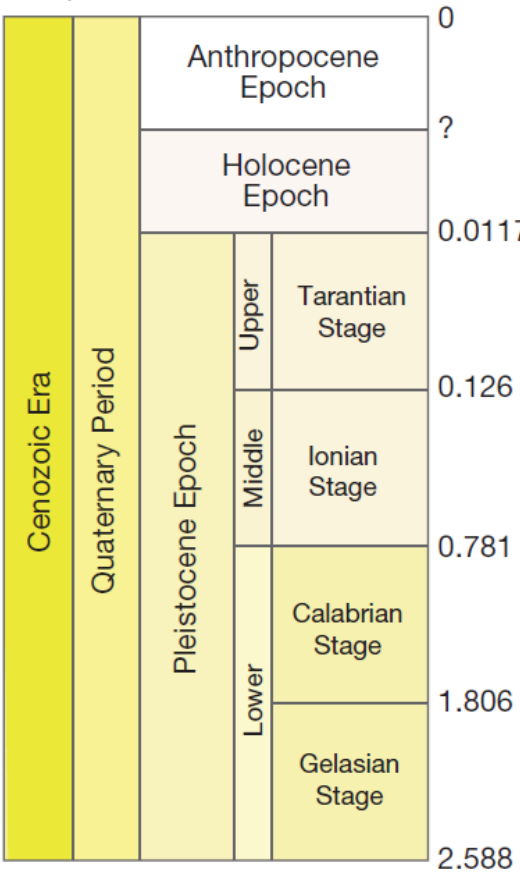
An Anthropocene Epoch?

- Consequences permanently visible in the “rock record” - **epoch ??**
- International Commission of Stratigraphy, “Working group Anthropocene”

