TEKTONIKA

The Evolving Role of Science Visuals in Geoscience: From Simple Illustrations to Storytelling Tools

Fabio Crameri *[1,2], **Lucia Perez-Diaz** [3]

[1]Undertone.design, Bern, Switzerland | [2]International Space Science Institute (ISSI), Bern, Switzerland | [3]Earth Scientist and freelance author-illustrator, Oxford, UK

How do you make geoscience figures visible (and relevant) today? In the ongoing battle to make sense of mountains of data, and despite the availability of powerful visualisation tools, many scientists struggle to uphold basic science quality standards like accuracy, accessibility, and reproducibility. In this piece, we discuss the fundamental role of graphics in our pursuit to understand the planet and how, as scientists, colour and pencil experience really matter.

Introduction

Visuals play a pivotal role in communicating scientific ideas. A single well-designed graphic can distil years of research into a compelling, curiosity-sparking device. Beyond representing complex concepts and their interconnections, effective visuals foster discussion and discovery. From field sketches to maps, concept diagrams, and data visualizations, the need for impactful graphics is especially pronounced in the geosciences. The nature of the science, which attempts to understand processes and systems that span vast spatial and temporal scales, often renders words insufficient.

Today, geoscientific graphics are more sophisticated than ever, blending expansive datasets, intricate modelling, and advanced rendering techniques. While this reflects advances in data availability and computational methods, it has also introduced new challenges: overwhelming detail, misinterpretation, and the demand for expertise in visual storytelling.

This article explores the evolving role of scientific graphics and advocates for fostering skills and collaborations to create visuals that are scientifically accurate, visually accessible, and intuitively compelling – all in service of science.

The Early Days: Simple Yet Effective Figures

Consider a seminal geoscientific paper from the 20th century. What images come to mind? In many cases, early graphics were minimalist, constrained by limited data, the absence of colour printing, and nascent understanding. Despite these limitations, these figures were purpose-driven, designed to communicate singular, groundbreaking ideas with clarity – and they were memorable too.

Take, for instance, Alfred Wegener's schematic maps illustrating continental drift or, even earlier, the ones by *Snider-Pellegrini* (1858) (Figure 1). By today's standards, these visuals might appear basic, but their simplicity was a strength, not a weakness: they conveyed powerful messages without unnecessary detail, leaving a lasting impression.

Another landmark visualization in the same field, some decades later, is the single-panel computer-based reconstruction of the South Atlantic produced by *Bullard et al.* (1965) – if you are a geodynamicist, this will have now appeared in your mind's eye without having to look it up either.

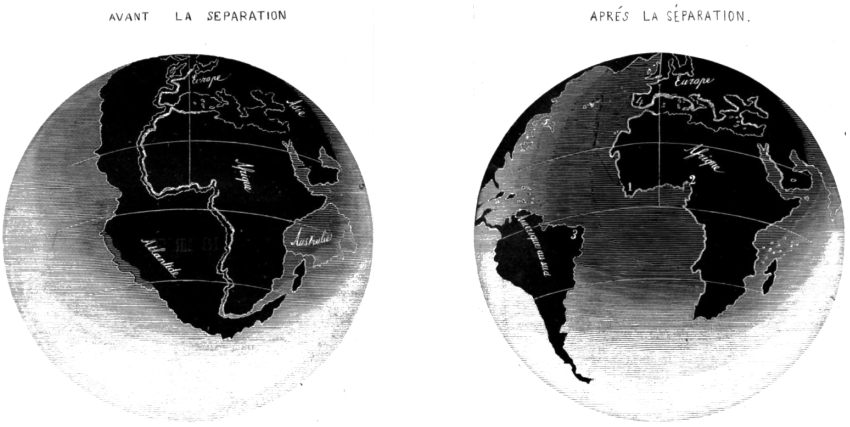
Such illustrations carried an immense impact by focusing on clarity and singularity of purpose. Unlike text, they are very memorable (can you remember any famous quote from any paper you have ever read?). They also do not attempt to provide all the answers, or show all the existing knowledge – they focus on what is most important. For example, Bullard could have superimposed on their figure the regions of occurrence of certain rock types across South America and Africa, but that would have distracted from the message, rather than reinforce it. Early geoscientific graphics avoided overwhelming the viewer with extraneous information, focusing instead on what mattered most.

