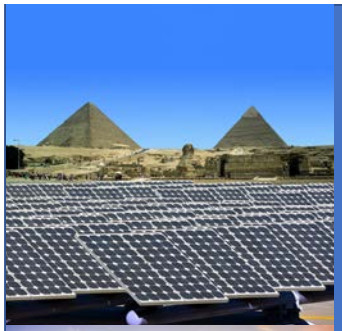


Earth materials and a sustainable future

Murray W. Hitzman, Director, Irish Centre of Research in Applied Geoscience
University College Dublin, Ireland

Halleluya-Naantu Ekandjo, PhD Candidate, Irish Centre of Research in Applied Geoscien
University College Dublin, Ireland

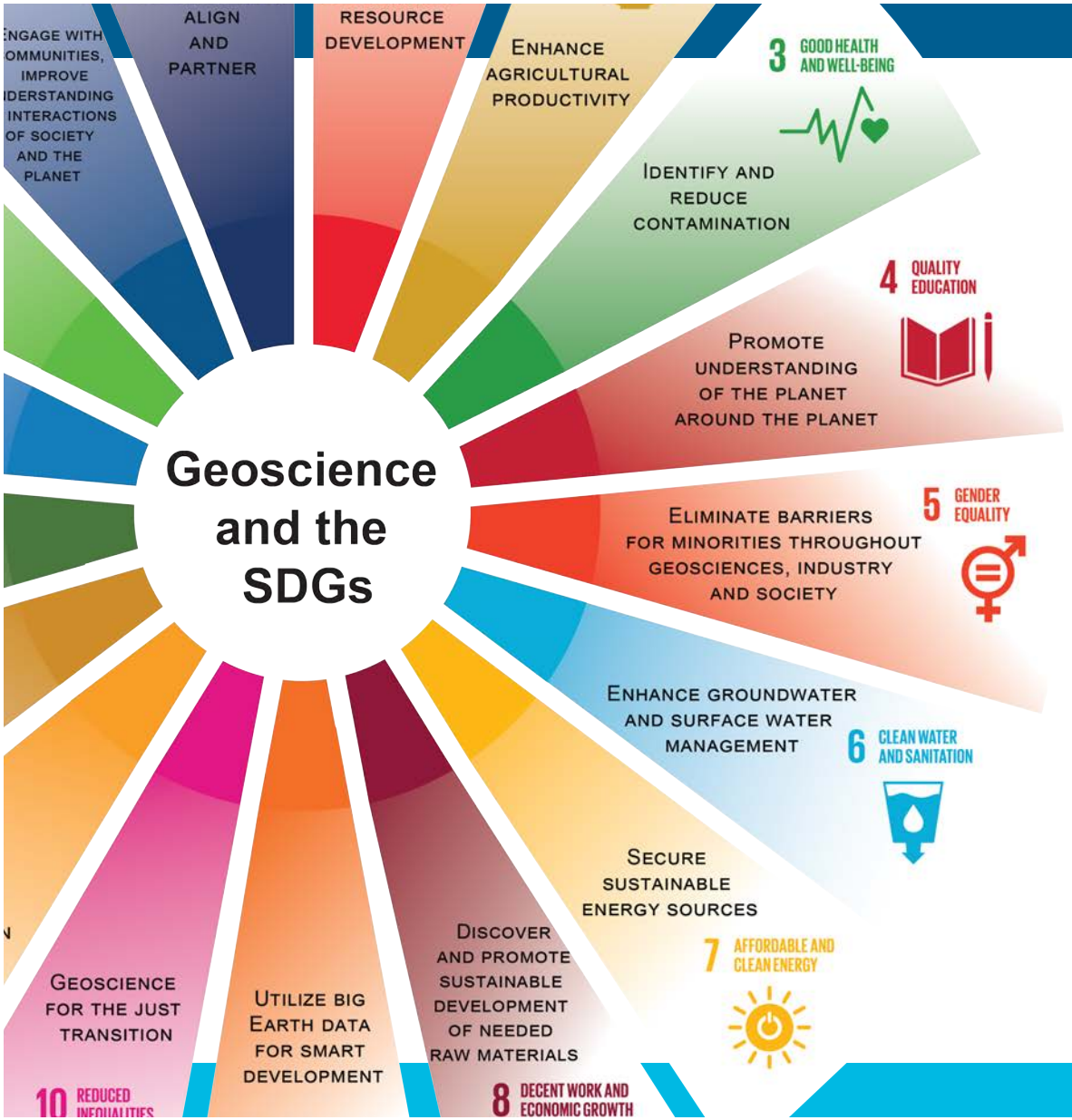
United Nations Educational, Scientific and Cultural Organization

International Geoscience Programme

Earth Materials for a Sustainable and Thriving Society

UNESCO Lecture Series

Organised in collaboration with IUGS and iCRAG



International Women's Day
8 March

United Nations

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Photo: Juergen Lang

Earth Materials and a Sustainable Future

A reliable, affordable, and just supply of earth materials can provide the foundation for a sustainable future — diverse young people will be the key to that future.

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https://www.nasa.gov/topics/earth/earthday/gall_earth_night.html

Framing the Future

Nature, 3 January 2002

Geology of mankind

Paul J. Crutzen

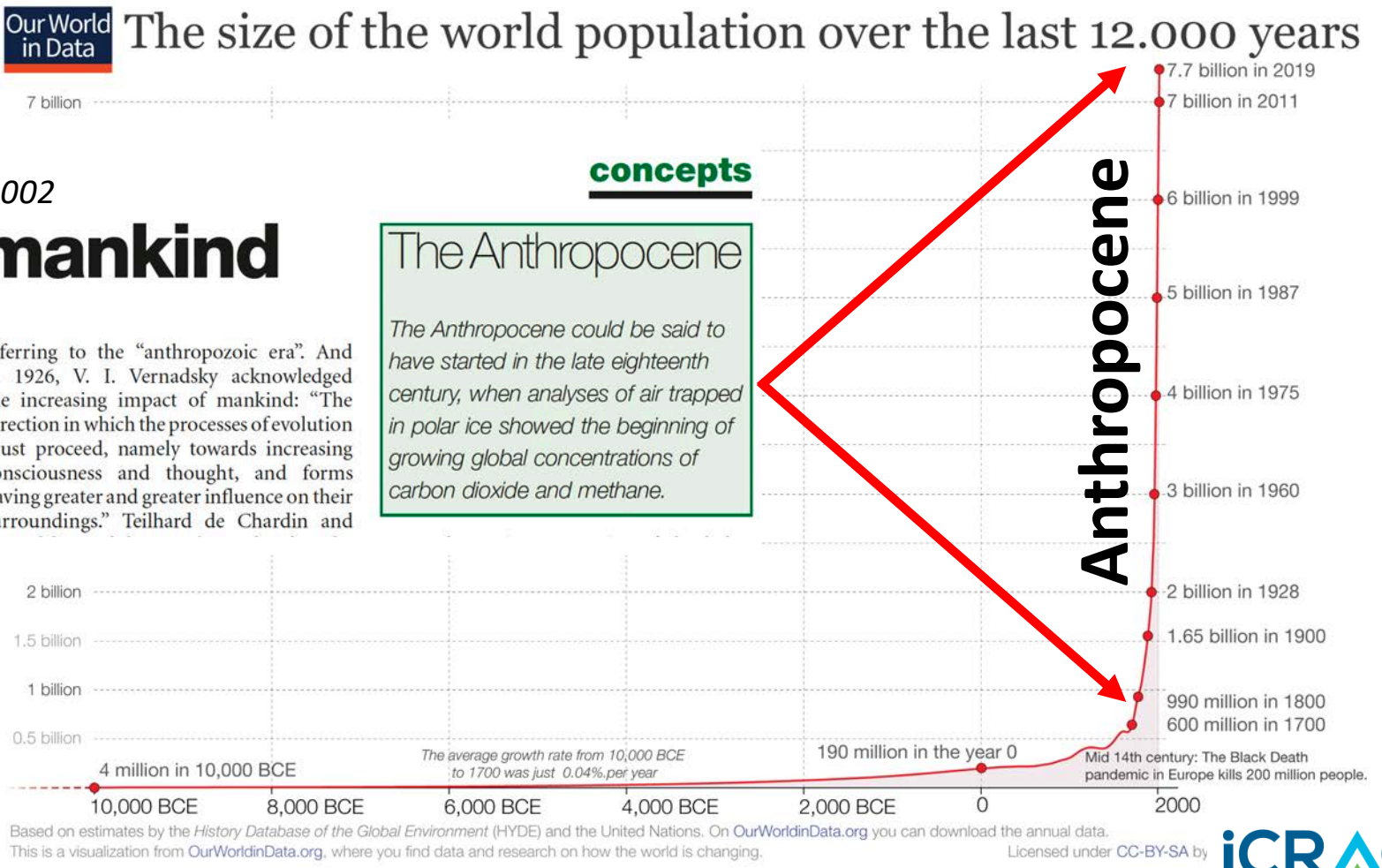
For the past three centuries, the effects of humans on the global environment have escalated. Because of these anthropogenic emissions of carbon dioxide, global climate may depart significantly from natural behaviour for many millennia to

