



Measuring the role of image representation in generating misconceptions related to plate tectonics

Brady J Haas, Scott K Clark ▪ Department of Geology



Introduction

An accurate understanding of the Theory of Plate Tectonics provides a framework through which most other dynamic Earth processes are understood. Previous studies have indicated that post-secondary students possess a range of alternative conceptions regarding plate tectonics¹⁻⁵. Some of these alternative conceptions may be derived from misinterpretations of subtle aspects in typical plate tectonic images. The goal of this study is to determine the effectiveness of a novel plate tectonics image that was specifically designed to minimize potential misconceptions.

Methods

We analyzed data from surveys completed by attendees to the 2008 and 2010 Geological Society of America national meetings. In 2008, 180 attendees completed the survey, which used an image that is based on the standard plate tectonic schematic cross section⁶. In 2010, 48 attendees completed a modified survey, with a novel plate tectonic image. This image was designed to reduce alternative conceptions that were documented in the analysis of the original image⁵.

Thirty surveys were randomly selected and analyzed from each dataset. Our analysis followed the methods described in Clark and Libarkin⁷. Validity and reliability of our analysis includes prior analyses of the original survey^{5,7} and inter-rater discussions wherein we achieved a consensus on our data interpretations.

References/ Acknowledgements

¹ DeLaughter, J.E., Stein, S., Stein, C.A., and Bain, K.R., 1998, Preconceptions about Earth science among students in an introductory course. *Eos*, v. 79, p. 429-432.
² Gobert, J.D., 2000, A typology of causal models for plate tectonics: Inferential power and barriers to understanding. *International Journal of Science Education*, v. 22, p. 937-977.
³ Steer, D.N., Knight, C.C., Owens, K.D., and McConnell, D.A., 2005, Challenging students ideas about Earth's interior structure using a model-based, conceptual change approach in a large class setting. *Journal of Geoscience Education*, v. 53, p. 415-421.
⁴ Wunderle, M.S., 2007, Investigating in-service educators' and undergraduates' mental tectonic models [M.S. thesis]. Athens, Ohio University, 60p.
⁵ Clark, S.K., Libarkin, J., Kortz, K., and Jordan, S. (accepted), Alternative conceptions of plate tectonics held by non-science undergraduates. Submitted to *Journal of Geoscience Education*.
⁶ Vigil, J.F. and Tilling, R.L., 2006, Schematic cross section of plate tectonics. United States Geological Survey, available from: <http://mineralsciences.si.edu/tdpmap/fom/xsection.htm> [Accessed 03 January 2011].
⁷ Clark, S. K. and Libarkin, J., 2011, Designing a mixed-methods research instrument and scoring rubric to investigate individuals' conceptions of plate tectonics. In A. Feig and A. Stoke (eds.) *Qualitative Inquiry in Geoscience Education Research*. Boulder, CO: Geological Society of America Special Paper.
⁸ Van der Pluijm, B.A., and Marshak, S., 2004, Earth structure: An introduction to structural geology and tectonics. New York, W. W. Norton & Company, 2nd ed., 656 p.
⁹ Kortz, K.M., Clark, S.K., Gray, K., Smay, J.J., Viveiros, B., and Steer, D., 2011, Counting tectonic plates: A mixed-methods study of college students' conceptions of plates and boundaries. *Geological Society of America Special Paper* 474.

We thank everyone who participated in this study. Support for this work was provided by the National Science Foundation's DUE CCLI program under Award No. DUE-0837185. Any opinions, findings, and conclusions or recommendations expressed in this publication are those of the authors and do not necessarily reflect the views of the National Science Foundation.

What do you see?

Survey Questions:

Identify by name anything related to plate tectonics

Explain what the colors below the surface represent

Estimate the % of the mantle that is liquid (magma)

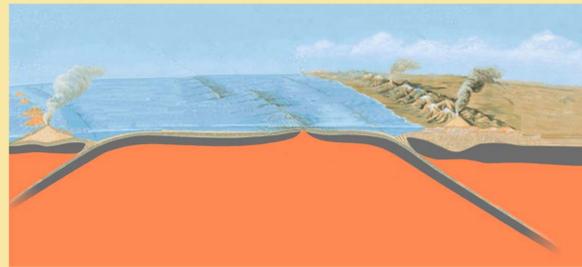
Circle areas where you think melting could be occurring

Explain why melting occurs in the places you indicated in the figure

Explain what causes tectonic plates to move

Indicate the location of each plate boundary and identify by name.

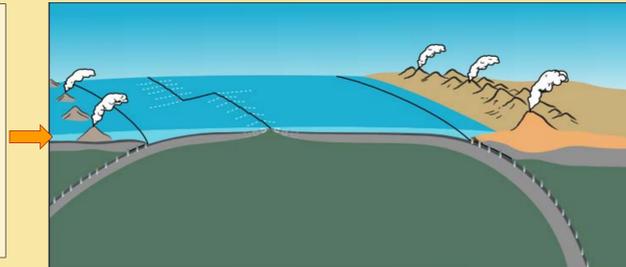
How many tectonic plates are in the image?