*✉ fabiocrameri@undertone.design

Geoscience
Graphic evolution

1885

After Snider-Pellegrini (1958)



2025

s-ink.org/plate-tectonic-earth-map

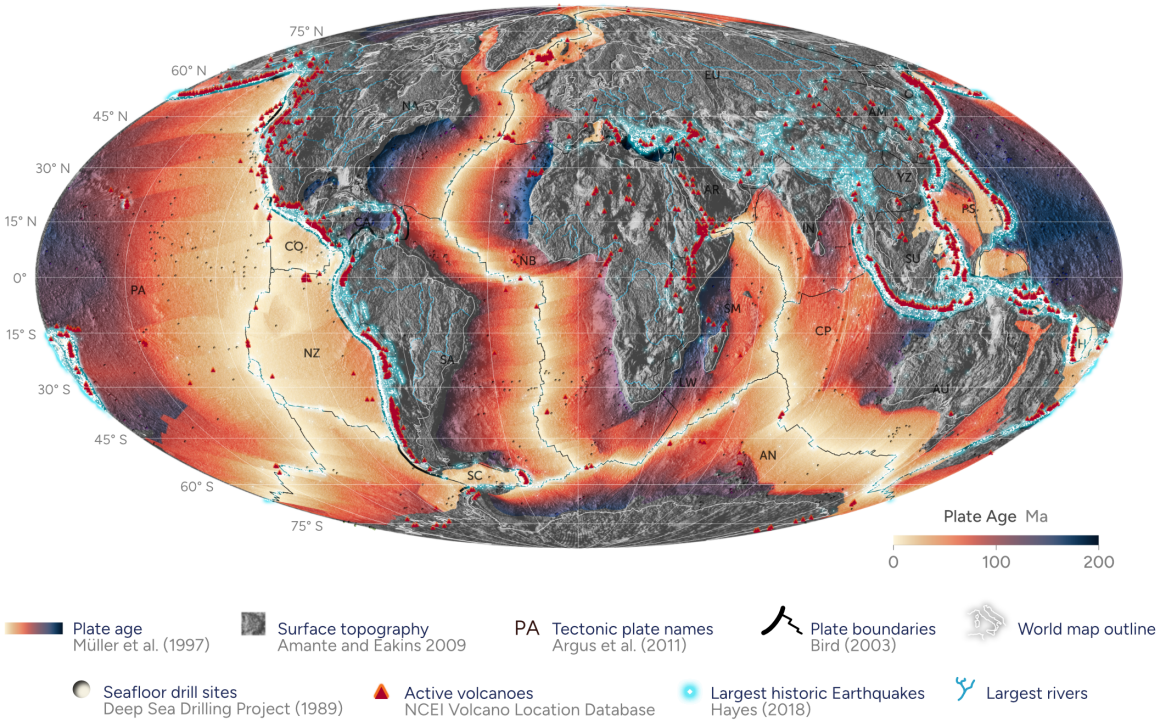


Figure 1 – Early vs. contemporary Geoscience graphics. Back since 1885, and during the early days of the plate tectonic theory, figures were simply conveying one point clearly, such as the shape similarity of some continental outlines in *Snider-Pellegrini* (1858). With today's availability of data and visualisation tools, figure making has become incomparably more sophisticated, needing to tell a story based on a multitude of content. Maintaining visual accuracy and accessibility has become a grand challenge. A professional approach to graphic design is needed. The modern data visualisation is available from s-ink.org/plate-tectonic-earth-map.

The Modern Dilemma: Data Overload and Ineffective Visuals

Over recent decades, advances in data collection and graphic design tools have transformed scientific visuals. However, this progress has come at a price. Today's figures often attempt to encapsulate vast amounts of information, resulting in dense, overwhelming results that confuse rather than clarify (see, for example, figures 1 and 2 in *Zeng et al.*, 2019).

This "more is better" approach can obscure key messages. Effective graphics require more than static representation – they must guide the viewer on a journey. Achieving this demands a careful balance: conveying complexity without sacrificing clarity.