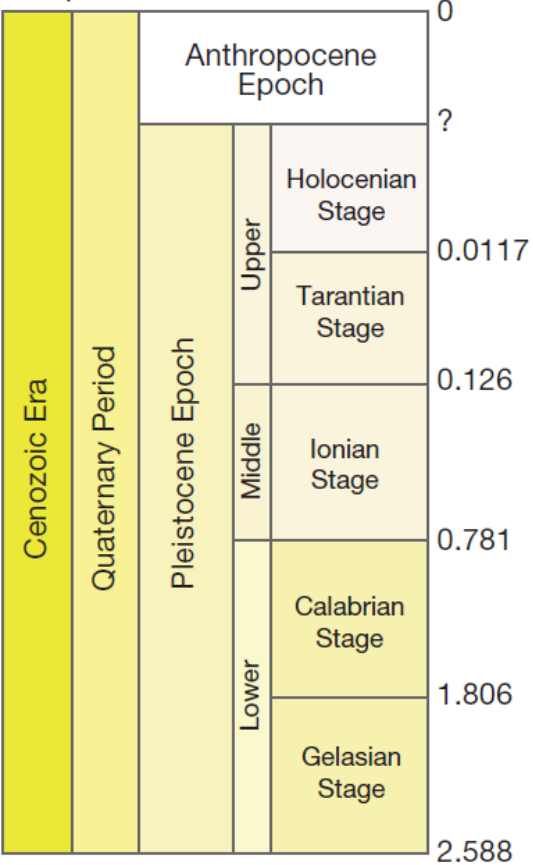
a Geologic Time Scale 2012



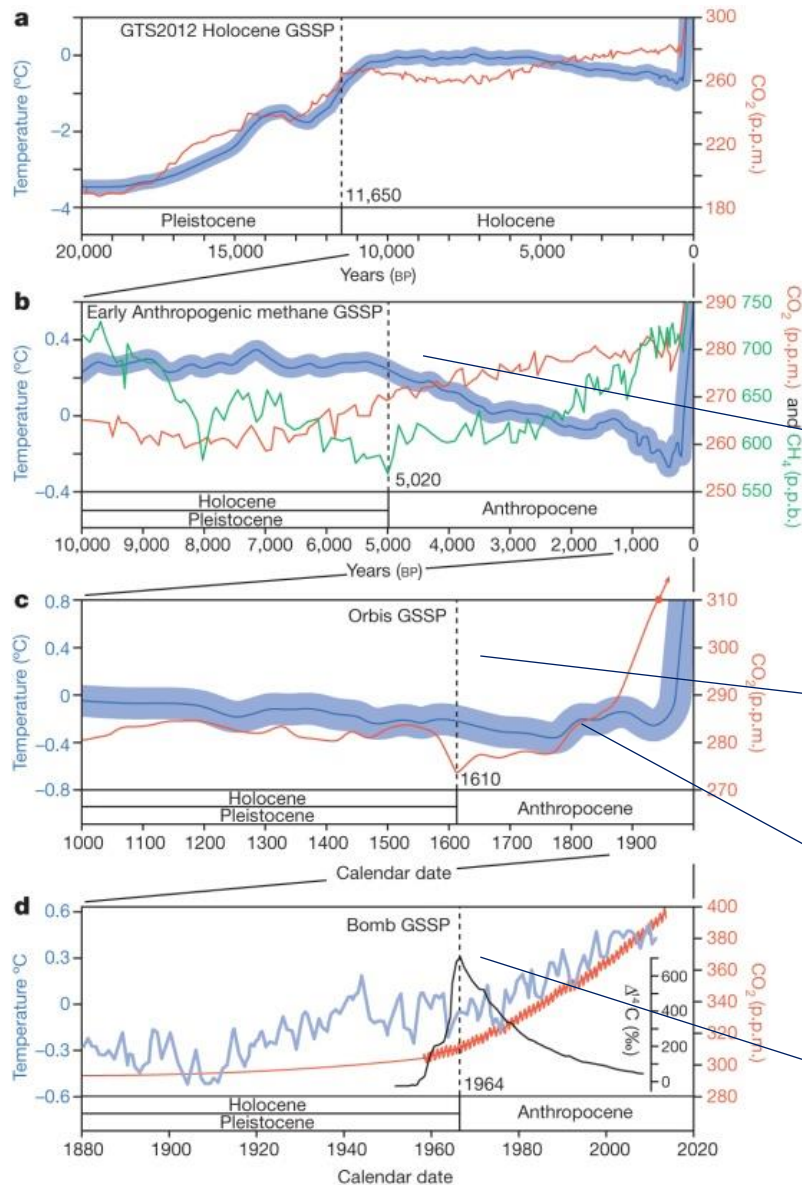
b Option 1



c Option 2



How to define the Anthropocene Epoch?



Formal criteria

1. “recorded in geological stratigraphic material” (marker!!)
2. “defined via lower boundary”

- Early agriculture and increase in methane levels (and changes in atmospheric chemistry)

Not same timing around globe, not everywhere detectable

- Anthropocene began with species exchange between Old and New

Cause – effect relation not well-established

- Industrialization - a sudden escalation in CO2 emissions and temperature increase
- Globally recognized peak in 14C due to increased atom bomb tests

No direct link to environmental change

How to define the Anthropocene Epoch?

Table 1 | Potential start dates for a formal Anthropocene Epoch

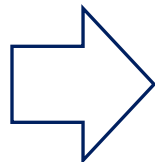
Event	Date	Geographical extent	Primary stratigraphic marker	Potential GSSP date*	Potential auxiliary stratotypes
Megaafauna extinction	50,000–10,000 yr BP	Near-global	Fossil megaafauna	None, diachronous over ~40,000 yr	Charcoal in lacustrine deposits
Origin of farming	~11,000 yr BP	Southwest Asia, becoming global	Fossil pollen or phytoliths	None, diachronous over ~5,000 yr	Fossil crop pollen, phytoliths, charcoal
Extensive farming	~8,000 yr BP to present	Eurasian event, global impact	CO ₂ inflection in glacier ice	None, inflection too diffuse	Fossil crop pollen, phytoliths, charcoal, ceramic minerals
Rice production	6,500 yr BP to present	Southeast Asian event, global impact	CH ₄ inflection in glacier ice	5,020 yr BP CH ₄ minima	Stone axes, fossil domesticated ruminant remains
Anthropogenic soils	~3,000–500 yr BP	Local event, local impact, but widespread	Dark high organic matter soil	None, diachronous, not well preserved	Fossil crop pollen
New–Old World collision	1492–1800	Eurasian–Americas event, global impact	Low point of CO ₂ in glacier ice	1610 CO ₂ minima	Fossil pollen, phytoliths, charcoal, CH ₄ , speleothem $\delta^{18}\text{O}$, tephra†
Industrial Revolution	1760 to present	Northwest Europe event, local impact, becoming global	Fly ash from coal burning	~1900 (ref. 94); diachronous over ~200 yr	¹⁴ N: ¹⁵ N ratio and diatom composition in lake sediments
Nuclear weapon detonation	1945 to present	Local events, global impact	Radionuclides (¹⁴ C) in tree-rings	1964 ¹⁴ C peak§	²⁴⁰ Pu: ²³⁹ Pu ratio, compounds from cement, plastic, lead and other metals
Persistent industrial chemicals	~1950 to present	Local events, global impact	For example, SF ₆ peak in glacier ice	Peaks often very recent so difficult to accurately date§	Compounds from cement, plastic, lead and other metals

For compliance with a Global Stratotype Section and Point (GSSP) definition, a clearly dated global marker is required, backed by correlated auxiliary markers that collectively indicate global and other widespread and long-term changes to the Earth system. BP, before present, where present is defined as calendar date 1950.

* Requires a specific date for a GSSP primary marker. †From Huaynaputina eruption in 1600 (refs 78, 79).

§ Peak, rather than earliest date of detection selected, because earliest dates reflect available detection technology, are more likely influenced by natural background geochemical levels¹⁰¹, and will be more affected by the future decay of the signal, than peak values.