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 must proceed, namely towards increasing consciousness and thought, and forms having greater and greater influence on their surroundings." Teilhard de Chardin and

concepts

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 growing global concentrations of carbon dioxide and methane.



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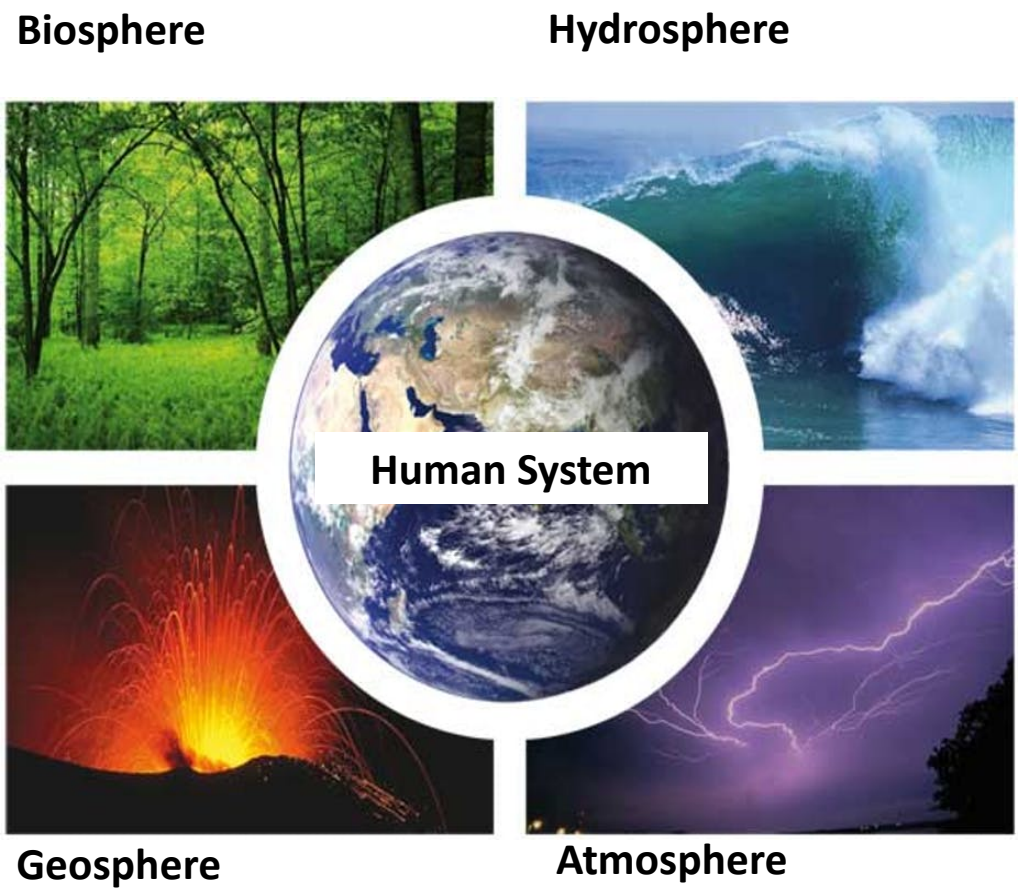
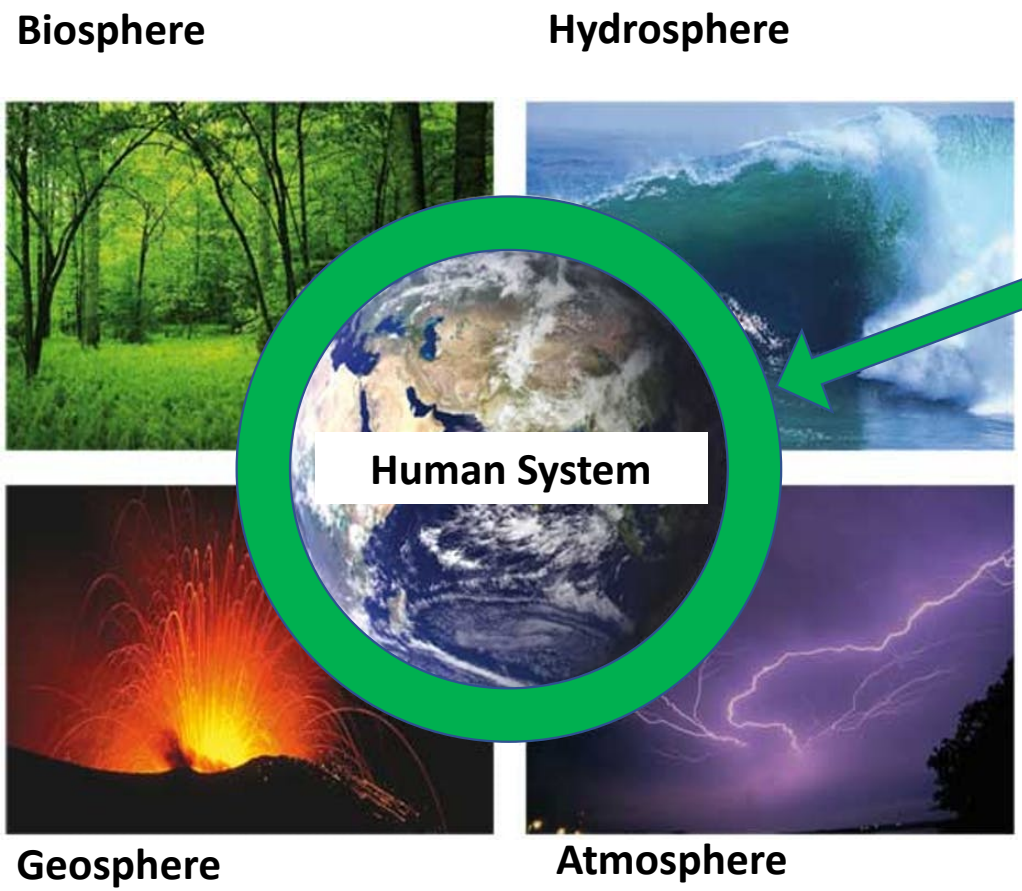
Framing the Future — Nature *and* Humans



