Geosite investigations: A framework for deciphering geological histories; an example from the Panama Rock region in the proposed Banks Peninsula GeoPark, Canterbury, New Zealand

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ABSTRACT

GeoParks have the potential to bring communities together. They can make them stronger through the focused efforts of creating a sustainable, educational, and community run tourist attraction that is focused on the natural and cultural history of an area. One of the staples of a GeoPark is the array of GeoSites within the confines of the park. In order to be successful these GeoSites must relay complex scientific information to the public in a way that is easy to understand and that captures the interest of the visitors. In this study, the Panama rock region was used as an example of relating geological information and processes. The first objective was to compile field observations and maps, analyze geochemical data and thin section observations to determine volcanic activities that created the region. This region highlights features including: the Panama Rock lava dome and dike, a dikes that cross-cuts through a smaller trachytic lava dome, a dike infilling an old scoria fissure in contact with scoria deposits, and a dike feeding a small upwelled lava in contact with a large ridge of welded scoria spatter. The second objective was to translate that information, using CorelDRAW, into an easy-to-understand information board complete with schematics and diagrams depicting the features' volcanic origins. A small study was done in order to measure the success of the use of diagrams in the informational board; this study yielded positive results. In doing this work, a framework for further GeoSites has been established.

INTRODUCTION

GeoParks bring together communities, recreation, scientific research, education, and tourism in one naturally and culturally significant area. These parks are envisioned and planned at a community level and use sustainable practices to keep it running. When established these parks have proven to be remarkable examples of sustainable business growth. There are currently efforts being made to apply for the approval for Horomaka Banks Peninsula GeoPark; if approved, this would be New Zealand's first GeoPark. This area is comprised of some of the best exposed volcanic features in the country as a result of volcanism some 13 to 6 million years ago (Hampton and Cole 2009). There is also a large variety of flora and fauna, Maori history, land use, and early European settlement history around the peninsula giving it a rich complex heritage that make it an ideal GeoPark location.

The GeoSites within the park have underlying geology that make them features on their own, but often have significant archeological, ecological, and cultural influences incorporated into the sites. It is critical to determine the natural and cultural histories of each site and then translate that scientific knowledge to the general public in an easy-to-understand manner. A study on the Brazil GeoParks by Piranha et al. (2001) summed up the important things to consider when creating a successful GeoPark education system. The information given in a GeoPark should be delivered in a “contextualized and globalized manner so that information and knowledge can evoke a greater interest in learning, values, and citizenship skills” (Piranha et al. 2001, p.294). This study uses the Panama Rock region as an example of this process. The process begins with collecting and deciphering the scientific information. The information is then put into an informational board dedicated to the science of the GeoSite, with the goal of educating the tourists and community how the features formed.

The Panama Rock region lies on the northeast flanks of Akaroa volcano, one of two main volcanoes that created the peninsula. By combining schematics, diagrams, and petrographic images with simple explanations of this scientific knowledge, the GeoPark visitors will be able to understand the geologic events that created the Peninsula. GeoPark visitors will be able to see and learn about the various geological features on a large, small, and microscopic scale as they travel around the peninsula.

GEOLOGIC BACKGROUND

History of Banks Peninsula Volcanoes

Located to the southeast of Christchurch, New Zealand, Banks Peninsula was shaped by the formation and resulting volcanic activity of the Lyttelton and Akaroa volcanoes. These are both Miocene in age and there is no evidence for formation due to tectonic extension or a mantle plume. Timm et. al. (2009) proposed that these volcanoes have formed by delamination of the lower crust. The two volcanoes are believed to have formed from two separate delamination events, Lyttelton from 11 to 9.7 m.y.a. and Akaroa from 9.3 to 8 m.y.a. (Hampton and Cole 2009). Akaroa is known to have lower silica concentrations, and samples suggest the source was ecologite with peridotite matrix (Timm et. al. 2009). The Lyttelton volcano erupted deposits higher in silica which suggested a mix of aesthenospheric melts and lithospheric melts (Timm et at 2009). The geologic features seen around the peninsula are mainly sourced from events associated with volcanic activity both these main volcanoes. The features include: constructional features like lava flows, scoria cones, and domes and hypabyssal features such as dikes and sills and erosional features (Hampton and Cole 2009).