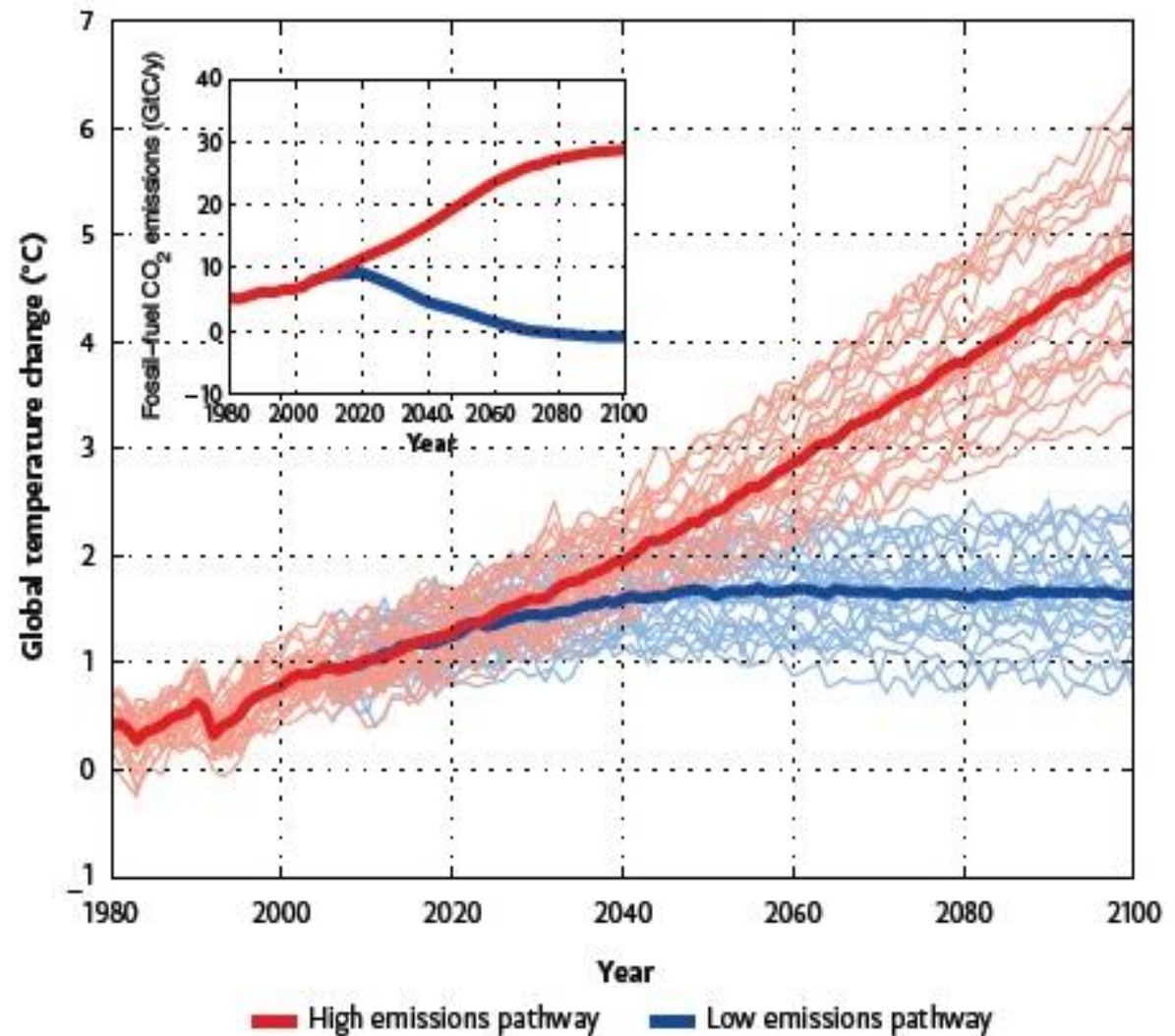
- Issues with finding a start date...



- Global synchronous?
- Preservation quality and ubiquity
- Causal relationship with environmental change
- Difficulties in accurately dating start...

No Anthropocene... yet?

- The idea that the **rates of change** are still accelerating (we are in stage 3...)
- Populations, CO₂ emissions, global warming, biodiversity loss etc. are still increasing and are not yet stabilising
- IPCC (2019): many drastic changes triggered by climate change may lie in store: food and water shortages, mass extinctions, irreversible loss of coral reefs and ice/snow, as well as “abrupt changes”

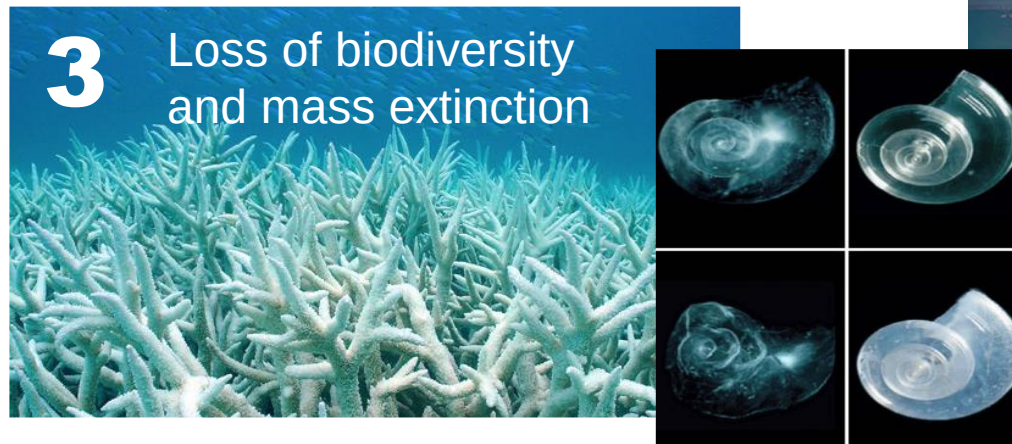


Climate Change Impact

- The Intergovernmental Panel on Climate Change (IPCC) – leading institution for studying and documentation of climate change (United Nations Environment Programme (UNEP) and (WMO) in 1988)



