Project Atlantis – An Exercise in the Application of Earth Science to a Critical Examination of a Pseudoscience Hypothesis

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ABSTRACT

I ask my first-year physical geology students to write an essay examining the Crustal Displacement hypothesis (Flem-ath and Flem-ath, 1995), a hypothesis that is inconsistent with the accepted understanding of crustal and mantle processes. The assignment involves designing a test of the hypothesis, based on the material covered in our discussion of the theory of plate tectonics and of how the theory evolved. The assignment is useful because it forces students to solidify their understanding of plate tectonics by applying their knowledge in a new context, teaches them about the process of scientific reasoning and the need for objective analysis of all hypotheses, and gives them practice in critical thinking. This type of assignment could be applied to many comparable pseudoscience hypotheses in a wide range of geological disciplines.

Keywords: plate tectonics; science; education – geoscience; education – undergraduate; education – science; geoscience – teaching and curriculum; history of geoscience.

INTRODUCTION

In my introductory physical geology course at Malaspina University-College the primary learning objectives are to become familiar with the nature and formation of minerals and rocks, and to gain an understanding of a variety of important geological processes. Some additional goals that are especially important to me include understanding the methods of science, learning about the history of earth science, promoting critical thinking, and encouraging students to apply the knowledge that they have gained.

In this course we look quite closely at the evolution of the theory of plate tectonics over the period from Alfred Wegener's publication of "The Origin of Continents and Oceans" (Wegener, 1915), to the early evolution of Plate Tectonic theory following the work of Hess (1962), Vine and Matthews (1963) and Wilson (1963a, 1963b, 1963c). We discuss why there was so much hostility to Wegener's ideas, and why, from our perspective, the geologists of the day did not adopt a more objective approach to his proposals.

One of my favourite assignments for students is an examination of a theory about the lost continent of Atlantis (Flem-ath and Flem-ath, 1995). I believe that this assignment is relevant to almost all of the stated learning objectives of the course.

The Flem-ath's thesis, which is based partly on an earlier publication of Hapgood (1970), holds that the *Continent of Atlantis* is actually Antarctica, and was shifted from its original location at a latitude of around 60° S, to its present location at the south pole 11,600 years ago, through a process is referred to as Crustal Displacement.

The civilization of Atlantis is described by Plato in his dialogues Timeaus and Critias, written during the decade prior to his death in 348 BC. Plato describes the demise of Atlantis, as follows:

> But afterwards there occurred violent earthquakes and floods; and in a single day and night of misfortune all your warlike men in a body sank into the earth, and the island of Atlantis in like manner disappeared in the depths of the sea. For which reason the sea in those parts is impassable and impenetrable, because there is a shoal of mud in the way; and this was caused by the subsidence of the island.

"Crustal Displacement" involves a dramatic and catastrophic shifting of the entire crust of the earth with respect to the mantle and core approximately every 41,000 years. The event of 11,600 years ago is suggested to have involved a maximum displacement of over 3000 km (approximately 30° on the earth's surface). A time frame for the movement is not clearly stated by (Flem-ath and Flem-ath, 1995), but from an interpretation of the text it was evidently very fast in a geological context - perhaps hundreds of years - perhaps even less. Rather than sinking beneath the sea, Atlantis is proposed to have moved to the south pole, while North America moved away from the north pole. Of course some areas of the crust would have moved much less than 3000 km, and others, at the poles of the rotation, would not have moved at all. Flem-ath and Flem-ath (1995) suggest that other crustal displacements - of a similar magnitude - have occurred at 52,600 and 93,600 years ago, and on into the past at intervals of 41,000 years.

In support of their theory, Flem-ath and Flem-ath (1995) cite evidence such as:

- the apparent similarity in size and shape between Atlantis (based on various written descriptions and maps) and Antarctica,
- a large number of oral and written histories of widespread flooding at various times in the past, and
- the development of agriculture at relatively high elevations around the time of the last "displacement".

The proposed geological mechanism behind massive crustal displacements is related to build-up of thick ice-sheets in polar and near-polar regions. The idea of dramatic crustal displacements was originally proposed by Hapgood (1970). In correspondence with Hapgood in the early 1950s, Albert Einstein wrote:

> In a polar region there is a continual disposition of ice, which is not symmetrically distributed about the pole. The earth's rotation acts on these unsymmetrically deposited masses, and produces centrifugal momentum that is transmitted to the rigid crust of the earth. The constantly increasing centrifugal momentum produced this way will, when it reaches a certain point, produce

> movement of the earth's crust over the rest of the earth's body, and this will displace the polar regions towards the equator. (Hapgood, 1970)

This quotation is reprinted in Flem-ath and Flem-ath (1995), but the authors also state, later on in the book, that Einstein actually doubted that the weight of the ice caps would have been sufficient to move the crust.

