

Summative Evaluation of the

TRAIL OF TIME

AT GRAND CANYON NATIONAL PARK

for University of New Mexico

Selinda Research Associates, Inc.

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ABSTRACT

The *Trail of Time* is a 4.56 km (2.83 mile) long geologic timeline trail on Grand Canyon's South Rim, designed to give visitors a visceral appreciation for the magnitude of geologic time within the context of Grand Canyon. This summative evaluation was the final stage in a multipart evaluation effort for the *Trail of Time* project, seeking to answer the question: "In what ways and to what extent do visitors develop a greater understanding of and appreciation for deep time and geology based on their experiences along the *Trail of Time*?" To answer this question, the study used a naturalistic methodology and a variety of quantitative and qualitative methods, including tracking and timing, unobtrusive observations of Park visitors walking the *Trail*, and depth interviews with selected respondents.

Data indicated that the completed *Trail of Time* contributed in positive ways to many respondents' experiences as they walked between Grand Canyon Village and Yavapai Geology Museum. It inspired many respondents to think and talk about the rocks of the Canyon, their ages, and geologic processes such as erosion and volcanism in ways that weren't happening during earlier formative evaluation studies. The *Trail* enhanced visitors' walks along the rim by giving them up-close looks and sensory experiences with rocks from the Canyon's depths. It also facilitated meaningful social engagements within some groups, as children counted off the markers together, friends helped each other understand what they were seeing through the viewing tubes, and people of all ages talked with each other about the rocks mounted on plinths. The *Trail* also gave intergenerational social groups new ways to keep younger children interested during their long walks along the Canyon's rim.

Many respondents gave evidence of being thoughtful and reflective along the *Trail*, especially as they talked about the ages of the rocks exposed in the Canyon. Some visitors gained a visceral or gut feeling for the immensity of geologic time. The *Trail of Time* was a complex and challenging exhibition and it took concentrated attention and committed time to figure out what it was and what it was trying to accomplish. Some visitors achieved an integrated understanding of the *Trail*. The data indicated that even when visitors focused mainly on the aesthetic—rather than interpretive—aspects of the Canyon, many also talked to noticed and talked about the plinth rocks and their ages, and sometimes about other interpretive elements along the *Trail*. Many of these respondents used vocabulary from the waysides and other signs and talked about *Trail of Time* concepts, including as they described their aesthetic experience of the Canyon.

The *Trail of Time* was a significant addition to the visitor experience at the South Rim of Grand Canyon National Park, reaching visitors with many levels of interest in and knowledge of the Canyon's geology. This report includes recommendations for improving the effectiveness of various components of the *Trail* and for ways that Park staff can support visitors' use and understanding of the *Trail of Time*.



EXECUTIVE SUMMARY

Introduction. The *Trail of Time* is a 4.56 km (2.83 mile) long geologic timeline trail on Grand Canyon’s South Rim composed of three segments, two of which were fully developed as of July, 2010, and were evaluated in this report. The *Trail* is designed to give visitors a visceral appreciation for the magnitude of geologic time within the context of Grand Canyon. The main *Trail of Time*—referred to as the *Deep Time Trail*—is a 2,000-meter segment, with each meter representing one million years of geologic history at the Grand Canyon. The *Million Year Trail* stretches eastwards from the *Deep Time Trail*’s time zero, serving as an introduction to the *Trail* for visitors walking from the east. The *Million Year Trail* moves visitors through a series of changing time/distance scales to help shift from the more familiar human perspective (years) to decades, centuries, millennia, hundreds of thousands, and finally to the million-year scale of the *Deep Time Trail*. The *Early Earth Trail* (which was not complete during our July visit to collect observation and interview data), begins at the *Deep Time Trail*’s 2,000 million year marker and stretches to Maricopa Point for an additional 2,560 meters. Maricopa Point represents the age of the Earth, almost 4.6 billion years.

Trail components.¹ *Trail* segments and entry points are demarcated by four plazas called **portals**.² The portals include signage and three-dimension cross-sections of the Canyon built of real rocks. Numbered bronze **markers** are embedded in the asphalt to mark time along the *Trail*. Thirteen interpretive **wayside signs** are located at intervals along the *Deep Time* and *Million Year* segments of *Trail of Time*.³ Spaced along the *Trail* are eight **viewing tubes** to help visitors connect wayside interpretation with geologic features within the Canyon. A total of 46 **rock plinths** are located along the two *Trail* segments. Atop each concrete plinth is a large sample of rock representing one of Grand Canyon’s named rock formations (such as Kaibab Limestone or Vishnu Schist). Additional interpretation available to *Trail of Time* visitors includes the **activity guide**, a brochure available at dispensers built into each portal plaza.

Overview of the evaluation. The summative evaluation was the final stage in a multipart evaluation effort, which included numerous formative evaluation studies conducted from 2004 to 2010. The goal of the summative study was to provide answers to the following research question: “In what ways and to what extent do visitors develop greater understanding of and appreciation for deep time and geology based on their experiences along the *Trail of Time*?” To answer this question, the evaluation team collected data on the range of ways that visitors engaged with, thought about, and felt about the *Trail*. We also assessed a broad range of learning outcomes of the *Trail of Time* experience.

Methodology and methods. The study used a naturalistic methodology.⁴ During the week of July 25-31, 2010, we conducted a four-day site visit with four researchers on site at Grand Canyon National Park. The evaluation team used a variety of quantitative and qualitative methods to

¹ All *Trail* components are described in detail and illustrated by photographs in Appendices A and B.

² An additional portal sign was installed at the far end of the *Early Earth Trail* after data collection was complete.

³ Three additional waysides have since been installed along the *Early Earth Trail*

⁴ Terms like “naturalistic methodology” and “depth interview” are defined in the Methodology and Methods section, below.



collect data for this study, including unobtrusive observations of visitors walking the *Trail*, and depth interviews with selected respondents. Respondents for this study were casual Park visitors observed and/or interviewed in their naturally-occurring social groups. In addition to the unobtrusive observation and depth interviews conducted during the July site visit, tracking and timing data were also collected throughout the months of July and August. Respondents for the tracking-and-time portion of this study were randomly selected according to an established protocol.⁵ Respondents for the rest of this study were *purposively* selected based on the results of previous data sets in order to achieve the greatest variability in data.

Overview of findings. Data indicated that the completed *Trail of Time* contributed in positive ways to many respondents' experiences as they walked between Grand Canyon Village and Yavapai Geology Museum. It inspired many respondents to think and talk about the rocks of the Canyon—and the ages of the rocks—in ways that weren't observed during the formative evaluations when the *Trail* was incomplete and components were being tested independently. The *Trail* enhanced respondents' walks along the rim by giving them up-close looks and sensory experiences with rocks from the Canyon's depths, and it facilitated meaningful social engagements within some groups, as children counted off the markers together, friends helped each other understand what they were seeing through the viewing tubes, and people of all ages talked with each other about the rocks mounted on plinths. It also gave intergenerational social groups new ways to keep younger children interested during their long walks along the Canyon's rim, and interpretive staff a context to discuss geology with visitors.

Use of the Trail. Of the 117 tracking-and-timing respondents tracked from either the east (Yavapai) or west (Village) end of the *Trail*, about a third (35%) walked the entire length of the *Million Year* and *Deep Time Trails* from one end to the other, 15% exited at the halfway point, and half (50%) entered and exited at the same point, usually walking just a short distance in, and then reversing direction and retracing their steps. The average length of time respondents took to walk the entire trail was 49 minutes, with the quickest trip (not counting joggers) being 23 minutes, and the longest an hour and a half. With a total of 71 components (13 interpretive wayside panels, 46 large rock samples on plinths, 8 viewing tubes, and 4 two-sided interpretive entry portals), 87% of all respondents stopped at one or more of these components. Respondents stopped at an average of 13 of the 71 components (18%). The average visitor stopped at 4 of the 13 waysides (32%), 3 of the 8 viewing tubes (32%), and at 6 of the 46 rock plinths (13%).

Respondents' engagements with the Trail of Time. Most visitors to the Trail of Time tended to be primarily focused on the view and/or with other members of their social group. When respondents stopped to engage with the *Trail*, many did so whole heartedly. These committed respondents counted markers as they walked, studied maps at portals, read wayside signs, peered through viewing tubes and touched—even caressed—the rocks on plinths. Respondents commonly stood together as they read signs or looked through viewing tubes. Many of the teaching-learning interactions we saw were parents talking with and explaining things to younger children. Many respondents gave evidence of being thoughtful and reflective along the *Trail*, especially as they talked about the immense age of the rocks exposed in the Canyon. Some respondents also described aesthetic experiences with the rocks on plinths, talking about the

⁵ See the Methods section and Appendix E.



colors, patterns, textures, and feel of the rocks. Fittingly, it was clear that, for most respondents, their strongest emotional engagements were with the Canyon. One of the goals of the *Trail of Time* project was not to detract from visitors' experiences of Canyon itself; there were many indications that this goal was achieved for most visitors.

Effectiveness of the portals. Tracking and timing data indicated that about half the respondents stopped at a portal as they were entering the trail. The portals appeared to fill an important role for meeting respondents' orientation needs. Many respondents read at least a few words of introduction to the *Trail*; some read "*Trail of Time*" aloud to others in their groups as they walked past without stopping. However, the portals were less effective at helping respondents understand the full meaning of the *Trail of Time*. In part because these cross-section structures were not labeled, many respondents did not figure out what the structures were and what they signified.

Effectiveness of the markers. Children often took the lead in noticing and paying attention to the markers. As they started walking west along the *Million Year Trail*, children often counted off the markers one-by-one, drawing their caregivers' attention to the numbered markers. Many adults in all-adult groups—including many who looked at rock plinths and waysides—did not pay much attention to the markers. Also, respondents walking east from the Village seemed less likely to notice the markers than when they began their journeys from Yavapai. Data indicated that many respondents did not integrate the markers, signage, viewing tubes, and rock plinths into a complete *Trail of Time* experience.

Effectiveness of the wayside signs. More respondents stopped at the wayside signs than any other component; a few waysides attracted the attention of more than half the respondents who passed them. Many respondents appreciated the wayside signs for both their geological (and historical) content and their maps and orientation information. Some waysides helped readers make sense of important ideas (like Canyon cutting and the age-relations of layered rocks). Waysides with particularly complex concepts such as uplift and unconformity were less effective for many visitors. The data indicated that the read-at-a-glance conversational titles helped some visitors quickly grasp the focus and main message of the signs.

Effectiveness of the viewing tubes. The viewing tubes seemed effective at linking the rocks on plinths to the rock bodies in the Canyon. Most visitors we talked with realized the rocks on plinths had been brought up from deep within the Canyon, even though this was never explicitly explained to them in signs. Because of that, most also realized the rocks deep in the Canyon were very, very old. The data indicated that the viewing tubes—a relatively low-tech and straightforward technology that has long been used in national parks—were helpful for some visitors to link points along the horizontal timeline to rock layers in the Canyon's walls, a primary challenge of the *Trail*.

Effectiveness of the rock plinths. The inclusion of the rocks on plinths transformed many visitors' experiences along the *Trail* in a number of positive ways. A large part of the rock plinth experience was touching the rocks and looking closely at them. Many children and adults ran their hands over the rocks and then talked about how their surfaces felt and how beautiful the rocks were. Some caregivers asked sensory questions to focus young children's attention. Many



respondents noticed and appeared to appreciate the ages of the rocks, and many times we heard respondents talking about how old a rock was. When respondents paid attention to the rock names on the plinths, they most often focused on the second more familiar part of the name, (e.g. limestone), rather than the formal name of the formation (e.g. Kaibab). Respondents often talked about the different rock types—granite, sandstone, limestone—remembering other places they had encountered those types of rocks. The “touch me” label on each plinth appeared to be effective, as there was little visitor hesitation to touch the rock exhibits. Whereas the minimal plinth interpretation was necessary to minimize information overload and intrusiveness of the exhibit rocks, many respondents were left with unanswered questions about the rocks (including parents who couldn’t answer their children’s questions). The data indicated that the rock plinths stimulated much interest, but some respondents passed on misinformation as they tried to explain the rocks to their companions. This may suggest that additional information in a brochure, for example, would be useful.

Effectiveness of the activity guide. Few respondents picked up an activity guide and even fewer used it along the *Trail*. Those respondents who had used the guide had mixed reactions—some found parts of it very useful, others found it confusing. For the activity guide to become a more useful component of the *Trail of Time* experience, a number of things have to happen: (a) More respondents need to find and look inside the guide dispenser; (b) more need to recognize what the guide is for and take one along with them; (c) more need to use the guide along the *Trail* (rather than sticking it in a purse or pocket); and (d) the guide needs to meet respondents’ needs as they use it, for example by answering questions about various rocks and other exhibits.

Role of the Trail in respondents’ experiences. The *Trail of Time* was a complex and challenging exhibition and it took concentrated attention and committed time to figure out just what it was and what it was trying to accomplish. Although some respondents achieved that level of understanding, it was clear that for most respondents, the *Trail of Time* was supplementary to the main experience—their views of the Grand Canyon. However, even those respondents who focused mainly on the aesthetic aspects of the Canyon also talked about the plinth rocks and their ages and sometimes other interpretive elements along the *Trail*. Many of these respondents used vocabulary from the signs and talked about *Trail of Time* concepts as they described their aesthetic experience of the Canyon, paving the way for their progression along geologic time learning journeys. Unlike at other types of informal science venues such as museums and science centers, visitors to outdoor settings such as Grand Canyon National Park tend to come primarily for the views, not the displays. The data indicated that the Trail helped many visitors become aware of and pay attention to geology and geologic concepts in ways they didn’t prior to installation.

The Million Year Trail. The *Million Year Trail* made important contributions to some respondents’ *Trail of Time* experience. For instance, it got some respondents—especially children—counting along with the markers. It also helped respondents place human history in the larger context of geologic history—including finding their own birth year. It was along the *Million Year Trail* however, that some respondents became confused about the meaning and purpose of the numbered markers.



Learning-related outcomes. This study revealed a range of learning outcomes related to the *Trail of Time* experience. For instance, the *Trail* was clearly getting many respondents to think and feel more about the geologic aspects of the Canyon—especially becoming aware of the Canyon’s rocks and how old they were. In addition, there were indications that many respondents were developing geology-related vocabulary, including rock names, and geologic constructs such as rock layers and rock formations. Some respondents were beginning to develop very basic geologic reasoning skills related to time and layered rocks, and others used the *Trail* to improve their existing skills. And by walking the *Trail*, some respondents gained a deep and powerful visceral or gut-level understanding of geologic time.

Conclusions and Recommendations. The data indicated that the *Trail of Time* was an important addition to visitor experiences at the South Rim of Grand Canyon National Park. It inspired respondents to think and talk about the rocks of the Canyon—and their ages—in ways that weren’t happening before. It enhanced respondents’ experiences of the Canyon by giving them up-close looks and sensory experiences with rocks from the Canyon’s depths. It gave families new ways to keep their children interested during their long walks along the Canyon’s rim. Some interpretive elements of the *Trail* were less effective, and recommendations for addressing these challenges are included including additional signage in the portal areas, brief rock layer identification labels on the viewing tubes, and increased park promotion and use of the *Trail*.



INTRODUCTION

The *Trail of Time* is a 4.56 km (2.83 mile) long geologic timeline laid out on a paved trail along the heavily-visited South Rim of Grand Canyon National Park. Along the main (*Deep Time* and *Early Earth*) sections of the *Trail*, each meter walked signifies one million years of Grand Canyon's geologic history. The *Trail* is designed to give visitors a visceral appreciation for the magnitude of geologic time within the context of Grand Canyon geology.

Overview of the Project

The concept of a scaled geologic walking trail along the heavily-visited South Rim was originally conceived in 1995 by Dr. Karl Karlstrom (University of New Mexico) and Dr. Michael Williams (University of Massachusetts). Their goal was to improve geoscience interpretation at Grand Canyon and communicate research advances in Grand Canyon geosciences to Park visitors. In 2001 Dr. Karlstrom, Dr. Williams, Dr. Steve Semken (Arizona State University), and Dr. Laura Crossey (University of New Mexico) began applying for funding from the National Science Foundation to implement the project. Major progress on the project started in 2006 when funding was obtained from the National Science Foundation Informal Science Education Program. Since then the *Trail of Time* project team has grown to include professionals with a variety of skills and expertise, including Ryan Crow (University of New Mexico), many partners at Grand Canyon National Park, professional exhibit designers at Jim Sell Designs, and professional evaluators at Selinda Research Associates, Inc.

Brief Description of the Trail of Time

This section provides a brief description of the *Trail of Time*. A more complete description with lists of components is included in [Appendix A](#). Photographs of the *Trail* and its various components are included in [Appendix B](#).

The *Trail of Time* is a walking timeline trail composed of three segments, two of which were fully developed as of July, 2010, and were evaluated in this report. The main *Trail*—referred to as the *Deep Time Trail*—is a 2,000 meter segment, with each meter representing one million years of geologic history at the Grand Canyon. Time zero on the *Deep Time Trail* is about 100 meters east of Grandeur Point (Fig. B-1 in Appendix B). From there the *Deep Time Trail* stretches along the South Rim of the Canyon westward to the east side of Grand Canyon Village, with the million-year marker 2,000 just east of Verkamps Visitor Center (Fig. B-2).

Stretching eastwards from the *Deep Time Trail*'s time zero—and serving as an introduction to the *Trail* for visitors walking from the east—is the *Million Year Trail*. The *Million Year Trail*'s time zero is near the junction of the South Rim Trail and the side trail from the Yavapai Point parking area (Fig. B-3). This segment moves visitors through a series of changing time/distance scales to help shift from the more familiar human perspective (of years) decades, and centuries, to millennia, hundreds of thousands, and finally to the million year-scale of the *Deep Time Trail*.



The *Early Earth Trail* (developed after the summative evaluation data collection took place) begins at the 2,000 million year marker near Verkamps Visitor Center and then stretches first westward through the Village and then bends northward to Maricopa Point for an additional 2,560 meters. Maricopa Point represents the age of the Earth, almost 4.6 billion years. Wayside signage along the *Deep Time Trail* illustrated the position of the *Early Earth Trail* and labeled the age of the Earth (Fig. B-4).⁶

Trail segments and entry points are demarcated by small plazas called Portals. Here visitors can step off the paved path and view signage mounted on a structure built of Grand Canyon rocks that were cut, polished, and then assembled to make a cross-section of the Canyon's geology (which geologists refer to as a stratigraphic column, Fig B-5). Signage on the portals introduces key ideas about the *Trail* appropriate to that point (Fig. B-6) and includes a map of the *Trail* pointing out "You Are Here" (Fig. B-7). The four portals (Table A-1 in Appendix A) are located at the Yavapai end of the *Million Year Trail* (Fig. B-3, B-5 through B-7); at the junction of the *Million Year* and *Deep Time Trails* (Fig. B-1); at the Grand Canyon Village end of the *Deep Time Trail*, a few dozen meters east of the 2,000 million year mark (Fig. B-2); and where a major side trail from Park Headquarters intersects the *Deep Time Trail* at the 1,000 million year mark (Fig. B-8).

Numbered bronze **markers** (also called **medallions**) are embedded in the asphalt to mark time along the *Trail*. Along the *Million Year Trail*, every meter is marked with a numbered marker, 4 inches (20.5 centimeters) in diameter (Fig. B-9). The time scale between markers varies along the *Million Year Trail*, from one year per meter at the east end (near Yavapai) to 100,000 years per meter at the west end (where it meets the *Deep Time Trail*). The scale is one meter equals one million years for the entire *Deep Time Trail*, with the first and last 10 meters of the *Deep Time Trail* marked by 4.5 inch (11.4 centimeter) diameter numbered marker every meter (Fig. B-10). Between 11 and 2,890 million years, every tenth marker is numbered. The meters in between are marked by smaller unnumbered circular bronze markers (Fig. B-11), 1.25 inches (3.2 centimeters) in diameter, which have been installed into the asphalt

Thirteen interpretive **wayside signs** are located at intervals along the *Deep Time* and *Million Year Trail* segments of the *Trail of Time* (Table A-2).⁷ *Deep Time Trail* waysides focus on topics such as the carving of Grand Canyon in the last 6 million years, the age of the rock layer that caps the Canyon rim (Fig. B-12), and Grand Canyon's oldest rock (1,840 million years old). Waysides along the *Million Year Trail* discuss climate change (Fig. B-13) and volcanism over the past million years and the history of humans living in and near Grand Canyon. The lower portion of each panel is a **wayside integration strip**. This includes a perspective drawing designed to help visitors locate themselves along the *Trail* in both geologic time and current-day space. Wayside integration strips along the *Million Year Trail* show the view from the Canyon towards the South Rim (Fig. B-14), while those for the *Deep Time Trail* show the view into the Canyon (Fig. B-15) to emphasize the differences between the two trail segments.

⁶ It has since been fully marked with bronze markers every 10 meters and four wayside-sized signs have been installed at key places along the timeline, including one that serves a similar function to the portals at Maricopa point.

⁷ Three additional waysides have been installed along the Early Earth Trail but were not yet installed at the time of the summative evaluation.



Spaced along the *Trail* are eight **viewing tubes** to help visitors connect wayside interpretation with geologic features within the Canyon (Table A-3). For instance, viewing tubes help visitors locate the Kaibab limestone that caps the Canyon's walls (Figs. B-16 and B-17) as well as the Colorado River deep within the Canyon (Figs. B-18 and B-19). The tubes are movable hollow sections of bronze-colored pipe, designed to point out a view in the canyon but not to magnify it. Each viewing tube also had an annotated sign depicting and labeling the view that was being highlighted.

A total of 46 **rock plinths** are located along the two Trail segments (Tables A-4A and A-4B). Atop each limestone plinth is a large piece of rock representing one of Grand Canyon's formally named rock formations (like the Kaibab Limestone and Vishnu Schist). Many of the specimens were collected deep within the Canyon and then rafted or helicoptered out. Although some of these rocks are closely tied to adjacent wayside signs (Fig. B-20), most are designed to stand alone (Figs. B-21 and B-22). The interpretation on the stand-alone plinths gives the rock formation's formal name and its age in millions of years (Fig. B-22A and B). The rock formation names usually include a proper name (like Rama or Kaibab) and a rock type (like schist or limestone).⁸ Each plinth also includes in small text the words, "Touch me," and a symbol for the *Trail of Time* (Fig. B-22B).

Additional interpretation available to *Trail of Time* visitors includes the **activity guide**, a brochure available at dispensers in each portal plaza (Fig. B-23). In addition, at the time of our site visit, visitors with cell phones could access a **cell phone message** describing the *Trail* by dialing a number on a sign at Yavapai portal (Fig. B-23).

Overview of the Evaluation

This report summarizes the summative evaluation of the *Trail of Time* at Grand Canyon National Park. It represents the final stage in a multipart evaluation effort, which included numerous formative evaluation studies conducted from 2004 to 2010 ([Appendix C: Evaluation and Research Reports for the Trail of Time Project](#)).

The first stage of the formative evaluation took place during fall, 2004. Rough prototype versions of the markers were laid out along the South Rim Trail between Yavapai and Mather Points, along with minimal interpretation at either end of the prototype trail. The report from this early study (Gyllenhaal & Perry, 2004) served as a basis for continued planning and development of the Trail, which eventually was relocated to the west of Yavapai Point.

