

Evaluation Brief EB4
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Communicating about Geological Concepts with Park Visitors

When designing interpretation, a common mistake developers make is starting out by talking about where they want visitors to end up. In other words, if we want them to learn about xxx, we tend to explain xxx to them, perhaps along with some important underlying constructs. An alternative—and highly successful—strategy is to start where visitors **are** and create a conceptual bridge, or series of steps, to get them to where we want them to be.

Similar to research and evaluation in other disciplines, the phase-one formative evaluation of the *Trail of Time* indicated that visitors tend to think about the Grand Canyon and its rocks in very different ways than geologists do (Gyllenhaal & Perry, 2004). In fact, other research indicates that even college students who have recently passed courses in basic geology still harbor ideas that differ widely from what they have been taught (Kusnick, 2002; Libarkin & Anderson, 2005; Libarkin, Anderson, Dahl, Beilfuss, Boone, & Kurdziel, 2005).

If even college courses have left many students thinking about the rocks in non-geological ways, then what hope is there for the *Trail of Time*? Kusnick (2002) claims that,

The schooling experiences that most dramatically shape the belief systems of the budding geologist are experiential: Field camp, problem-solving field trips, and the apprenticeship of graduate school. These experiences require an immersion in the thought patterns of geology, building core beliefs about the nature of the geological world (p. 38).

Kusnick also points out that traditional models of geological education often introduce these sorts of experiences at the senior level of college or graduate school, but that much earlier “authentic experiences can help students avoid misconceptions that may be difficult to overcome later in their education” (p. 38).

Perhaps we should view the *Trail of Time* as an authentic experience for the general public—a way to start them out on their journey towards geologic understanding. However, to be successful, the *Trail of Time*'s interpretation will need to effectively help visitors evolve their basic ways of thinking about rocks and landscapes and how they form, and provide them with the appropriate guidance and support to help them along their geology-learning journey especially given that they are arriving at the Grand Canyon with some very natural and deep-seated alternative understandings.

Many visitors have alternative ways of thinking about geology

In order to design effective interpretation, it is essential that we understand visitors' alternative ways of thinking about geology, and start our interpretation at that point. Following is a brief overview of what the research indicates will be the primary alternative conceptions visitors to the rim will bring with them.

A “rock” is something relatively small and discrete, like a pebble or stone. When geologists think “rock” they envision either a category of Earth material (like limestone or sandstone) or a large-scale, continuous mass within the Earth (like the Kaibab Limestone or Coconino Sandstone). To most non-geologists a “rock” is a much smaller bit of material, commonly something they can hold in their hands (Kusnick, 2002). That means geologists and visitors may mis-communicate when talking about rocks. For



instance, the question, *How did this rock form?* has very different meanings for geologists and non-geologists. “The geologist translates the question as *To what category of rock type does this sample belong, and what is the process by which rock in that category forms?* Many students translate the question to mean, *How did this sample get to be a pebble?*” (Kusnick, 2002, p. 34).

Outcrops are just big chunks of rock embedded in the dirt. When visitors see large bodies of rock in the field, they may consider them to be big discrete chunks of rock embedded in a mass of dirt and stones—not surface manifestations of much more extensive and continuous underlying layers (Ault, 1984; Kusnick, 2002). In other words, many visitors do not understand the concept of *bedrock*. They may see continuous bands of color and shelves of rock in the walls of the Grand Canyon, yet fail to realize that these represent continuous layers of rock that stretch for miles underground—and that once stretched all the way across what is now the Grand Canyon.

Rocks form on human scales of time and space. Visitors may think about geologic processes as happening on human scales of space and time. For instance, even when college students can quote the age of the Earth correctly, they may still talk of rocks as forming on amazingly short time scales (Kusnick, 2002).

The Earth is mostly stable and unchanging. Visitors to the Grand Canyon, in their everyday lives, often think of rocks and landscapes as unchanging. For instance, they may believe that hand-specimen rocks found on the ground or in a stream formed where they are found (Kusnick, 2002).

Humans have dominated Earth-shaping processes. Because many people think of the earth as relatively stable, it’s not surprising that they think of Earth-shaping processes as being the result of human interference. Kusnick (2002, p. 36) explains that people often have difficulty “imaging a world operating independently of human activity. When they envision the geologic world, humans are in the foreground.”

Any changes to the Earth took place long ago. When confronted with something as dramatic as the Grand Canyon, many visitors are tempted to think about how it formed. However, research indicates that these visitors think of the Canyon as forming in the past and as now essentially complete (Gyllenhaal & Perry, 2004).