I characterize the crustal displacement hypothesis as pseudoscience. Firstly, it is based largely on circumstantial evidence; and secondly, it's advocates do not appear to have a clear understanding of geological processes that they invoke, and make no attempt to reconcile their hypothesis with the numerous well-documented observations of the earth's crust and mantle with which it is inconsistent. For example, there is no mention of the systematic distribution of islands related to mantle plumes, nor of the consistent patterns of magnetic orientation in rocks and sediments, and no explanation of what might happen to mantle-rooted features such as subduction zones in the event of a crustal displacement. Finally, the authors make no effort to suggest ways in which the theory might be objectively tested using scientific methods.

THE EXERCISE

In introducing the assignment to students I am careful not to voice any negative opinions. I describe the theory as objectively as I can, and then ask students to write an essay describing a procedure to test the Flem-ath theory using earth-science methods. I suggest that their methods may include any of the kinds of studies that we have discussed in the lectures on plate tectonics, or any other scientific technique that might be useful.

I stress that I do not want them to argue for or against the crustal displacement hypothesis, only to suggest a credible procedure for testing the hypothesis, one that should provide clear and definitive evidence enabling them to either accept or reject the hypothesis. I also ask them to indicate what results they would expect to get from their method(s) if the hypothesis is true and if it is false, and to consider any experimental errors in their results that might lead to an incorrect interpretation of their data. I recommend that they approach the assignment by thinking about what sort of predictions one could make based on the Crustal Displacement hypothesis, and then about how those predictions could be tested using the sorts of techniques which were used to substantiate the theory of Plate Tectonics.

Responses to the assignment are interesting and varied. To begin with, many students have great difficulty understanding how to approach the problem because it does not fit the usual model of "summarize what you have learned so far", and they did not expect to be asked to use their knowledge to venture into a new and apparently unorthodox direction. Some students find it difficult to maintain objectivity. A few either detect my negative bias, or develop their own, and attack the theory strenuously; while a few embrace the theory and do their best to support it, in some cases introducing other evidence of questionable scientific merit. On the other hand, most students become engaged in the project, and use the Flem-ath hypothesis to develop some objective, thoughtful and sensible predictions about how the process would affect the rocks of the earth's crust, and then design viable and credible procedures to gather information that would enable them to test those predictions.

The most commonly suggested procedure involves the use of remnant magnetic orientation studies in rocks formed just before and just after 11,600 years ago. The main weakness in many of these proposals is a lack of attention to the need for accurate dating of the sampling media, and a failure to suggest a credible dating method. Most students suggest collection of samples from basaltic flows, and many recognize the importance of obtaining data from several widely-spaced locations. One of the persistent suggestions is that the sampling must be done on Antarctica, in spite of several reminders that this is supposed to be a global phenomenon, and therefore that there must be numerous more accessible, more hospitable and more geologically suitable places to visit.

Another common suggestion is to carry out an assessment of the timing of volcanism related to mantle plumes. This procedure normally involves looking for evidence that volcanism has ceased at a once-active hot spot, and has since started up at some new area up to 3000 km away. Many of these proposals lack an acknowledgement of some uncertainty about the length of time that might be necessary for volcanism to be detectable in crust that has been recently and suddenly shifted over top of a mantle plume.

Other suggestions include careful assessment of changes in terrestrial and marine fauna and flora in regions that have undergone significant displacement, analysis of the age of ice on Antarctica and of post-glacial features elsewhere, and a search for the extensive volcanism that should have resulted from the heat generated by a 30^{o} crustal displacement. Many students propose the use sea-floor magnetic reversal patterns to solve the problem, forgetting or ignoring that the magnetic-reversal time scale is not appropriate for events that are purported to have happened within the past few tens of thousands of years.

DISCUSSION

I value this Atlantis assignment as a teaching tool for many reasons:

1. Firstly, and most importantly, this exercise forces students to be clear in their understanding of the plate tectonic processes that they have begun to understand, and how those differ dramatically from the processes suggested by Hapgood (1970) and Flem-ath and Flem-ath (1995). Similarly, it forces them to solidify their understanding of some of the procedures and reasoning that led to the wide acceptance of plate tectonic theory in the 1960s. They need to do this in order to extend these techniques to the resolution of a problem that is different from the one described in the lectures or in textbooks.