During later stages of the formative evaluation, Selinda Research Associates conducted a series of short studies aimed at specific aspects of the *Trail's* development. Findings were written up as shorter reports or *evaluation briefs*. The 26 briefs were either (a) a summary of what we have summarized from the literature about a topic, and/or (b) the results from quick testing of prototypes. These are listed in Appendix C, along with links to PDF files on the *Trail of Time* website. The data gathered during formative evaluations was also discussed in a published report

⁸ Rock type names (like limestone and granite) are always used to identify plinth rocks, even in cases in which the formal rock unit name is "X Formation."



about the development of the *Trail of Time* (Karlstrom, Semken, Crossey, Perry, Gyllenhaal, Dodick, *et al.*, 2008).

This summative evaluation study included assessment of the *Million Year Trail* as well as the *Deep Time Trail*, but not the *Early Earth Trail*. The evaluation also did not include the *Trail of Time* website or accompanying electronic media, or any print materials beyond the activity guide available for use along the *Trail*. The core summative evaluation team consisted of Deborah Perry and Eric Gyllenhaal of Selinda Research Associates, and Karl Karlstrom of the University of New Mexico, who was PI for the project.

Goals and Intended Audiences for this Report

The goal of this evaluation is to provide answers to the following research question, as stated in the summative evaluation plan:

In what ways and to what extent do visitors develop greater understanding of and appreciation for deep time and geology based on their experiences along the Trail of Time?

To answer this question, we collected data on the range of ways that respondents engaged with, thought, and felt about the *Trail*. We also assessed a broad range of learning outcomes of the Trail of Time experience, relating these outcomes to aspects of the *Trail* that seemed particularly effective or that did not work as well for most respondents.

We hope this report will provide useful feedback for both the *Trail of Time* project team and the project's funders. In addition, we hope it will be of use to the Grand Canyon National Park staff as they design interpretive geoscience programs with the *Trail* in mind and plan for long-term maintenance of the *Trail*. Finally, we hope these findings will be of use to staff at other parks, museums, and other informal science institutions as they plan and design timeline exhibits for installation on their sites.



METHODOLOGY AND METHODS

The summative evaluation began with the collaborative development of (a) a detailed evaluation plan outlining the research question, the design of the study, and a description of methods and methodology, and (b) a topical framework (see [Appendix D](#)). The following approach of data collection and analysis was laid out in the evaluation plan and then carried out at Grand Canyon.

Methodology

The summative evaluation study used a naturalistic methodology. Naturalistic inquiry is a rigorous and disciplined approach to collecting, analyzing, and reporting data gathered in natural (as opposed to laboratory) settings. Naturalistic methodologies emphasize collecting data using a mix of methods, primarily qualitative, and triangulating findings. Naturalistic evaluation reports tend to be narrative in format, enabling the researchers to capture and report the findings in respondents' own words.

Methods

The evaluation team used a variety of quantitative and qualitative methods to collect data for this study. Following is a brief description of each of the methods used.

Tracking and Timing

To gain an understanding of how long visitors were walking along the *Trail of Time* and how thoroughly they were using its components, researchers completed a tracking and timing study with help from National Park Service (NPS) staff. Data collectors unobtrusively followed randomly selected visitors as they walked the *Trail*, recording where and when they entered and left the *Trail* and where and how long they stopped at *Trail* components. Data collectors followed a standard protocol for selecting respondent and used a one-page form to record data. Copies of the written instructions and tracking and timing form are attached as [Appendix E](#).

On the first day of the July site visit to Grand Canyon, Selinda researchers trained nine National Park Service (NPS) staff to collect tracking and timing data. NPS staff collected data through the end of August, completing forms for 132 respondents.

Unobtrusive Observations

During unobtrusive observations, researchers watched respondents from a short distance as they explored the *Trail of Time*. The researchers tried to remain as unobtrusive as possible so they would not affect the visitor experience, but they did not try to disguise themselves. Once a respondent group was selected (see selection of respondents below), notes were taken about which portals, waysides, viewing tubes, and plinths the group stopped at; how long they stayed; and what they did and said at each stop. As part of these observations, the researcher paid particular attention to four types of visitor engagements: physical, social, intellectual, and emotional, as described below. These types of engagements are not—and are not meant to be—mutually exclusive.



Physical engagements were all the physical things respondents did along the *Trail*, such as walking or sitting, reading signs, looking through a viewing tube, touching a rock, and so forth.

Social engagements were the ways in which respondents engaged with each other to make meaning of their *Trail* experiences. These included verbal exchanges, body language, storytelling, teaching-learning interactions, and other social activities that contributed to active meaning-making. For the purposes of this study, it did not include social interactions that were not focused on the *Trail* content, such as discussing the events back home or where to go for lunch.

Intellectual engagements were all the ways in which respondents engaged cognitively and intellectually with the content of *Trail*. They included making comparisons, remembering something they learned in school, or relating something to their personal life. It also included “aha” moments or other indications that a respondent makes a personally meaningful connection.

Emotional engagements were all the ways that respondents engaged emotionally with the overall *Trail* environment and interpretation. Researchers looked for a variety of emotional responses to both the content of the *Trail* as well as the design and interpretation. These included appreciation, excitement, anger, surprise, satisfaction, frustration, or confusion. For the purposes of this study, it did not include emotional responses to the Canyon itself, except as it related directly to the *Trail of Time*.

Although most unobtrusive observations involved following one group as they walked a portion of the *Trail*, researchers also used two variations on this approach. During *extended observations*, the researcher spent a half hour or more along one short section of the *Trail*, watching and listening as a series of visitor groups engaged with the *Trail*, its interpretation, and each other. The researcher observed and recorded how these groups engaged with the components, recorded segments of conversation, and sometimes timed how long individual groups stayed at a component. *Incidental observations* included short observations and snatches of conversation collected when the researchers were involved in other activities. For instance, researchers sometimes were observing one group when a member of a nearby group said or did something interesting or revealing. Rather than breaking off contact with the first group, the researcher made a few quick notes, adding context to the notes after the main activity was complete. This approach allowed researchers to record relatively rare events that otherwise would have been lost.

During the four-day July site visit to the Park, researchers completed 145 observations of visitor groups, including more than 500 individual respondents.

Depth Interviews

After a respondent group had been observed for awhile, and/or as they were preparing to leave the *Trail*, the researchers sometimes approached them and invited them to participate in an interview. These depth interviews were open-ended and conversational in nature, allowing for the respondent to set the direction of the conversation and the researcher to gather data in the



visitor's own words. While researchers had a loosely structured interview protocol to guide the conversation, the specific questions asked of any particular respondent were unique to that respondent. The researchers used their background and experience to ask non-threatening questions to elicit information that would enable them to answer the broader questions on the topical framework. In addition, they recognized additional interesting threads that were not on the topical framework and often followed up on them. No identifying information was asked of the visiting group. Depth interviews typically lasted for 5-20 minutes depending on the needs and interests of the group. When feasible—and with respondents' permission—depth interviews were recorded using a digital audio recorder and later transcribed for analysis.

During the four-day July site visit to the Park, researchers completed 56 depth interviews, including more than 100 individual respondents.

Document Reviews

To gain an understanding of what respondents may have heard about *Trail of Time* before encountering the exhibition, the researchers (a) reviewed a tabloid format newspaper that was given to respondents as they entered the Park, including both the July and October editions of these documents; (b) photographed and analyzed signage related to *Trail of Time*, and (c) informally reviewed a number of newspaper and social media websites related to *Trail of Time* and Grand Canyon National Park.

Data Analysis

Data analysis for this study has been an on-going process using a modified inductive constant comparison approach whereby each unit of data was systematically compared with all previous units of data (Lincoln & Guba, 1985). For instance, immediately after each observation or interview, researchers hand wrote debriefs in the field, fleshing out their notes, reflecting on and analyzing their findings. Later that day, researchers typed up more complete debriefs, comparing the observation and interview data with data from previous data collection sessions and developing preliminary conclusions. Each evening (and at most lunch breaks) researchers gathered for group debriefs, where they discussed and analyzed the day's findings. Analysis continued as data and findings were compared among the researchers and among data types. Researchers also held a final group debriefing by phone to triangulate findings and resolve any contradictory findings. A brief summary of the data that contributed to the analysis is included as [Appendix F: Sources of Data](#).

Once all the tracking and timing data was received and entered into an Excel spreadsheet, basic statistics were calculated for each type of data and for each component of the *Trail*. These statistics were then compared among subgroups of respondents, such as family vs. all-adult groups and respondents who entered at different portals or who walked different segments of the Trail.

Although a variety of data collection strategies were employed, these data were not treated separately. In accordance with standards for naturalistic inquiry, data were integrated to develop a comprehensive and multi-faceted understanding of different issues from a variety of angles. The reader of this report won't find, for example, the results of document reviews or a summary



of interview findings. Rather, the report discusses findings on a range of topics as spelled out in the topical framework, integrating all the data relevant to each topic. The reported findings synthesize results that emerged from interviews, reviews of online sources and documents, and observations.

Knowledge Hierarchy Technique

When visitors show a range of understanding of an exhibit or concept, as they did for the *Trail of Time*, one useful way of describing such data is through the development of a knowledge hierarchy (Perry, 1989, 1993). A knowledge hierarchy presents a range of visitor understandings about a certain topic, based on the assumptions that (a) there is an internal knowledge structure inherent in an exhibit topic, and (b) this hierarchy is located at the intersection of the exhibit developer's and the visitor's organization and understanding of the topic. Thus, a knowledge hierarchy is simply a description of the *range of visitors' understandings about a topic within the context of the planned exhibit*. It emerges from the data, rather than being predetermined by the researchers. It usually describes six or seven levels of understanding, which characterize a full range of how most visitors to the exhibition think about a topic, usually by increasing levels of sophistication, representing, in manageable form, virtually all visitors' understandings about that aspect of the topic.

The structure of knowledge hierarchies tends to follow a pattern (adapted from Perry, Garibay, & Gyllenhaal, 1998). This example has six levels, although five and seven level hierarchies are sometimes more appropriate.

- Level 0:** **"Don't know and don't care."** Visitors at this level often have not thought much about the topic and have not developed any particular interest in it. Visitors at this level *can* develop a curiosity about topic; it is just that they have not thought about it much on their own.
- Level 1:** **"Don't know, but I was wondering."** These visitors have formed questions about the topic in their minds, but they have not yet developed answers to their questions.
- Level 2:** **These visitors are interested enough in the topic that they have formed some understanding of it,** but their ideas are unsophisticated, largely incomplete, and sometimes incorrect in important ways.
- Level 3:** **These visitors have a fairly accurate *basic* understanding** of the topic, although they may be fuzzy or sometimes incorrect on the details.
- Level 4:** **These visitors have a more sophisticated and accurate understanding** of the topic and may articulate detailed information about one or more aspects of it. These visitors often have a particularly strong interest, background in college-level courses, or direct experience working with the subject.



Level 5: These visitors have a very sophisticated understanding of the topic, and include people who have studied the topic extensively or have chosen a career related to the topic.

The knowledge hierarchy approach was used to analyze several aspects of visitor learning along *Trail of Time*, as described later in this report.

Research Design

Data Collection

Selinda Research Associates conducted one site visit with four researchers on site at Grand Canyon National Park. The site visit took place during the week of July 25, 2010 and included four days of data collection. Data collection was led by project manager Deborah Perry and lead researcher Eric Gyllenhaal. Additional data collectors included Diane White (Selinda Research Associates), who assisted with observations, interviews, and on-site data analysis during the site visit, and Rebecca Mathews Frus (Arizona State University), who participated in the tracking and timing study and on-site data analysis.

In addition, nine National Park Service staff collected the tracking and timing data along the *Trail*. They were trained by Deborah Perry on July 26. Then, during August, each data collector completed anywhere from 3 to 22 forms.

Respondents

Respondents for this study were casual Park visitors observed and/or interviewed in their naturally-occurring social groups.⁹ Researchers strove to include as many different social group configurations as possible, but did not seek out intact tour, school, or other organized groups. However, individuals or small groups who were sub-sets of these types of organized groups were sometimes included as respondents when they fit the other selection criteria. For descriptive data about the respondents who participated in this study, please see [Appendix G](#).

Respondents for the tracking-and-time portion of this study were randomly selected according to an established protocol. The data collectors were instructed to select the fifth person to cross an imaginary line once the previous unit of data collection was complete, and then track his or her group. The tracking-and-timing data were also stratified in that data collectors were instructed to track certain proportions of visitors from each of the three *Trail* entrances.

Respondents for the rest of this study were *purposively* selected (Miles & Huberman, 1994). Purposive sampling is a technique where each respondent is selected based on the results of previous data sets in order to achieve the greatest variability in data. As data were gathered and preliminary analysis was conducted, new questions and areas of study emerged. Respondents were then selected purposively to illuminate different types of visitor experience. This ensured that data was gathered from a variety of respondents with a maximum range of experiences as

⁹ Note that a “social group” may be an individual walking the *Trail of Time* alone.



they related to the *Trail*. Children were sometimes purposively selected for observation, but were not interviewed unless parental permission was secured.

Because we sampled purposively rather than randomly, we do not report percentages for data collected through observations and depth interviews. All that percentages would tell us is what proportion of respondents for this study engaged with exhibits or answered our questions in a certain way; these findings would not be generalizable to a larger population of visitors. Instead, when appropriate, we use the adjectives *all*, *most*, *many*, *some*, *few*, and *none* to describe tendencies in the purposive sample (Wolf & Timitz, 1981).

In accordance with standards for conducting naturalistic methodology, the unobtrusive observation and interview portion of this study used a smaller sample size than one would typically find in many positivistic methodologies. While in some research paradigms this is cause for concern, it is a strength of naturalistic methodology. By studying fewer cases in more depth, we were able to develop a more complete and meaningful understanding of the visitor experience than would be possible by collecting less information from a larger number of respondents.

Ethical Treatment of Respondents

Selinda Research Associates, the *Trail of Time* project team, the National Park Service, and the National Science Foundation are committed to the ethical treatment of respondents. Our research adhered to standard professional practices for conducting research in informal settings. All respondents were guaranteed anonymity and gave informed consent. In addition, signs were posted during all on-site evaluations informing visitors that data collection was taking place. Furthermore, we ensured that the disruption of visitors' experiences was kept to a minimum.

Based on discussions with the National Park Service's Social Science Program, we received official notification that OMB approval was not required for this study. Both of the lead researchers in this study have completed and are certified in the National Institutes of Health *Human Participant Protections Education for Research Teams*, and one has been certified under the University of New Mexico's *CITI Collaborative Institutional Training Initiative Human Research Course*.

Limitations

Due to the resources available, this study was necessarily limited in scope. When conducting a research study using naturalistic methodologies, it is standard practice to continue collecting data until a state of redundancy is reached. Redundancy is the point at which no new information is gleaned, despite repeated attempts to elicit additional findings. In the real world, redundancy is difficult to achieve for all items on the topical framework, primarily due to limited resources. In this project we collected observation/interview data during the four days on site (not including time lost to inclement weather), plus tracking and timing data during the month of August. In this study redundancy was achieved for many of the issues listed in the topical framework. However, in some areas of the study researchers were unable to explore the issue in enough depth to reach



redundancy. Issues that could not be resolved satisfactorily were either not included in the final report or were identified where appropriate in the report.



FINDINGS

Physical Engagements with the *Trail of Time*

Using the Trail

Visitors to the *Trail of Time* used the trail in a range of ways. Most respondents tended to engage in at least one of five different ways, with some overlap between these categories.

The View: Many visitors walked the *Trail*, paying attention mostly to the view. These respondents may or may not have noticed the markers and other interpretive elements, but tended not to pay attention to them. During interviews with these visitors, many mentioned they had pretty much ignored these aspects of the trail, choosing instead to focus on the view and the surrounding environment.

Social: Many visitors walked the trail primarily as a social experience. These respondents seemed mostly focused on conversations with their visiting companions, although also sometimes pausing to notice and comment on the view, or a brief encounter with a random interpretive element such as a viewing tube.

Learning: A few visitors walked the *Trail* primarily as an interpretive or educational experience, thoughtfully and thoroughly engaging with many if not most of the *Trail* components. For these visitors, the *Trail* appeared to be a focus of their visit, and there appeared to be a deliberate attempt to learn all that could be learned from the interpretation. These respondents tended to engage with the *Trail* in a variety of ways including touching rocks, reading interpretive panels, looking through the viewing tubes, counting the markers, and discussing what they were finding out about.

Traveling: A few visitors appeared to be using the *Trail* primarily as a way to get from point A to point B, for example, from Headquarters to Grand Canyon Village, or from Yavapai Museum to their car in the Headquarters parking lot. These respondents were often, but not always, park employees. These respondents tended not to stop at interpretive elements, although sometimes glanced at a wayside panel, or rock as they passed it.

Exercise: And a few people visiting the *Trail* appeared to be using it primarily as a jogging or speed walking trail to get exercise. Like the Traveling respondents above, these respondents tended not to stop at interpretive elements, although sometimes glanced at a wayside sign or rock as they passed it.

The first three types of visitors mentioned above tended to take advantage of the seating provided, walking along until they wanted to take a rest, sit and enjoy the view, or tie a loose shoelace. We also found that when it rained—which happened somewhat frequently, since data collection took place during Arizona’s monsoon season—the *Trail* tended to be vacated rather quickly. Because we were only able to collect data during a limited period of time, we don’t know the effect of cold, snow, or ice.



In addition to these five ways of engaging with the *Trail*, we also identified a few respondents who used the trail in unique and idiosyncratic ways, for example a person engaged in bird watching, and another who used a time marker to identify the location where they met up with a family member. One group of visitors that we didn't observe directly used the *Trail* in homage to someone they knew, as evidenced by a note they wrote on a park bench at the Time Zero portal which said: "RIP We walked a million miles for you." And in a previous trip to Grand Canyon we saw park rescue employees use a marker to identify where a visitor had gone over the edge.

The most common type of physical engagement along the trail (other than of course walking the *Trail*) was paying attention to the rocks. This often entailed stopping to touch them, but also included visitors glancing at them as they walked by, saying their names out loud (although this was usually just the rock type such as granite, or limestone), and remarking about their ages.

Time along the Trail

Unlike at other types of informal science venues, visitors to the park had many goals for their visit that did not necessarily involve learning. In addition, many were constrained by externally imposed schedules such as tour itineraries. Given the size and scope of the *Trail of Time*—and of Grand Canyon National Park—we shouldn't be surprised that most respondents spent less than a half hour along the *Trail* and used only a small proportion of its components. Many respondents walked only part of the *Trail* or spent considerable amount of time off the *Trail*, at the edge of the Canyon, and many respondents walked right by most of the components they approached.

Respondents in the tracking and timing study took, on average, about 50 minutes to walk the entire *Trail of Time* (Table H-1 in [Appendix H](#)). Those respondents who entered and exited the *Trail* from the same portal averaged only 20 minutes (Table H-1). Of course, part of that time was spent looking at and photographing the Canyon, and a considerable amount of time was spent just walking along the paved trail. On average, respondents who walked the entire Trail spent only about three to four minutes, or less than 10% of their visit, stopped at components like signs, viewing tubes and rock plinths. These time statistics were similar for both all-adult groups and groups with children (Table H-2). Respondents who walked the *Trail* alone moved more quickly and walked less of the *Trail* (Table H-2).

Stops Along the Trail

Although almost 9 out of 10 respondents we tracked stopped at one or more components (Table I-1 in [Appendix I](#)), on average respondents stopped at a relatively small number of the 71 *Trail* components (Table I-2). Respondents stopped at an average of 13 of the 71 components (18%). The average visitor stopped at 4 of the 13 waysides (32%), 3 of the 8 viewing tubes (32%), and at 6 of the 46 rock plinths (13%). Although the rock plinth statistic seems low, there were indications the many respondents read the ages and names of some rock plinths at a glance, without stopping. Respondents in all-adult groups stopped at more components on average compared with both groups that included children and with respondents who walked the *Trail* alone (Table I-3)

Most individual components were stopped at by relatively small percentages of respondents (Tables I-4 through I-7). On average for respondents who walked the whole *Trail*, about one in



three stopped at any individual wayside or viewing tube, about one in five stopped at any given portal, and one in eight stopped at any individual rock (Table I-8).

That said, when respondents stopped and engaged with the *Trail*, many did so whole-heartedly. They counted markers as they walked, studied maps at portals, read wayside signs, peered through viewing tubes and touched—even caressed—the rocks on plinths. The data indicated that the *Trail of Time* was often a small but important part of visitor’s South Rim experience. Even those who devoted much time and effort to the *Trail* were still distracted by many other things—especially by Grand Canyon!

Social Engagements with the *Trail of Time*

Social engagements include the ways that visitors made meaning together along the *Trail of Time*. These included teaching/learning behaviors, parents scaffolding a child’s learning, visitors directing the attention of others in their groups, asking and answering a question, recalling earlier shared experiences, and explaining something that wasn’t clear to another member of a group. We also tried to discern the extent to which social engagements were a function of what visitors brought with them (e.g. prior knowledge & experience) and the extent to which they were a function of the available interpretation.

We observed a broad range of social engagements along the *Trail of Time*. Many respondents who stopped at the waysides stood together as they read signs and looked at sign graphics. Many of these respondents pointed to text and graphic on the waysides and discussed various concepts, explaining and asking questions as they worked to understand the important ideas. Families sometimes walked together along the *Trail* as a child counted off the markers, with help from parents with larger numbers or if English was not their native tongue. Group members took turns looking through the viewing tubes, talking about how the tubes worked and pointing out and discussing what they saw. Respondents sometimes looked closely at the rocks together, with one person often taking the lead to explain what they remembered about that rock type, either from school or from pursuing a personal interest in geology.

It was fairly common to overhear discussions and even arguments about topics related to the *Trail*. For instance, we heard a few respondents debate how the bronze markers related to the rock layers in the Canyon, and what forces contributed to the creation of the Canyon. Some of these discussions were clearly inspired by *Trail of Time* components, but others (like debates about the Canyon’s origins) were inspired by the Canyon itself. Unlike in a museum exhibition, the *Trail*’s design spread information over a distance of more than two kilometers. For this reason, data indicated that when discussing a particular topic or concept such as the age of the canyon, or how the canyon was formed, many respondents were far from the particular wayside that would help them settle their arguments. In some cases they had already passed the relevant wayside sign.

Many discussions were inspired by the portal maps and perspective drawings of the *Trail* on the wayside integration strips, although most of these discussions were visitors trying to figure out where they were and deciding which way to go next. Wayfinding was something groups had to



deal with before they could focus on the Trail's geoscience interpretation, so that means at least some of the time recorded at portals and waysides was not devoted to learning about geology.

Many of the teaching-learning interactions we saw were parents talking with and explaining things to younger children. Parents tried to focus younger children's experiences on the sensory aspects of plinth rocks, comparing rough and smooth, hard and soft. They tried to explain what granite was, and how sedimentary rocks differed from igneous ones. And they did their best to explain why there were no dinosaurs in the Canyon's rocks and answer their children's other questions. Although these teaching-learning experiences commonly were inspired by the *Trail's* components, for some of these respondents, they were located far from where they might find interpretive support.

Intellectual Engagements with the *Trail of Time*

Intellectual engagements include the ways in which visitors engaged cognitively and intellectually with the *Trail of Time*. They included observing, identifying, making comparisons, contrasting, creating connections, developing questions, remembering something they learned in school, or relating something to their personal life.