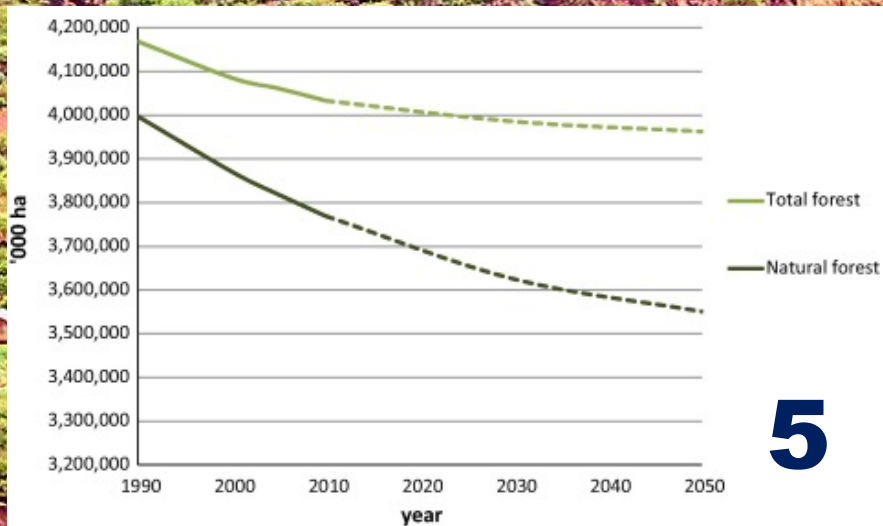
Weather extremes
and consequences...