Panama Rock region

The region used in this study is located on the flanks of Akaroa volcano, 3 km west of Le Bons Bay. Panama Rock itself is a lava dome approximately 200 m in diameter that has a 10 m thick dike running into it. A few hundred meters northwest there are various small-scale volcanic features including: a small trachytic lava dome with a cross-cutting dike, an exposed lava flow underneath a large ridge made of strongly welded scoria spatter, a in filled scoria fissure, and another set of parallel dikes. One dike has a contact with the red scoria deposits that dip away from either side of the dike. The other dike potentially feeds a small upwelled lava feature that is adjacent to the spatter ridge. These features are believed to have originated from magma similar to or slightly more evolved than the magma that fed Akaroa volcano, based on geochemistry and crystal textures.

METHODOLOGY

A field study was completed on Panama rock and the surrounding area. Key geologic features that were observed included: Panama Rock lava dome and dike, an in filled scoria fissure, a smaller trachytic lava dome, multiple dikes, and a massive ridge outcrop of strongly welded scoria splatter, as well as scoria deposits that exhibited lesser degrees of welding. Samples were taken from most sites, as well as GPS coordinates, photos, strike/dip measurements, and other observations. This information was compiled to put together a rough geologic map of the area that was completed during the field excursion.

To complete the first objective of determining the small-scale volcanic events that occurred, a variety of methods were used. Cross cutting relationships were taken into account, as well as whole rock geochemistry results from various sample sites around the region, to correlate the various sites. Major and trace element analyses were carried out by University of Canterbury lab technicians using x-ray fluorescence spectroscopy (XRF) and analyzed by Rowan Lowden. Oriented thin sections of dikes and domes were analyzed by Jenn Garvin.

The second objective, of translating the information to the public through a GeoSite, was done using CorelDRAW. A large A2 informational board was created to compile the information complete with diagrams and other schematics to illustrate the small-scale volcanic events that formed the key features around the region. Petrographic images were also added to show the micro-scale structures in rock samples seen around the site. To attempt to evaluate the success of such a schematically-driven information board, a small study was completed. 12 individuals with no geology background were asked to participate. 6 randomly chosen were given only the description of the small lava dome with onion-skin jointing, and the other 6 were given the description along with the figure that depicts the dome formation (Appendix 1). Participants were given 2 minutes to read over the information before being asked to return the paper with the explanation. Ten minutes later participants were asked to write down how the onion-skin jointing forms. A maximum of 3 points could be awarded for an answer exhibiting a thorough understanding of how this feature forms.

RESULTS

Geochemical data did not vary enough to distinguish major variations between the features enough to put on the informational board. A slight evolution in the magma was seen with increasing silica content within the two basaltic dikes, scoria deposits, and what is assumed to be a small upwelled lava or highly welded scoria. The analyses of geochemistry are discussed in detail in Lowden's study (2013), but were not used to explain features on the GeoSite board. Thin section photo micrographs were used to display two micro-scale structures including a small scoria spatter clast and plagioclase crystal alignment due to flow banding in Panama Rock. Schematics and small-scale volcanic diagrams were created using CorelDraw and were either adapted from previously made figures, made originally, or taken and cited from other sources. The final product is attached to the end of this report.

Results from the 12 person (Table 1) study showed a general increase in understanding of the volcanic formation from the people who were shown both the diagram and worded description. Five out of six participants who were shown both the description and diagram scored a perfect score, while only two of the six in the other group scored the perfect three.

Table 1. Compiled scores for Group 1 (description only) and Group 2 (description and diagram). Scores ranged from 0-3 and were determined based on the displayed level of understanding of onion-skin jointing formation

Group 1 Description only	3	1	2	2	3	1	**Total: 12**
Group 2 Description and diagram	3	3	3	3	2	3	**Total: 17**

DISCUSSION

The volcanic processes needed to be translated into layman's terms in order to create the successful GeoSite informational board. In a short article in Nature magazine from 1913 it was concluded that the main factor in successfully teaching the natural sciences to a public audience includes insuring that the knowledge is thread in a logical sequence that links together events, sciences, and communities in a logical and interesting method. That was the goal of this project.