The more social forms of intellectual engagements are discussed in the previous section, and those were the sorts of engagements we could observe directly along the *Trail*. As we interviewed respondents during and after their experiences, we discovered a range of other ways that respondents engaged cognitively with the content of the exhibition. Many respondents gave evidence of being thoughtful and reflective along the *Trail*, especially as they considered the immense age of the rocks exposed in the Canyon. Others talked of comparisons they made between the rocks they saw along the *Trail* and rocks they had encountered elsewhere (like in kitchen counters). We also heard about a few "aha" moments, times when a respondent makes a personally meaningful connection. We'll report many examples of respondents' intellectual engagements in the section on [Learning-related Outcomes](#), below.

For now, let's close with some examples of respondents' questions raised by their *Trail of Time* experiences. One of indicators of meaningful intellectual engagements is when respondents develop their own questions. The data indicated that many respondents developed questions as they walked along the *Trail*. These were about equally divided between content-related questions and questions about the *Trail* itself. Examples of content-related questions included:

How do mountains form?
Why are the rocks red?
How did the Canyon form?
Why are rocks deep in the Canyon tilted?
Is this granite?
What's granite?
Vishnu—is that a god or something?



Examples of questions that respondents asked about the *Trail* included:

What are these markers?

Why are the markers by hundreds now?

Why [do they say] 1,000 million and not 1 billion?

Why are there long sections of Trail with no rocks [plinths]?

Most of the questions about the *Trail* and many of the content-related questions were answered in wayside signs and other interpretation along the *Trail*. However, in part because the interpretation was so spread out—over more than two kilometers—many respondents did not find the answers to their questions in the *Trail*'s interpretive signage. Respondents often were in the wrong place to answer the question that had just occurred to them, or they were not paying attention when they walked past the wayside with the answer. Either way, they missed the place that their question was answered. Other questions were not answered by *Trail of Time* interpretation, but were answered elsewhere in the Park—at the Yavapai Geology Museum, on ranger-led tours, or by books in the visitor center stores. Sometimes respondents answered each others' questions—sometimes accurately, and sometimes not. Often respondents argued about the answers, never reaching a satisfactory conclusion or instead settling on an incomplete or incorrect answer.

Emotional Engagements with the *Trail of Time*

Emotional engagements included the ways that visitors responded emotionally to the overall *Trail* and its environment. These emotions included appreciation, excitement, anger, surprise, satisfaction, frustration, or confusion.

Fittingly, was clear that, for most respondents, their strongest emotional engagements were with the Canyon. Respondents had much to say about their emotional responses to the Canyon's size, depth, beauty, and changing moods. One of the goals of the *Trail of Time* project was not to detract from visitors' experiences of Canyon itself; there are many indications that this goal has been achieved for most visitors.

That said, respondents also expressed a wide range of emotional engagements with the *Trail*. For instance, some respondents described their sensory and aesthetic experiences with the rock plinths. They talked about the colors, patterns, textures, and feel of the rocks. For instance, as a French group walked past, slowing at one of the rocks, we heard the words "Schist" and "magnifique!" Other respondents said the rocks were so beautiful they wanted them for their kitchen countertops back home. The tubes also had their admirers, such as the respondent who exclaimed, "Look, there's the river! Did you see the river? I would never have seen it!"

Some reactions to the *Trail*'s components were less positive, though, such as a respondent who said about a viewing tube, "It's stupid, it doesn't magnify anything!" Some respondents also expressed their frustration with the numbered markers, asking things like, "What are the markers for? I don't get it." (This last topic is discussed in greater depth in the next section, [Making Sense of the Trail of Time](#).)



Not surprisingly, some respondents' emotional engagement with the *Trail* was based on their religious beliefs and preexisting views about the age and evolution of the Earth, which sometimes differed from information in the *Trail's* interpretation. Respondents' with these beliefs expressed a range of reactions to the *Trail*, from amusement to irritation. Some of these respondents pointed out that the signs are presented as facts, not viewpoints, and that there were other viewpoints—which they considered to be equally or more valid—that were not expressed. Some respondents expressed their doubts about how scientists could know what happened long ago—“so who was there taking notes?” Others seemed resigned to the situation. “Whatever... we don't hold the same beliefs, but everybody's entitled to their own belief. [The Canyon] is still beautiful.”

Making Sense of the *Trail of Time*

There were indications that some respondents developed a pretty thorough understanding of the *Trail of Time* as they walked along it. Some respondents figured out the timeline concept behind the *Trail* pretty quickly; others took longer as they noticed and studied the markers, portals, wayside signs, and rocks on plinths, and talked about them with others in their groups. However, other respondents along the *Million Year Trail* and in the Time Zero portal area expressed frustration and confusion as they tried to figure out the markers and how they related to the Canyon and the other components of the *Trail*. This has been an issue since the earliest stages of formative evaluation (Gyllenhaal & Perry, 2004). These respondents often tried to invest “too much” meaning in the markers, expecting that the exact placement of the marker signified some specific event in the Canyon's geologic history. As they struggled to understand the meaning of the markers, they almost seemed to be thinking too hard, and to be punished for their efforts as they became more and more confused.

Meaning of the Markers

Most respondents who noticed the markers realized they had something to do with time—they told how old something was. However, many of these respondents did not understand that the position of individual markers was arbitrary, i.e. it was determined by the start and end points of the timeline, not a specific geologic event. Rather these respondents used the evidence they found along the *Trail* to develop tentative theories that attached inappropriate meaning to the location of each marker. Most of these theories were incomplete or incorrect in important ways, for example:

- **Linked to specific placement of that marker.** Respondents often tried to link the meaning of each marker to its exact place along the *Trail*. They thought the markers told them something about where they were standing, or what they were seeing from that point.
- **Linked to elevation.** Respondents sometimes linked the markers to the elevation of the *Trail* at that point, or to elevations in the Canyon. For instance, one respondent guessed that the markers showed the depth that the cutting of the Canyon had reached at that time.



- **Linked to progress of Canyon’s erosion.** Respondents often included some reference to the erosion of the Canyon in their theories about the bronze markers. Some hypothesized that markers showed how far back the Canyon had been cut at that point in time.
- **Linked to Canyon’s rocks.** Some respondents' hypotheses about the markers included the rocks exposed in the Canyon walls. This theory works along 270 million year and older sections on the *Deep Time Trail* but not on younger sections of the *Trail*. For instance, some respondents walking the *Million Year Trail* thought the markers were related to the ages of the rocks in the Canyon. One respondent guessed that the markers meant steps down into the Canyon—walk down 100 steps into the Canyon and get to 100 million-year-old rock.

Although these hypotheses were incorrect, we see them as evidence that respondents were working hard to figure out the *Trail of Time*. In a sense they tried too hard, attaching too much meaning to each marker. Since many respondents missed the signs that explained the markers, their independent efforts led them astray.

However, as noted above, other respondents did understand the *Trail of Time* to varying degrees. In the next section we discuss a technique for describing the full range of visitor understandings (and misunderstandings) of the *Trail*.

Making Sense of the Trail of Time

As described in the methods section ([above](#)), knowledge hierarchies can be used to present a range of visitor understandings about a certain topic. Later in this report we will present knowledge hierarchies for two geoscience concepts represented along the *Trail of Time*. At this point, however, it seems useful to consider respondents’ understanding of the *Trail of Time* itself. Because many visitors’ misunderstandings of the *Trail* have been showing up since the earliest stages of the formative evaluation, this hierarchy represents an elaboration of a hierarchy originally developed in Gyllenhaal & Perry (2004).

Level 0: "I don't know what those markers on the *Trail* are, and I don't care." By convention, respondents would be placed at this level because they expressed little interest in the markings and signs they found along the *Trail of Time*. In practice, respondents who had not yet noticed the markers started out here. Some respondents who were more focused on views from the South Rim and the aesthetic experience of the Canyon said they were not that interested in the markers. However, most respondents who noticed the markers rarely stayed at Level 0 for long. In other words, some visitors did not notice the markers and so clearly fell into the “Don’t know Don’t care” camp. But once they noticed the markers, most visitors became curious about them.

Level 1: "I don't know what those markers are, but I'm curious." These respondents noticed the markers and had not yet figured out what they were about, but they were curious. Many respondents seemed to quickly reach this level, but once they started to develop their own theories about the markers, they jumped to the next level.



- Level 2: Developed some ideas about the markers on the trail, but they were incomplete or incorrect.** Many respondents either reached this level before the interview or achieved it as we talked with them about what the markers meant. These respondents had a range of alternative understandings about the *Trail*. Some of them were beginning to figure out that the *Trail* was a timeline, but they still had some misunderstandings about what that meant. As noted earlier, many respondents wanted to link the markers 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. Other Level 2 respondents were coming closer with their guesses about the *Trail* but were unable to confirm what they figured out on their own. We should also note that some Level 2 respondents—especially those walking east from the Village—realized that the rock plinths were ordered in time even if they had not yet noticed the markers or linked them to the rock plinths. Finally, some respondents—especially children—focused on the markers and pretty much ignored the rocks and interpretation. They realized, to some extent, that they were counting back in time, but they did not realize that the time related to rocks and events in the Canyon’s history. We regard that as another example of Level 2 (i.e., and incomplete) understanding.
- Level 3: Understood that the markers were part of a timeline related to Grand Canyon.** These respondents (a) had the basic idea that the *Trail of Time* was a timeline; (b) knew that it had a beginning and an end; (c) realized that the timeline was, in some way, related to what they saw in the Canyon, but (d) did *not* try to invest too much meaning to the specific locations of the markers. These respondents realized that the *Trail* was a timeline about the geology of Grand Canyon. Some respondents reached this level on their own. Others seemed to reach it as we talked with them about the timeline concept; they needed some extra help—scaffolding—to help them reach this level of understanding.
- Level 4: The timeline gives specific ages for the rocks and events that formed the Grand Canyon.** This level included respondents who realized that the wayside signs and rock plinths were positioned along the marker-defined timeline because they represented things that happened at a particular point to the Canyon’s history. They figured out what the markers really meant—that they related to the interpretation placed along the *Trail*. This level was represented some of the respondents we talked with.
- Level 5: The timeline is a metaphor for the immensity of geologic time.** This level is reserved for those respondents who went beyond a literal understanding that the *Trail* is a timeline toward an understanding of the *Trail*’s metaphoric meaning. In other words, the *Trail* got them thinking about and even *feeling* the immensity of time as it related to the Grand Canyon (the visceral understanding discussed in the Outcomes section of this report). We talked with just a few respondents who had reached this level on their own, although some additional respondents reached this level as we talked with them.



Level 6: *The Trail of Time* is a tool for helping visitors learn about “deep time,” which is a key concept in geology and biology. This level included geologists and educators who had a complete understanding of the *Trail* and what it is trying to accomplish (such as the project team and Park rangers). We also found a few respondents on this level, including a father and son who were deeply interested in geology and a parent who was focused on making the Canyon an educational experience for her children.

Most respondents we talked with were at level 0, 1, or 2, with a few of each starting at 3, 4, or above. Most respondents moved up a level or two during the interview. This would indicate that adults and older children were certainly capable of understanding the timeline concept, the story of the Canyon, and even the Timeline’s metaphoric meaning when we explained it to them. The challenge for visitors was that it was difficult to figure out the *Trail of Time* concept through the interpretation that occurred at wide intervals along the *Trail*—especially considering distractions such as basic wayfinding, their group’s dynamics, not to mention the beauty of the Canyon itself.

So, what could be done to help more visitors reach higher levels of this hierarchy? As will be noted in the next sections, many visitors who stopped at the portals used them for orientation rather than to learn about the *Trail*. Both the It’s About Time wayside near the Yavapai portal (Fig. B-24) and the cell phone tour at Yavapai portal included useful information, but only 15% of the visitors we tracked stopped at It’s About Time, and we observed that even fewer accessed the cell phone tour. In the Recommendations section we suggest ways the Park can help, such as adding information about *the Trail of Time* to Park publications (as was done during the *Trail* opening in October, 2010) and enlisting the Park’s interpretive staff to help visitors understand their *Trail of Time* experiences.

Effectiveness of *Trail of Time* Components

In this section we take a closer look at visitors use and understanding of the major components of the *Trail of Time*.

Entrance Portals

The entrance portals were designed to introduce visitors to the *Trail of Time*, prepare them for their walk along the *Trail*, and stimulate reflection as they completed each stage of their journey. Data indicated that about half of the respondents who entered the *Trail* at either the Yavapai or Headquarters portals, stopped for a closer look. A bit more than a third of respondents who began at the Village end of the *Trail* stopped at that portal (Fig. Table I-4B). It should be noted however, that in anticipation of visitors not wanting to stop, these signs were designed to be read at a glance and on the move. In fact, data indicated that some respondents gleaned information from the portal panels without stopping, such as learning that they were beginning the *Trail of Time*, or that they had just walked a million years. At the same time, we also noted that many of the respondents who did stop tended to focus their attention on the map (Fig. B-7), sometimes walking away without even noticing (for example) the name of the *Trail*.

It was also interesting to note that a smaller percentage of respondents who were entering the *Trail* stopped at the Village portal than at either of the other two (Table I-3). This may be



because the portal at the Village end is set back from the first markers (Fig. B-2), and perhaps also that the sign by the first markers is not about the *Trail of Time*.

Each portal area was dominated by a cross-section structure built of real rocks. Although this was not labeled, a few respondents figured out on their own what it was and what it signified. For instance, we heard one father tell his children to touch the rocks at the bottom and feel how hard and smooth they were, because they were much older than the rocks higher up. In another group a woman pointed it out and clearly explained it to her husband, who said he completely missed it until she called it to his attention.

It was fairly common to hear respondents read aloud or paraphrase text from the portal labels, especially headers such as “Welcome to the *Trail of Time*” and “Congratulations, you’ve walked a million years.” There was also quite a bit of evidence that respondents were using portal maps for orientation and wayfinding. However, because the portals were two-sided, half of the maps were oriented in ways that differed from the lay of the land. For instance, on the east side of the Yavapai portal, one group decided that they should walk straight ahead to get to the Geology Museum based on their naïve reading of the map. There were similar issues with respondents misreading the maps on the east side of Time Zero portal, and the north side of Headquarters portal.

Given visitors’ needs for orientation, we also looked at some of the existing Park’s signage that was not developed as part of the *Trail of Time*, but that affected visitors’ experiences along the trail. Although some of it appeared to do an excellent job of meeting visitors’ needs (like the signs giving distances and directions to destinations where the headquarters trail meets the South Rim trail (Fig. B-30). In other areas, visitors were confused and irritated when they couldn’t figure out where things were. For example, for visitors traveling east past the Yavapai portal, there were no signs giving directions and distances to the rest rooms or the museum at the fork in the trail. And for visitors walking from the Yavapai parking lot to the rim, it would be useful to include directional signs for (a) the *Trail of Time*, (b) Grand Canyon Village, and (c) Yavapai Museum (similar to those where the headquarters trail meets the South Rim trail).

Maps are essential to most visitors to the South Rim. We saw many respondents carrying their Park newspapers and consulting its map (which they receive as they enter the Park). At the portals, most respondents who stopped went right to the map, pointing and talking about it. Many respondents’ portal experiences were almost exclusively about orientation and wayfinding, with a few exceptions. The portal maps seemed essential, but they may actually distract visitors from the portal information about the *Trail of Time*. It would be great if visitors’ orientation needs could be met by clear signage so that visitors’ attention might focus on the more educational goals of the portal signs.

Time Zero Portal

The portal and additional signage at Time Zero (where the *Deep Time* and *Million Year Trails* meet) was a particularly complicated space for visitors, as it included many components and lots of information in a fairly small space (Figs. B-1 and B-25 to B-27). About a quarter of visitors who walked the entire *Trail* stopped at one or the other side of the Time Zero portal (Table I-



4A). The Canyon Cutting wayside averaged comparable attention from visitors, and the Magic Meter was stopped at by slightly fewer visitors (Table I-5). The data indicate that far fewer respondents attended to all of the major components along this short section of *Trail*, resulting in confusion about the shift in time scale. For instance, one respondent attended to the bronze Magic Meter embedded in the Trail but not the adjacent Magic Meter wayside panel. During the interview she asked, “But what happened in a million years? It’s a million years of *what?*” She was clearly frustrated, although she eventually figured out most of it with the interviewer’s help.

There were indications that the brief texts on the Time Zero portal signs effectively communicated with visitors even if they did not stop and read in depth. The “Congratulations. You have just walked a million years” text was read aloud by many visitors. The time and distance information in these signs helped respondents decide what they wanted to do next. Some who entered the *Trail* at Yavapai accepted the challenge to walk a million years, and then turned back once they realized they had reached their goal (walking back towards Yavapai on the *Million Year Trail*). Others calculated that the Trail was “really long, like three or four miles,” and decided to walk just part of it. Approaching the east side of the Time Zero portal, one woman paraphrased the text: “Now we can walk 2 billion years.” They talked about it a bit, and then turned back.

The Canyon Cutting wayside was also effective for most visitors who stopped and read it. For instance, one respondent read the text and called to others in his group, “Come over here!” [He points to the last (first) 6 meters of the *Deep Time Trail*.] “We came in at 1,000, and we walked 1,000 steps. Look at this. The river carving took just the last six steps! Isn’t that neat?” His family concurred. As noted during the formative evaluation, the issue of how the canyon formed was very important to many visitors. It seems unfortunate that only 10% of the 132 respondents in the tracking and timing sample stopped at this wayside.

Markers

As we have seen from the earliest formative evaluations of the *Trail of Time*, children have taken the lead for most family groups when it comes to noticing and paying attention to the markers. Younger children counted off the markers with their parents beside, sometimes holding their hands, often getting help with the larger numbers (or with saying the numbers in English if they were visitors from other countries). Children were most apt to notice the changes in scale along the *Million Year Trail*. Teens and young adults most often were the ones who noted the patterns in the scale changes and came up with explanations for those patterns.

That said, many children who counted off the markers never made the connections between the markers and the other interpretation along the *Trail*. And many adults who looked at rock plinths and wayside never paid much mind to the markers. For instance, one adult who read “1 step = 1 million years” aloud did not notice the markers in the *Trail* until asked about them in an interview. As noted earlier, the portal and “It’s About Time” wayside signs explaining the markers occurred early on the *Million Year Trail*. Adults who had not read those signs—and sometimes those who read them—came up with their own explanations for the markers, sometimes with disconcerting results (see [Meaning of the Markers](#), above). Children, too,



developed theories about the markers. For instance, a boy, about 11 years old, speculated that the numbers might go all the way around the Grand Canyon.

Most of the children we observed counting off the markers were walking east to west, from Yavapai towards the Village. We saw occasional exceptions, such as this 13-year-old who started at the Village and finally reached the *Million Year Trail*.

The boy [walking from the west] started counting off the years near the younger end of the Trail, followed closely by his father. At about 48 years, the father said, "That's my label!" The boy counted "14, 13, 12" and they stepped back to 13. "I'm born!" He ended with, "1, Today!"

However, this almost never happened as children walked from the west along the *Deep Time Trail*—few children who started at the Village counted the markers as they walked. Children who started counting on the *Million Year Trail* often continued counting past the Time Zero portal. Also, among respondents we talked with, adults walking east from the Village seemed less likely to have noticed the markers within the first 500 meters or so of *Trail*.

This makes perfect sense. On the *Million Year Trail*, the counting starts easy and gets progressively harder. Most children could figure it out on their own or with help from caregivers and older siblings. But when you start at year 2,000 million, there is little opportunity to build momentum to carry you across the gaps. Children counting from the east were sometimes taken aback when they encountered the first gap between numbered markers at 10 million years, but children as young as seven recovered quickly when they saw the 20 million year marker. Starting from the west, the numbers are difficult to say at first—"2,000 million...1,999 million...1,998 million..."—and then there is a 10-meter gap before the next numbered marker. Although none of our respondents talked about this as such, it seems that counting from the west is harder to figure out, harder to do, and not as much fun—especially since the numbers are getting smaller, lessening the sense of accomplishment. Counting from the east begins with your birthday; counting from the west begins with eleven markers with big numbers and then a series of circles in the pavement that aren't nearly as engaging. This seemed to make a large difference in visitors' *Trail of Time* experiences.

Perhaps because of the numbered markers every meter or some other aspect of the *Million Year Trail*, respondents walking from the east seemed more likely to get the timeline idea. For respondents walking from the west, the *Trail* was about rocks and their ages, but it was not about walking along a timeline in the same way as those who started at the other end. For them the time dimension came from the numbers on the plinths more often than from the markers on the pavement.

Wayside Signs

Looking at only visitors who walked the entire *Trail*, the wayside signs were stopped at, on average, by about a third of respondents (Table I-5).¹⁰ The Horizontal Layers wayside was the

¹⁰ We chose this subsample of tracking-and-time respondents because they had an opportunity to view all the wayside signs during their walk.



most popular sign stopped at by about half of the sample; the Magic Meter wayside received the least attention, stopped at by only one in five respondents (Table I-5). That said, there were indications that most respondents who stopped at these complex signs only devoted enough time to absorb some of the content. For instance, the average stop duration at the waysides was only 30 seconds, varying from about 15 seconds (Climate Change, Canyon Cutting, and Human Cultures) to about 40 seconds (Explosion of Life and Great Unconformity).

Many respondents appreciated the wayside signs for both their geological (and historical) content and their maps and orientation information. Some waysides helped readers make sense of important ideas (like Canyon cutting and the age-relations of layered rocks), but others seemed less helpful at advancing respondents' understanding of complex geological ideas (like uplift and unconformities).

Some respondents used the signs primarily for orientation, focusing on the wayside integration strips (Figs. B-14 and B-15) for orientation. They used these perspective drawings of the Canyon's South Rim as maps of the area, figuring out where they were and where they wanted to go next. And they did this rather than building a better understanding of the *Trail of Time*. The wayside integration strips were less than ideal for this purpose, because the distances were distorted to, for instance, focus visitors' attention on the relatively short span of the *Million Year Trail*. One respondent, reading the Human Cultures wayside at 1,000 years, told his companions they were already half way to the Village. The distance information was there, on the wayside, but he didn't notice it. It seemed that many respondents, in the short time they devoted to the waysides, did not notice that the drawing was not to scale.

Viewing Tubes

Looking at only visitors who walked the entire *Trail*, the viewing tubes were stopped at, on average, by about a third of respondents (Table I-6). Several of the tubes attracted attention from about 40% of the respondents, including the Colorado River, Earthquakes and Volcanoes, and Horizontal Layers (Table I-6).

The viewing tubes provided a social experience for many groups, as respondents would call over others in their group to see them and talk about what they saw. We also heard respondents work together to figure out exactly what the tubes were all about, and what they could accomplish. For instance, respondents were sometimes surprised and disappointed that the tubes lacked lenses—they did not magnify the view. Many respondents understood that the tubes focused their attention—"It just points right at it"—but others were disappointed that the tubes didn't focus like a telescope. The data indicated that, for many respondents, figuring out the viewing tubes took some effort. We observed respondent groups talking about their confusion with the tubes and then working together to make sense of them based on similar things they experienced, like telescopes and viewing tubes encountered elsewhere in National Parks.

