

Blocks Module Teacher's Guide

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I. Module Description

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- A. **Overview**- This module contains various animations and interactive movies exploring the three-dimensional nature of geologic features. Students can view, interact with, and discuss different geological features represented by block diagrams. This module was created to help students develop the spatial skills necessary to visualize subsurface geometries of geologic features. The five main sections of the module are layers, folds, faults, unconformities, and intrusions. Interactive movies within each section allow students to rotate blocks, make blocks partially transparent, offset faults, cut into blocks, erode layers, deposit layers, and reveal unconformities. Along with this teacher's guide, a **content guide** (for instructors) has been created to briefly explain and define the terminology found within the module to facilitate the preparation of class materials. A **student guide** has also been created to provide a brief overview of the module for students and facilitate their use of the module outside of class.
- B. **Rationale for module** – Research on and observations of student understanding of geology have noted several misconceptions stemming from the difficulties students have visualizing subsurface features (Kali & Orion, 1996; Piburn, et al., 2002). This lack of visualization ability is believed to result in students' troubles reconstructing geologic histories of locations. The primary purpose of this module is to help students develop the skills necessary to visualize geologic features in the field. Research has cited students' difficulties discerning key features of structures (e.g., disembedding) amid distracting superficial features in the field (Frodeman, 1996). This module provides a virtual environment that helps students visualize orientations of subsurface features and their interactions with surfaces. Within each section students are shown simple, individual features first, then features are added to increase the complexity of each example.
- C. **Learning Cycle Approach**- The module was designed using the Learning Cycle approach. This instructional strategy covers concepts in three phases: 1) Exploration, 2) Term/Concept Introduction, and 3) Application. Concepts were introduced in this order to encourage students to develop definitions and discover connections between concepts rather than memorizing terms and definitions. The Exploration Phase allows students to interact with movies covering each main topic to develop a visual understanding first. This phase is followed by the Term/Concept Introduction Phase in which students are introduced to the appropriate terms and concepts for each topic. The Application Phase encourages students to integrate several concepts by solving a

complex problem. These problems are open-ended, require students to use several concepts, and do not have a right or wrong answer.

D. **Layout** – The opening page of the module provides links to a list of files, four links to different starting points for the module (two for the full version and two for an abbreviated version), and Worksheets. The Abbreviated Module Home and Abbreviated Module both lead to a shorter version of the full module suitable for use in a one-hour lab by non-geology majors or high school classes.

- **List of Files** – organized by module sections. Within each section, files are arranged by specific type with a brief description of the action (rotation, slicing, etc.) allowed for each movie. For example, all layers movies are listed on a separate page with horizontal layers movies grouped together.
- **Main Module Home** – links to the introduction section of the full module. The introduction shows users how faces are labeled throughout and shows examples of the changes that can be made to movie files by clicking and dragging the mouse in one or two directions (up and down or left and right). This section can be skipped after the first use of the module, unless a review is needed.
- **Main Module** – goes directly to the main menu of the full module, skipping the introductory screens linked through the Main Module Home page. You can start here after your first visit to this website.
- **Worksheets** – takes users to Microsoft Word and PDF files of the worksheets used throughout the five sections of the module. These can be printed all at once before starting the module or separately before each section is begun.
- **Abbreviated Module Home** – takes users to the introductory pages describing labeling of block faces and changes that can be made in interactive movies. This link goes to a condensed version of the Main Module and goes into less depth on each topic. This abbreviated version was developed with the intent to cover the material in a shorter amount of time for use at the high school or introductory college geology laboratory level.
- **Abbreviated Modules** – takes users to the abbreviated module. There are two main sections in this shortened version:
 - **Module 1** – layers, folds, intrusions, and unconformities
 - **Module 2** – faults

E. **Student Assessments** – Within each of the five sections of the module versions, questions are presented to encourage active engagement. Answers to these questions can be written or drawn on the corresponding worksheets that can be printed from the Worksheets link or from the CD-ROM (See Section IIC for more detail about question types). At the end of each section, students can take a quiz (typically 5 questions) to review concepts learned. Quiz questions generally fall into one of the following categories:

- Multiple choice with pictorial answers asking students to identify missing faces of a block or how one face changes after cutting into a block. Students click on an answer and receive feedback along with an interactive movie showing the answer.
- Sketching faces or blocks after rotating or cutting into a block.
- Draw a block based on an ordered list of geologic events. This task begins in the layers section by having students draw tilted layers and builds in complexity in each section's quiz by adding events.

- The last question in the module asks students to draw a block containing an ordered list of several complex geologic transformations.

II. Learning Objectives and Questions for Discussion

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A. Learning Objectives:

1. General:

- Students will be able to visualize and describe geologic structures in three dimensions.
- Students will be able to explain how internal geometries are expressed by the views seen on the faces of the blocks.
- Students will be able to interpret the face views of a block and build the internal geometries of features using visual penetrative abilities (VPA).
- Students will be able to explain how the expression of geologic structures would change as blocks are cut or eroded into.
- Students will be able to reconstruct sequences of events (geologic histories) given a block showing a series of geologic features.
- Students will be able to draw a block consistent with a given list describing a geologic history.