When the Earth changes, it does so through catastrophic events. Visitors also tend to believe that any changes to the stable Earth involved large-scale catastrophic events, like earthquakes or explosive volcanic activity (Kusnick, 2002). During the phase-one formative evaluation, some visitors attributed the formation of the Canyon to an asteroid crash, “the big bang,” gigantic glaciers, or huge lakes that once filled the Canyon (Gyllenhaal & Perry, 2004).

Rocks grow from pebbles. Some visitors bring alternative explanations about how rocks form. For instance, they think that rocks are formed “by sediments sticking together in the bottom of a river to make pebbles. These pebbles grow larger by accretion of more sediment” (Kusnick, 2002, p. 34). Thus some visitors’ ideas may be inspired by an incomplete knowledge of geology (e.g., sediments become rocks), but they do not think on a scale that allows them to understand the formation of extensive layers of sedimentary rock.

Rock layers grow thicker at a continuous rate. Even when visitors have enough background in geology to recognize that sedimentary rocks accumulate in layers, they may still “put undue emphasis on both size and numbers of layers when considering the age of geological layers” (Dodick & Orion, 2003, p. 436). For instance, they may want to mark off “the strata into equal portions of time, almost as if they were units on a physical ruler” (p. 436). An example of this was the Grand Canyon visitor who guessed that the *Trail of*



Time's prototype markers were equivalent to steps down into the Canyon—go down 100 steps, get to 100 million-year-old rock (Gyllenhaal & Perry, 2004).

The Grand Canyon is all about the huge hole in the ground and how it formed—the rocks are just background for the hole. Many respondents in the phase-one study were amazed by the vast dimensions of the Canyon, and many were wondering about its origins. They saw the rocks as beautiful for their shapes and colors, but the rock layers themselves were not particularly meaningful to these visitors or the source of much speculation as to their origins (Gyllenhaal & Perry, 2004). These visitors might be surprised to discover that the *Trail of Time's* interpretation was almost all about the rocks—not the Canyon and how it formed.

The placement of markers along the Trail of Time has special meaning – they are specifically linked to a particular spot. Many respondents in the *Trail of Time* phase-one evaluation tried to link the periodic markings to (a) the elevation of the *Trail* at that point, (b) events that took place at that specific point, or (c) landscape features they could see especially well from that point (p. 22). These visitors had not achieved a basic understanding of what the *Trail* was all about. They did not realize that the *Trail* was an abstract timeline draped along the rim of the Canyon, and that the location of the markers was relative to that abstract timeline rather than to features or events in the Canyon (Gyllenhaal & Perry, 2004).

Timelines have to be vertical. The *Trail of Time's* horizontal timeline confused many visitors, often those who already understood that vertical rock layers showed the passage of time. For instance, many visitors had trouble figuring out how to relate the markings on the horizontal *Trail* to the vertical layers of rock in the Canyon walls (like the visitor, mentioned above, who guessed that the markers were exactly equivalent to steps down into the Canyon). A few insisted that the *only* acceptable way to portray a geologic timeline was vertically (Gyllenhaal & Perry, 2004).

What comprises a basic understanding of the Canyon's rocks?

The previous section focused on visitors' alternative ways of thinking. This section focuses on how geologists think and how visitors could begin to think more like geologists do. Combining basic understandings from several of the knowledge hierarchies reported in the phase-one evaluation, here is one possible set of basic concepts that underlie a more sophisticated understanding of the Canyon's layered rocks (Gyllenhaal & Perry, 2004). In other words, we are suggesting that the following set of concepts is at the intersection of what visitors will be able to grasp, and what geologists know—virtual first steps, so to speak.

- **Bedrock.** The color bands in the Canyon walls represent rock layers that are widespread and continuous under the surface for long distances. (This expresses the concept of *bedrock* as related to the Park.)
- **Formerly continuous.** These rock layers once ran continuously through the now-empty space occupied by the Grand Canyon.
- **Naming.** These rock layers can be recognized and named throughout the Park by matching them to color bands, cliffs, slopes, and benches in the Canyon walls.
- **Sediments.** These now-solid rocks were once dispersed materials, called sediments, like sand and shells.
- **Environments.** These materials accumulated in particular environments that once existed here, when the land was near or below sea level. Different materials accumulated in different environments.



- **Simultaneity.** Each of these continuous layers formed at (about) the same time in the distant past—geologists can assign an age date to each layer.
- **Superposition.** The bottom layers formed first, and then the upper layers were deposited on top of them.
- **The Rock Record.** Within each rock layer, we can see evidence of what happened during and after that rock’s deposition. That’s why geologists say, “Rock layers record the history of the Grand Canyon.”
- **Unconformities.** The Canyon’s rock layers recorded some parts of the Canyon’s history, but not others. The “gaps” in the rock record are called unconformities.