That said, the tubes seemed effective, especially at linking the rock plinths to the rock bodies in the Canyon. Almost every visitor we talked with realized the rocks on plinths had been brought up from deep within the Canyon, even though this was never explicitly explained to them. Because of that, most also realized the rocks deep in the Canyon were very, very old. The rock



plinth experience seemed to be a partial lesson on the principle of superposition, at least as it applied to Grand Canyon: Deep is older.

Some of the interpretation with the tubes (e.g., B-16 and B-17) was less than effective. For instance, names of rock types (like Kaibab) and landscape features (like the Uinkaret volcanoes) lacked pronunciation. Therefore some respondents hesitated to say names like “Uinkaret” out loud, and others mispronounced them. (“Oh yeah, I see the Hoochie Coochie volcano.”) Weather also played a role in tube effectiveness; on hazy or cloudy days, respondents couldn’t see the volcano. Perhaps most importantly, the Great Unconformity tube inadvertently misled some respondents who were trying to see this feature. This tube was aimed at a section of the unconformity that cut off a vertical, white dike, which made it easier to pick out this feature (Figs. B-28 and B-29). Unfamiliar with the term “unconformity,” some respondents decided that this prominent white feature was, itself the unconformity. The accompanying sign was not much help because it pointed out the unconformity at a place that was uncomfortably close to the white dike.

We should also point out that some respondents focused so closely on the tubes that they missed the adjacent signs—they looked, but didn’t know what they were seeing. During formative evaluation the team tested signs placed directly on the curved wall supporting the tube, and these proved effective. Adding similar signs should be a priority for remediation.

Rock Plinths

During formative evaluation we were able to test the use of single rocks as part of the wayside experience. Just placing those few labeled rocks beside the prototype wayside signs seemed to add quite a bit to the *Trail of Time* experience. However, we were not able to test the use of stand-alone rocks brought up from the Canyon’s depths—displayed singly or in sequence—so we weren’t quite sure how these additions would change respondents’ experiences. Based on the summative evaluation, we are pleased to report that the addition of the 40 plus rocks on plinths transformed many respondents’ experiences in very positive ways.

Looking at only visitors who walked the entire *Trail*, the individual rock plinths were stopped at, on average, by about 12% of respondents (Table I-7C), but many more read the rock ages and names at a glance, slowing down and even briefly stopping while walking past the plinths (but not for the three seconds required to be counted as a stop). Some even read aloud the ages and rock names as they walked by. As can be seen in Tables I-7A and B, respondents tended to stop more often at rock plinths during the first half of their journeys than at those they encountered later on their walks.

For a different perspective on these data, Table I-9 shows the number of plinths that tracking and timing respondents stopped at, using the entire sample. About 60% of respondents stopped at at least one plinth, 27% stopped at at least five plinths, and so forth. 40% of the sample did not stop at a single plinth; however many of these respondents walked only part of the *Trail* and thus encountered few if any plinths.



A large part of the rock plinth experience was touching the rocks and looking closely at them—a sensory and aesthetic experience as much as a geologic one. Finding out the rock’s age seemed to be more important to respondents than learning its name. And when viewing tubes were present, many (but not most) respondents took the opportunity to examine the deep-canyon sources of the rocks on plinths.

Touching the rocks seemed very important to some respondents. About 30% of those who walked the entire Trail were observed reaching out to touch a plinth rock, compared with 17% for the entire sample (some of whom never got close to a rock). Some respondents seemed to touch every rock, almost ritualistically. We watched a few respondents pass a rock, stop, and then run back to touch it. One boy, about 7, kept stopping to touch every rock he passed, even after his mom said, “You already touched all of them, come on.” We saw many children and adults run their hands over the rocks and then talk about how it felt. Parents often asked sensory questions to focus young children on the rocks.

“Is it smooth? You feel it,” asked the father of a five-year-old boy at a Supergroup limestone. The son rubbed his hand on the flat surface and said, “That didn’t hurt me.”

Many respondents also paid attention to the ages of the rocks. In fact, a few groups walking from the west started to get the idea that there was directionality to the rocks’ ages, even though they paid no attention to the numbered markers. As one respondent noticed, “They’re getting older and older.” But this group had not made the connection between the rock ages and the markers on the trail, so they did not really get the idea that they were walking a timeline. Other respondents did make that connection, and for them the rocks seemed to help the timeline idea make sense. That said, a few overheard visitor comments had us wishing we had a chance to get deeper into their thinking about rocks and time. For instance, one visitor on viewing the beautiful, fresh looking rocks, some with polished faces remarked that one rock looked “too new” to be that old.

When respondents paid attention to the rock names on the plinths, they usually focused on the second part of the name, as evidenced by reading aloud the generic part of the name (limestone), not the formal name of the rock formation (Kaibab). Respondents often talked about the names of the rock types—granite, sandstone, limestone—remembering other places they had encountered those types of rocks. Granite, especially, was noted for its occurrence on kitchen countertops and gravestones. Perhaps it was the familiarity of these rocks types that made respondents comfortable enough to use their names in conversation. The one time we heard a respondent use the name “pegmatite” in conversation was when he reminded his family they had a piece in their front yard.

When respondents were familiar with rock types they could go beyond just saying their names. For instance, we overheard one visitor talk about his observation that there was more sandstone and limestone on one section of the *Trail* and more granite on the other. Respondents also joked around with familiar rocks:



Talking about the lava rock as they walked past and touched it, three members of a family (teens and older) had this conversation after touching the black rock that had been sitting in the sun:

“Hot”

“Hot rock”

“A lot cooler than it used to be.”

It seemed at least one member of this group understood the significance of the volcanic specimen and was ready to have some fun with it

We also heard a few respondents say the formal rock formation names aloud, with “Vishnu” a particular favorite. One boy walking past rocks near the far west end of the *Deep Time Trail* read the names aloud: “Vishnu schist, Brahma schist, Rama schist.” However, most respondents did not talk about the first parts of the rock names. Perhaps this was because the names were sometimes hard to pronounce, or that many visitors had no context for understanding them. As one respondent said, “Vishnu—is that a god or something?”

We observed only a few respondents who got beyond the ages, names, and initial sensory impressions. For instance, one parent pointed out a conglomerate to his child and said, “That rock has lots of little other rocks in it.” Some respondents also searched for fossils in the specimen of Kaibab limestone, and some noticed the footprints in the Coconino sandstone. However, respondents, as a rule didn’t seem to know much about what to look for in a rock. Respondents walked right past specimens with ripple marks, cross-bedding, preserved mud cracks, mineral veins, stromatolites, and a variety of other inclusions with nary a second glance. Parents knew that their children should feel the textures of the rocks, but beyond that they seemed at a loss for what to talk about with their children. And the plinth signs, minimal as there were, really didn’t help beyond naming the age and rock type. Perhaps if more information had been available about the rocks—on plinth labels or elsewhere—some visitors would have stopped more often and had more satisfying learning experiences about the rocks.

Effectiveness of the Million Year Trail

The *Million Year Trail* made some very important contributions to respondents’ *Trail of Time* experience. For instance, it got respondents—especially children—counting along with the markers. It allowed respondents to see human events placed on the *Trail of Time* timeline, including finding their own place in time. As one respondent said, if they can’t see where they fit in, “1 million has nothing to do with me.” The *Million Year Trail* also helped some respondents develop a visceral feeling for a million years. In part because of all the activity generated by counting markers and thinking about humans’ place in time, the *Million Year Trail* seemed to add a level of energy that otherwise was missing from the *Trail*.

However, it was along the *Million Year Trail* that respondents became most confused about the meaning and purpose of the markers. This has been an issue since the earliest stages of formative evaluation (Gyllenhaal & Perry, 2004). Once the markers were older than 270 million years, it was easier to see the *Trail* as a timeline of rock ages because at least some of the markers clearly related to rocks—with ages in years in their plinths—that respondents’ could see right in front of



them. However, when the *Million Year Trail*'s markers read 1 year, or 100 years, or 10,000 years, some respondents did not understand what those dates related to. That's where some respondents started developing their misunderstandings about the markers as detailed in the [Making Sense of the Trail of Time](#) section, above. When a version of the *Million Year Trail* was tested in hallways at Arizona State University and Hebrew University of Jerusalem, the researchers did not notice respondents having similar mis-interpretations of the markers (Semken, Dodick, Ben-David, Pineda, Watts, & Karlstrom, 2009). The problems of seeing too much significance in the markers happened once the *Million Year Trail* was moved Grand Canyon.

Activity Guide and Cell Phone Tour

The activity guide was designed to help visitors better understand and use the *Trail* and to provide supplemental information and experiences for visitors. During data collection in July, we made sure the guide dispensers were continuously stocked with *Trail of Time* activity guides, keeping count of how many guides were removed each day. Several dozen guides were removed from the brochure dispensers each day that we kept track. No tracking and timing respondents were observed picking up a guide; however, during unobtrusive observations, a few respondents were observed picking up a guide, and a few were seen using it along the *Trail*. Our conclusion is that, during data collection, the guides were contributing to few respondents' experiences along the *Trail*.

Those respondents who had picked up and used a guide expressed mixed reactions to it. A few told us they found parts of it very useful, but others found parts of it confusing. For instance, one respondent said he had looked closely at the block diagrams and found them very useful. Another respondent, who had entered at the Village, said she was confused about how you would find your birthday along a *Trail* where time was measured in millions of years. Also, the July 2010 guide incorporated a photograph of a portal rock structure as part of a geologic cross-section, but neither visitors nor evaluators recognized that this graphic identified rock layers in both the rock structure and the Canyon.

There were indications that respondents who had not noticed the guide dispensers as they entered the *Trail* liked the idea that a guide to the *Trail* was available. For instance, a home-schooling mom was ecstatic when we presented her a guide, which she hoped to use as she developed a unit about rocks for the coming year. Another respondent noticed the dispenser as he exited the *Trail*, "NOW a brochure, where were they when we needed it?" This suggests that a more noticeable and better labeled guide dispenser would increase use of the guides.

For the activity guide to become a more useful component of the *Trail of Time* experience, a number of things have to happen: (a) More respondents need to find the guide dispenser and look inside it; (b) more need to recognize what the guide is for and take one along with them; (c) more need to use the guide along the *Trail* (rather than sticking it in a purse or pocket); and (d) the guide needs to meet respondents' needs as they use it. In the [Recommendations](#) section below, we make suggestions about how to improve each step in this process.



Similarly, we saw only a few respondents notice the signs for the cell phone tour, and only two groups we observed actually played the tour along the *Trail*. We noted that only the cell phone sign at Yavapai sign directed visitors to dial the tour about the *Trail of Time*; the cell phone sign at Village portal directed visitors to a tour about Grand Canyon Village. Reviewing the cell phone tour, it obviously included useful information about, for instance, what the *Million Year Trail* is about. However, during our study it did not seem to be having much impact on the experiences of respondents we watched and talked with.

Strengths and Weaknesses of the Timeline Approach

As noted above, the timeline approach provided really useful perspectives on Grand Canyon geology to visitors who entered with some experience with and knowledge about the Canyon's rocks. Just putting rocks on a timeline provided a structure that allowed some observant visitors to discover some things on their own, like the rocks getting older in one direction and how there is more sandstone and limestone on one end of the *Trail* and more granite at the other.

Also, because the *Trail's* timeline was so stretched out, it really did help some visitors achieve a visceral or gut level understanding of the age of the Canyon's rocks. The *Trail* is stretched out over more than two kilometers, and most geologic topics are only dealt with at one sign. Therefore, the places where respondents' questions first occurred to them were often widely separated from the places where their questions were answered in wayside signs. For instance, the explanation of Canyon cutting—the answer to many visitors' most pressing geological question—occupied only one wayside panel along the *Trail* and would have been conceptually difficult to place anywhere else as the exhibits were designed to be tied to the timeline.

It's important to note that the *Trail of Time* is only one part of Grand Canyon National Park's overall approach to geological interpretation. This evaluation found evidence that visitors who had also gone on a ranger-led walk, visited the Yavapai Geology Museum, or rafted through the canyon had particularly meaningful experiences along the *Trail*. (See [Relationship of Trail of Time Experiences to Other Interpretive Experiences](#), below.) In the recommendations section we discuss ways in which the Park can maximize the value of the *Trail* to visitors by linking it more firmly to the other interpretive experiences available in the Park.

Contributions of *Trail of Time* to Respondents' Park Experiences

Those respondents who stopped and really paid attention to the *Trail of Time* found their visits to the Canyon transformed. They appreciated Grand Canyon in new and more meaningful ways and saw things they otherwise never would have seen, like the rocks from deep within the Canyon. Those who heard about the Canyon's rocks during ranger talks, but to not get the see or touch them, appreciated getting to experience them first hand. And those who had already seen the rocks on raft tours gained new perspectives, new understandings about how the rock types and names fit together into a sequential history of the Canyon.

That said, it was clear that for many and perhaps most visitors, the *Trail of Time* was supplementary to the main experience—views of the Grand Canyon. Other factors also distracted



respondents from the *Trail of Time*. For instance, some respondents were distracted by animals—a deer in velvet, squirrels, chipmunks, ravens, and so forth. However, weather seemed to be one of the most important influences on respondents' commitment to the *Trail*. Storms quickly cleared most respondents off the *Trail*. However, despite light rain and distant thunder on some days, some respondents were still walking slowly and looking at views, rocks, and waysides. Bright sun and hot weather also deterred some respondents from attending to the *Trail*. For instance, one sweaty visitor told us he walked the whole trail, but he only looked at some of the rocks. He said he didn't really get anything out of it, but he didn't intend to. "I mostly wanted to get to our destination without boiling over!"

That said, only about 10% of the visitors in our tracking and times sample failed to stop at a single *Trail* component. Even those visitors who focused mainly on the aesthetic aspects of the Canyon also talked to us about the plinth rocks and their ages and other interpretive elements along the *Trail*. Many of these visitors used vocabulary from the waysides and other signs and talked about *Trail of Time* concepts even as they proclaimed their allegiance to their aesthetic experience of the Canyon. It seems that any exhibition placed in an outdoor setting of immense visual beauty could have trouble attracting and holding visitors' attention. Perhaps we should be pleased that visitors paid as much attention to the *Trail* as they did, considering the setting. The one caveat to this would be that the *Trail of Time* was a complex and challenging exhibition and it took concentrated attention and committed time to figure out just what it was and what it was trying to offer. As was noted earlier, many visitors did not figure out the timeline aspects of the *Trail*.

Relationship of *Trail of Time* Experiences to Other Interpretive Experiences

We talked with a number of respondents who had interpretive experiences about Grand Canyon geology before arriving at the *Trail of Time*. For instance, several respondents had been rafting in the Canyon, others had been on ranger-led tours, and some had visited the Yavapai Geology Museum. These respondents described the relationships between their *Trail of Time* and other interpretive experiences.

In some cases respondents described how their interpretive experiences provided background information that helped them understand what they were seeing along the *Trail*. For instance, a family had taken a one-day raft trip on the Colorado River, so they had seen rocks like those displayed on *Trail* before. They said they could make sense of the rocks along the *Trail*, in part, because they had seen and heard about them before on their raft trip. In a similar vein, a French-speaking respondent described the difficulties he was having translating some names of plinth rock types from English into French. He said he was glad he had been to the Geology Museum before he walked the *Trail*, because he otherwise would have felt much more confused.

Respondents shared other cases where relationships between *Trail* and other interpretive experiences seemed complementary. For instance, one family described attending a ranger program where the ranger talked about the rocks but did not show them any examples. These respondents described how the rocks they saw and touched along the *Trail* gave them first-hand experience with these rock types, *and* how the ranger talk helped them better understand the rocks they encountered along the *Trail*. The ranger talk provided otherwise unavailable



information about the rocks, and the *Trail* provided a kind of experience they otherwise would have missed out on.

Another family that had been whitewater rafting described some interesting feedback between their experiences on the rafting trip and along the *Trail of Time*. They had seen so many rocks in the Canyon that they were having trouble sorting them all out until they walked the *Trail of Time*.

It wasn't until we did this walk that we realized how it was all laid out. [The rocks were] kind of confusing when we did the whitewater rafting; it's kind of jumbled up, the ages....All the signs [on the rock plinths]...finally give you an idea of the chronological order from the oldest to the youngest rocks. And before we did this walk, I didn't have a sense of it at all.

Their experience in the Canyon gave meaning to the *Trail* rocks, but seeing the rocks laid out along a timeline helped them make sense of the “jumble” of rocks they had seen in the Canyon. These findings suggest that the *Trail*—at least for some visitors—can provide new perspectives on that pre-existing knowledge.

What we don't know, at this point, is how visitors' experiences along the *Trail of Time* may influence or enrich their later interpretive experiences in Grand Canyon National Park, and how those later interpretive experiences may help visitors better understand what they saw along the *Trail*. Perhaps GCNP staff can collect their own stories about these sorts of interpretive interactions and use them to develop more effective ways of talking with the public about both the *Trail* and Grand Canyon geology.

Learning-related Outcomes

This study revealed a range of learning outcomes related to the *Trail of Time* experience. For instance, the *Trail* was clearly getting respondents to think more about the geologic aspects of the Canyon—especially about the Canyon's rocks and how old they were. Many respondents were using geologic vocabulary as they talked with their companions, including names of rock types and words like “layers” and “formation.” Respondents with an existing interest in geology or rocks found much to enjoy along the *Trail*; other respondents had their interest in rocks or some other aspect of geology piqued as they walked along the *Trail*.

Range of Outcomes

The following section describes the major learning-related outcomes that respondents seemed to be taking away from their *Trail of Time* experiences.

Thinking more about geology

The *Trail* was clearly getting respondents to think more about the geologic aspects of the Canyon—especially about the Canyon's rocks and how old they were. Many respondents were



using geologic vocabulary as they talked with their companions, including names of rock types and words like “layers” and “formation.”

Piquing curiosity, inspiring interest

Respondents with an existing interest in geology or rocks found much to enjoy along the *Trail*; other respondents had their interest in rocks, the ages of the Canyon and its rocks, or some other aspect of geology piqued as they walked along the *Trail*.

Helping respondents connect time to rock

Most respondents we talked with along the heart of the *Deep Time Trail* had noticed and talked about ages of the rocks mounted on plinths. Furthermore, most of the respondents also recognized that the plinth rocks came from deep in the Canyon.

Learning facts and concepts

Many respondents we talked with could name specific things they learned from the interpretation along the *Trail of Time*. We talked with many respondents who discovered the age of a specific rock or the name of a particular rock type or layer. Some respondents expressed surprise that there were earthquakes at Grand Canyon or delight at finding out that volcanoes were nearby. Because of the wide range of information included on the wayside signs, the *Trail of Time* experience contributed in small ways to respondents’ interest in and understandings of a wide range of topics. Also, the number of waysides was limited, so the *Trail* would be minimally intrusive on the visitor experience of the Canyon. Therefore, the *Trail* touched on most aspects of geology briefly, usually on one or two signs at most, and most respondents failed to attend to the few places each subject was mentioned.

The one topic quite a bit of factual learning seemed to be taking place was about the names and classification of the rocks placed along the *Trail*. However, providing more detailed information rock types and how they formed was not a major topic of the *Trail*. Most learning about rocks, beyond names and ages, took place as respondents’ shared their personal understandings (and misunderstandings) with one another—parents teaching children, friends teaching friends, and home schoolers taking photos for a rock classification activity they were planning for the fall. In the recommendations section we suggest some ways that the *Trail* and related publications could contribute to respondents’ understandings of this topic.

Helping respondents develop a visceral feeling about geologic time

One of the goals for the *Trail of Time*, as stated on the project website, is to “visceral appreciation for the magnitude of geologic time.” This goal seems to have been achieved on several levels. One family who put it all together had spent several weeks touring parks on the Colorado Plateau, including white water rafting on the Colorado River. This is what the 13-year-old son said he got out of his *Trail of Time* experience.

I knew the number, that this was 1.8 billion years old. But you don’t really get a grasp of how much that is until you’ve walked one point eight billion years, where every step is a thing. It’s like, uh, it’s 1.8 billion years [said quickly], but then you do this walk and it’s like huh, it’s one—point—eight—billion—years [said slower].



His father talked about the appreciation he had gained for how long it took to erode the Grand Canyon.

There's a saw cutting into the layers, and it shows the Canyon was made in, what was it, six million years?... Which is again, so quick, so insignificant. Yeah, six steps!

And talking about how long humans had been at the Canyon, the dad said, "Probably a tiny sliver," and his son said, "It would be microscopic."

This family firmly connected their walking experience to the age of the Canyon, but many other respondents—especially children—got a feeling for how long a million or a billion was without realizing there was a connection to the age of the Canyon's rocks. For instance, a seven-year-old boy raced ahead of his family, counting every million-year marker as he went. He told his father, "I'm going to keep walking and see where it gets us to." When the boy returned about five minutes later, he proudly announced, "I got up to 210 million years old!" Another young man arrived sweaty and breathless at the picnic tables outside Verkamps Visitors Center. He asked for a drink of water, because "I just ran two billion years." For both respondents, it was clear that they made a visceral connection between long distances and vast amounts of time, but they did not connect this to the ages of the Canyon's rocks.

A third type of visceral connection was made by respondents who could imagine what it would feel like to walk a long distance that represented a vast amount of time, but who stopped short of actually walking the walk. We called this "visceral by proxy." For instance, we overheard respondents reading that it was a million steps from here to San Francisco, California, and being very impressed—especially if they had driven that distance a few days before. We also saw respondents turn back to the east at the Time Zero portal, apparently deciding that 2 billion years was too far to walk.

It was clear that many respondents failed to make this sort of visceral connection, in part because many never noticed the markers or understood their purpose. But, for those who counted along with the markers *and* attended to the wayside and portal signs about time, developing that sort of connection happened with some frequency.

Learning and practicing geological reasoning skills

Looking at layered rocks as evidence of time seemed to be new to most respondents we talked with. It's also significant that most respondents seemed more focused on rock layers rather than erosionally-shaped landforms that looked like castles or temples. This seemed like an accomplishment for the Trail, and a kind of geologic thinking. These respondents were not thinking "bands of color," but rock layers with continuity along and across the Canyon—something we did not see too often during earlier formative evaluations of the *Trail*.

We also noted other evidence that respondents were thinking geologically, even if they were sometimes wrong on the details. For instance, consider the following exchange between parent and six or seven year old child:



Parent: Dinosaurs are only in the top layer.
Child: What's in the bottom layer?
Parent: Nothing, it's too old.

The details were wrong, but the basic idea—akin to the principle of superposition—was there. We overheard another parent with two young children (maybe 4 and 6) talking about the Rama and Bhrama schists and nearby rocks. In answer to one of the kids' questions, he said, "Dinosaurs are about 300 million years old. All of these are extremely old rocks." So, his date for the first appearance of dinosaurs was off by about 50 million years, but he had the basic idea right – he was thinking like a geologist.

Learning Outcomes: Knowledge Hierarchies

Many of the respondents we talked with could name specific things they learned from the interpretation along the *Trail of Time*. We talked with many respondents who discovered the age of a specific rock or the name of a particular rock layer. Others expressed surprise that there were earthquakes at Grand Canyon or delight at finding out that volcanoes were nearby. However, we can't really appreciate this learning if we view it as isolated facts. Rather, we like to think of learning as a journey towards understanding, and facts are important because they play a role in this journey. The knowledge hierarchy approach—introduced earlier in this report—gives us a chance to explore respondents' journey towards understanding of concepts about the Canyon's geologic history. Knowledge hierarchies put facts and concepts in context, identifying how far a visitor has come along the journey. For this report, two knowledge hierarchies were developed: (a) the time significance of rocks in Grand Canyon, and (b) the cutting of the Canyon.