Loss of biodiversity
and mass extinction

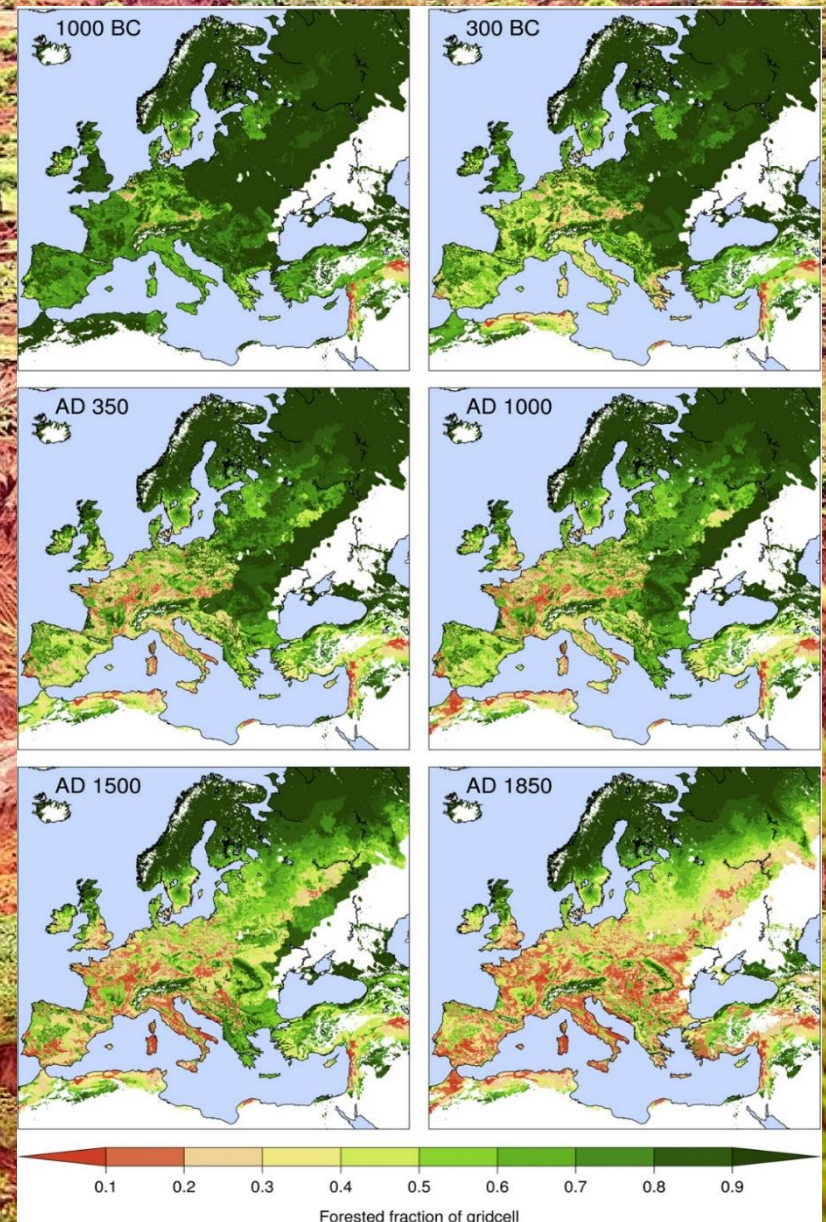


Landscape Use



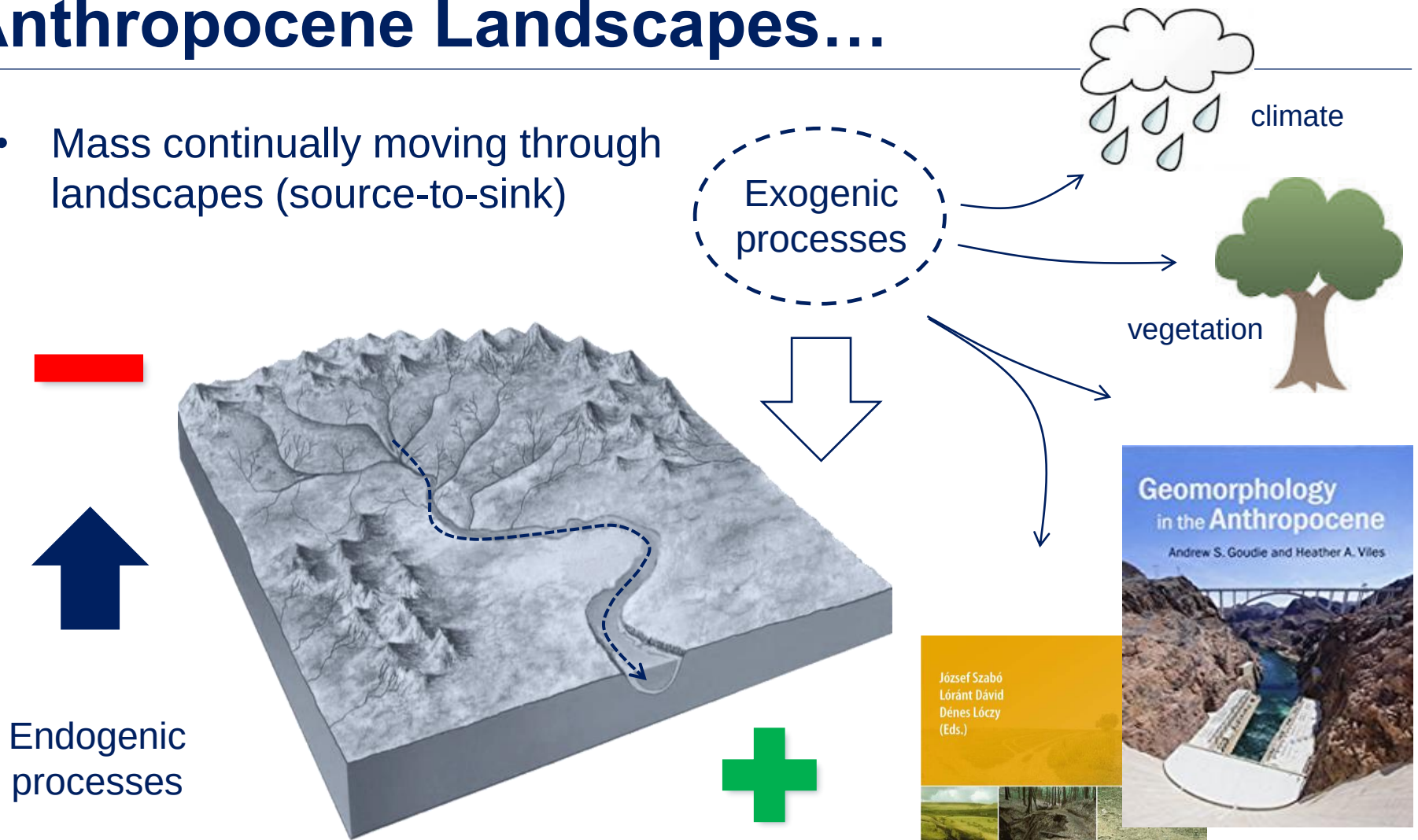
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- Forest (and vegetation) loss and land use change – global and recent?

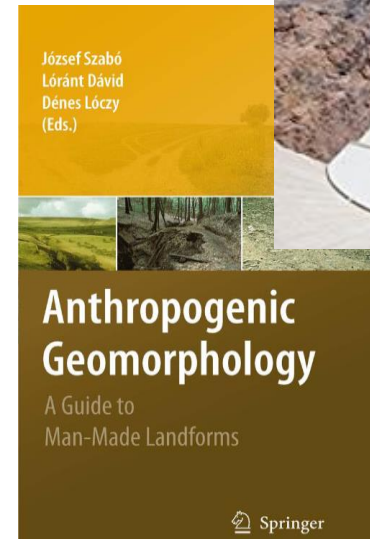


Anthropocene Landscapes...

- Mass continually moving through landscapes (source-to-sink)



- Landscapes and landforms as product of **erosion**, transport and **deposition**



Anthropogenic Geomorphology

- Mineral exploitation and building = anthropogenic erosion and sediment transport?



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Cities & Cultural Landscapes