The Role of Storytelling in Scientific Figures

Science holds some of the most fascinating stories of humanity, so, by extension, that makes us (scientists) storytellers "by default". Except, we are not, and most of us do not feel too comfortable about our own ability to strike the required balance to achieve effective storytelling through graphics – retaining scientific accuracy whilst appealing to our viewer's curiosity. Doing this is a powerful way to contribute to scientific advancement, through graphics that illuminate, engage, and inspire.

To tell compelling stories, there are two important tasks: designing with purpose and engaging with audiences (see Figure 2).

The Devil in the Details: Importance of Graphic Design in Science

Nuance in graphic design can make or break a figure, and while some design choices may simply be "nice to have", others are essential, including:

Scientific accuracy

Science figures, in particular illustrations, often need some form of content simplification. As with other aspects of science communication, a fine balance needs to be found between simplicity and richness of information. Simple content is easier to digest but contains less information; more complex content contains more information but can be difficult to grasp. The general rule of thumb is to have one key message per figure.

For any valuable science figure containing a chart or a scale (that is, for most data visualisation), it is imperative that both are accurate. Charts or scales that present certain parts of the data differently than others in an obscure manner are misleading. Two prominent examples are obscure pie charts (*Crameri et al.*, 2022) and colour bars with perceptually-uneven colour gradients (*Crameri et al.*, 2020). Both are unsuitable for accurate data representation because our visual apparatus (eyes, optical nerves, and optical cortex) can neither capture angles nor colours in a straightforward, even manner. Avoiding such pitfalls goes a long way in creating scientifically accurate figures.

While suitable charts are widely available from your visualisation software of choice, scientifically accurate colour gradients are less widely distributed, but openly available from e.g., www.fabiocrameri.ch/colourmaps (*Crameri*, 2018). Such an example, the Scientific colour map 'lipari', is used to accurately represent the age of oceanic plates in Figure 1.

Visual accessibility

To be useful, a science figure should reach its audience. Designing them in a visually accessible manner is, therefore, another must. This includes graphic aspects such as legible typefaces and fonts, colour-blind friendly colour combinations, or sufficiently high contrast ratios between graphical elements (see *Crameri et al.*, 2022, 2024, for in depth information and resources). The easiest way to check for colour-blind friendly colour combinations is to desaturate the figure (doable with any standard graphics software, such as Apple Preview or Windows Image Viewer) and check its readability in greyscale. – Try it out with Figure 1!

Other related aspects, which are easily overlooked, are accessible figure captions (see *Crameri et al.*, 2024), and ALT-text (see *Chiarella et al.*, 2020).

Unobstructed reproducibility

A science figure—like any other scientific publication—should be, at least in principle, reproducible. In particular for data visualisations, reproducibility is important and achieved with (ideally permanent) links to the raw data and clear and easy-to-follow user information. Clearly licencing your science figure (for an example, see the metadata provided on s-ink.org/plate-tectonic-earth-map), or even uploading it to an online archive, such as Zenodo or s-ink.org, helps clarify ownership and copyright for later reuse. Online sharing platforms, in particular, help to distribute your science figure and facilitate their use in papers, presentations, teaching, or outreach.

Non-essential assets

While scientifically accurate and visually accessible figures are the first step, various graphic design assets can enhance their impact. An often overlooked one, unfairly, is empty space. Empty space is probably the most undervalued graphic design aspect in academia, while being massively important. It is the antipode of a highlight, without which a highlight cannot exist.

Academic Figure design guideline

Stage 1: Reflect

Before you start creating any graphics, ask yourself:

- What is the main ***purpose*** of the graphic?
- What is the key ***message***?
- What is secondary?
- Who makes up the ***audience*** (knowledge level, expertise, interests)?
- Are there any ***guidelines*** that you are required to follow (e.g., journal figure guidelines)?

Is this something you need professional help to achieve?
*– **Reach out** to scientific graphic designers and artists!*

Stage 2: Create

Make your graphics:

Scientifically accurate

- ***Scales***, such as axes and colourbars, with evenly spaced ticks and perceptually uniform colour gradients, respectively
- ***Dimensions*** in SI-units and no plural forms

Universally accessible

- ***Legibility*** through clear, sans-serif typeface and suitable font size
- ***Colour-blind readability*** with scientific colour palettes
- ***ALT text*** describing figure content for the visually impaired and machine readability
- ***Captions*** clear, concise, and colour-blind friendly (e.g., don't use words like "green", "red"), citing any re-used elements

Effective

- ***Grids*** help to organise content
- ***Hierarchy*** highlights your main content
- ***Intuitive design*** ensures the viewer can navigate figures without getting lost
- etc.