The time significance of rocks in Grand Canyon

This hierarchy looks at visitors' understanding of the time significance of the rocks layers that they see in the Canyon's walls and of the un-layered igneous and metamorphic rock bodies that occur in the deepest parts of the Canyon. The ideas here may seem complex, especially at the upper levels of the hierarchy. However, they represent the basic intellectual "tool kit" that geologists used to establish the time significance of the Canyon's rocks.

Level 0: "I don't know, and I don't care." Respondents at this level had little prior knowledge about and/or interest in the rocks as evidence of past times, although they often were impressed by their beauty and shapes and/or by the evidence they provided of "God's greatness." They had not thought about the time significance of the rocks in any great detail, and it was not something about which they expressed much curiosity.

Level 1: "I don't know, but I'm curious." These respondents did not know much about the time significance of the rocks they saw in the Canyon, but they were curious and wanted to know more. As they explored the Park, they had been wondering how old the rocks were, but they did not find or develop answers to their questions.

Level 2: Some knowledge, but it's incomplete or incorrect. These respondents were interested enough that they had developed a theory or hypothesis about the ages of the



rocks in the Canyon. Some respondents believed all the rocks were less than 10,000 years old. Other respondents' understandings were based on scientific ideas or suppositions, but were incomplete or incorrect—such as young respondents who thought they had found dinosaur claws or teeth in the Park, but had really found triangular fragments of limestone that formed before the time of the dinosaurs.

Level 3: Basic understanding of the time significance of layered rocks in the Canyon.

Respondents on this level:

- (a) Realized that the rock layers in the Canyon walls were widespread and could be seen all around the Canyon's walls. (In other words, they had at least a basic understanding of the concept of *bedrock*.)
- (b) Realized each layer of bedrock formed at a certain time, and thus any rock, plucked from the Canyon and placed on a plinth could be given an "age."
- (c) Realized that rock layers of different ages could be recognized and named throughout the park by matching them to cliffs, slopes, and benches.

Respondents who spent some time at the Horizontal Layers wayside and viewing tubes often gained enough knowledge that they reached, or at least approached, this level of understanding.

Level 4: Deeper understanding of the time significance of the Canyon's rocks.

Respondents on this level had a basic understanding of some geological principles, at least as they applied to the ages of rocks seen in Grand Canyon. For instance, they understood one or more of these ideas:

- (a) They realized that the older rocks were deeper in the Canyon—they had an understanding of the general *law of superposition* (upper levels are younger), at least as it applied to this context.
- (b) They understood that each rock layer was continuous around the Canyon's walls (principle of *lateral continuity*)
- (c) They recognized that each layer was (about) the same age wherever they saw it in the Park
- (d) Some also realized that the oldest rocks in the Canyon—although not layered as such—still had time significance, in part because they could be directly dated in absolute years.

Most respondents who reached this level probably did so gradually as they accumulated new understandings, and many were here because they came to the trail with this understanding, perhaps having studied geology in a formal setting.

Level 5: Familiar with the major rock units in the Park and their time significance.

These respondents knew many of the major rock units by name and knew in general terms when the major layers were formed. We met some respondents who reached this level through multiple interpretive experiences, including raft trips on the Colorado and ranger tours that prepared them to learn at higher levels from their *Trail of Time* experience.

Level 6: Sophisticated understanding and appreciation of the layered rocks both in the Park and in a regional context. These respondents would think about the rocks like



geologists do. Most significantly, respondents at this level understood the concept of the unconformities and their significance as “gaps” in the geologic record of the Park.

Many experiences along the *Trail* supported visitor learning along this hierarchy. For instance, this was a major theme for the Horizontal Layers wayside, which was visited by about half of the tracking and timing sample who walked the entire *Trail* and by 15% of the entire sample (many of whom never passed that point). Therefore, it’s not surprising that many respondents who had engaged with the exhibits along this section of the *Trail* gave indications that they moved up a level on this hierarchy.

The cutting of the Canyon

During the formative evaluation (Gyllenhaal & Perry, 2004), there were indications that most respondents were interested in how the Canyon formed, and that many had their own theories of how that happened. Some respondents in that study did talk about erosion, and some specifically mentioned the Colorado River eroding the rock. However, other respondents wondered how the river could have done it on its own. Respondents’ alternative theories included erosion by glaciers, giant lakes, wind, and a river that meandered the entire width of the current Canyon. Others speculated that an asteroid crash or the “big bang” may have played a role (Gyllenhaal & Perry, 2004). We were left wondering if respondents’ theorizing might have been more accurate if they had a better perspective on the immense amounts of time available for the Colorado River to erode the Canyon—6 million years. With 6 million years, even a seemingly modest force (like the Colorado River) had time enough time to do the job.

Given what the project team explained to us about the cutting of the Grand Canyon, the evaluators defined a Level 3 understanding as: “For more than five million years, the Colorado River and its tributaries have been carving the Grand Canyon through rock layers that were gradually uplifted from near sea level.” Note the emphasis on time, continuity, and uplift. Given that as Level 3, the rest of the knowledge hierarchy looks like this:

Level 0: "I don't know, and I don't care." Respondents at this level had little prior knowledge about and/or interest in the geologic processes that formed the Grand Canyon. They had not thought about them in any great detail, and erosional processes did not seem to be something about which they were curious. Respondents who focused on aesthetic aspects of the Canyon and some Biblical-time Christians or “young-earth creationists” belonged on this level.

Level 1: "I don't know, but I'm curious." These respondents said they did not know how the Canyon was formed, but they were curious about it. As they explored the Park, they had been wondering why the Canyon was so deep and wide, and why the rocks came in so many interesting shapes. However, many respondents tried to answer their questions about the Canyon on their own or using Imax shows or Park interpretation. It seemed that most respondents did not linger long on Level 1.

Level 2: Some knowledge, but it's incomplete or incorrect. These respondents were interested enough that they had developed a theory or hypothesis about how the



Canyon was formed. Although based on reasonable suppositions, their understandings were incomplete or incorrect. For instance, some respondents on this level wanted to have *really big forces* (like glaciers) create the Canyon, often relatively quickly (like asteroid impacts). Some respondents expressed doubts that the Colorado River alone could cut that deep. Others imagined the Canyon completely filled with water that somehow helped form the Canyon. (We heard this latter theory even from visitors who were not referencing the Noachian flood.) Some respondents on this level also realized that they needed a theory to explain the widening of the Canyon, but the forces to which they attributed this widening were not enough to do the job (e.g., wind erosion). It may be significant that some of the processes noted above can produce *wide* results (e.g., lakes and glaciers), which may be an attempt to carve out the depth *and* width of the Canyon with a single process.

Level 3: Basic understanding of how the Grand Canyon was cut to its current depth

This level included respondents who realized that, for more than five million years, the Colorado River and its tributaries have been carving the Grand Canyon through rock layers that had been uplifted more than a mile above sea level. To help respondents reach this level, they needed to believe that 6 million years is a really, really long time, so that seemingly modest forces (like the Colorado River) had enough time to accomplish the job.

Level 4: Expanded understanding that includes the processes that widened the Canyon.

These respondents understood that additional erosional processes helped to widen the Canyon, and that these processes include the effects of weather and gravity on the walls of the Canyon.

Levels 5 and 6: More sophisticated understanding of the erosion of the Grand Canyon.

Although we did not talk with any general respondents on these upper levels of the hierarchy, we suspect that Level 5 and up respondents understood the role that dry climates played in shaping these erosions processes and their results; know something about the concept of parallel retreat of cliff faces; or show a range of other understandings more typical of people who have studied erosion and geomorphology in school or worked with these concepts as part of their career.

We observed and spoke with some respondents who moved up a level or two on this hierarchy by attending to the Canyon Cutting wayside and adjacent river-polished rock. Some of those also demonstrated that they had developed a visceral understanding of the relative age of the Canyon. However, only a quarter of those who walked the whole trail stopped at this wayside, and only 10% of our total tracking and timing sample stopped here (many of those did not pass it). The origins of the Canyon are discussed only at this wayside, and most respondents took no notice of it because they missed the sign.



Maintenance-related Issues

Experience has shown that outdoor exhibitions can take a beating from both visitors and the elements, and the data indicated that *Trail of Time* will be no exception. As we collected visitor data for this evaluation, we also documented wear-and-tear beginning to take its toll on the *Trail*, even though most components have been in place for just a short time. Since this will eventually have an impact on the visitor experience, we thought we should call it to the attention of the extended *Trail of Time* team.

Trail and Markers

We noted that the inset portions of *Deep Time Trail* markers collect bits of gravel (Fig. J-1 in [Appendix J](#)). When the markers were stepped on repeatedly, as in front of a wayside sign, the metal in the recessed portions was scratched. A few of the markers in high-traffic areas were starting to look scratched up (Fig. J-2) as the paint was wearing off the recessed parts. This was anticipated and should look better once it is completely removed.

As would be expected along any hard path, the South Rim Trail asphalt was cracked in places (Fig. J-3), and in some cases this will eventually affect the bronze markers. In fact, the asphalt around a few of the small circular markers was already patched in places (Fig. J-4). We also noted ants tunneling at sides of markers, which may eventually lead to undermining (Fig. J-5).

Two additional marker-related issues include some markers with chips or cuts in edges (Fig. J-6). This occurred during a bad snow year when the park was using construction equipment to remove snow drifts from the trail. They have since purchased snow blowers to remove it while not impacting the trail markers. Also, along some parts of the *Trail* there were circular remains of glue from paper markers used during formative testing (Fig. J-7). But this will be covered as the Park was committed to re-sealing the pavement.

A final trail-related note: One *Trail* section floods, leaving mud behind covering one bronze marker (Fig. J-8) and several circular ones. If the Park decides to remove the dried mud, they should take care not to damage the markers.

Portals

At the Time Zero portal, on the back corner of the rock column, a slab of the portal rock came off during fabrication. Maybe this has already been noted and taken care of (there is some glue or epoxy visible), but this may be an indicator of future maintenance issues (Fig. J-9).

Elsewhere we noted young people climbing on the portal structures. As visitors continue to climb on them, the rock structures may be stressed more than planned for in their initial design.

Rocks and Plinths

Although most plinth rocks were in good shape, one sample broke as it was drilled and was never installed (the Jupiter limestone, Fig. J-10). Visitors apparently had replaced the Jupiter with a piece of Kaibab limestone. By having (1) broken rocks and (2) the wrong rock, it may suggest vandalism to visitors, and it also breaks trust because better informed respondents may



no longer be certain they can trust what they see along the *Trail*. It would be better to place a sign that explains that the Jupiter rock was damaged during installation and they are locating another piece.

Although most of the other plinth rocks looked pretty sturdy, some were fractured, and a few clay-rich rocks were starting to disintegrate in spots (Fig. J-11). Park staff should keep an eye on these rocks, because they may need to be replaced more often. It would be best to keep extra rocks on hand, but here's a reminder to be careful how those rocks are stored—several rocks had dried tape-glue on their exposed surfaces (Fig. J-12).

The plinths themselves have also suffered. Pine sap was dripping onto plinths and encrusting their surfaces (Fig. J-13, J-14). There was also leaf staining and chips and scratches on some plinths (Fig. J-15).

The Carbon Canyon limestone, unlike the other rocks, was mounted with its polished surface at an angle, and boot prints were clear on the polished surface (Fig. J-16, J-17) indicating that overly enthusiastic visitors might someday topple the rock or its plinth.

It was too soon for plinth rocks to be taking on a polish (with or without staining) where they are frequently touched, but—as experience with hands-on rocks and sculptures in museums demonstrates—eventually it will happen. The Park will have to decide how much of this they can tolerate and prepare appropriately.

Viewing Tubes

Although the viewing tubes and their housings look as if they were bronzed, the coating that protected the underlying metal was, in fact, fairly brittle and is beginning to chip and scrape off (Fig. J-18). The Park should plan on refinishing or replacing these exhibits.



CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The *Trail of Time* was an important addition to the visitor experience at the South Rim of Grand Canyon National Park. It inspired respondents to think and talk about the rocks of the Canyon—and their ages—in ways that just weren't happening before. It enhanced respondents' visits to the Canyon by giving them up-close looks and sensory experiences with rocks from the Canyon's depths. It gave families new ways to keep their kids interested during their long walks along the Canyon's rim.

This study revealed a range of learning outcomes related to the *Trail of Time* experience. For instance, the Trail was clearly getting respondents to think more about the geologic aspects of the Canyon. Many respondents were using geologic vocabulary as they talked with their companions, including names of rock types and words like “layers” and “formation.” Respondents with an existing interest in geology or rocks found much to enjoy along the *Trail*; other respondents had their interest in rocks or some other aspect of geology piqued as they walked along the *Trail*. Many respondents we talked with could name specific things they learned from the interpretation along the *Trail of Time*. Because of the wide range of information included on the wayside signs, the *Trail of Time* experience contributed in small ways to some respondents' interest in and understandings of a wide range of topics. One of the goals for the *Trail of Time*, as stated on the project website, was to help visitors develop a “visceral appreciation for the magnitude of geologic time,” and this goal seems to have been achieved for some visitors. Finally, there were indications that many visitors were thinking about the Canyon a bit more like geologists do. For instance, looking at layered rocks as evidence of time seemed to be new to most respondents we talked with. It was also significant that most respondents were increasingly focused on rock layers—compared to erosionally-shaped landforms that looked like castles or temples—than had been observed prior to the installation of the *Trail*.

The *Trail* also presented a number of challenges. Most respondents attended to relatively few of the interpretive components of the *Trail*, in part because they were distracted by the spectacular views from the South Rim and their needs to navigate the Park and stay on schedule. Respondents starting at Yavapai often missed the explanations of the *Million Year Trail*, which left many of them confused about the numbered markers and how they related to the Canyon's rocks and erosional evolution. Respondents starting at the Village sometimes failed to notice the numbered markers until their journey was almost complete, so they had to patch together their understanding of the time dimensions of the *Trail* from the ages on the rock plinths and wayside signs. While many respondents developed a new interest in Grand Canyon rocks, most of those who did were unable to take this new interest to the next step. The wayside signs dealt with challenging topics in ways that left some respondents a bit confused and overwhelmed about the topic. And some really important ideas—like how and when the Grand Canyon formed—were missed by respondents who walked past the brief interpretation while distracted by other issues.



Some of the challenges identified were a consequence of using a timeline as an underlying organizing design construct in a large outdoor setting. When the placement of ideas and specimens is determined by age and duration of events rather than visitors' interest and learning needs, this creates challenges. And when bronze markers are sunk into the edge of an internationally significant natural wonder, visitors may be set up to ascribe the individual markers with more meaning than they deserve.

Recommendations & Lessons Learned

This section includes a range of recommendations for improving the effectiveness of the various components of the *Trail* through remediation. It also includes suggestions for the Park Service about ways to support visitors' use of the *Trail of Time*. The following changes will help the *Trail* more effectively achieve its goals and meet visitors' needs and interests.

Trail Entrances

Add a small sign on or beside each portal rock structure that tells visitors that these are the real rocks found deep in the Canyon and that identifies the rocks by name, using the same names as are found on the rock plinths. Also, the geologic cross-section in the activity guide could be redesigned and labeled so that it is clear that this represents the portal rock structures (see Activity Guide section below).

The portals, ringed and floored with different kinds of rocks, could be places for a sign/exhibit on "how do you look at a rock" – more than just the name of the rock type, also look for grain size, internal structure, fossils, and so forth. Again, this could be part of the brochure/guide.

Replace the non-*Trail of Time* signage at the 2,000 million year marker with signage specifically about the *Trail of Time*. Based on tracking and timing data, we can expect that this will be the only signage that some visitors encounter about the *Trail*, so it needs to explain the *Trail* clearly to a whole range of visitors.

Add enough numbered markers so that every meter is marked for at least the first 50 meters walking from the west, or even better to the Oldest Rock wayside and Elves Canyon gneiss plinth (1,840 million years).

Viewing Tubes

Add labels on the curved wall by the tube or on the platform identifying what visitors are looking at. (These were prototyped, and they were shown to improve participants' experiences with the tubes during formative testing.)

Modify the interpretation at the Great Unconformity tube to make it clear that the unconformity is the horizontal line below the flat-lying rocks and the white dike was cut off by the unconformity (and is not the unconformity itself).



Activity Guide

We recommend designing a more attractive guide dispenser that includes a short text about the purpose of the guide and then placing dispensers not only at all four portals but also at additional locations along the *Trail*, such as where there is seating or where there is a whole series of stand-alone plinths in a row.

We also recommend designing a new guide that it can both add to visitors' experiences along the *Trail* and be used as a reference once they return home. One side should include two types of information that visitors need: (a) a simplified illustrated explanation of how the Canyon formed. This should be specially designed to correct some of the mis-interpretations that visitors were coming up with along the *Million Year Trail*; and (b) a reference guide to the rock formations exposed in the Canyon's walls that includes: a complete cross-section of the Grand Canyon (as on the July 2010 brochure), a more recognizable photo of a portal rock structure with text informing visitors that these are made of real rocks found deep in the Canyon, and the mnemonic for the major rock formation names, linked to either the cross-section drawings on the waysides and/or the portal structure.

As noted above, there were many indications that respondents were interested in the Grand Canyon rocks displayed on plinths, and they had many unanswered questions about these rocks. The second side of the activity guide would be a useful place to answer those questions, because visitors could then take it along with them as they explore other parts of the Canyon and other sites on the Colorado Plateau. For instance, side two could be an illustrated guide to rock types and rock formation names found along the *Trail*:

1. There should be a brief explanation about the formal rocks names seen on the plinths – how the names are structured, with a few examples.
2. Include a reminder about the three types of rocks (igneous, sedimentary, and metamorphic) and where they can be found in the Canyon and along the *Trail*.
3. The rest of this side should be an illustrated guide to rock types, using photos of specimens found at the portals in the paving and low walls. This can be presented as a kind of scavenger hunt, where visitors can search either the portals or the plinths to find examples. It can also be used in reverse – if visitors find the name “schist” and want to know what it is, they can consult this guide.
4. Be sure to prototype and test this approach.

Because visitors can purchase guides to Grand Canyon geology with detailed block diagrams of the Canyon's history, we recommend leaving those out of the activity guide.

Park Signage

We recommend the redevelopment of Park signage near and along the *Trail of Time* to do a better job of helping visitors orient themselves and navigate the Park. For instance, Include directional signs for the *Trail of Time*, Grand Canyon Village, and Yavapai Museum for visitors reaching the South Rim trail from the Yavapai parking lot (similar to signs where the headquarters trail meets the South Rim trail).



Also, signage should be consistent in the name for the new museum at Yavapai Point. Is it the Yavapai Geology Museum (as some signs say) or the Yavapai Observation Station (as it said on a paper sign in the building's window)?

Park Publications

We recommend that the Park include information about the *Trail of Time* in future editions of the Park newspaper and in maps handed out at entrances and visitors centers. This information can serve as “advertising” for the *Trail*, but it can also serve an educational role as an advance organizer helping visitors understand what the *Trail* is, how it is laid out, and what it tries to accomplish. A brief explanation of the *Million Year Trail* might also be appropriate in the Park newspaper. It would also be useful to develop a publication to sell in Park gift shops to increase awareness of the *Trail* and give visitors a way to extend the experience once they get home.

Park Programming

We recommend that Park rangers talk about and explain the *Trail* in their regular presentations, especially those on South Rim trail. The Park should also consider posting roving rangers along the *Trail* to help visitors who seem to be having trouble understanding it and to answer visitors' many questions about the *Trail* and Canyon geology. If possible, shuttle bus drivers should also be asked to talk about the *Trail of Time* as part of their spiel to their riders.

Cell Phone Tour Signage

These tours have the potential to add an important dimension to visitors' experiences. The sign at the Village portal should direct visitors to a message about the *Trail of Time*, rather than the Village (as it did during July 2010). Also, include additional cell phone signs near benches and overlooks along the *Trail*.

Long-term Maintenance of the Trail of Time

Design and secure funding for a long-term maintenance plan that takes into account the special maintenance needs of the *Trail of Time*, as will be detailed earlier in this report. For instance, plan now for long-term replacements of plinth rocks and potentially short-term replacements of the most vulnerable specimens.

Lessons Learned about Wayside Signs.

An extraordinary amount of time went into the iterative development, prototype testing, and refinement of the wayside signs, including focused attention to the development of the narrative text and graphic images. Although we don't recommend changes to the current wayside signs, it does seem that we can learn several lessons from both the development of these signs and what visitors are taking away from the current signage. One lesson is that, although time-consuming and at times painful, testing the waysides with real visitors in the real setting proved invaluable and resulted in interpretation that was more accessible by more visitors than was otherwise possible. It also became obvious that “less is more,” i.e. by focusing on fewer, more focused key messages, visitors were more able to glean the important content from each sign. It also became clear that spreading an exhibition over such a great distance presented a number of challenges



including the fact that key message—such as the age of the Canyon, and the processes used to cut the Canyon—can easily be missed by a large portion of visitors. Ideally, strategies might be developed to ensure that these key foundational messages are repeated in meaningful and interesting ways so that visitors have a better chance of encountering the message at one of the relatively few places where they stop, and those who encounter the message multiple times will be better able to elaborate on their understanding of it.



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APPENDICES

[Appendix A. Detailed Description of the *Trail of Time*](#)

[Appendix B. Photographs of the *Trail of Time*](#)

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Appendix A. Detailed Description of the *Trail of Time*

Overall Trail of Time

The *Trail of Time* is a walking timeline trail composed of three segments, two of which were fully developed as of July, 2010, and were evaluated in this report.

The main *Trail*—referred to as the *Deep Time Trail*—is a 2,000 meter segment, with each meter representing one million years of geologic history at the Grand Canyon. Time zero on the *Deep Time Trail* is about 100 meters east of Grandeur Point (Fig. B-1 in Appendix B). From there the *Deep Time Trail* stretches along the South Rim of the Canyon westward to the east side of Grand Canyon Village, with the million-year marker 2,000 just east of Verkamps Visitor Center (Fig. B-2).

Stretching eastwards from the *Deep Time Trail*'s time zero—and serving as an introduction to the *Trail* for visitors walking from the east—is the *Million Year Trail*. The *Million Year Trail*'s time zero is near the junction of the South Rim Trail and the side trail from the Yavapai Point parking area (Fig. B-3). This segment moves visitors through a series of changing time/distance scales to help shift from the more familiar human perspective (of years) decades, and centuries, to millennia, hundreds of thousands, and finally to the million year-scale of the *Deep Time Trail*.

The *Early Earth Trail* (developed after the summative evaluation data collection took place) begins at the 2,000 million year marker near Verkamps Visitor Center and then stretches first westward through the Village and then bends northward to Maricopa Point for an additional 2,560 meters. Maricopa Point represents the age of the Earth, almost 4.6 billion years. Wayside signage along the *Deep Time Trail* illustrated the position of the *Early Earth Trail* and labeled the age of the Earth (Fig. B-4). This section has since been fully marked with bronze markers every 10 meters and four wayside-sized signs have been installed, including three wayside signs at key places along the timeline and one that serves a function similar to the portals at Maricopa Point.