2500 BC = ca. 4500 years



Pyramids in the Egyptian desert
UNESCO World Heritage

Lost cities in the Bolivian jungle

<https://www.youtube.com/watch?v=VaXrX0veR9Y>



ca. 1600 - 600 years

Las Medulas, Spain – Roman gold mine
(1st century AD), UNESCO World Heritage



<https://www.youtube.com/watch?v=wkMyBida63I>

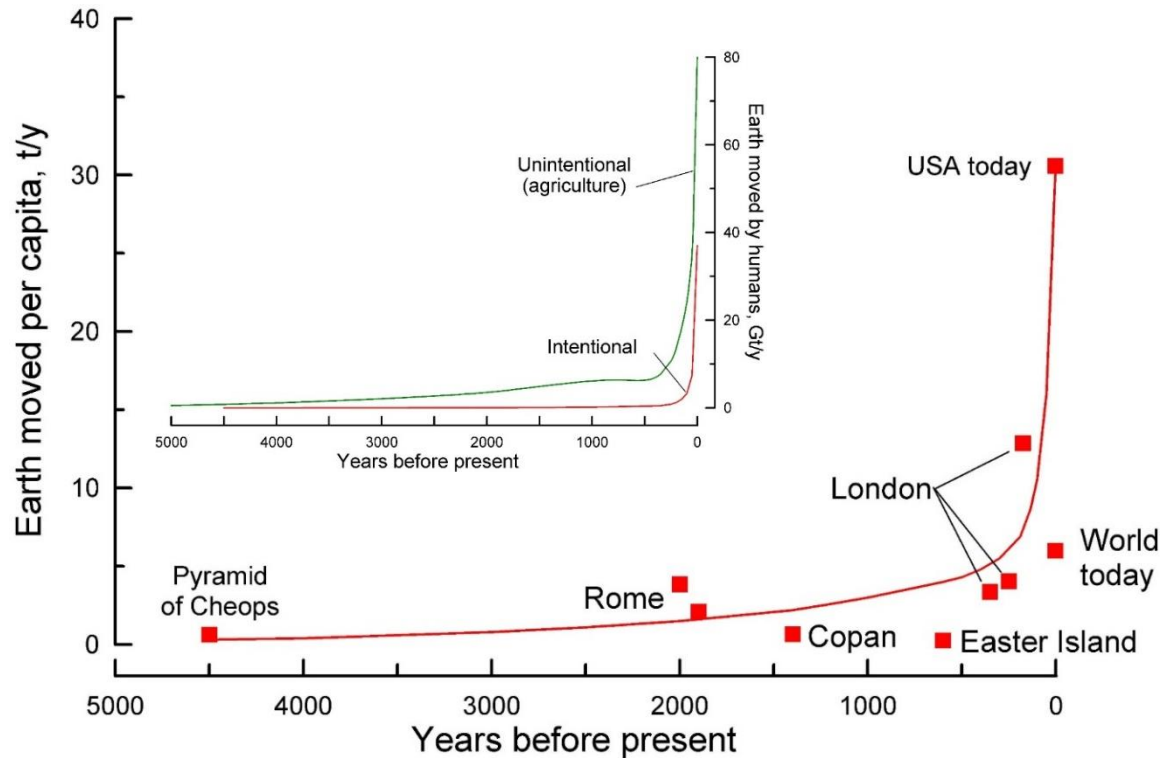
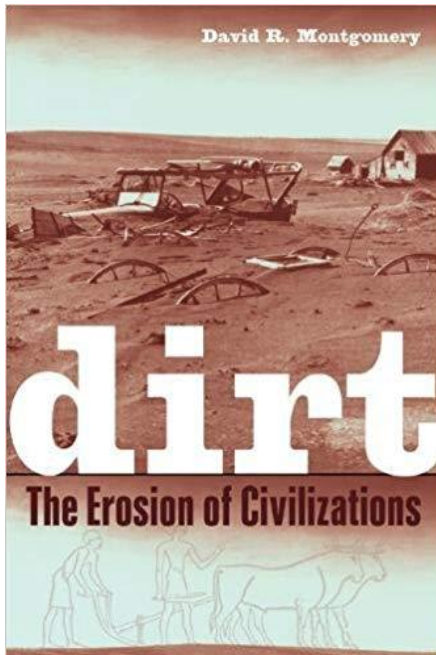


Angkor Wat in Cambodia
(ca. 900 years)

<https://www.youtube.com/watch?v=o6Kq4XF1zKU>

Landscapes and “Earth Moving”

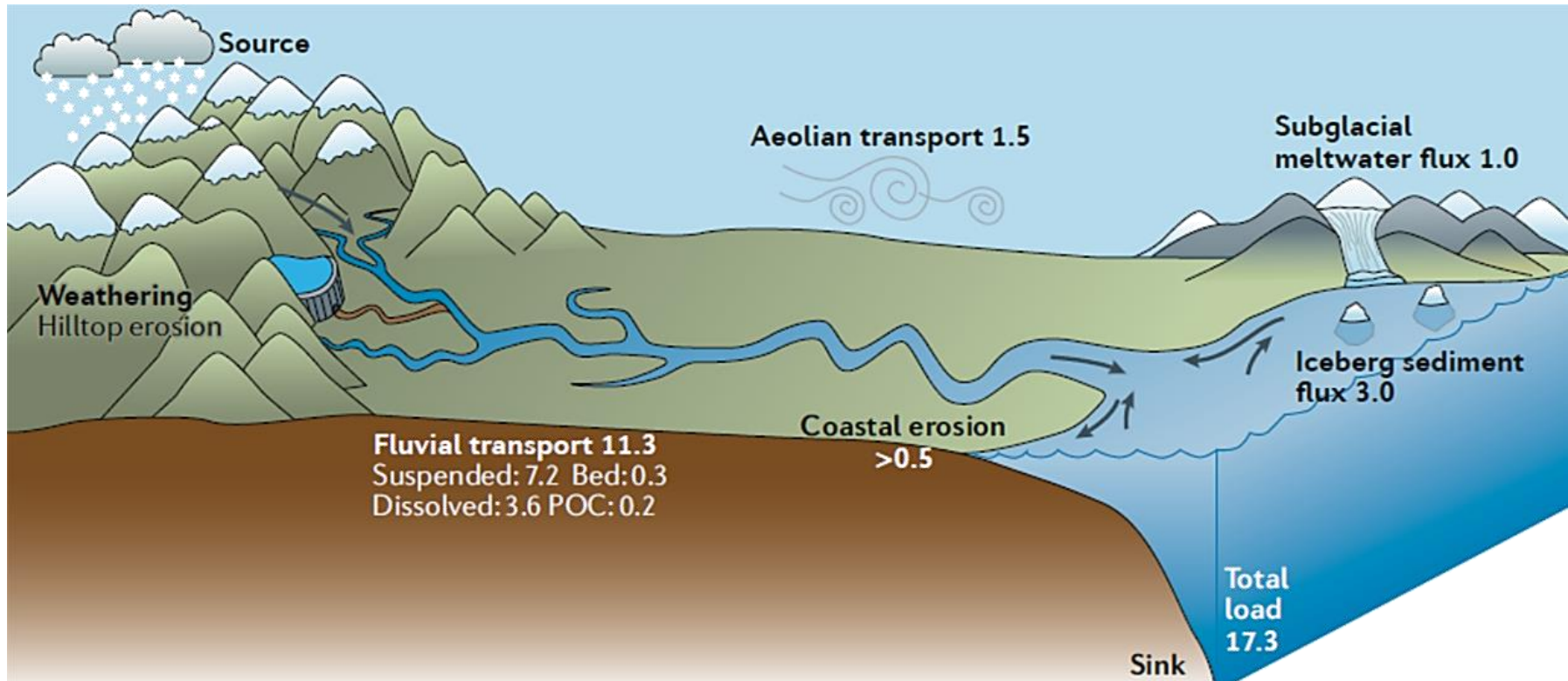
- USA in early 90s: 0.8 Gt house building, 3.2 Gt mining etc., 3 Gt roads etc (would fill Grand Canyon in 400 years !!)
- Total world ca. 30-35 Gt material moved (without agriculture)



