

“The Earth is like a...” – teaching geoscience through analogies

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LEARNING THROUGH ANALOGIES

Analogical reasoning helps us make sense of the world. It allows us to use prior knowledge from one domain (“You know how wood floats in water?”) to understand another (“This is similar to how tectonic plates float on the asthenosphere!”), can make abstract ideas relatable and simplify complex ideas (“Floating lower or higher is half the explanation of relative sea level changes”), and trigger new insights (“Does that mean that erosion of the Himalayas will raise the mountain roots...?”).

GOOD ANALOGY USE

Draws on the strengths of analogies and avoids reinforcing or introducing misconceptions. Glynn (2008) recommends teachers:

- 1) make sure students know the (supposedly) familiar *source domain* (or students may *transfer* existing misconceptions);
- 2) clearly establish the *structural relations* between the *source* and the *target domains*;
- 3) be explicit about mapping the source to the target domain (particularly causal features);
- 4) clearly indicate the *limits* of the analogy, where it breaks down or may be misleading.

Analogies

Analogies allow students to apply (*transfer*) their knowledge of a familiar example (the *source domain*) to an unfamiliar example (the *target domain*). To use analogies successfully (*draw inferences*), students must map the relevant similarities (*structural relations*) between the two examples and ignore incidental ones, and know the *limits* of the analogy.

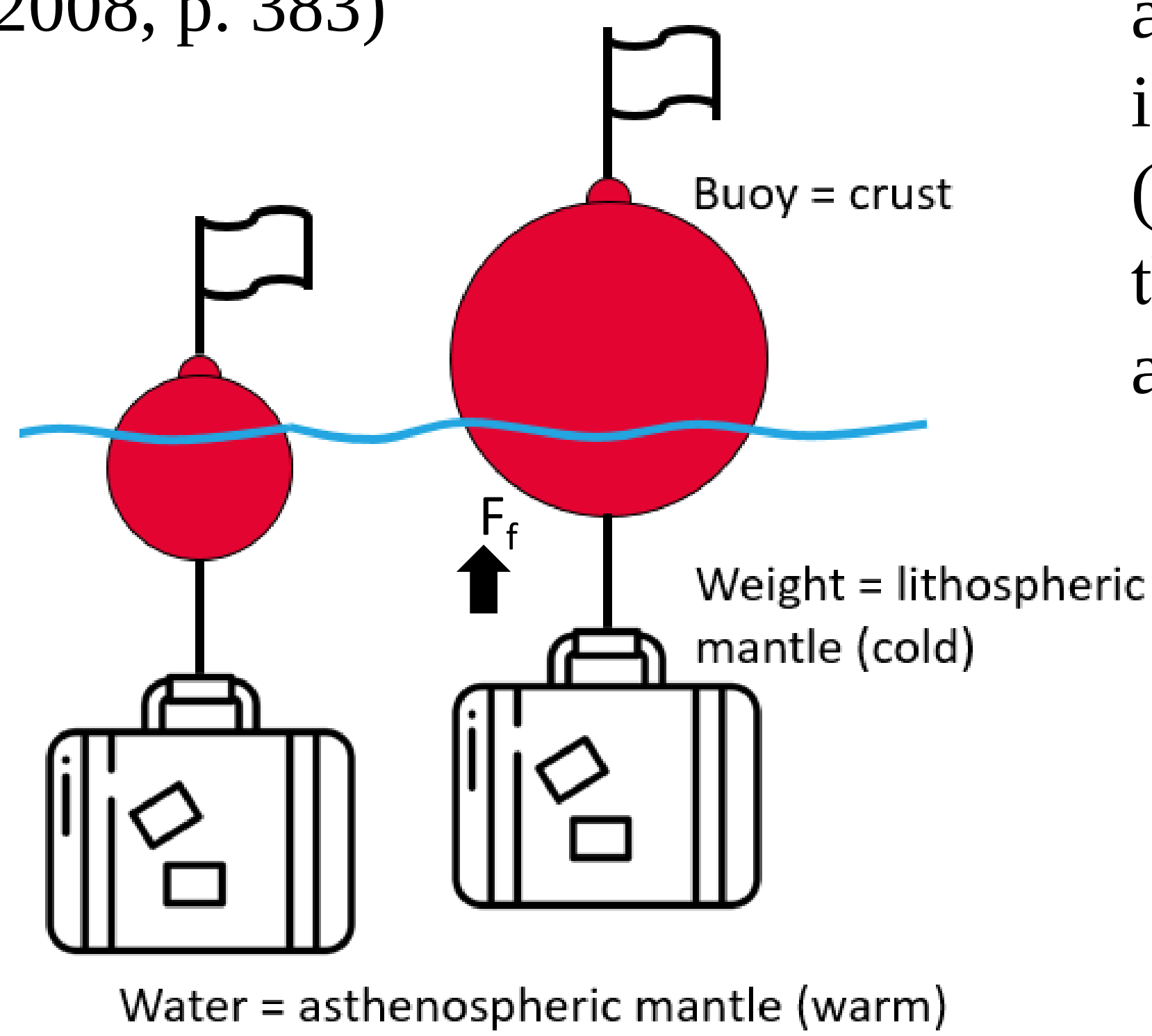
THE CHALLENGE OF USING ANALOGIES

Analogies are powerful teaching tools, but students may not fully understand the *source domain*, may map irrelevant *relations*, fail to grasp the *limits* of the analogy, or the analogy may simply be poorly chosen. In our study of introductory geoscience textbooks (Dunnett et. al, 2024), we found that analogies are very common, but only 1/3 are fully explained. As illustrated below, the physics implied by some analogies is also incorrect.