Portals

Trail segments and entry points are demarcated by small plazas called **portals**. Here visitors can step off the paved path and view signage mounted on a structure built of Grand Canyon rocks that were cut, polished, and then assembled to make a cross-section of the Canyon's geology (which geologists refer to as a stratigraphic column, Fig B-5). Signage on the portals introduces key ideas about the *Trail* appropriate to that point (Fig. B-6) and includes a map of the *Trail* pointing out "You Are Here" (Fig. B-7). Portals (Table A-1 in Appendix A) are located at the Yavapai end of the *Million Year Trail* (Fig. B-3, B-5 through B-7); at the junction of the *Million Year* and *Deep Time Trails* (Fig. B-1). A major side trail from Park Headquarters intersects the *Deep Time Trail* at about the 1,000 million year mark, and a fourth portal is located along the Headquarters trail at about 10 meters from the junction (Fig. B-8).



Portals	Marker / location	Notes
Yavapai Portal	0 years	East end of the <i>Trail</i> .
Time Zero Portal	1,000,000 / 0 years	Where the <i>Million Year Trail</i> meets the <i>Deep Time Trail</i>
Headquarters Portal	1,001 million years	Where the headquarters trail meets the <i>Trail of Time</i>
Village Portal	1,950 million years	West end of the <i>Trail</i> .

Table A-1. List of portals.

The plaza at each portal is paved with rock slabs and bounded by rock specimens that are often large enough to sit upon (e.g., Figs. B-3 and B-8). The rocks used to build each plaza are representative of rocks formed during the time interval of the section of *Trail* that visitors are about to walk. For instance, the Yavapai portal is surrounded by large pieces of basalt lava that had naturally broken into hexagonal columns (Fig. 32), and the Village portal is paved by slabs of metamorphic rock and bounded by metamorphic boulders (Fig. 33).

Additional specimens of Grand Canyon rocks are located at the junction of the headquarters and South Rim trails, including large specimens of limestone with fossil stromatolites (Fig. 34), which are discussed in a wayside sign near this junction.

Markers

Numbered bronze **markers** (also called **medallions**) are embedded in the asphalt to mark time along the *Trail*. Along the *Million Year Trail*, every meter is marked with a numbered marker, 4 inches (20.5 centimeters) in diameter (Fig. B-9). The time scale between markers varies along the *Million Year Trail*, from one year per meter at the east end (near Yavapai) to 100,000 years per meter at the west end (where it meets the *Deep Time Trail*). The scale is one meter equals one million years for the entire *Deep Time Trail*, with the first and last 10 meters of the *Deep Time Trail* marked by 4.5 inch (11.4 centimeter) diameter numbered marker every meter (Fig. B-10). Between 11 and 2,890 million years, every tenth marker is numbered. The meters in between are marked by smaller unnumbered circular bronze markers (Fig. B-11), 1.25 inches (3.2 centimeters) in diameter, which have been installed into the asphalt

Wayside Signs

Thirteen interpretive **wayside signs** are located at intervals along the *Deep Time* and *Million Year Trail* segments of the *Trail of Time* (Table A-2). Three additional waysides were installed along the *Early Earth Trail* after data collection for the summative evaluation. *Deep Time Trail* waysides focus on topics such as the carving of Grand Canyon in the last 6 million years, the age of the rock layer that caps the Canyon rim (Fig. B-12), and Grand Canyon's oldest rock (1,840 million years old). Waysides along the *Million Year Trail* discuss climate change (Fig. B-13) and volcanism over the past million years and the history of humans living in and near Grand Canyon. The lower portion of each panel is a **wayside integration strip**. This includes a



perspective drawing designed to help visitors locate themselves along the *Trail* in both geologic time and current-day space. Wayside integration strips along the *Million Year Trail* show the view from the Canyon towards the South Rim (Fig. B-14), while those for the *Deep Time Trail* show the view into the Canyon (Fig. B-15) to emphasize the differences between the two trail segments.

Wayside signs	Marker / location	Notes
It's about Time	20 years ago	
Human Cultures	1,000 years ago	
Climate Change	20,000 years ago	
Restless Region	100,000 years ago	
Magic Meter	1,000,000 / 0 years ago	
Canyon Cutting	6 million years ago	
Uplift and Erosion	60 million years ago	
Horizontal Layers	270 million years ago	
Explosion of Life	585 million years ago	
Great Unconformity	1,010 million years ago	
Supergroup Rocks	1,160 million years ago	
Crust Formation	1,719 million years ago	
Oldest Rock	1,840 million years ago	

Table A-2. List of wayside signs.

Viewing Tubes

Spaced along the *Trail* are eight **viewing tubes** to help visitors connect wayside interpretation with geologic features within the Canyon (Table A-3). For instance, viewing tubes help visitors locate the Kaibab limestone that caps the Canyon's walls (Figs. B-16 and B-17) as well as the Colorado River deep within the Canyon (Figs. B-18 and B-19). The tubes are movable hollow sections of bronze-colored pipe, designed to point out a view in the canyon but not to magnify it. Each viewing tube also had an annotated sign depicting and labeling the view that was being highlighted.



Viewing tubes	Marker / location	Notes
Colorado River	49 million years ago	
Volcanoes and Earthquakes	200,000 million years ago	
Kaibab Limestone	271 million years ago	Visitors move tube to view Kaibab on both south and north rims
Horizontal Layers	274 million years ago	
Explosion of Life	584 million years ago	
Great Unconformity	1,009 million years ago	
Grand Canyon Supergroup	1,163 million years ago	
Building of a Continent	1,719 million years ago	

Table A-3. List of viewing tubes.

Rock Plinths

A total of 46 **rock plinths** are located along the two Trail segments (Tables A-4A and A-4B). Atop each limestone plinth is a large piece of rock representing one of Grand Canyon’s formally named rock formations (like the Kaibab Limestone and Vishnu Schist). Many of the specimens were collected deep within the Canyon and then rafted or helicoptered out. Although some of these rocks are closely tied to adjacent wayside signs (Fig. B-20), most are designed to stand alone (Figs. B-21 and B-22). The interpretation on the stand-alone plinths gives the rock formation’s formal name and its age in millions of years (Fig. B-22A and B). The rock formation names usually include a proper name (like Rama or Kaibab) and a rock type (like schist or limestone). Rock type names (like limestone and granite) are always used to identify plinth rocks, even in cases in which the formal rock unit name is “X Formation.” Each plinth also includes in small text the words, “Touch me,” and a symbol for the *Trail of Time* (Fig. B-22B).



Rock plinths	Marker / location	Notes
Banded spring deposits	20,000 years ago	
Basalt (lava rock)	90,000 years ago	
River-polished rock	6 million years ago	
Kaibab limestone	270 million years ago	
Toroweap sandstone	273 million years ago	
Coconino sandstone	275 million years ago	
Hermit shale	280 million years ago	
Supai Group: Esplanade sandstone	285 million years ago	
Supai Group: Wescogame conglomerate	295 million years ago	
Supai Group: Manakacha sandstone	305 million years ago	
Supai Group: Watahomigi limestone	315 million years ago	
Surprise Canyon conglomerate	320 million years ago	
Redwall limestone	340 million years ago	
Temple Butte limestone	385 million years ago	
Muav limestone	505 million years ago	
Bright Angel shale	515 million years ago	
Tapeats sandstone	525 million years ago	
Grand Canyon Supergroup: Sixtymile conglomerate	650 million years ago	
Grand Canyon Supergroup: Walcott shale	742 million years ago	
Grand Canyon Supergroup: Awatubi limestone	750 million years ago	
Grand Canyon Supergroup: Carbon Butte sandstone	760 million years ago	
Grand Canyon Supergroup: Duppa sandstone	770 million years ago	
Grand Canyon Supergroup: Carbon Canyon limestone	780 million years ago	

Table A-4A. List of rock plinths (first half of list).



Rock plinths	Marker / location	Notes
Grand Canyon Supergroup: Jupiter limestone	790 million years ago	
Grand Canyon Supergroup: Tanner limestone	800 million years ago	
Grand Canyon Supergroup: Nankoweap sandstone	900 million years ago	
Grand Canyon Supergroup: Cardenas basalt	1,100 million years ago	
Grand Canyon Supergroup: Dox sandstone	1,130 million years ago	
Supergroup stromatolite	1,160 million years ago	
Grand Canyon Supergroup: Shinumo sandstone	1,170 million years ago	
Grand Canyon Supergroup: Hakatai sandstone	1,180 million years ago	
Grand Canyon Supergroup: Bass limestone	1,190 million years ago	
Grand Canyon Supergroup: Houtauta conglomerate	1,200 million years ago	
Quartermaster granite	1,375 million years ago	
Phantom granite	1,662 million years ago	
Cremation pegmatite	1,698 million years ago	
Horn Creek granite	1,713 million years ago	
Ruby gabbro	1,716 million years ago	
Vishnu basement rock	1,719 million years ago	
Trinity granite	1,730 million years ago	
Diamond Creek granite	1,736 million years ago	
Zoraster granite	1,740 million years ago	
Vishnu schist	1,745 million years ago	
Brahma schist	1,750 million years ago	
Rama schist	1,755 million years ago	
Elves Chasm gneiss	1,840 million years ago	

Table A-4B. List of rock plinths (second half of list).



Additional Interpretation

Additional interpretation available to *Trail of Time* visitors includes the **activity guide**, a brochure available at dispensers in each portal plaza (Fig. B-23). In addition, at the time of our site visit, visitors with cell phones could access a **cell phone message** describing the *Trail* by dialing a number on a sign at Yavapai portal (Fig. B-23). The message was about 3 minutes and 45 seconds long.



Appendix B. Photographs of the *Trail of Time*



Figure B-1. Overview of time zero on the *Deep Time Trail*, looking east towards the *Million Year Trail*. This photo shows the major components of the Trail, including bronze markers (circles on left side of *Trail*), a rock plinth (lower left), wayside signs (left center), a viewing tube (up the trail from the second sign) and a portal (on the right).



Figure B-2. The west end of the *Deep Time Trail* near Verkamps Visitor Center. The portal is in the upper center of the photo. The sign in the lower left is not part of the *Trail of Time*.





Figure B-3. The east end of the *Trail of Time*, looking east. The side trail behind the portal goes to the Yavapai Point parking area and the main trail continues to the Yavapai Geology Museum.

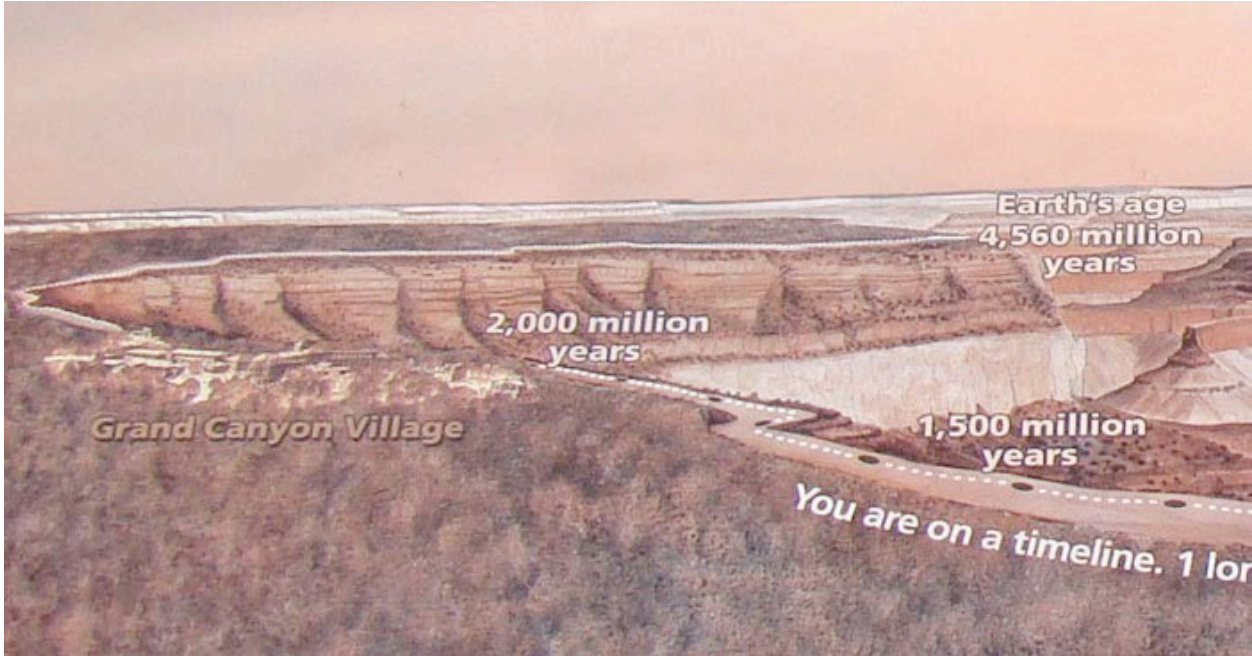


Figure B-4. The far end of the *Early Earth Trail* (Maricopa Point) identified on a wayside sign as “Earth’s age 4,560 million years.”





Figure B-5. Cross-section of Grand Canyon rocks at Yavapai portal.

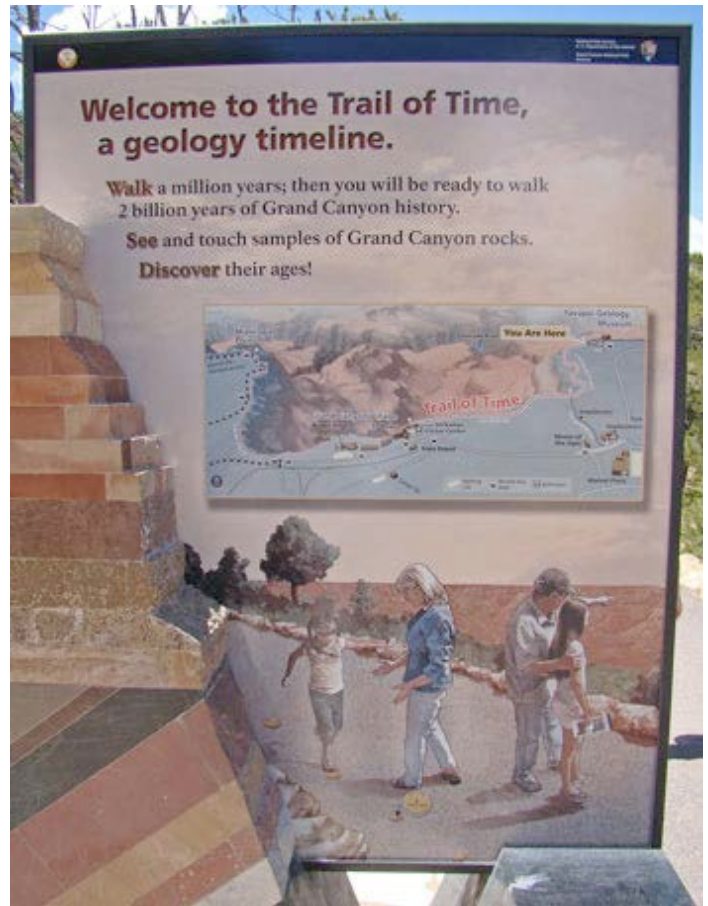


Figure B-6. Sign with map at the Yavapai portal.

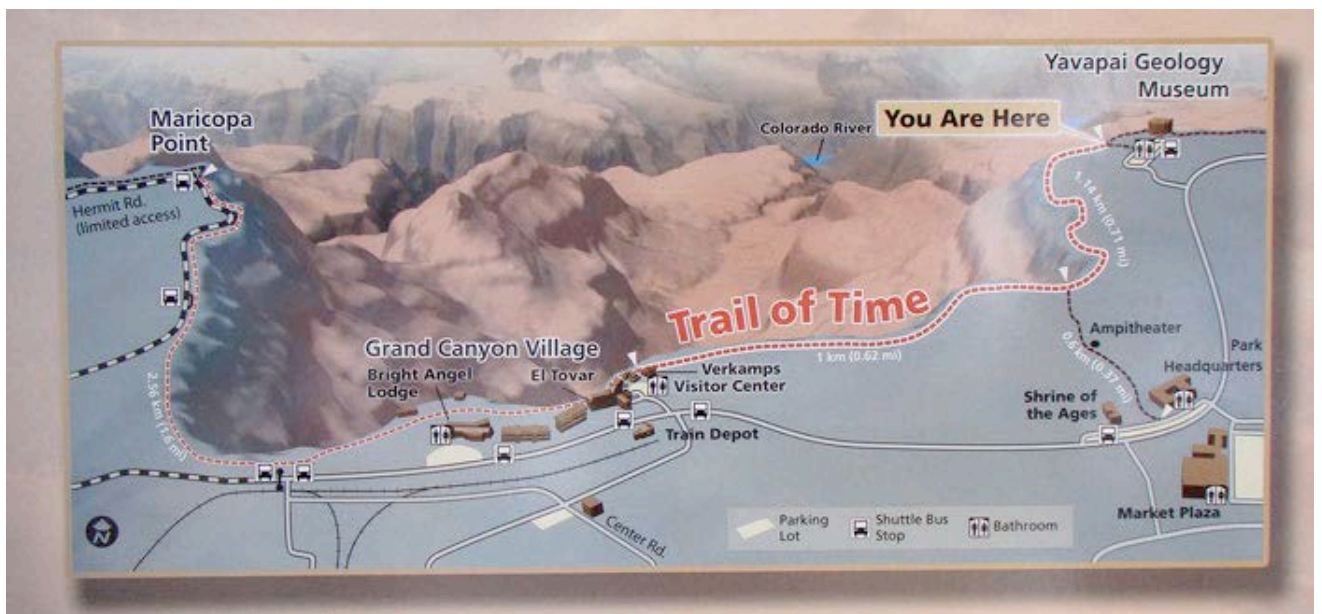


Figure B-7. Map on sign at Yavapai portal.





Figure B-8. Portal at the junction with the Headquarters trail.



Figure B-9. Example of bronze marker from the *Million Year Trail*.



Figure B-10. Example of bronze marker from the *Deep Time Trail*.





Figure B-11. Example of circular marker from the *Deep Time Trail*.



Figure B-12. Wayside sign at 270 million year marker on the *Deep Time Trail*.

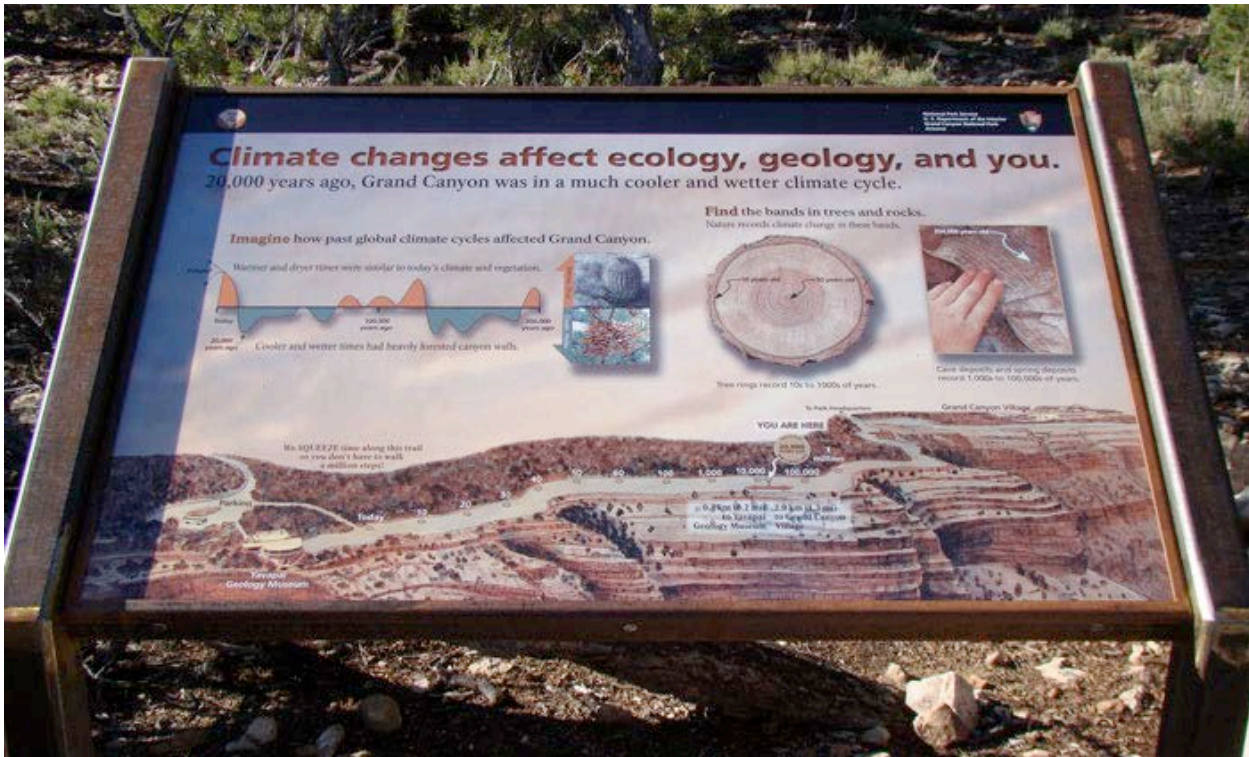


Figure B-13. Wayside sign about climate change along the *Million Year Trail*.



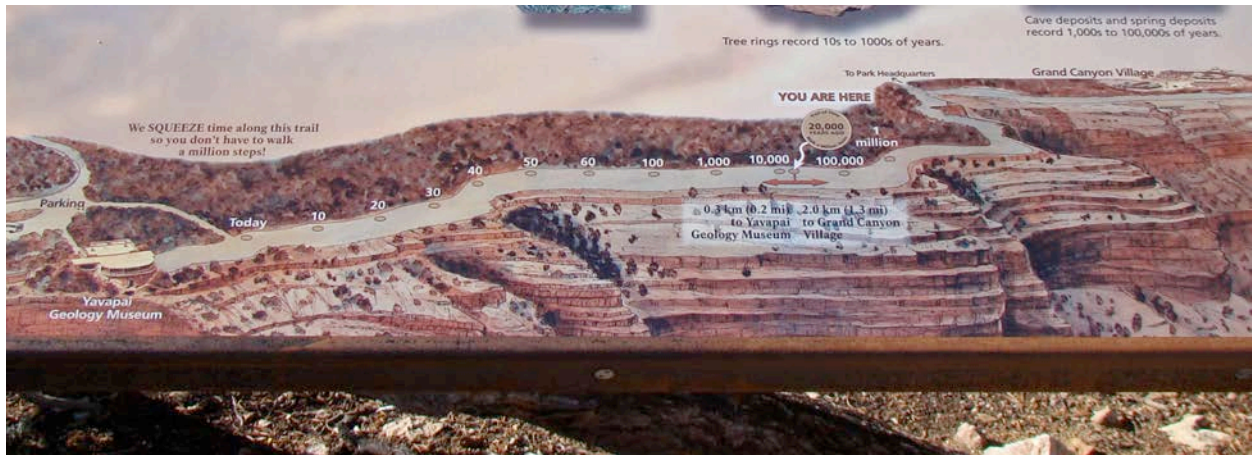


Figure B-14. Wayside integration strip on a *Million Year Trail* wayside sign (Climate Change).