Figures, photographs, and diagrams complemented the worded description with the intent of making the information easier to understand. These diagrams can get complicated easily, especially when trying to depict processes going on in the subsurface. If the descriptions that accompany the figures are not written simply enough or they do not properly explain the diagram, there will be a higher chance that the concept will not be understood.

There are studies that conclude that diagrams do not aid in understanding and are more difficult to understand than the worded descriptions. A study done by Henderson (1999) found that accuracy of diagram interpretation relied heavily on the learner's existing knowledge. This would pose as a problem for many of the park visitors who do not have the necessary geologic background to easily grasp the concepts. This study also found that interpretation relied upon the understanding of drawing conventions, which is difficult when they vary from diagram to diagram. This is something that was taken account of while creating the GeoSite board. Diagrams were created with the goal of depicting the volcanic processes as simply as possible.

A brief study was completed to measure the potential success of the Panama Rock GeoSite informational board. The completed survey, although it did yield positive results, should be taken as a very approximate base line for further work to be done from in the future. This was a very small-scale survey completed in order to get a grasp on how effective the GeoSite information board was. In order to obtain results that can be used as concrete evidence for this idea that geoeducation is more successful through the combined use of descriptions and diagrams, a larger scale study should be done in a GeoPark that is already established with a steady stream of visitors. By doing this, the GeoSite framework created in this study can be further improved and will be successful right-off the bat when the Horomaka Banks Peninsula GeoPark is established.

Recommendations for future work

The next steps towards in the project would include going through this process and making a summarized informational board for all 12 primary GeoSites. The next major phase that this process will need to be implemented in is the design of the GeoPark headquarters. This headquarters should be where the large in-depth descriptions of the main Banks Peninsula geology, ecology, and cultural backgrounds of the region should be displayed and put out there in an interactive manner. If the information is relayed simply and in an interactive hands-on way it will get visitors excited to go out and explore the park and dive into the rich heritage of Banks Peninsula.

CONCLUSIONS

This study has established a framework that could be followed by future GeoSites. The resulting informational board was created in an attempt to highlight and explain the exposed volcanic features seen around the Panama Rock region. It used simple explanations and diagrams to depict these subsurface processes. Some of these processes were shown all the way down to a microscopic level and all processes were related back to the larger scale of Akaroa volcano. A small study was completed in order to attempt to understand whether these diagrams successfully aided understanding of geological concepts or not. The results yielded a positive result indicating increased understanding with the addition of a diagram to the worded description. However, this was a very small study; further studies need to be done to accurately measure the effects of including diagrams with worded descriptions.

ACKNOWLEDGMENTS

A huge thank you goes out to Samuel Hampton for his guidance and help on the formatting of this poster. I’d also like to thank Darren Gravley for his help throughout the semester. This project couldn’t be done without the Frontiers Abroad program, its countless research opportunities and intensive field camp. One more thank you goes out to the other awesome members of the Panama Rock region field team: Jenn Garvin, Rowan Lowden, and Karina Graeter!

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Appendix 1. The two onion-skin jointing explanations given to participants in the study.

Group 1 -

There is a small circular lava dome to the northeast of Panama Rock. This dome exhibits an interesting onion-like internal structure that has been exposed by quarrying. This type of dome forms on the surface as lava upwells and accumulates in the center. As material continues to accumulate it pushes older layers outwards. This process forms concentric onion-like layers. As it cools the rocks contract and the joints form in the onion skin pattern.

Group 2 –

There is a small circular lava dome to the northeast of Panama Rock. This dome exhibits an interesting onion-like internal structure that has been exposed by quarrying. This type of dome forms on the surface as lava upwells and accumulates in the center. As material continues to accumulate it pushes older layers outwards. This process forms concentric onion-like layers. As it cools the rocks contract and the joints form in the onion skin pattern.

Onion layering from west side of cryptodome