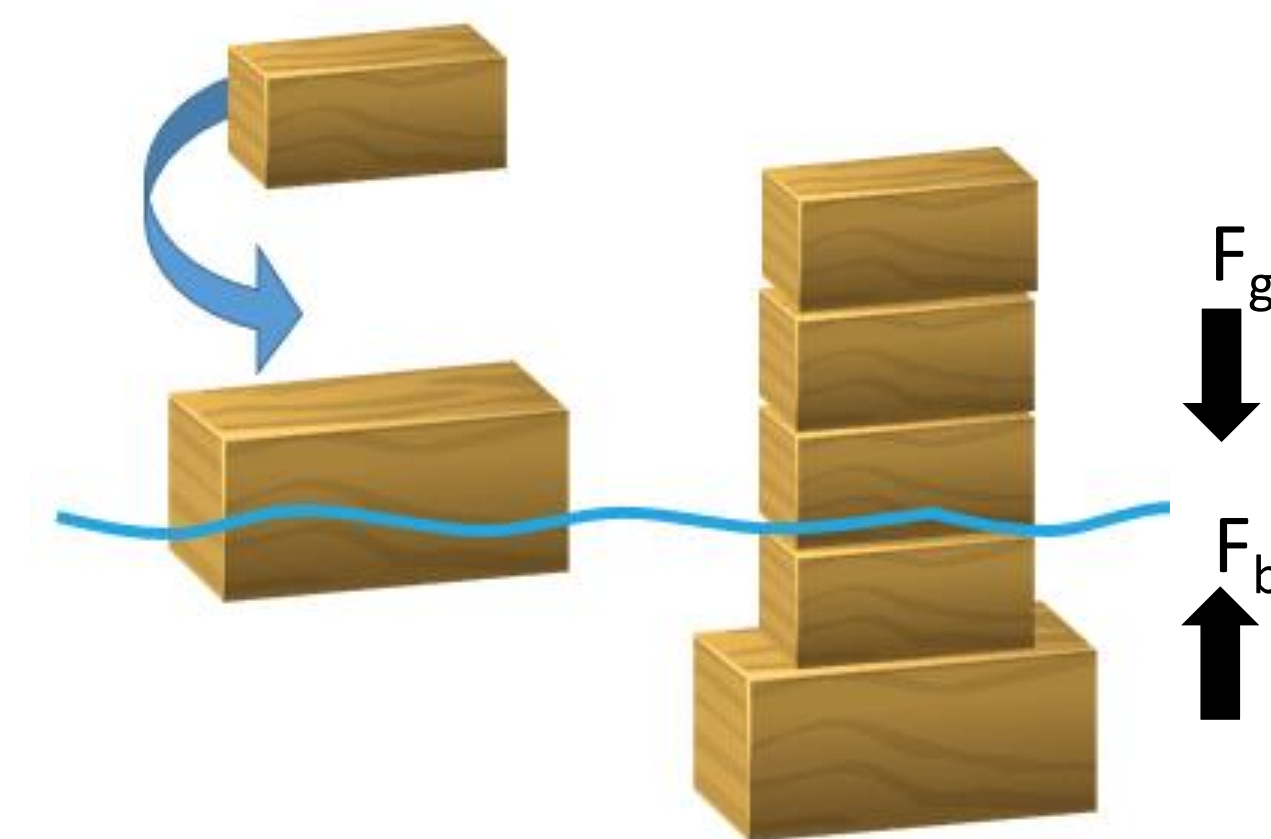
EXAMPLE FROM INTRODUCTORY TEXTBOOK IN GEOSCIENCES

Statement: “*the crust acts like a buoy that holds the lithosphere up; the bigger the buoy (the thicker the crust), the higher the lithosphere floats*” (Marshak, 2008, p. 383)

Previous mapping of the analogy: In the source domain, “*an object attached to a larger buoy will float higher*”, while in the target domain, the “*continental crust lifts up the lithospheric mantle below it*” (Jee et al., 2010).



At first glance, the buoy-analogy seems appropriate. Drawing the situation and comparing to another analogy (blocks-of-wood-in-water) shows that it introduces unnatural behavior of the lithosphere (rising with thicker crust) and a fictitious force (F_f) that “*holds up*” or “*lifts up*” the lower layer (in addition to gravity F_g and buoyancy F_b).



RECOMMENDATIONS

- Analogies should be used carefully and explored fully with the students (Glynn 2008).
- If an analogy illustrates the *physics* of the Earth’s behavior, we suggest adding a 5th item to Glynn’s recommendations: explicitly check that the underlying physics of the source and target domain match (e.g. draw the force diagrams).

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