Framing the Future — Nature *and* Humans

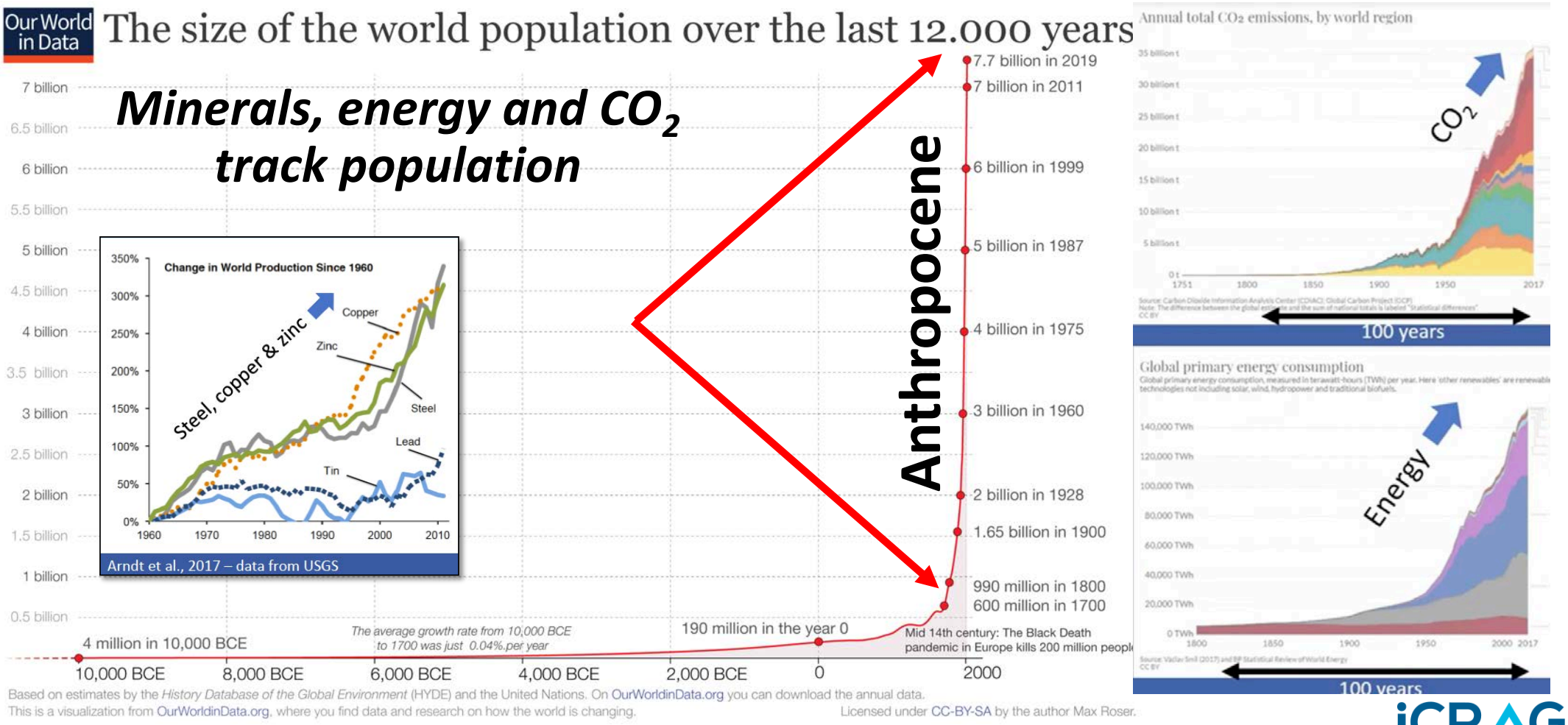


Earth Materials —

At the intersection of two very complex systems

Earth: from the planet
Materials: people want them

Framing the Future — Demand



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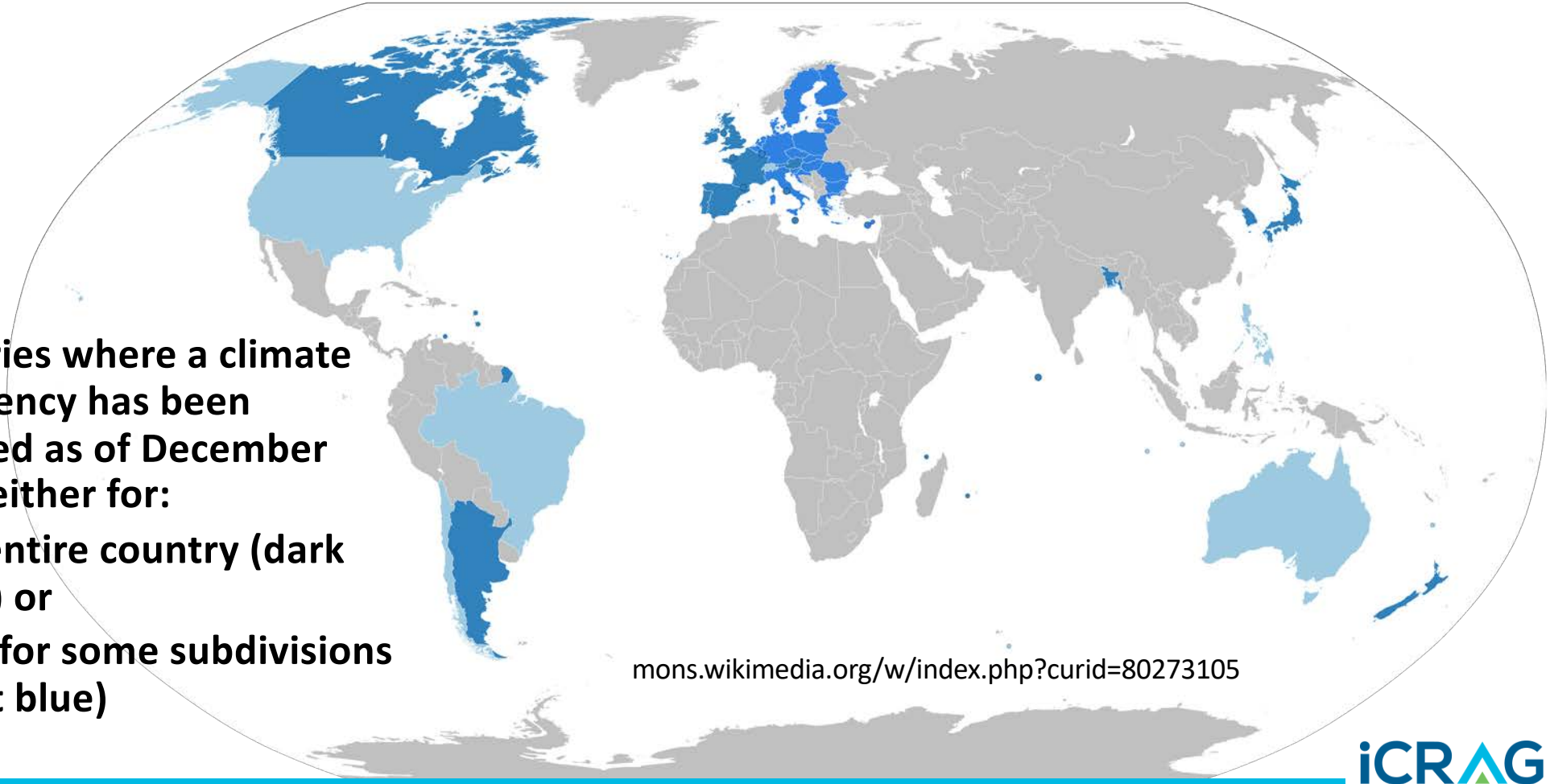
Framing the Future — Climate Emergency