Recommendations for the prototype *Walking Guide*:

- **Limit the content in the guide to focus on a few (four or five) of the basic geology concepts listed above.** Reinforce these concepts throughout the *Guide*’s text and graphics. For instance, the *Guide* could emphasize interrelated stratigraphic concepts, such as *Bedrock*, *Naming*, *Simultaneity*, *Superposition*, and *Unconformities*. Each of these concepts should be introduced and then reinforced at several places throughout the *Guide*. Topics such as the uplift and erosion of the Canyon, sediments and sedimentary environments, and the record of changing environments may be mentioned within the context of these primary concepts, but more detailed discussions of these concepts should be reserved for later stages of the *Trail*’s interpretation.
- **Deliberately address each alternative understanding listed above.** For example:
 - Throughout the *Walking Guide*, emphasize that vast, incredible, sweeping changes have taken place during the Canyon’s history. The Earth here was anything but stable.
 - When the term “rock” is used, make it clear that the *Guide* is discussing the rock layers that underlie the Grand Canyon and that these are vast and continuous in scope—that they are more than “big chunks of rock embedded in the dirt.”
 - The text for the erosion of the Canyon (at 6 million years) should emphasize that the Canyon was eroded by water flowing into and through the Colorado River and its tributaries. Later stages of *Trail* interpretation can discuss evidence for this timing. We also recommend portraying 6 million years as an incredibly long time—long enough for the falling and running water to do its incredibly vast work.
 - Carefully introduce the concept of unconformities (but without specifically addressing the concept of rates of deposition). Perhaps the idea of *gaps* can be raised as an answer to a question that visitors may naturally ask about the *Trail of Time*. That question could be something like, “Why are there big stretches where nothing happens along the *Trail of Time*?” The answer could be, “That’s because there were long stretches of time when no rock was formed here at the Grand Canyon—or when existing rock was eroded away.”
 - Think about the goals of the Grand Canyon’s Rock Layers image, and then make sure the image’s text supports those goals. For instance, the goals may be to (a) illustrate that the oldest layers are deepest in the Canyon, (b) show that the rock layers continue below the surface, and (c) give examples and pronunciations of the naming of rock layers. Develop text that supports those goals.
- **Design to stimulate and facilitate conversation.** Design the *Walking Guide* text to encourage visitor groups to talk about it among themselves. For instance, write the text so that parents can easily read and discuss the concepts with their children and others in their group. This does not mean using child-like storytelling devices. Rather, using straightforward text and reinforcing basic concepts works for all



groups that include members who are less familiar with geologic concepts, regardless of whether those group members are children or adults.

- Test the *Walking Guide* iteratively through at least two rounds of on-site formative evaluation.

References

- Ault, C. R., Jr. (1984). The everyday perspective and exceedingly unobvious meaning. *Journal of Geological Education*, 32(2), 89-91.
- Dodick, J., & Orion, N. (2003a). Cognitive factors affecting student understanding of geologic time. *Journal of Research in Science Teaching*, 40(4), 415–442. http://stwww.weizmann.ac.il/g-earth/articles/whole_articles/jrst_article.pdf
- Gyllenhaal, E. D., & Perry, D. L. (2004). *Phase one of formative evaluation for the Trail of Time at Grand Canyon National Park*. Unpublished manuscript, University of New Mexico, Albuquerque, NM. <http://www.selindaresearch.com/TrailOfTimeFormativeFINAL.pdf>
- Kusnick, J. (2002). Growing pebbles and conceptual prisms - Understanding the source of student misconceptions about rock formation. *Journal of Geoscience Education*, 50(1), 31-39. http://www.nagt.org/files/nagt/jge/abstracts/Kusnick_v50n1p31.pdf
- Libarkin, J. C., & Anderson, S. W. (2005). Assessment of learning in entry-level geoscience courses: Results from the Geoscience Concept Inventory. *Journal of Geoscience Education*, 53(4), 394-401. <http://newton.bhsu.edu/eps/libarkinanderson2005JGE.pdf>
- Libarkin, J. C., Anderson, S. W., Dahl, J., Beilfuss, M., Boone, W., & Kurdziel, J. P. (2005). Qualitative analysis of college students' ideas about the Earth: Interviews and open-ended questionnaires. *Journal of Geoscience Education*, 53, 17-26. <http://newton.bhsu.edu/eps/libarkinetalJGE2005.pdf>