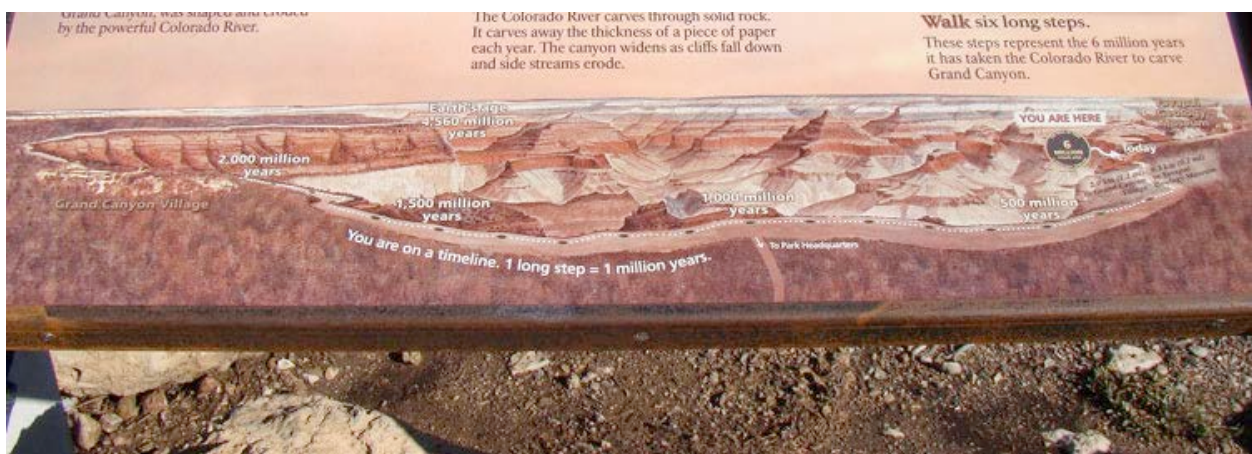


Figure B-15. Wayside integration strip on a *Deep Time Trail* wayside sign (Canyon Cutting).



Figure B-16. Viewing tube integrated with a wayside sign (Horizontal Layers at 270 million years).





Figure B-17. Closer look at viewing tube from Fig. B-16 showing adjustable tube with notches and interpretive sign (Horizontal Layers at 270 million years).



Figure B-18. Viewing tube for Colorado River.



Figure B-19. View of river through the tube.





Figure B-20. Rock plinth integrated with a wayside sign (Climate Change along *Million Year Trail*).



Figure B-21. Series of stand-alone rock plinths (at about 1,700 million years).



Figure B-22A. Stand-alone rock plinth (Rama schist at 1,755 million years).



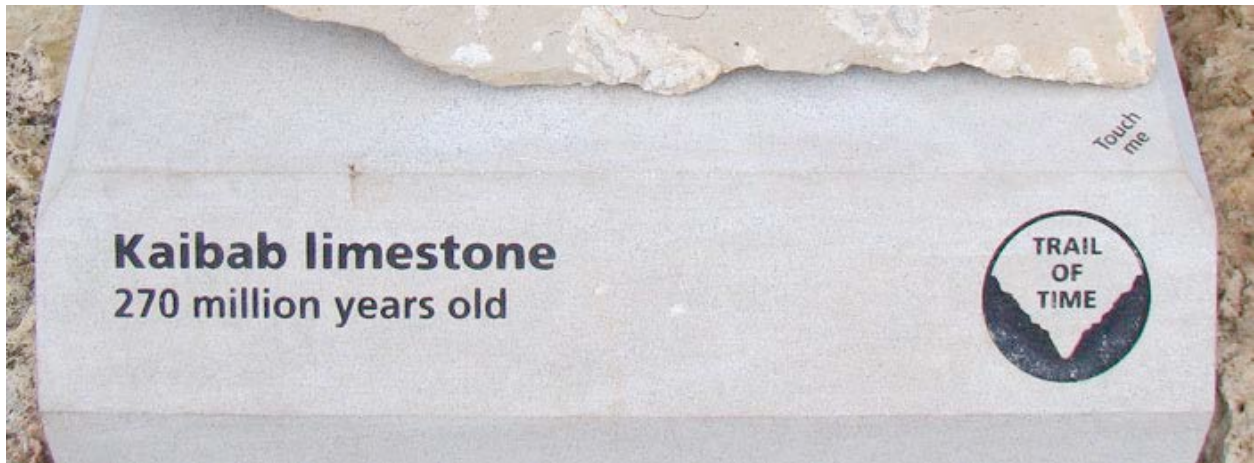


Figure B-22A. Example of the text and graphics on a rock plinth. Note the “Touch me” label on the right corner of the plinth.



Figure B-23. Activity guide dispenser and signage for cell phone tour (at Yavapai portal).



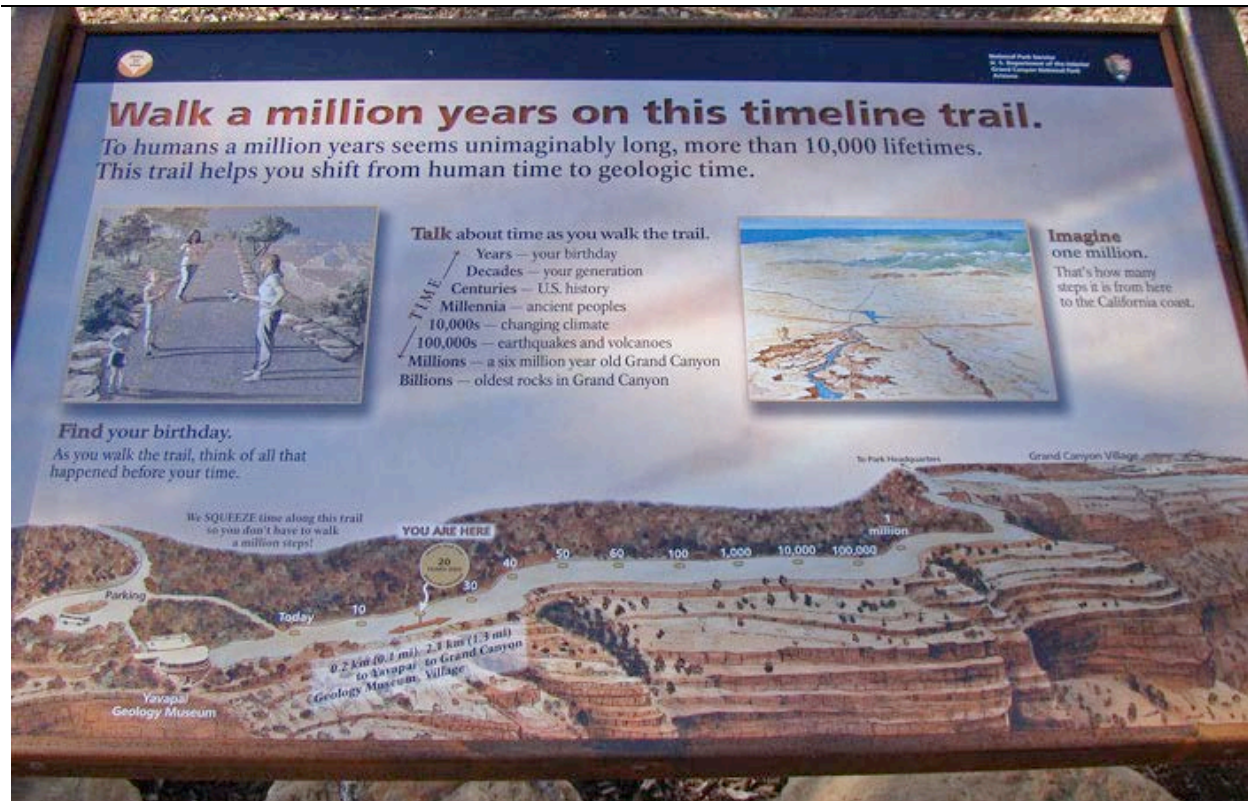


Figure B-24. It's About Time wayside, which explains the purpose of the *Million Year Trail* (just west of Yavapai portal).





Figure B-25. Paving stones and “magic meter” at Time Zero portal.



Figure B-26. Bronze Magic Meter and Magic Meter wayside sign at Time Zero portal.

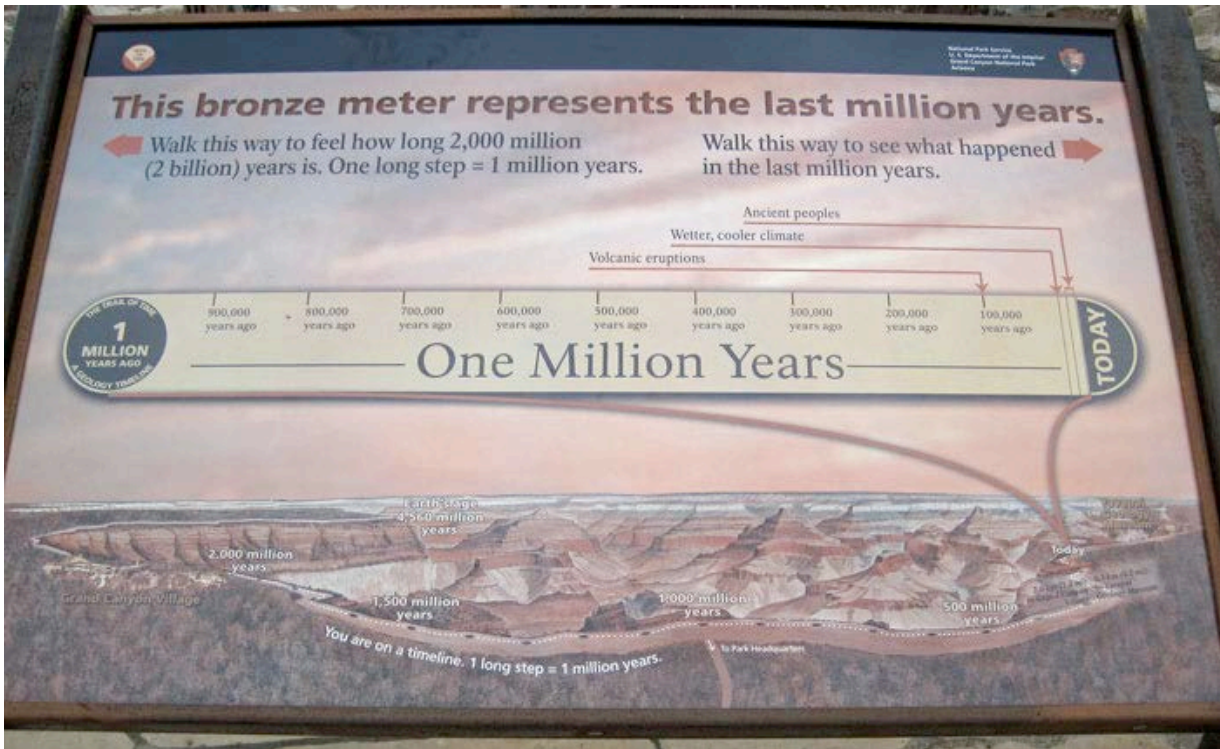


Figure B-27. Closer view of Magic Meter wayside sign at Time Zero portal.



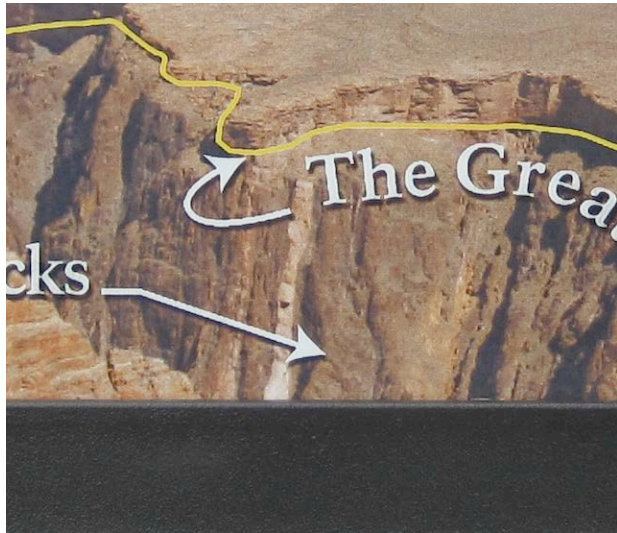


Figure B-28. Graphic from the Great Unconformity viewing tube's sign.



Figure B-29. The view through the Great Unconformity viewing tube.



Figure B-30. Sign at the junction of the headquarters trail and South Rim trail.





Figure 32. The Yavapai portal plaza is surrounded by large pieces of basalt lava that had naturally broken into hexagonal columns, as well as by other rocks formed during the last million years.



Figure 33. The Village portal plaza is paved by slabs of metamorphic rock and bounded, in part, by boulders of metamorphic rock.





Figure 34. Boulders of limestone with fossil stromatolites, located at the junction of the headquarters and South Rim trails.



Appendix C. Evaluation and Research Reports for the *Trail of Time* Project

The *Trail of Time* evaluation team has produced a large number of reports about the formative evaluation of *Trail of Time*. These are listed in the next two sections. In addition, the *Trail of Time* project team has also published about the project. These citations are listed in the third section of this appendix.

Long-format evaluation report

The first stage of the formative evaluation took place during fall, 2004. Rough prototype versions of the markers were laid out along the South Rim Trail between Yavapai and Mather Points, along with minimal interpretation at either end of the prototype trail. The report from this early study is available online:

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. Available online at the Selinda Research Associates website:
<http://selindaresearch.com/TrailOfTimeFormativeFINAL.pdf>

Evaluation briefs

During later stages of the formative evaluation, Selinda Research Associates wrote up findings as shorter and often preliminary evaluation briefs. These briefs were either (a) a summary of what we have summarized from the literature about a topic, and/or (b) the results from quick testing of prototypes. Their purpose was primarily to provide quick summaries of important information in order to help inform the design/development process. Because the information in these briefs is necessarily quick and preliminary, some of them have not been fully vetted by the rest of the *Trail of Time* team. They will be updated and revised as time allows. Links to PDF versions of the briefs on the *Trail of Time* project website are below:

[Evaluation Brief #1: Large Numbers](#)
[Evaluation Brief #2: Printed Trail Guides](#)
[Evaluation Brief #3: Maps in Interpretation](#)
[Evaluation Brief #4: Visitors and Geology](#)
[Evaluation Brief #5: Cognitive Overload](#)
[Evaluation Brief #6: 10-Meter Marker Circle Text](#)
[Evaluation Brief #7: 10-Meter Markers Time Transition](#)
[Evaluation Brief #8: Why the timeline is horizontal](#)
[Evaluation Brief #9: Prototype Walking Guide](#)
[Evaluation Brief #10: Temporary Signage](#)
[Evaluation Brief #11: On-Site Testing](#)
[Evaluation Brief #12: Off-Site Temp Sign Illustration](#)
[Evaluation Brief #13: Off-Site TAT Markers](#)
[Evaluation Brief #14: Off-Site MT 6ma 70ma 270ma Waysides](#)



[Evaluation Brief #14a: Recommendations](#)
[Evaluation Brief #15: On-Site Testing April 2008](#)
[Evaluation Brief #16: Off-Site Testing June 2008](#)
[Evaluation Brief #17: On-Site Testing July 2008](#)
[Evaluation Brief #18: ToT Humor](#)
[Evaluation Brief #19: Off-Site Testing December 2008](#)
[Evaluation Brief #20: Off-Site Testing January 2009](#)
[Evaluation Brief #21a: Off-Site Testing March 2009](#)
[Evaluation Brief #21b: Waysides for March 2009 testing](#)
[Evaluation Brief #22: Off-Site Testing Pronunciations](#)

Additional publications about the *Trail of Time*

The *Trail of Time* project and research teams have published descriptive and research studies related to the *Trail of Time*. These are listed below.

Karlstrom, K., Semken, S., Crossey, L., Perry, D., Gyllenhaal, E. D., Dodick, J., Williams, M., Hellmich-Bryan, J., Crow, R., Bueno Watts, N., & Ault, C. (2008). Informal geoscience education on a grand scale: the Trail of Time exhibition at Grand Canyon. *Journal of Geoscience Education*, 56(4), 354-361. Available online at the *Trail of Time* website: http://tot.unm.edu/documents/karlstrom08_tot.pdf

Semken, S., Dodick, J., Frus, R., Wells M., Perry, D., Bryan, B., Williams, M., Crow, R., Crossey, L., & Karlstrom, K. (Nov.-Dec., 2009) Studies of informal geologic time learning at the “Trail of Time” in Grand Canyon National Park. *Informal Science Review*, 99, 1-5. Available online at the *Trail of Time* website: http://tot.unm.edu/documents/semken_et_al_2009.pdf

Semken S., Dodick J., Ben-David O., Pineda M., Watts N., & Karlstrom, K. (2009). Timeline and time-scale cognition experiments for a geological interpretative exhibit at Grand Canyon. Proceedings of the NARST 2009 Annual Meeting. Available online at the *Trail of Time* website: http://tot.unm.edu/documents/semken09_tatex.pdf



Appendix D. Topical Framework

Trail of Time

Summative Evaluation

Topical Framework

Selinda Research Associates, Inc.

July 2010

I. Description and Context

1. How was the *Trail of Time* positioned along the Canyon's rim and in relation to other developments in the Park (like parking lots and the Yavapai Geology Museum)?
2. What was the nature of the numbered markers along the *Trail*, and how did these change from one end of the *Trail* to the other?
3. How many exhibit units were there, including portals, wayside interpretive signs, viewing tubes, and rock plinths? How were they positioned relative to one another?
4. What were the intentions and hoped for outcomes for each unit? For the *Trail* as a whole?
5. What were the different sections of the *Trail*, and how were visitors made aware of the differences between them?
6. What was the nature of the walking guide, and how was it made available to visitors?
7. What other support materials were available to visitors to acquaint them with the *Trail of Time*, before, during, or after their visits (e.g., Park newspaper, news stories in local media, etc.)?

II. Visitor Engagements

A. Physical

1. What was the range of ways visitors used the *Trail of Time* as a whole? How did visitors move along the *Trail*?
2. In what ways and to what extent did visitors engage with the markers embedded in the *Trail*?
3. How did they move among portals/waysides/viewing tubes/plinths? Between *Trail*-related experiences and other experiences?
4. Did visitors tend to engage with most of the units (portals, waysides, viewing tubes, plinths, walking guide), or did they skip some or many of them? Did they engage more with one type of unit than with another?
5. In what ways did physical engagements differ when visitors moved east to west (younger to older) as opposed to west to east (older to younger)?
6. What was the range of ways that visitors engaged with individual waysides? In what ways and to what extent did visitors physically engage with the signs, rocks, viewing tubes, and the Canyon itself?
7. In what ways and to what extent did visitors engage differently along the two sections of *Trail* studied in this evaluation?
8. How did visitors find and how often did they pick up a walking guide? In what ways and to what extent did visitors incorporate the walking guide into their *Trail of Time* experience?



9. In what ways were physical engagements for children and adults the same and different along the *Trail*? For families with young children as opposed to adult-only groups?
10. In what ways and to what extent were visitors' physical engagements linked to their religious beliefs and preexisting views about deep time and evolution?

B. Social

1. In what ways and to what extent were visitors engaged in teaching-learning (broadly defined) activities?
2. How were visitors jointly constructing meaning?
3. What forms of collaboration did visitors engage in, and how did this collaboration manifest itself, physically and intellectually?
4. What was the nature of adult-child interactions, especially those between children and their adult caregivers? In what ways were these the same and different between different types of trail components?
5. What sorts of social engagements incorporated use of the walking guide?
6. In what ways were social engagements for children and adults the same and different throughout the exhibition? For families with young children as opposed to adult-only groups?
7. In what ways and to what extent were visitors' social engagements linked to their religious beliefs and preexisting views about deep time and evolution?

C. Intellectual

1. In what ways and to what extent were visitors' minds engaged by the *Trail of Time*?
2. What intellectual processes were they using? Observing? Comparing and contrasting? Making connections?
3. In what ways and to what extent did visitors make sense of the numbered markers embedded in the *Trail*? To what extent did visitors notice changes in the markers along the *Trail*, and how did they make sense of them?
4. In what ways and to what extent did visitors make intellectual connections between the numbered markers and the portals, rock plinths and wayside interpretive signs? Between the markers and rocks visible in the Canyon?
5. In what ways did intellectual engagements differ when visitors moved east to west (younger to older) as opposed to west to east (older to younger)? Did this affect visitor meaning making or how quickly visitors made sense of the markers and overall timeline?
6. In what ways and to what extent were visitors able to resolve the horizontal timeline with the vertical stratification as seen in the Canyon and as depicted at the portals and in the waysides?
7. In what ways and to what extent did visitors understand and make sense of the differences between the *Million Year Trail* and *Deep Time Trail*? To what extent were visitors aware that there was a third, undeveloped *Early Earth Trail* out to Maricopa Point?
8. How was the intellectual experience the same and different when visitors walked the entire *Trail*? Was there a cumulative cognitive effect when visitors walked the entire *Trail*?



9. In what ways and to what extent were visitors' intellectual engagements influenced by their earlier experiences with school geology and with geology in other parks and other informal settings?
10. What sorts of intellectual engagements resulted when visitors discovered and used the walking guide? How did visitors understand and make sense of the walking guide, and in what ways and to what extent did the guide contribute to their intellectual engagement with the *Trail of Time* and its geological ideas?
11. In what ways and to what extent did other interpretive materials available in the Park (e.g., the newspaper and Yavapai Geology Museum) contribute to visitors' intellectual engagements along the *Trail of Time*?
12. What questions did visitors generate and/or explore as they walked the *Trail*?
13. In what ways were intellectual engagements for children and adults the same and different? For families with young children as opposed to adult-only groups?

D. Emotional

1. In what ways and to what extent were visitors emotionally engaged along the *Trail of Time*? What was the nature of their emotional engagement?
2. In what ways and to what extent did visitors emotionally engage with the large numbers portrayed on the numbers markers and signage?
3. How did emotional engagements vary among the different sorts of exhibit units?
4. In what ways did visitors emotionally engage with the beauty and aesthetic aspects of the Canyon, and how did that contribute to or conflict with their engagements with the *Trail*?
5. What sorts of emotional engagements resulted when visitors discovered and used the walking guide?
6. In what ways and to what extent were visitors frustrated or confused by their experiences along the *Trail*? If so, what were the sources of frustration/confusion?
7. In what ways and to what extent were visitors' emotional responses to the *Trail* linked to their religious beliefs and preexisting views about deep time and evolution?
8. In what ways and to what extent were visitors appreciative of the *Trail*, and how did they describe its contributions to their enjoyment and other aspects of their experience?
9. In what ways were emotional engagements for children and adults the same and different?

III. Visitor Learning Outcomes

1. How successful was the *Trail* as a whole at accomplishing goals like giving visitors a visceral feeling about geologic time, helping them to connect time to rock, and highlighting geology as integral to Grand Canyon?
2. In what ways and to what extent were visitors learning geological ideas and skills? To what extent were these ideas closely linked to the Canyon and rock exhibits as opposed to more general in scope?
3. What new ways of thinking or understanding did visitors leave the *Trail* with? In what ways and to what extent did visitors become aware of something they didn't know before? For instance, how did their perceptions of and understandings of rocks types and rock layers evolve? To what extent did they envision past environments and changes from past to present?