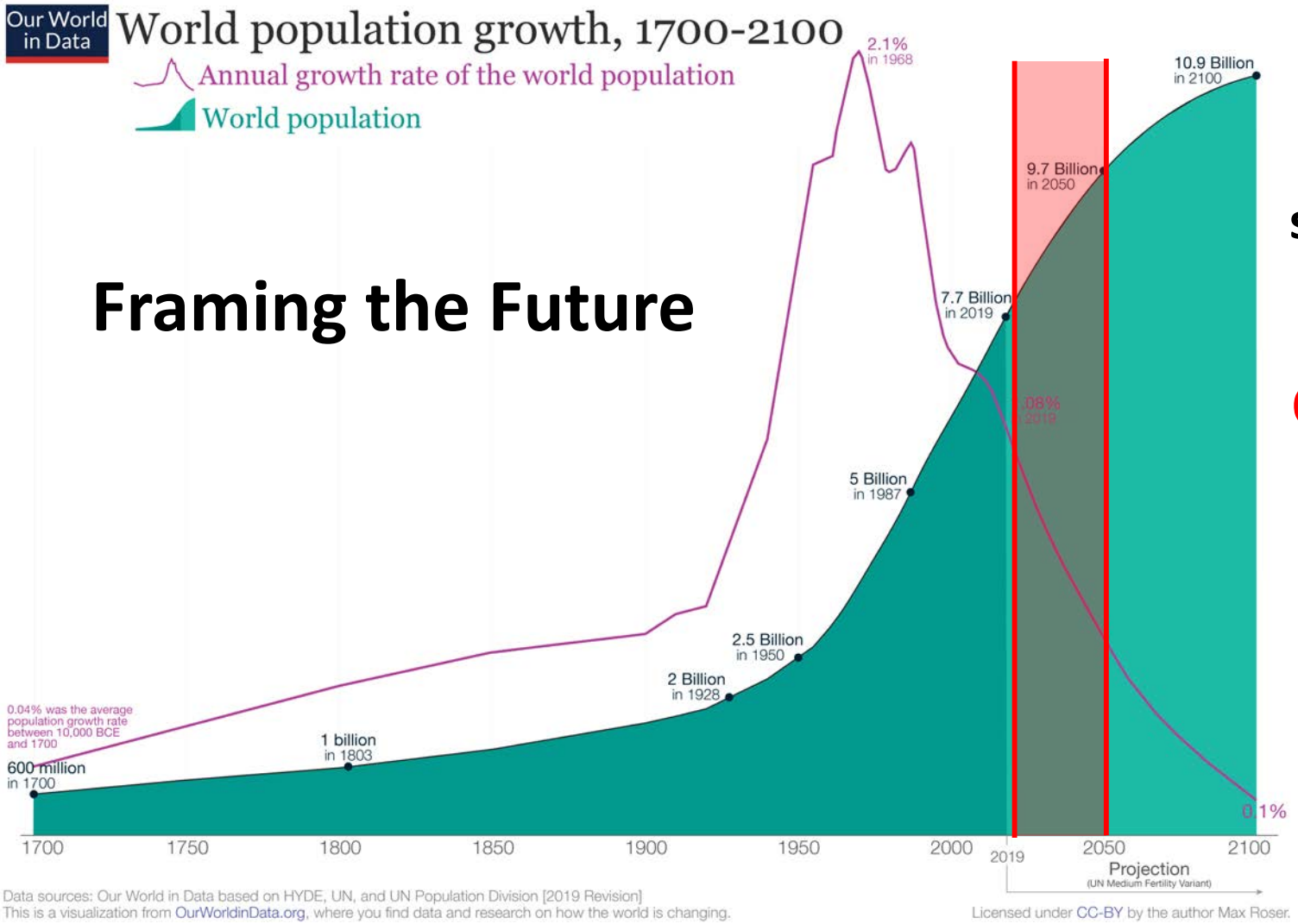
Countries where a climate emergency has been declared as of December 2020, either for:

- **the entire country (dark blue) or**
- **only for some subdivisions (light blue)**



mons.wikimedia.org/w/index.php?curid=80273105

Framing the Future



Time we have to reach our sustainable future —

ONE GENERATION

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Framing the Future —
A Just, Equitable, and Sustainable Society

Earth material (metals, industrial minerals, and building/ development materials) are linked to every one of the SDGs.

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Photo: Juergen Lang

Earth Materials and a Sustainable Future

- Earth materials — what are they?
- Earth Materials and the UN Sustainable Development Goals
- Earth materials — where they are, production & the circular economy

Visions for the future

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https://www.nasa.gov/topics/earth/earthday/gall_earth_night.html

Earth Materials *(Raw Materials - EU)*

Metals

https://www.kingspan.com/us/en-us/product-groups/metal-roof-wall-systems/education/natural-metals

Industrial minerals

http://www.treepower.net/habitat/main5.html

Building materials

https://www.123rf.com/photo_77479345_natural-stone-wall-made-of-wire-mesh-and-crushed-rocks-building-materials-industry-gabion-box-for-ba.html

NOTE: WATER is also a very important earth material but is not considered in this talk

Earth Materials — Metals

Metals

https://www.kingspan.com/us/en-us/product-groups/metal-roof-wall-systems/education/natural-metals

Bulk metals

Al, Cu, Fe, Mn, Ni, Zn

Technology (“critical”) metals

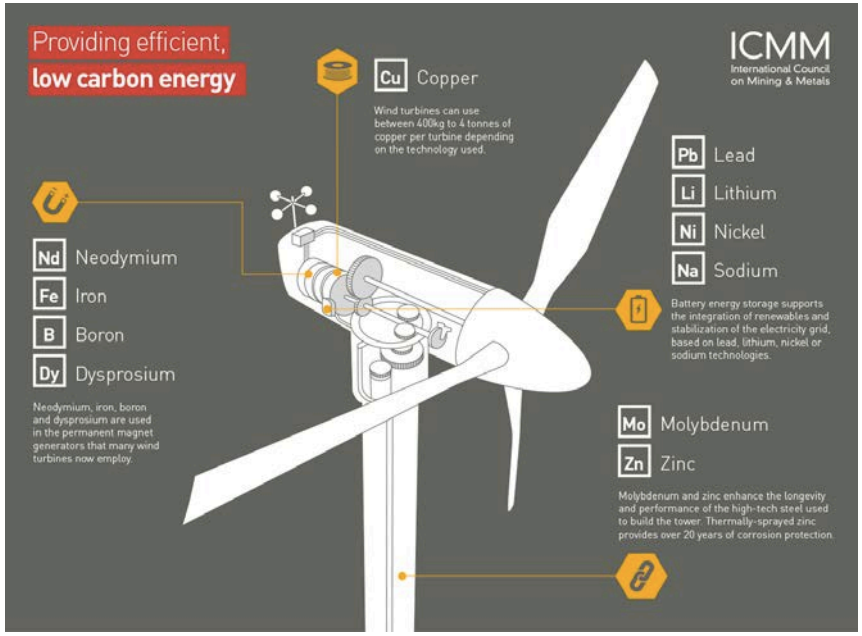
Co, Ge, Ga, In, Li, REE, Te

Metals

- Major component in renewable energy and electrification of transportation – SDGs: 1, 6, 7, 9, 11, 12, 13.
- Negative impacts of metal extraction and use must also be reduced — SDGs: 3, 6, 8, 11, 13, 14, 15, 16.

Metals

Fungarume Cu-Co deposit, Democratic Republic of Congo, *Hitzman*



Metals are required to build a sustainable decarbonized future.

Industrial Minerals

- Necessary for agriculture and wide range of manufacturing — SDGs 1, 2, 3, 6, 7, 8, 9, 11, 12, 13
- Negative impacts of production must also be reduced — SDGs 3, 6, 8, 11, 12, 13, 14, 15, 16

Industrial Minerals

Industrial minerals are required for sustainable agriculture, construction and manufacturing.