Engaging

- Consider how your audience interacts with your graphics: what will ***draw them in***?
- ***Familiar elements*** (like commonly used plot types) can lower the intimidation factor

Stage 3: Share

Make your graphics:

Reproducible and reusable

- Clarify any ***used data***
- Add figure ***copyright licence***
- Provide ***adjustable file formats***

Available

- ***Upload figure*** to online repository

Figure 2 – How to design a figure with purpose? Like a scientific study, a successful science figure has a clear purpose, is tailored to its audience and medium, is scientifically accurate and universally readable, effective and engaging, and reproducible and reusable. This guideline is available from s-ink.org/science-graphic-design-guideline.

To boost your figures — and their message — visually, other basic graphic design tools and principles, such as contrast, hierarchy, and continuity, can be learned in a graphic design class, or through the many resources freely available online (from blog posts to YouTube videos).

Engage, then communicate

Scientific visuals are powerful tools for sparking curiosity and fostering understanding, but their impact hinges on more than just accuracy and readability. A meticulously crafted graphic may convey complex information, but if it fails to connect with its audience, its message is lost. The key lies in designing visuals that not only inform but also engage. A whimsical illustration or a relatable cartoon can break down barriers, making science accessible and intriguing for non-specialists. Whether it's a child marvelling at a colourful depiction of Earth's interior or a professional intrigued by a clever social media post, the right graphic can serve as a gateway to deeper exploration.

Effective communication requires empathy (*Perez-Diaz*, 2024). Scientists often consider what they want to say and who their audience is, but truly engaging design goes further. It considers where and how the audience encounters the information and why it matters to them. Lowering the intimidation factor with familiar visuals or adding humour to technical concepts can draw viewers in, transforming curiosity into understanding. By designing graphics with audience engagement in mind, scientists can make their work resonate, fostering a genuine connection to the science behind the image.

Why More Attention and Expertise is Needed

Visuals have never been mere complements to text – they are central to scientific communication. As data complexity grows, so too does the importance of thoughtful figure design. Poorly conceived visuals risk alienating audiences (or even confusing them), but well-crafted graphics can inspire curiosity, illuminate ideas, and foster deeper engagement.

To meet this challenge, scientists—including academic journals (see e.g., the Tektonika Figure Guideline for authors)—must embrace graphic design as a critical skill, investing in training and (where needed) collaborations with visual experts (*Crameri and Hason*, 2024). High-quality visuals require a blend of technical skill, artistic creativity, and audience awareness (*Christiansen*, 2022). A figure designed for a peer-reviewed article will differ from one aimed at public outreach, and scientists must adapt their approach accordingly. In some ways, scientists should learn something from advertisers who routinely promote a single product in a multitude of ways specifically tailored to the media, and not just the audience. Have you noticed how adverts on the concourse of a train station have a lot less text than those inside a train's carriages, where you are sitting down bored instead of rushing through?

Ultimately, the goal of scientific visuals is to communicate knowledge better than text alone. By honing visual storytelling skills, scientists can ensure their discoveries resonate with diverse audiences, inspiring both professionals and the public to engage with the world around them in new and meaningful ways. And if that does not convince you, there is something else: good graphics will get your science (and, by extension, you) noticed.

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Data and software availability

Data sets represented in Figure 1 are from *Müller et al.* (1997); *Amante and Eakins* (2009); *Bird* (2003); *Argus et al.* (2011); *NCEI* (2024); *Hayes et al.* (2012); *Deep Sea Drilling Project* (1989). The Scientific colour maps (*Crameri*, 2018) are freely available from www.fabiocrameri.ch/colourmaps. The original data visualisations shown here are available in various formats from s-ink.org. The handwritten typeface 'Fufu' is available from s-ink.org/fufu.

Declaration of interests

Both authors offer graphic design consulting and training services through www.fabiocrameri.ch/masterclasses and www.luciaperezdiaz.com/workshops, respectively.

Copyright notice

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