2008 Survey Image

Changes between images

- dark asthenosphere
- slab descending toward core-mantle boundary
- dehydration indicated
- plate boundaries highlighted
- clouds removed
- surface features de-emphasized



2010 Survey Image

<p>Most Frequently Labeled Features (n=30):</p> <ol style="list-style-type: none"> 1. Subduction Zone (57%) 2. Mid-Ocean Ridge/Rift (53%) 3. Island Arc (47%) 4. Continental Crust (33%) 	<p>Does the novel image change how people interpret plate tectonics?</p> <ul style="list-style-type: none"> • In 2010, more respondents noted the plate boundaries • This suggests that this change may be effective at clearly indicating boundaries 	<p>Most Frequently Labeled Features (n=30):</p> <ol style="list-style-type: none"> 1. Mid-Ocean Ridge/Rift (50%) 2. Subduction Zone (47%) 3. Diverging Plate Boundary (37%) 4. Convergent Plate Boundary, Island Arc (33%)
<p>Range of responses for two of the colors/layers:</p> <p>Orange: liquid magma-core, magma, ductile material/partial melt, asthenosphere, basement, (±lithospheric, ±upper) mantle</p> <p>Gray (light and/or dark): asthenosphere, lithosphere, lithospheric plates, bedrock, basalt, (±continental, ±oceanic) crust, (±lithospheric, ±upper) mantle</p>	<ul style="list-style-type: none"> • In 2008, the orange-colored mantle was explicitly defined twice as "magma" • In 2010, the green-colored mantle in the was never associated with the words "magma" or "liquid" • (NOTE: The mantle consists almost entirely of solid rock) 	<p>Range of responses for two of the colors/layers:</p> <p>Green: asthenosphere, plate, below Moho, (±upper) mantle</p> <p>Gray (light and/or dark): asthenosphere, plate boundary, oceanic sediment, above Moho, (±oceanic, ± mantle) lithosphere, (±continental, ±oceanic) crust</p>
	<ul style="list-style-type: none"> • In 2008, 27% of respondents indicated that the mantle consists of 61 - 100% magma • In 2010, only 15% reported such high amounts of magma • The orange color may give the false impression of a higher degree of melt 	
<p>Other locations or no indication of melting: 15.7%</p> <p>Red circles are areas where melting occurs</p>	<ul style="list-style-type: none"> • The number of responses that indicated melting at the ends of the plates was more than double in 2008 than in 2010 • Disappearing tectonic plates appear to lead people to think the plates are melting 	<p>Other locations or no indication of melting: 7.8%</p>
<p>Example response:</p> <p>"because the mantle & crust is being pushed to the core where it gets hot"</p>	<ul style="list-style-type: none"> • Most melting in the mantle occurs due to a decrease in pressure or the addition of water • The indication of hydration in the 2010 image seems to have had little impact on people's responses 	<p>Many responses were ambiguous, such as:</p> <p>"rock is being subducted under the surface"</p>
<p>Coded responses (n=39) grouped by concept:</p>	<ul style="list-style-type: none"> • The dominant forces that cause the plates to move are ridge-push and slab-pull⁸ • These results indicate that convection (an early model of plate motion) is still the most popular explanation • Responses in the 2010 survey do not show any indication of improvement 	<p>Coded responses (n=40) grouped by concept:</p>
<p>These questions were not asked in 2008 GSA survey. However, in a related study on geoscience novices using the 2008 image⁹...</p>	<ul style="list-style-type: none"> • Approx. 80% identified the convergent boundaries • 54% identified the divergent boundary • None identified the transform boundary 	<ul style="list-style-type: none"> • Approx. 70% identified the convergent boundaries • Approx. 70% identified the divergent boundary • 13% identified the transform boundary
	<ul style="list-style-type: none"> • In that same study⁹, 30% of geoscience novices correctly identified 4 plates 	<ul style="list-style-type: none"> • 52% of respondents correctly counted 4 plates.

Summary

Initial analysis suggests that the novel image may be more effective at properly communicating basic plate tectonics concepts than the standard image.

Respondents to the 2010 survey...

- more readily identified plate boundaries
- never labeled the green colored mantle as "magma"
- estimated an overall lesser degree of liquid in the mantle
- were not as likely to indicate melting at the ends of the subducting slabs

Future Work

In our ongoing analysis, data from the Geologic Experience Questionnaire that each respondent completed is being analyzed for possible correlations between respondents' levels of geologic expertise and their answers. While this study suggests that the novel image may be more effective at presenting plate tectonic concepts, research interviews and eye-tracking studies will enable us to 1) distinguish between responses that are based exclusively on prior knowledge versus responses that are influenced by image interpretation; and, 2) develop a more comprehensive understanding how images can help to counter the formation of misconceptions.