Potash in the underground Uralkali Potash Mine #2, Berezniki, Russia, 2017. Photo © Edward Burtynsky, courtesy Flowers Gallery, London / Nicholas Metivier Gallery, Toronto

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Building (Construction, Development) Materials

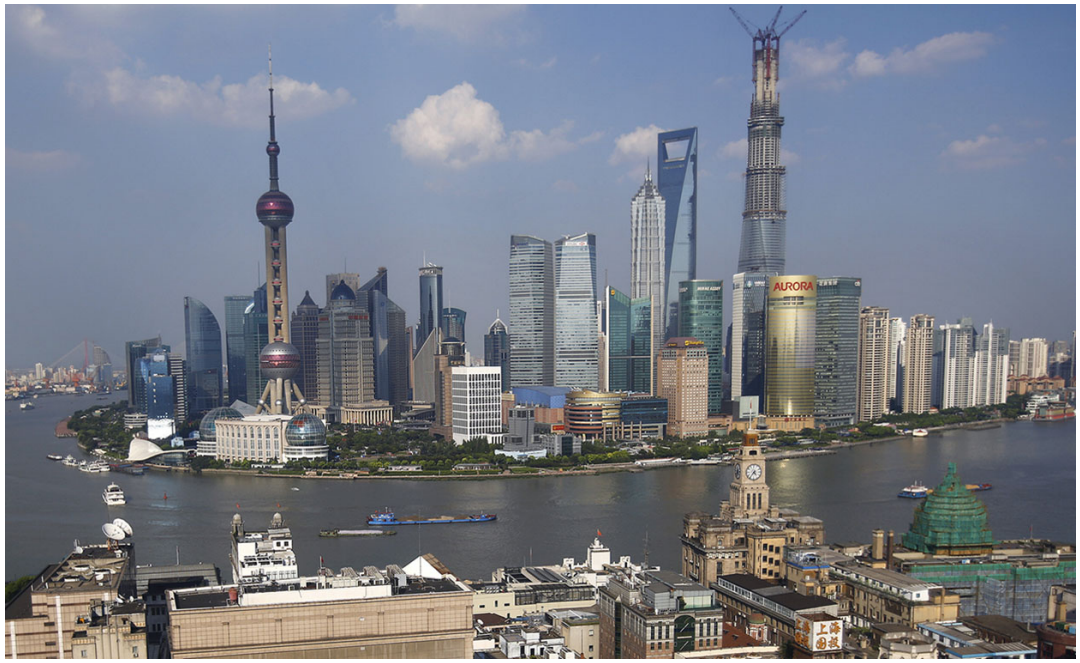
- Necessary for rebuilding of more energy efficient infrastructure — SDGs: 6, 7, 8, 9, 11, 12, 13
- Negative impacts of production must also be reduced — SDGs 3, 6, 8, 11, 12, 13, 14, 15, 16

Building Materials

Shanghai 1987

The Atlantic magazine

Shanghai 2013



The explosive growth in China (still ongoing) will be joined by the need to rebuild energy efficient infrastructure in the developed world and construct energy efficient infrastructure in the developing world.

Required Scale of Production of Earth Materials

- For just one metal - copper - the world annual consumption is approximately 24M tons per year.
- This is the equivalent of all the copper produced from the giant Bingham Canyon mine between 1902 and 2020.
- We are using the equivalent of the total resources of Bingham Canyon each year — just to keep up we need to recycle and/or find and put into production one Bingham Canyon a year.

“Circular economy is based on the principles of

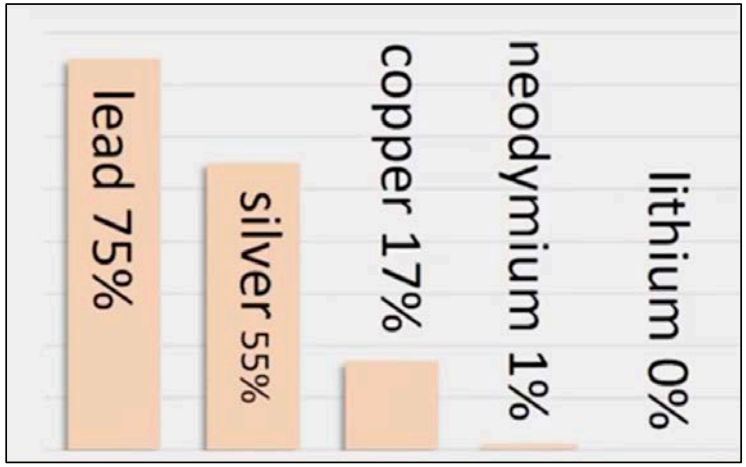
- **designing out waste and pollution,**
- **keeping products and materials in use, and**
- **regenerating natural systems.”**

Ellen MacArthur Foundation

Earth Materials and The Circular Economy

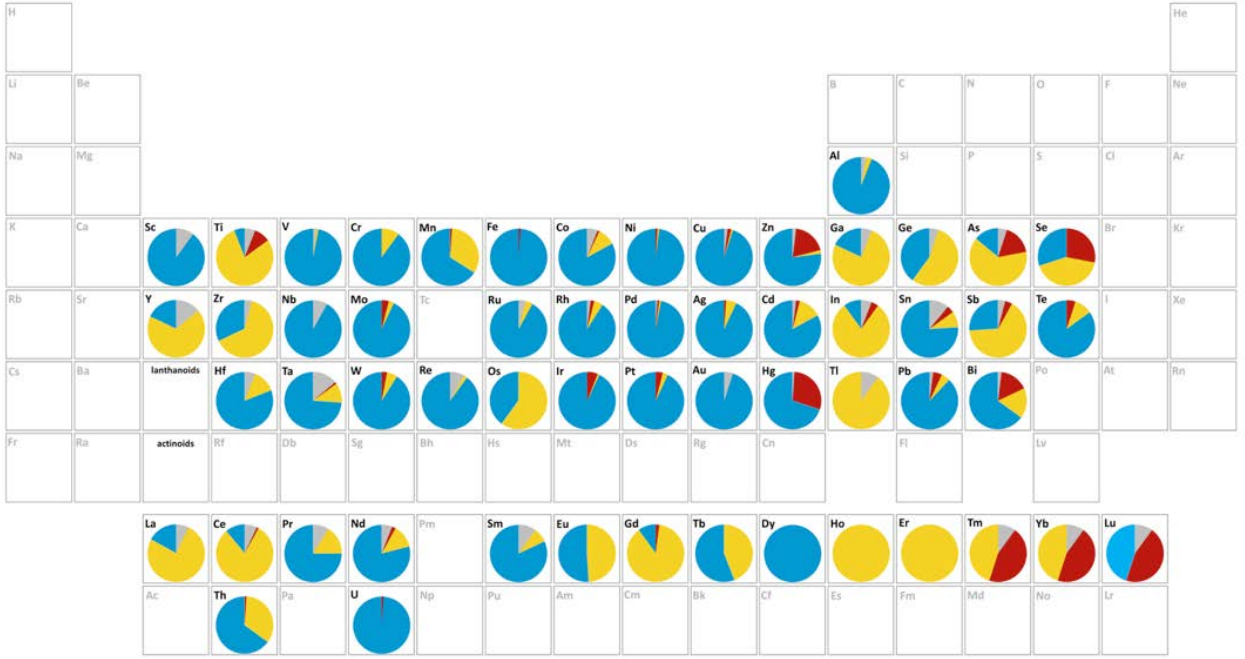
- **Critical need to reduce waste and increase recycling at ALL stages of earth materials production and use.**
- **Also, a critical need for materials stewardship to ensure produced materials stay in use for as long as possible**

Earth Materials Recycling Opportunities



Recycling Input Rates (EU Raw Materials Scoreboard)

Recycling earth materials is part of the solution, but we have a long way to go…



Ciacci, Reck, Nassar, and Graedel. 2015. Lost by Design. *Env Sci & Tech* 49(16): 9443-9451.

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Those with less economic ability often recycle more than those of us with more economic ability - perhaps we need to learn from them?