4. To what extent was there evidence of visitors developing and practicing geological reasoning skills (like superposition, erosion, and lateral extent)? How did visitors' geological reasoning skills evolve as a result of interacting with the *Trail*?
5. For each interpretive component, which of the intended learning outcomes appeared to be achieved, and which were not?
6. What was the contribution of the *Million Year Trail* to visitors' conceptual understanding of the *Deep Time Trail* and the *Trail of Time* as a whole? Did the changing time scale get them thinking about time, help visitors make the transition from human to geologic time, confuse them, some of each, or something else?
7. How did visitors' connections with Grand Canyon, geology, and geologic time change or evolve as a consequence of engaging with the *Trail*?
8. In what ways and to what extent was visitors' curiosity piqued? How did visitor interest in and attitudes towards Grand Canyon, geology, and geologic time change or evolve as a consequence of engaging with the *Trail* or some part of it?
9. When visitors made multiple visits and used the *Trail* repeatedly, how did their thinking evolve over time?
10. In what ways and to what extent did the walking guide contribute to visitors' learning outcomes along the *Trail of Time*?
11. In what ways were learning outcomes for children and adults the same and different?
12. In what ways and to what extent were visitors' learning outcomes linked to their religious beliefs and preexisting views about deep time and evolution?

IV. Visitor Motivations

1. In what ways and to what extent were the six visitor motivations engaged: communication; curiosity; confidence; challenge; control; and play? (This is based on Deborah's Perry's model of intrinsically motivating museum experiences, also known as, "What makes learning fun?" See <http://selindaresearch.com/learning.htm> for references and links.) How can these findings inform continued development of the walking guide?
2. Along which sections of the *Trail* and at which units (portals, waysides, viewing tubes, plinths, walking guides) were different motivations more or less engaged?
3. In what ways were visitor motivations for children and adults the same and different?

V. Design & Installation

1. Which aspects of the design of the numbered markers, exhibit units, and two sections of the *Trail* contributed in what ways to meaningful visitor experiences?
2. Did visitors notice the different marker designs, and, if so, how did they think and feel about them?
3. What aspects of the design contributed to visitors' orientation along the *Trail* (e.g., knowing what the *Trail of Time* was and where they were along it in time and space)? What are the relative contributions of the portal maps, wayside integration strips, markers, and so forth?
4. What role did the Wayside Integration Strip play in helping visitors' meaning-making experiences?
5. What instructional design strategies were incorporated into the *Trail of Time*, and how effective were they? What instructional design strategies were violated, and what impacts did this have of the visitor experience?



6. In what ways did the design contribute to maintenance challenges, and what were the impacts of these challenges on the visitor experience?
7. In what ways and to what extent did different design elements work the same and differently for children and for adults?



Appendix E. Tracking & Timing Written Instructions and Form

The following written instructions were given to the Park Service data collectors during their training session:

Trail of Time Summative Evaluation
Tracking and Timing Training
Selinda Research Associates, Inc.
July 27, 2010

Before collecting data

- Make sure you have the following:
 - clipboard
 - protocol sheets
 - sharp pencils
 - watch or stopwatch
 - evaluation signs to post by the portals
 - string to post the signs
- Tie the evaluation sign around a tree in a noticeable place before the portal entrance.

While collecting data

- Choose a respondent by taking the fifth visitor who crosses the entrance line.
 - A respondent must be an individual who is at least 18 years old.
 - If two individuals cross the line at same time, track the person closest to you.
 - Don't choose anyone who is a runner/jogger or part of a guided tour or organized group.
- A stop is defined as 2-3 seconds, both feet on the ground and the respondent paying attention to a unit.
- Fill out protocol sheets **completely**:
 - sheet number
 - date
 - your name
 - entrance (circle the portal)
 - exit (X the portal)
 - gender
 - approximate age (best guess)



- # in group, description of group, especially if there are children in the group
 - time start/stop
 - total time (hrs:mins) in bold box
 - describe special circumstances on back of sheet.
- If a visitor asks you what you are doing, briefly explain that you are studying how visitors use the trail. If they ask other questions refer them elsewhere. Do not engage in a conversation with them or help them decide where to go.

After collecting the data

- Take down the evaluation signs.
 - Return all materials, including the signs.
 - Check to make sure all the forms are completely filled out.
 - Place completed protocol sheets in the designated place.
 - Sign the log.
-

A copy of the Tracking and Timing data collection form is included on the following page:



Sheet # Date Start/End Data Collector

Weather Conditions: Elapsed time: (hrs:mins)

Description of Respondent (age, gender, racial/ethnic, special, etc.):
I GC AG

Marker	Type	Name	Duration (secs)	Stamps (hr:min)	Arrows	Notes
-	Portal	Yavapai Portal - E				
-	Portal	Yavapai Portal - W				
20	Sign	It's about Time				
49	Tube	Powell Alt Location				
1,000	Sign	Human Cultures				
20,000	Plinth	Banded spring deposits				
20,000	Sign	Climate Change				
90,000	Plinth	Basalt (lava rock)				
100,000	Sign	Restless Region				
200,000	Tube	Volcanos and Earthquakes				
-	Portal	Time Zero Portal - E				
-	Portal	Time Zero Portal - W				
-	Marker	Bronze Meter				
-	Sign	Magic Meter				
6	Plinth	River-polished rock				
6	Sign	Canyon Cutting				
60	Sign	Uplift and Erosion				
270	Plinth	Kaibab limestone				
270	Sign	Horizontal Layers				
271	Tube	Kaibab Near and Far				
273	Plinth	Toroweap sandstone				
274	Tube	Horizontal Layers				
275	Plinth	Coconino sandstone				
280	Plinth	Hermit shale				
285	Plinth	SG: Esplanade sandstone				
295	Plinth	SG: Wescogame conglomerate				
305	Plinth	SG: Manakacha sandstone				
315	Plinth	SG: Watahomigi limestone				
320	Plinth	Surprise Canyon conglomerate				
340	Plinth	Redwall limestone				
385	Plinth	Temple Butte limestone				
505	Plinth	Muav limestone				
515	Plinth	Bright Angel shale				
525	Plinth	Tapeats sandstone				
584	Tube	Explosion of Life				
585	Sign	Explosion of Life				

Marker	Type	Name	Duration (secs)	Stamps (hr:min)	Arrows	Notes
650	Plinth	GCS: Sixtymile conglomerate				
742	Plinth	GCS: Walcott shale				
750	Plinth	GCS: Awatubi limestone				
760	Plinth	GCS: Carbon Butte sandstone				
770	Plinth	GCS: Duppa sandstone				
780	Plinth	GCS: Carbon Canyon limestone				
790	Plinth	GCS: Jupiter limestone				(missing)
800	Plinth	GCS: Tanner limestone				
900	Plinth	GCS: Nankoweap sandstone				
1,001	Portal	Headquarters Portal - S				
1,001	Portal	Headquarters Portal - N				
1,009	Tube	Great Unconformity				
1,010	Sign	Great Unconformity				
1,100	Plinth	GCS: Cardenas basalt				
1,130	Plinth	GCS: Dox sandstone				
1,160	Plinth	Supergroup stromatolite				
1,160	Sign	Super Group Rocks				
1,163	Tube	GC Supergroup				
1,170	Plinth	GCS: Shinumo sandstone				
1,180	Plinth	GCS: Hakatai sandstone				
1,190	Plinth	GCS: Bass limestone				
1,200	Plinth	GCS: Houtauta conglomerate				
1,375	Plinth	Quartermaster granite				
1,662	Plinth	Phantom granite				
1,698	Plinth	Cremation pegmatite				
1,713	Plinth	Horn Creek granite				
1,716	Plinth	Ruby gabbro				
1,719	Tube	Building of a Continent				
1,719	Plinth	Folded Vishnu basement rock				
1,719	Sign	Crust Formation				
1,730	Plinth	Trinity granite				
1,736	Plinth	Diamond Creek granite				
1,740	Plinth	Zoraster granite				
1,745	Plinth	Vishnu schist				
1,750	Plinth	Brahma schist				
1,755	Plinth	Rama schist				
1,840	Plinth	Elves Chasm gneiss				
1,840	Sign	Oldest Rock				
1,950	Portal	Village Portal - E				
1,950	Portal	Village Portal - W				



Appendix F. Sources of Data

Data type	Number	Description	Contact hours*
Unobtrusive observations	145	Observations of visitors walking along the <i>Trail</i> .	50
Depth interviews	56	Interviews of visitors after they had walked some or all of the <i>Trail</i> .	40
Tracking and timing	132	Visitors who were unobtrusively tracked and timed as they walked the <i>Trail</i> .	45
		subtotal	135
Document reviews	25 documents	Reviews of Web pages, social media sites, and publications related to the <i>Trail</i> .	20
Group debriefs with evaluation team	9 sessions	Included two debrief sessions each day of data collection and an extended phone debrief once the data collectors had returned home.	25
		subtotal	45
		Grand Total	180

* Contact hours include both time spent along the *Trail* and time spent on written debriefs. All data collector times are added together.



Appendix G. Descriptions of Respondents

Tracking and Timing Study

Group Type	Number of Groups	Percent
Groups with children	55	42%
All-adult groups	58	44%
Individual visitor (alone)	18	14%
Unknown	1	<1%
TOTALS:	132	100%

Table G-1. Types of groups observed during tracking and timing study.



Appendix H. Time Along the *Trail*

Entrance	Exit	N	Time (hour : min)		
			Mean	Median	Range
Yavapai (east)	Yavapai (east)	17	0:19	0:17	0:01 - 0:52
Yavapai (east)	Headquarters	3	0:26	0:30	0:19 - 0:32
Yavapai (east)	Village (west)	19	0:51	0:45	0:23 - 1:33
Village (west)	Village (west)	42	0:17	0:10	0:00 - 2:14
Village (west)	Headquarters	14	0:38	0:40	0:12 - 1:09
Village (west)	Yavapai (east)	22	0:47	0:49	0:26 - 1:12

Table H-1. Time along the *Trail* by how far respondents walked. (Total N = 117)

Type of Group	Time on <i>Trail</i> (whole sample)	Time to walk the entire <i>Trail</i>	% who walked the entire <i>Trail</i>
All-adult groups	0:34 (n = 52)	0:48 (n = 23)	44%
Groups with children	0:34 (n = 47)	0:52 (n = 16)	34%
Individuals	0:18 (n = 17)	0:44 (n = 2)	12%

Table H-2. Comparisons of mean time on *Trail* for different types of groups. This sample includes only respondents who started at the Yavapai or Village end of the *Trail*. Time is in Hours:Minutes. (Total N = 116, because group type was not included for one respondent.)



Appendix I. Stops Along the *Trail*

Type of Component	Percent who stopped at one or more examples
Any component	87%
Portal	48%
Wayside sign	66%
Viewing tube	53%
Rock plinth	61%

Table I-1. Percentage who stopped at least once at at least one component calculated for the entire sample (N = 132)

Entrance	Exit	N	Number of Stops		
			Mean	Median	Range
Yavapai (east)	Yavapai (east)	17	3.5	3	0 - 8
Yavapai (east)	Headquarters	3	5.7	5.0	1 - 11
Yavapai (east)	Village (west)	19	14.7	16	0 - 31
Village (west)	Village (west)	42	2.0	1	0 - 16
Village (west)	Headquarters	14	7.6	7.5	0 - 20
Village (west)	Yavapai (east)	22	12.7	10	0 - 51

Table I-2. Average number of stops made along the *Trail*, comparing entrances and how far they walked. (Total N = 117)

Type of Group	Mean number of stops (whole sample)	Mean number of stops (walked entire <i>Trail</i>)	% who walked the entire <i>Trail</i>
All-adult groups	9.3 <i>(n = 52)</i>	16.2 <i>(n = 23)</i>	44%
Groups with children	6.7 <i>(n = 47)</i>	10.4 <i>(n = 16)</i>	34%
Individuals	2.8 <i>(n = 17)</i>	9.5 <i>(n = 2)</i>	12%

Table I-3. Comparisons of mean numbers of components stopped at for different types of groups. This sample includes only respondents who started at the Yavapai or Village end of the *Trail*. (Total N = 116, because group type was not included for one respondent.)



Portals	Marker / location	Percent who stopped:	
		East to West	West to East
Yavapai Portal	0 years ago	47%	18%
Time Zero Portal	1,000,000 / 0 years ago	26%	27%
Headquarters Portal	1,001 Million years ago	5%	0%
Village Portal	1,950 Million years ago	26%	27%
	MEANS¹¹:	26%	18%

Table I-4A. Percent who stopped at portals (either side), calculated for those walking the entire *Trail*. Note that Headquarter Portal was set back from the rim trail by several meters. (N=41; walked East-West N= 19; walked West-East N=22)

Portals	Marker / location	Percent who stopped:
Yavapai Portal	0 years ago	49%
Headquarters Portal	1,001 Million years ago	47%
Village Portal	1,950 Million years ago	37%
	MEANS:	44%

Table I-4B. Percent who stopped at portals (either side), counting only those who entered at each portal. (N=132; entered at Yavapai N = 39; entered at Headquarters N = 15; entered at Village N = 78)

¹¹ The bottom row for Tables I-4 through I-7 is the mean of the rows directly above. For instance, for Table I-4A, this could be interpreted as follows: On average, portals were stopped at more frequently by respondents walking east to west than by those walking east to west (26% vs. 18%).



Wayside signs	Marker / location	Percent who stopped:	
		E to W	W to E
It's about Time	20 years ago	47%	18%
Human Cultures	1,000 years ago	58%	27%
Climate Change	20,000 years ago	42%	23%
Restless Region	100,000 years ago	32%	23%
Magic Meter	1,000,000 / 0 years ago	21%	18%
Canyon Cutting	6 million years ago	37%	18%
Uplift and Erosion	60 million years ago	42%	41%
Horizontal Layers	270 million years ago	53%	45%
Explosion of Life	585 million years ago	53%	27%
Great Unconformity	1,010 million years ago	16%	41%
Supergroup Rocks	1,160 million years ago	21%	23%
Crust Formation	1,719 million years ago	26%	36%
Oldest Rock	1,840 million years ago	21%	36%
	MEANS:	36%	29%

Table I-5. Percent who stopped at wayside signs, calculated for those walking the entire *Trail*. (N=41; East-West N= 19; West-East N=22)

Viewing tubes	Marker / location	Percent who stopped	
		E to W	W to E
Colorado River	49 million years ago	58%	23%
Volcanoes and Earthquakes	200,000 million years ago	58%	23%
Kaibab Limestone	271 million years ago	42%	27%
Horizontal Layers	274 million years ago	37%	41%
Explosion of Life	584 million years ago	26%	32%
Great Unconformity	1,009 million years ago	5%	23%
Grand Canyon Supergroup	1,163 million years ago	11%	27%
Building of a Continent	1,719 million years ago	32%	45%
	MEANS:	34%	30%

Table I-6. Percent who stopped at viewing tubes, calculated for those walking the entire *Trail*. (N=41; East-West N= 19; West-East N=22)



Rock plinths	Marker / location	Percent who stopped	
		E to W	W to E
Banded spring deposits	20,000 years ago	26%	5%
Basalt (lava rock)	90,000 years ago	26%	9%
River-polished rock	6 million years ago	16%	14%
Kaibab limestone	270 million years ago	5%	9%
Toroweap sandstone	273 million years ago	11%	14%
Coconino sandstone	275 million years ago	21%	9%
Hermit shale	280 million years ago	16%	9%
Supai Group: Esplanade sandstone	285 million years ago	16%	0%
Supai Group: Wescogame conglomerate	295 million years ago	0%	5%
Supai Group: Manakacha sandstone	305 million years ago	0%	0%
Supai Group: Watahomigi limestone	315 million years ago	11%	5%
Surprise Canyon conglomerate	320 million years ago	11%	5%
Redwall limestone	340 million years ago	0%	9%
Temple Butte limestone	385 million years ago	5%	5%
Muav limestone	505 million years ago	32%	9%
Bright Angel shale	515 million years ago	32%	14%
Tapeats sandstone	525 million years ago	11%	14%
Grand Canyon Supergroup: Sixtymile conglomerate	650 million years ago	26%	5%
Grand Canyon Supergroup: Walcott shale	742 million years ago	21%	18%
Grand Canyon Supergroup: Awatubi limestone	750 million years ago	16%	5%
Grand Canyon Supergroup: Carbon Butte sandstone	760 million years ago	26%	5%
Grand Canyon Supergroup: Duppa sandstone	770 million years ago	11%	0%
Grand Canyon Supergroup: Carbon Canyon limestone	780 million years ago	21%	5%

Table I-7A. Percent who stopped at rock plinths (first half of list).



Rock plinths	Marker / location	Percent who stopped	
		E to W	W to E
Grand Canyon Supergroup: Jupiter limestone	790 million years ago	16%	5%
Grand Canyon Supergroup: Tanner limestone	800 million years ago	16%	9%
Grand Canyon Supergroup: Nankoweap sandstone	900 million years ago	16%	9%
Grand Canyon Supergroup: Cardenas basalt	1,100 million years ago	5%	5%
Grand Canyon Supergroup: Dox sandstone	1,130 million years ago	5%	5%
Supergroup stromatolite	1,160 million years ago	16%	9%
Grand Canyon Supergroup: Shinumo sandstone	1,170 million years ago	0%	9%
Grand Canyon Supergroup: Hakatai sandstone	1,180 million years ago	37%	14%
Grand Canyon Supergroup: Bass limestone	1,190 million years ago	11%	14%
Grand Canyon Supergroup: Houtauta conglomerate	1,200 million years ago	26%	18%
Quartermaster granite	1,375 million years ago	11%	14%
Phantom granite	1,662 million years ago	11%	14%
Cremation pegmatite	1,698 million years ago	16%	23%
Horn Creek granite	1,713 million years ago	5%	23%
Ruby gabbro	1,716 million years ago	0%	9%
Vishnu basement rock	1,719 million years ago	16%	14%
Trinity granite	1,730 million years ago	5%	23%
Diamond Creek granite	1,736 million years ago	21%	32%
Zoraster granite	1,740 million years ago	11%	27%
Vishnu schist	1,745 million years ago	0%	36%
Brahma schist	1,750 million years ago	0%	23%
Rama schist	1,755 million years ago	21%	36%
Elves Chasm gneiss	1,840 million years ago	5%	23%

Table I-7B. Percent who stopped at rock plinths (second half of list).



Rock plinths	Percent who stopped	
	E to W	W to E
MEANS:		
	13%	12%

Table I-7C. Overall means for percents who stopped at rock plinths, calculated for those walking the entire *Trail*. (N=41; East-West N= 19; West-East N=22)

Type of Component	Mean percent who stopped		Mean of two directions
	E to W	W to E	
Portals	26%	18%	22%
Wayside signs	36%	29%	32.5%
Viewing tubes	34%	30%	32%
Rock plinths	13%	12%	12.5%

Table I-8. Comparisons of means for percents who stopped at four types of *Trail of Time* components, calculated for those walking the entire *Trail*. (N=41; East-West N= 19; West-East N=22)

Number of Rock Plinths Stopped at	0	>=1	>=5	>=10	>=15	>=20	>=25	>=32
# respondents	52	80	35	14	4	2	2	1
% respondents	39%	61%	27%	11%	3%	2%	2%	1%

Table I-9. Number of plinths that tracking and timing respondents stopped at, using the entire sample. About 60% of respondents stopped at at least one plinth, 27% stopped at at least five plinths, and so forth. (N = 132)



Appendix J. Photographs of Maintenance Issues

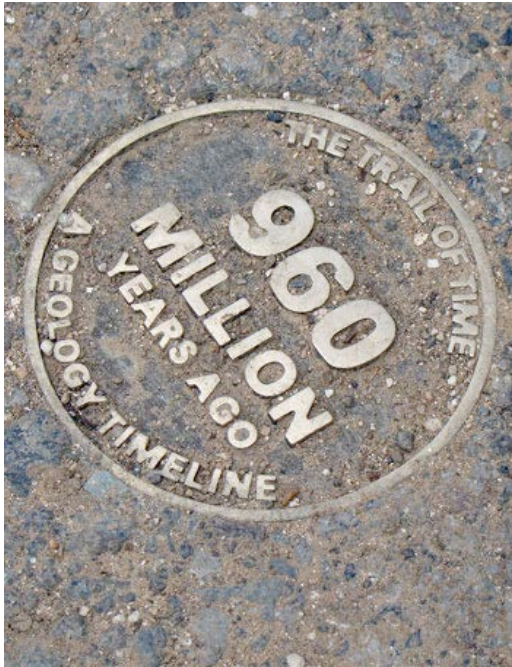


Figure J-1. *Deep Time Trail* markers collect gravel and sand.



Figure J-2. Some *Deep Time Trail* markers are getting scratched up.



Figure J-3. *Trail* asphalt cracked in places.



Figure J-4. Crumbled asphalt around some circle markers has already been patched.





Figure J-5. Ants tunneling around and perhaps undermining sides of markers.



Figure J-6. A few circle markers were chipped by a front-end loader removing snow.



Figure J-7. Faint remains of glue from paper markers used during formative evaluation.



Figure J-8. One section of the *Deep Time Trail* floods, burying some markers in mud.





Figure J-9. Broken rock at back corner of the Time Zero portal.



Figure J-10. Jupiter __ broke during installation, and visitors found a replacement.



Figure J-11. Some clay-rich rocks are beginning to disintegrate on spots.

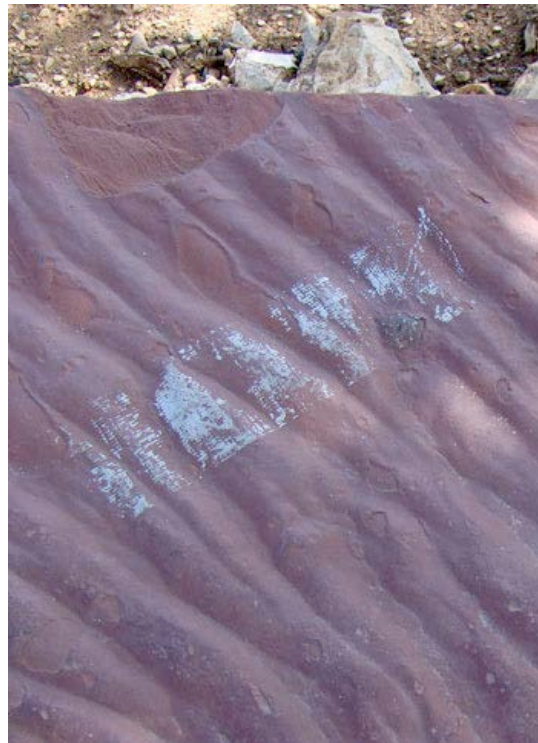


Figure J-12. Dried glue from tape.





Figure J-13. Pine sap is dripping onto plinths in some places. This plinth has one drip.



Figure J-14. Close up of the heaviest sap encrustation at Supergroup stromatolite.



Figure J-15. Some plinths are stained by decaying plant remains, and some are chipped (near center of lower edge of sloped face).





Figure J-16. Front face of Carbon Canyon limestone is cut at an angle.



Figure J-17. Boot prints on angled rock show that visitors might push hard.



Figure J-18. Paint on viewing tubes and housings is chipped, scratched, and scraped.