- Agriculture: 1500 Gt/yr moved (ploughing etc.) – 75 Gt/yr eroded – 10-15 Gt/yr reach ocean (24 Gt/yr ~ fluvial sediment export from continents!)
- Soil erosion ca. 10 x than through weathering and erosion alone...

Anthropocene Source-to-Sink...

- The Earth's present Anthropocene **sediment load** (net land-to-sea sediment delivery and anthropogenic sediment production) **exceeds 300 billion tons (Gt) per year**, a mass flux that **includes a small (<6%) contribution from natural processes**



- Anthropocene land-to-sea sediment flux (Gt per year) in 2010

Anthropocene Source-to-Sink...

- **Sediment production** (supply) from anthropogenic soil erosion, construction activities, mineral mining, aggregate mining, and sand and gravel mining from coasts and rivers, has increased by about **467%** between 1950 and 2010



Anthropocene Source-to-Sink...

REVIEWS

- Transport of sediment to the coastal ocean (via rivers, wind, coastal erosion, and ice loss) has **decreased by 23%** between 1950 and 2010, transport of fluvial particulates including organic carbon has decreased by 49% over the same period; offsets include increases in sediment delivery by icebergs and glacial melt

Earth's sediment cycle during the Anthropocene

Jaia Syvitski¹, Juan Restrepo Ángel², Yoshiki Saito^{3,4}, Irina Overeem¹, Charles J. Vörösmarty⁵, Houjie Wang⁶ and Daniel Olago⁷

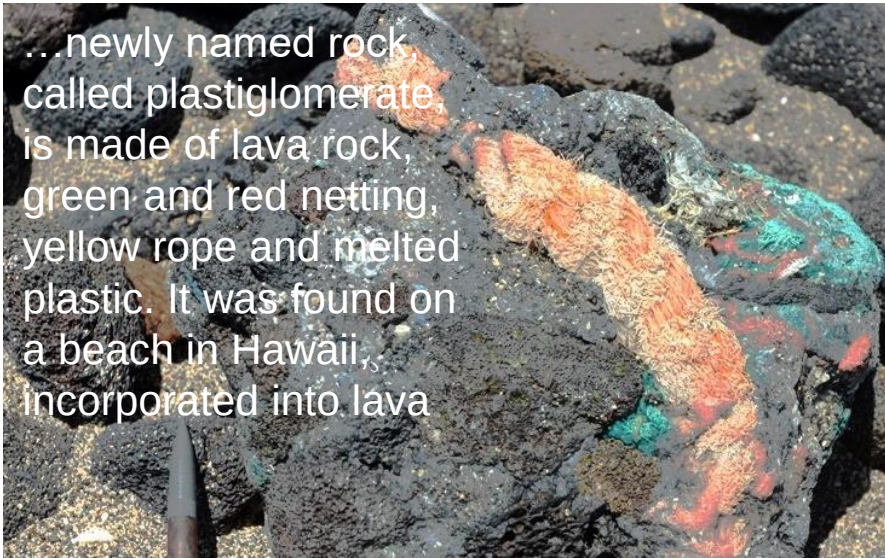
- If it were not for sequestration of sediment behind dams, global rivers would have increased their particulate loads by **212%** between 1950 and 2010



- Sediment consumption** in the Anthropocene, including from reservoir sequestration, highway development and coal and concrete consumption, has increased by about **2,550%** between 1950 and 2010
- And the marine sedimentary environment? From resuspension of seafloor sediment from trawling, dredging and land reclamation, anthropogenic transport seems to have increased by **780%** between 1950 and 2010

Anthropocene Geology

...newly named rock, called plastiglomerate, is made of lava rock, green and red netting, yellow rope and melted plastic. It was found on a beach in Hawaii, incorporated into lava



Plastiglomerates

Source
- burning
Fate
- burial
- geological record
Environ. Impact
- aesthetics
- chemical release



Pyroplastics

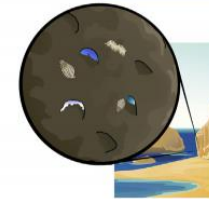
Source
- burning and weathering
Fate
- persistence in the environment
Environ. Impact
- chemical release
- AIS/ARG transport*