2. In order to complete the Atlantis assignment successfully, students must also have some appreciation for the process of scientific investigation. In this context I look for the formulation of well-reasoned predictions from the Flem-ath and Flem-ath (1995) hypothesis, the careful design of experiments that should effectively test

those predictions, and the recognition of the potential for experimental errors that might compromise the results. In his useful exercise on interpretation of sea-floor magnetic patterns, Shea (1988) emphasized the importance of teaching the principles of scientific investigation and the process through which a hypothesis is independently tested, and is gradually transformed into an acceptable theory.

3. An assignment of this type makes students aware of the value of, and the need for, objective analysis of all hypotheses, including those that challenge orthodoxy, as the Flem-ath hypothesis does. The important point that I try to make with this exercise is that when confronted with a new idea our first instinct should not be to reject it out of hand, nor to accept it without thought. Instead, we should attempt to understand the idea and its implications, and then carefully evaluate its merits in the context of what we already know, or can learn, about the subject. As they become more comfortable with this process, students will realize that they have the tools and the skills to evaluate scientific ideas and to recognize pseudoscience and hoaxes.

4. A further outcome of this type of assignment is the development of critical thinking skills. According to the *National Council for Excellence in Critical Thinking* "Critical thinking is the intellectually disciplined process of actively and skilfully conceptualizing, applying, analyzing, synthesizing, and/or evaluating information gathered from, or generated by observation, experience, reflection, reasoning, or communication, as a guide to belief and action." (Scriven and Paul, 2002). Bailin et al. (1999) state that critical thinking involves a number of key components, including having the background knowledge to understand the problem, the skill to appraise arguments, statements and definitions and the ability to carry out responsible deliberation. They also suggest that critical thinking involves some important "habits of mind", including respect for reason and truth, an inquiring attitude, open-mindedness, fair-mindedness, independent-mindedness and respect for legitimate intellectual authority. I believe that the Atlantis assignment gives students practice in critical thinking, because it requires the conceptualization and appraisal of what the Flem-ath hypothesis means, the application of background geological knowledge, and the use of fair, open and independent thinking.

5. Finally, the reference to a classical story in this assignment helps to emphasize the importance of maintaining a broad perspective in any discipline. Tepper (1999) discusses the value of interdisciplinary thinking in his description of "Geomythology", a course focused on connecting earth science with the classics. He states that: "Besides learning about the geology, history and literature of the Mediterranean region, students in Geomythology gain an appreciation of the interconnectedness of knowledge in these seemingly unrelated disciplines. The course also provides opportunities for critical and imaginative thinking, both of which are underrepresented in many introductory science courses." An exercise with a similar theme is described by Block (1975).

The Crustal Displacement hypothesis is just one example of a topic which lends itself to analysis by undergraduate earth science students, and which can promote critical thinking, an understanding of the process of scientific advancement, and an opportunity to apply and reinforce geological concepts. There are countless other hypotheses in existence which could form the basis for similar assignments. For example, there is the concept of California sinking into the sea following a series of major earthquakes (Gentry, 1969), or the long-held belief in intelligent life on Mars (Hoagland, 1996). There are also numerous films that provide opportunity for critical geological analysis, such as *Jurassic Park, Dante's Peak, Volcano* and *The Day the Earth Caught Fire* (the story of the earth being blasted out of its orbit by too many nuclear tests), or even *Godzilla*, as suggested by Feldman and Wilson (1998).

It would also be useful to consider some of the more controversial biblical stories from a geological context. For example, Soroka and Nelson (1983) describe an exercise in which students try to place some physical constraints on a flood of biblical proportions. Students might also be challenged to discuss the merits of "creation science" in the context of historical geology or palaeontology.

In addition, there are innumerable local popular beliefs that could provide appropriate material for geological analysis by students. For example, some residents of Vancouver Island believe that our groundwater is largely derived from Mt. Baker, a prominent and often visible composite volcano some 150 km away on the mainland. When I tell my students that this belief is widely held, most of them just laugh. Few of them stop to think "Is this possible?", "Why is this unreasonable?", or "How could we test this idea?".

Finally, the tabloid press supplies us with new and fantastic stories every day, many of which could benefit from some analysis of their geological credibility.

CONCLUSION

The Atlantis Project is a teaching and learning tool that meets many of the objectives of an introductory Physical Geology course. It promotes understanding of Plate Tectonics and the evolution of Plate Tectonic theory, it gives students background and practice in science methodology, it forces them to use critical thinking skills, and it allows them to apply the knowledge that they have gained. This type of assignment could be applied to many different topics in almost all areas of earth science.

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