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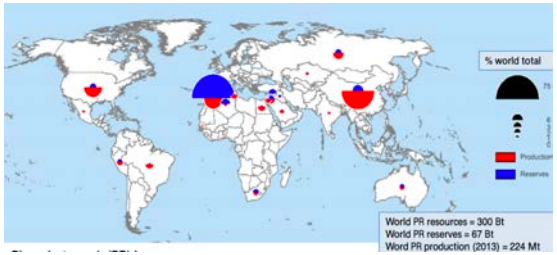
Location of Earth Materials

While sources of building materials are very widely distributed, the best sources of many earth materials are unequally distributed across the planet — countries are NOT created equal when it comes to earth material endowment.

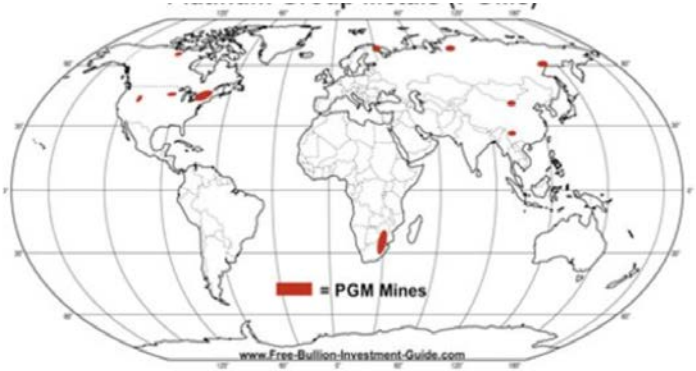
Many sources of earth materials are located far from the locations of consumption.

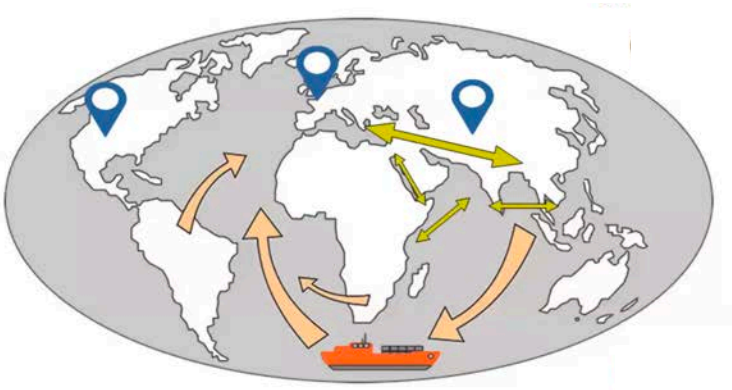


Phosphate, *USGS, https://ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupDetailDoc&id=13828&no=33S*

Cu, *USGS*

PGE, *https://www.free-bullion-investment-guide.com/platinum-and-palladium-buying-guide.html*





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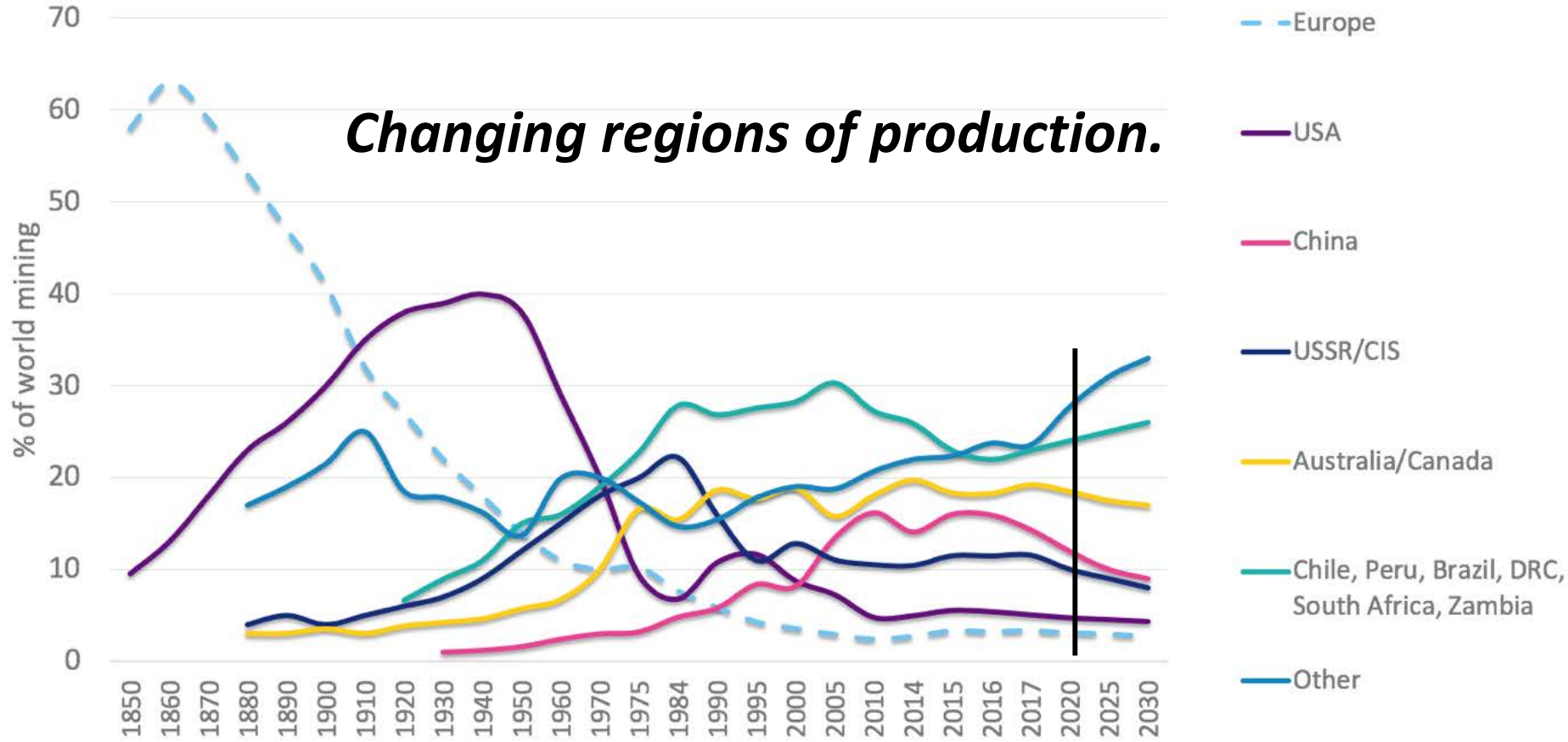
Metals Mining Regions - 1850 to Present



Source: Sames, RMG Consulting

Differing Production of Earth Materials

Different types of earth material deposits require different types and scales of production.

- **Bulk materials mining** (bulk metals, industrial minerals, some building materials) — large scale mining by companies requiring large labor forces. Need to utilize technologically optimized approaches to develop economies of scale.

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- **Niche materials** (many technology metals, high value industrial and construction minerals/materials) — modern small-scale mining that may not be labor intensive and potentially has short-term, small-footprint.

All types of materials may also be produced by formal or informal artisanal mining that is generally labor intensive.

