### The Challenge of Assumptions

A Comparison of Curricular Materials and Empirical Learning Progressions in Middle Grades Plate Tectonics

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# Developing a Learning Progression in Plate Tectonics

- Based on literature around student understanding of plate tectonics
- Tested iteratively through student interviews
- Total of 196 students grades 5-12 and undergraduates
- Three progress variables:
  - Plate Movement
  - Plate Dynamics
  - Intra-plate Interaction

	Plate Movement	Plate Dynamics	Intra-Plate
Learning Progression in Plate Tectonics	<u>Dynamic System</u>	Convection Currents Mantle Movement (Heat) Mantle Movement (Other)	Plate System Conservation of Mass Conveyer Belt Disappearance of Plates
	Intermittent/ Historic Motion	Subsurface Processes Events Surface Processes	Gaps Between Plates
	otatic		 Static

#### Research Question

Compare patterns of student concept development between **theoretical materials** and an **empirically based** learning progression around the paradigm of Plate Tectonics

#### Content Standards

#### SCIENCE EDUCATION







1996

2013

2012

#### Project 2061 Resources



1989 and 2013

AAAS 1993 and 2009 AAAS 2001 and 2007

#### Teacher Resources



Hazen and Trefil 1991 and 2009



#### Driver et al 1994 and 2013

#### Benchmarks Summary

- □ K-2: "Changing Things"
- □ 3-5: Earth's geological features/events
- **6**-8: Features that **shape** Earth's surface, but not **formation**
- 9-12: Theory and phenomena of plate tectonics
  radioactive decay's role in rock dating and geological time

## Earth Science not taught in High Schools

Postponing integration of evidence, ideas to grades 9-12 effectively ensures they will not be taught at all Number of states requiring a Life Science course

- Number of states requiring a Physical Science\*\* course
- Number of states requiring Earth and Space Science concepts be included as a requirement
- Number of states requiring an Earth or Earth/Environmental Science course



(AGI, 2013)

#### Standards documents avoid systemic understanding

- CTS: Middle grades students not asked to employ systemic understanding
- LP: Students show systemic understanding when taught that way

#### Focus on history leads to confusion

- CTS: focus on explaining history of plate tectonics
  - Fossils, continent shapes, magnetic striping
- Historical evidence in instruction led to student non-normative understandings:
  - plates only move sometimes
  - Magnets cause plate movement

#### Small focus misses Big Ideas

- Current K-8 instruction covers pieces of the whole
  earthquakes and volcanoes
  - phenomena that shape Earth's surface
  - define Earth's surface as made of plates
- This approach leads to piecemeal understanding
- Students focus on boundaries and static features
- Systemic understanding delayed or prevented

#### NGSS: Better, but not sufficient

- 4<sup>th</sup> grade: Historical evidence of plate tectonics
- 6<sup>th</sup>-8<sup>th</sup> grade: Tectonic processes generate new ocean floor at ridges and destroy sea floor at trenches
- High School: Unifying theory of plate tectonics
  - Radiometric decay
  - Convection and heat transfer
  - Integration of observational evidence

### Implications for college teaching

- Be aware of students' limited background
- Prior learning focused on pieces, not system
- Help students create deeper understanding by challenging their non-normative models