Plastic pollution in the Anthropocene

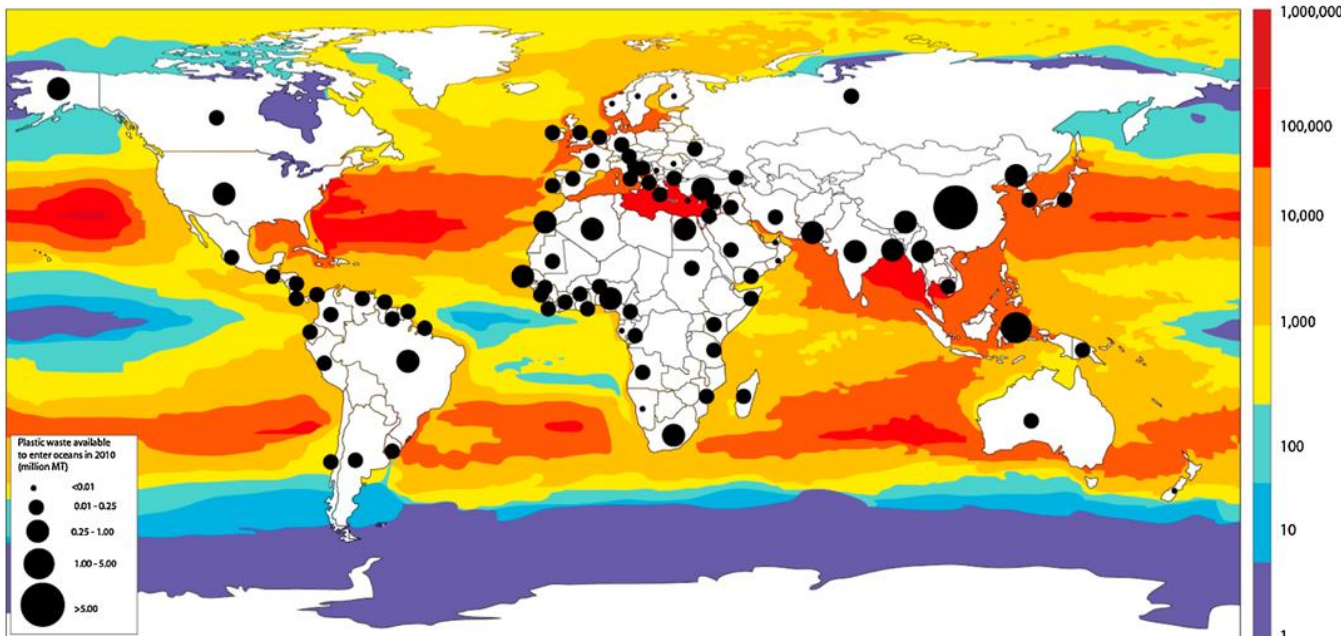
Plasticrusts

Source
- wave action
Fate
- fragmentation
- persistence in the environment
Environ. Impact
- plastic ingestion*



Anthropoquinas

Source
- Litter within sedimentary rock
Fate
- geological record
Environ. Impact
- aesthetics

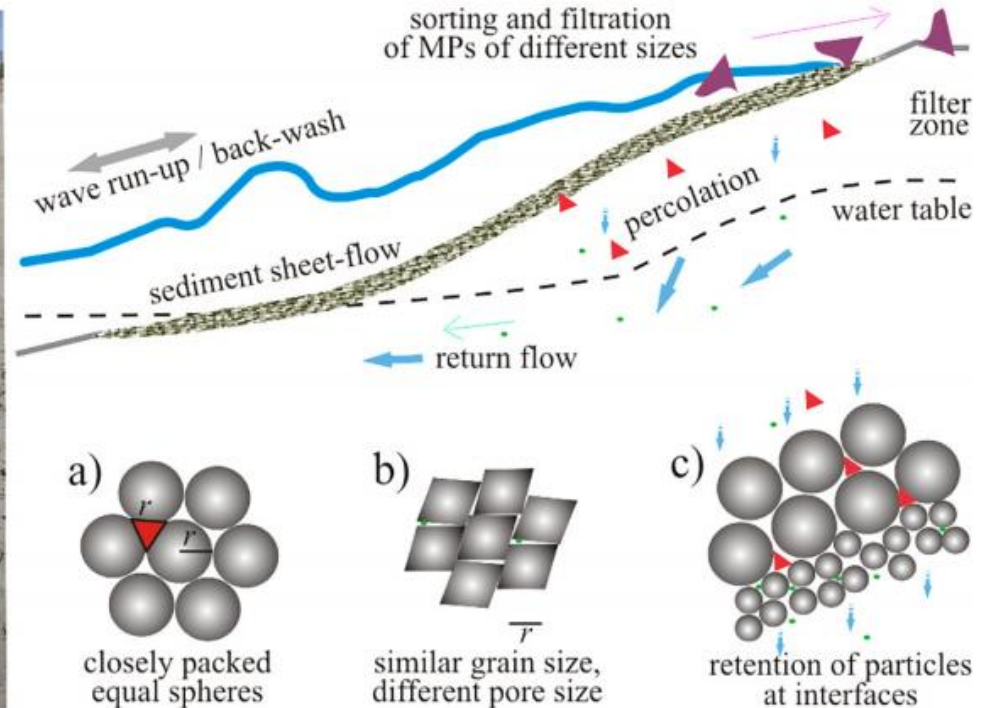


- Plastic = new rock type & sediment ??
- Rivers are the main road for plastic pollution

Anthropocene Sediment Transport



- Plastic = change in process properties ??



- Plastic = integrated in the stratigraphic record

The Future – Anthropocene Landscapes

- As geomorphologists, **understanding physical processes is key to predicting the rates and magnitude of future change...** and validating predictions using past and present data
- We can use our knowledge to **help mitigate climate change** and to develop **strategies to better manage the environment** in the future
- New and exciting **opportunities** are arising for exploration/applications in Geomorphology
- e.g. look beyond the horizon...