After Sidorenko et al., 2020

Earth Materials Production Requirements

All earth materials production projects, with the possible exception of artisanal sites, require the project have —

- **High economic returns (or important governmental function, eg. critical for national goals),**
- **Low adverse social and environmental impact.**

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Earth Materials and Social Justice

Map from Environmental Justice Atlas showing projects with conflicts or resistance for:

- **Type:** Building materials extraction (quarries, sand, gravel)
- **Type:** Mineral ore exploration
- **Type:** Mineral processing

https://ejatlas.org/ accessed 02/24/2021

Regulation and Governance — Production

- **Effective domestic regulation and governance of earth materials production operations are critical to enable such operations to have a positive impact on the lives of people living in proximity to the operation.**
- **Responsible corporate practices must go hand in hand with good governance to ensure effective partnerships.**
- **Transparency and real cooperation are critical at all stages of projects (exploration through production to closure and beyond) to realize mutual benefits for communities, government, and companies.**

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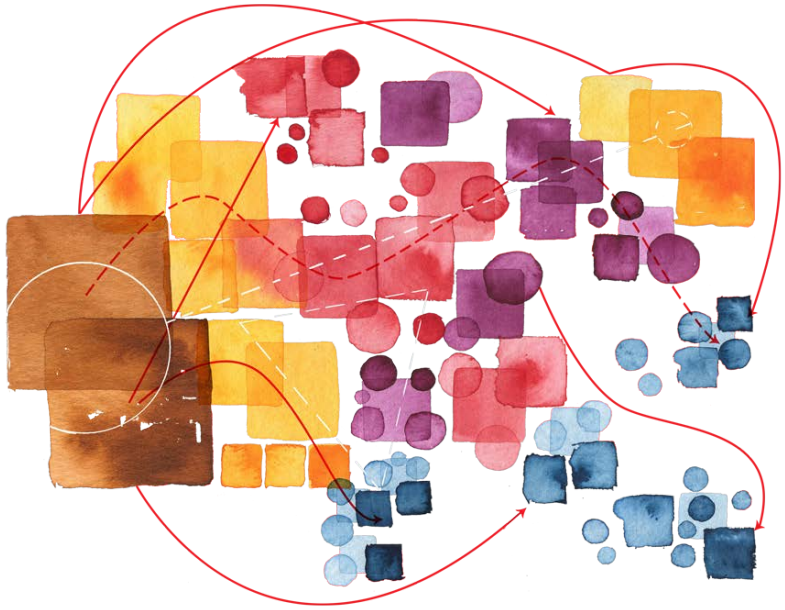
Regulation and Governance — Supply Chains



https://kit.exposingtheinvisible.org/en/what/supply-chain.html

Public Law 111–203
111th Congress

An Act

July 21, 2010
[H.R. 4173]

To promote the financial stability of the United States by improving accountability and transparency in the financial system, to end "too big to fail", to protect the American taxpayer by ending bailouts, to protect consumers from abusive financial services practices, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

Dodd-Frank Wall Street Reform and Consumer Protection Act. 12 USC 5301 note.

SECTION 1. SHORT TITLE; TABLE OF CONTENTS.

(a) SHORT TITLE.—This Act may be cited as the "Dodd-Frank Wall Street Reform and Consumer Protection Act".

Sec. 1502. Conflict minerals.

- **Government actions and NGO efforts have helped establish idea that companies are individually responsible for the impact their business can have, anywhere along their supply chain for earth materials.**
- **The leading international standard for this kind of supply chain due diligence was developed by the Organization for Economic Cooperation and Development (OECD) and the UN.**
- **The future will probably include additional focus on supply chains from consumers.**

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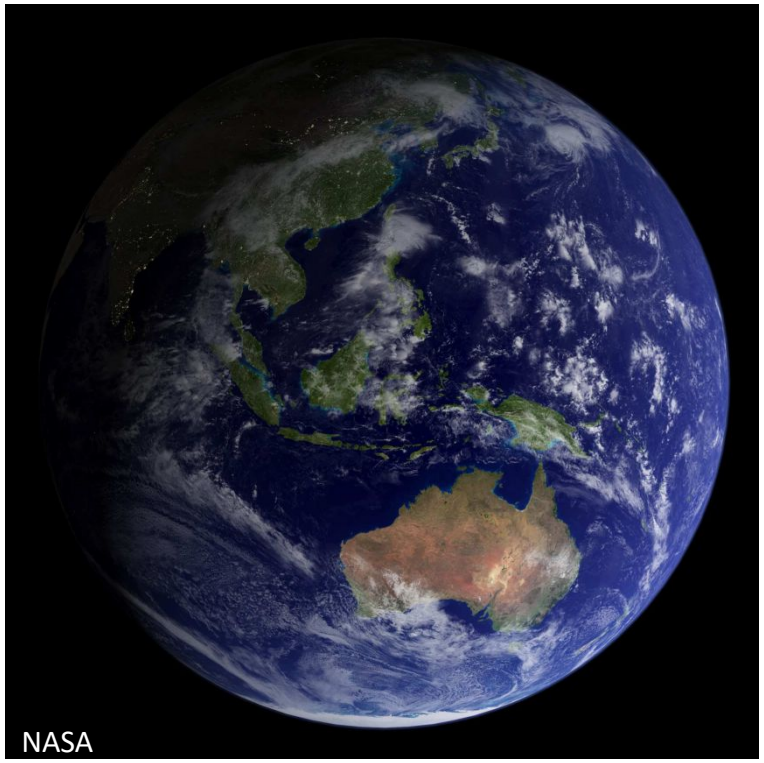
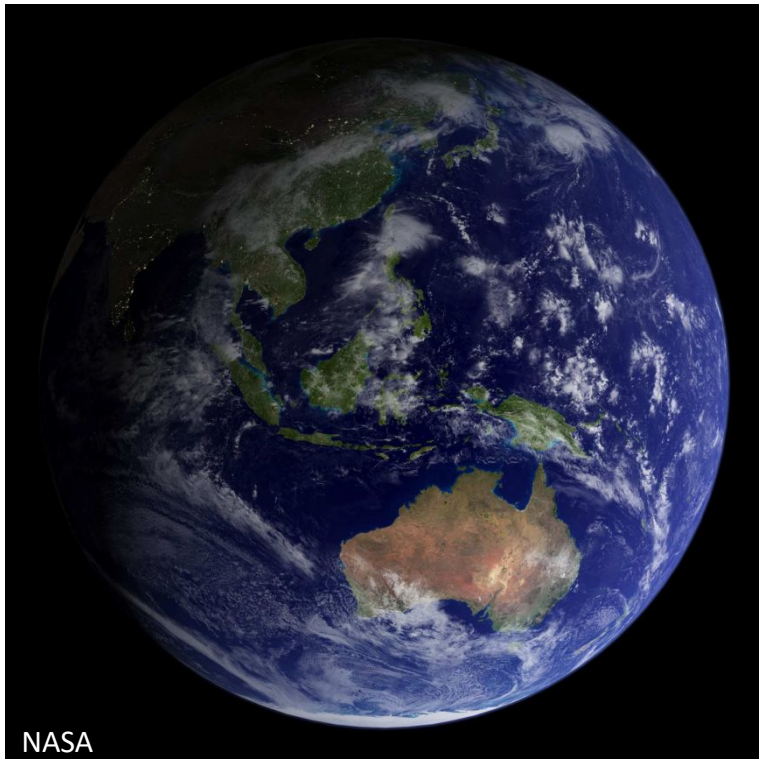
Assessment

- While we have had several centuries to develop means of evaluating the economic aspects of a (mining) project,
- And we have in the past 50 years refined means of conducting environmental assessments of (mining) projects,
- We are still struggling how to adequately assess the highly varied and commonly site-specific social impacts of a (mining) project.



Climate Emergency

- **We need earth materials to allow us to decarbonize our way of life and to provide equitable and just standards of life for all on the planet.**



Climate Emergency

- We need earth materials to allow us to decarbonize our way of life and to provide equitable and just standards of life for all on the planet.
- **However, production of such materials, if not done well, can exacerbate the climate problem through increased energy usage and adverse land use.**

Article | Open Access | Published: 01 September 2020

Renewable energy production will exacerbate mining threats to biodiversity

Laura J. Sonter ✉, Marie C. Dade, James E. M. Watson & Rick K. Valenta

Nature Communications **11**, Article number: 4174 (2020) | Cite this article

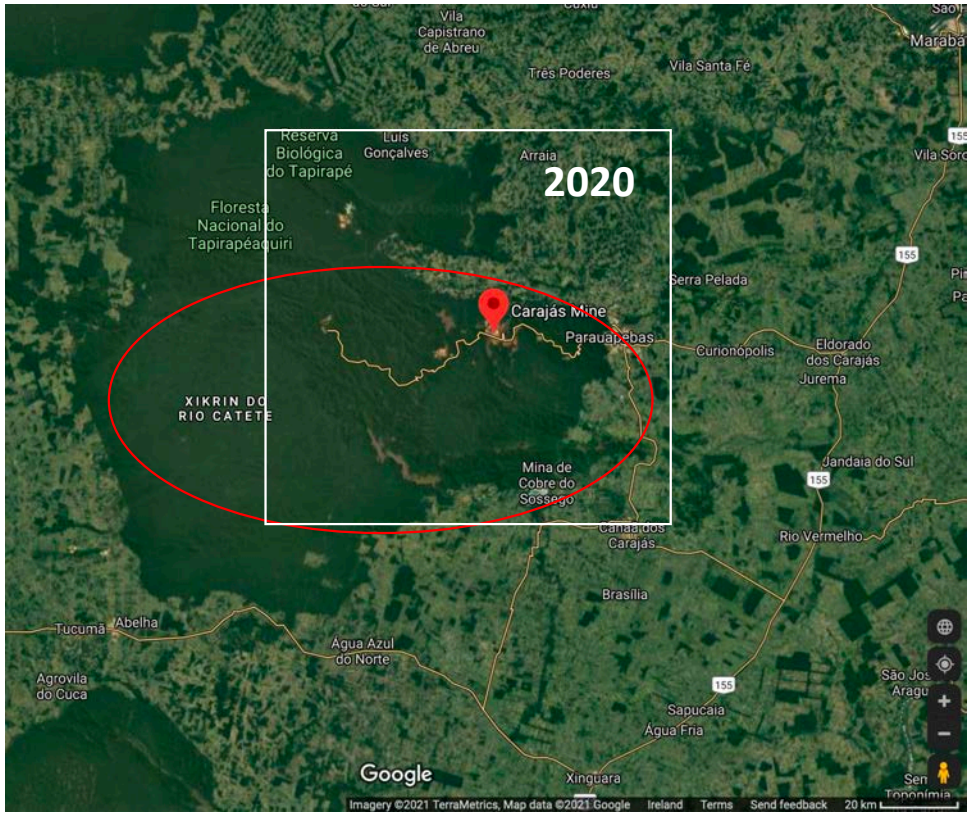
24k Accesses | **4** Citations | **766** Altmetric | Metrics

Abstract

Renewable energy production is necessary to halt climate change and reverse associated biodiversity losses. However, generating the required technologies and infrastructure will drive an increase in the production of many metals, creating new mining threats for biodiversity. Here, we map mining areas and assess their spatial coincidence with biodiversity conservation sites and priorities. Mining potentially influences 50 million km^2 of Earth's land surface, with 8% coinciding with Protected Areas, 7% with Key Biodiversity Areas, and 16% with Remaining Wilderness. Most mining areas (82%) target materials needed for renewable energy production, and areas that overlap with Protected Areas and Remaining Wilderness contain a greater density of mines (our indicator of threat severity) compared to the overlapping mining areas that target other materials. Mining threats to biodiversity will increase as more mines target materials for renewable energy production and, without strategic planning, these new threats to biodiversity may surpass those averted by climate change mitigation.

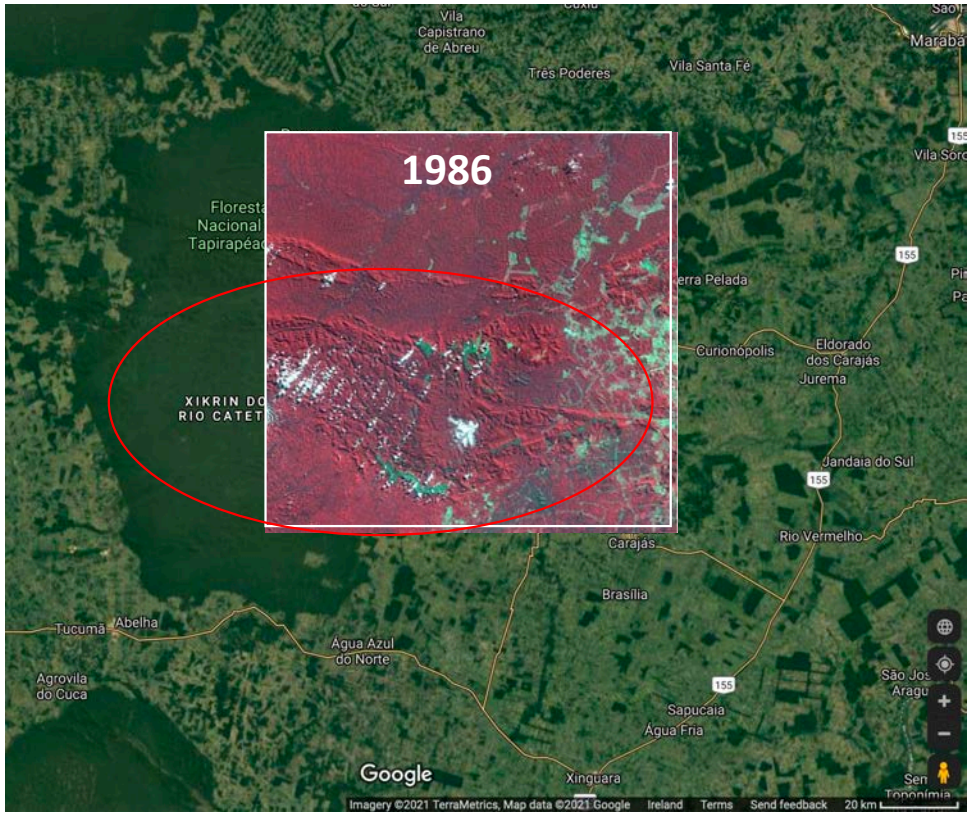
Biodiversity

- **Biodiversity is directly linked to geodiversity, the two cannot be separated and need to be considered together.**
- **Production of earth materials needs to continuously remain cognizant of threats to and opportunities for increasing biodiversity.**



Biodiversity

- Production of earth materials needs to continuously remain cognizant of threats to and opportunities for increasing biodiversity.
- **Google image showing remaining undeforested Amazon jungle south of the Amazon River, Brazil - the forested area is largely the Carajás mining reserve.**



Biodiversity

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https://scentofpine.org/gw101-1/

Earth Materials

- **We have only scratched the surface of the planet in our search for the materials required to build a sustainable future.**
- **We should have no fear of running out of any of these materials in the future, though the location of such resources may be problematic for societal reasons.**

- **The ceiling of the Pantheon in Rome is 2000 years-old, it is the largest unreinforced concrete dome in the world.**
- **We do not know exactly how to make this Roman concrete.**

Hubris ?

Grand Challenges

- The ceiling of the Pantheon in Rome is 2000 years-old, it is the largest unreinforced concrete dome in the world.
- We do not know exactly how to make this Roman concrete.

Hubris ?

- **Technology has allowed us to undertake amazing feats of earth materials production, processing and manufacturing.**
- **While we are adept at evaluating technical, economic, and increasingly environmental aspects,**
- **We lack the knowledge of how to most efficiently recycle what we produce**
- **And we are only now discovering how we properly evaluate and mitigate the societal impacts of such production.**

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- The ceiling of the Pantheon in Rome is 2000 years-old, it is the largest unreinforced concrete dome in the world.
- We do not know exactly how to make this Roman concrete.

Hubris

We must recognize we are on a journey to learn how to sustainably live on our planet and utilize its materials in ways that allow us to solve our multitude of challenges — climate, biodiversity and societal.

One Generation

Our young people have taken up and will be equal to the challenge of ensuring we use earth materials for a sustainable and thriving society.

Owen Daugherty, Thousands skip school in Belgium, for fourth-straight week to attend climate march, The Hill, 31st January 2019, https://thehill.com/policy/international/europe/427871-thousands-of-students-skip-school-for-fourth-straight-week-fo

THANK YOU!

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