2. Layers:

- Students will be able to visualize geometries of layers in order to predict and draw concealed faces of a block.
- Students will be able to draw a missing face of a block given two other faces or draw two faces given one face and a description of the layers.
- Students will be able to describe the differences between angles of layers (gently versus moderately versus steeply dipping)

3. Folds:

- Students will be able to differentiate between syncline and anticline folds and identify and describe those differences.
- Students will be able to identify folds plunging at various angles (gently versus moderately versus steeply dipping).

4. Faults:

- Students will be able to define different types of faults and compare and contrast, verbally and pictorially, the differences between:
 - normal and reverse faults and
 - strike-slip, dip-slip, and oblique faults.
- Students will be able to describe the difference between the apparent offset of layers and the true displacement of those layers in a fault.

5. Intrusions:

- Students will be able to identify and describe the differences in geometries of dikes, sills, and plutons by sketching these features on the faces of blocks.
- Given a rotating block on screen, students will be able to predict the relative ages of intrusions versus other geologic events (such as faulting, folding, and erosion).

6. Unconformities:

- Students will be able to predict and draw on a block face the geometry of layers, folds, and faults beneath a covered unconformity.

B. **Questions and Activities for Discussion:**

1. How does changing the angle of tilt of a layer affect what we see on the surface?
2. How would the surface of an area containing moderately dipping layers change as erosion occurs?
3. How would this surface change if the area contained oblique layers and has been eroded?
4. Draw what you would see at the surface if anticline folds were tilted to steeply dipping.
5. Draw what you would see at the surface if syncline folds were tilted to gently dipping.
6. Draw a side view to explain the difference between normal faults and reverse faults. Show the side view both before and after faulting.
7. Draw a top view to explain the difference between strike-slip, dip-slip, and oblique faults. Show the top view both before and after faulting.
8. List features that would help you identify an intrusion as a dike, sill, or pluton. Draw a sketch of a block that contains each type of intrusion.
9. What are some clues you can use to determine whether an intrusion is relatively older or younger than other geologic features? For example, what would a block look like if an intrusion was **older** than a normal fault? What would a block look like if the intrusion was **younger** than the normal fault?
10. What clues can you use to determine what features beneath an unconformity will look like?
11. If we were able to reveal the unconformity, what would you expect the new surface to look like?

III. Materials and Resources

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- A. **Time requirements** - The full module was originally developed for use in an undergraduate geology summer class and required 2-3 hours to complete. However, the menu-driven design of the module allows each of the five sections to be covered in separate 30-45 minute units. The abbreviated version of the module requires about 1 hour to complete and can be covered as two separate units. The module was designed to be used by student groups with 2 – 4 students per group to encourage discussion of ideas and interpretation of information.
- B. **Movies** - The movies included in the module are QuickTime Virtual Reality (VR) movies that allow users to control movement and changes by clicking and dragging the mouse vertically and/or horizontally. (Arrows were included above each movie to indicate what change will occur when the mouse is dragged a certain direction.) This allows students to control changes rather than passively watching a movie play straight through from beginning to end. The majority of the movies are between 100 KB and 2.7 MB. Several are smaller, and one movie is 4.7 MB.

The **List of Files** link on the opening page of the module allows movie files to be extracted and used in lecture/lab discussions or incorporated into personalized lesson plans as desired. This also allows concepts to be reviewed as needed in lecture. A single movie file can be selected prior to lecture and saved. This will prevent the need to enter the module and click through screens to the appropriate page.

- C. **Worksheets** - Worksheets were developed for each section to encourage active student participation. Preliminary observations of student use showed tendencies for them to click through the module if not held accountable for the information. Questions were placed randomly throughout each section, and although students can explore concepts in any order, they are encouraged to visit each screen of the module. Worksheets can be printed from Microsoft Word or PDF files from an index located at the beginning of the module. Copies of the worksheets are also included at the end of this guide.

Various open-ended questions were developed for the worksheets to encourage critical thinking and prevent students from focusing on getting the right or wrong answer. Students are asked to sketch unseen faces of blocks, sketch faces after cutting into blocks, draw blocks when given a series of geologic events, and to describe key features of blocks. Movies are often provided on screens immediately following questions to provide students with the opportunity to check and modify their answers.

- D. **Programs needed** - The movies used throughout the module require QuickTime that can be downloaded for free from <http://www.apple.com/quicktime/download/>. For Guides and PDF Worksheet files, Adobe Acrobat can be downloaded from <http://www.adobe.com/products/acrobat/readstep2.html>.
- E. **Opening activities** – Before using this module to cover subsurface features, activities should be performed to determine the amount of prior knowledge with which students enter an earth science or geology course. Concept maps have been shown to be an effective initial and continuing activity (Piburn and Baker, 1997). Concept maps can be altered as lessons progress to assess and monitor students' conceptual understanding.

Open-ended discussions are another effective tool to discover students' preconceptions in science. Alternatively, concept sketches are another effective way (particularly in geology) to gauge student understanding before, during, and after presentation of a concept (Johnson and Reynolds, 2005). These drawings of concepts can also be used as a way to actively engage students in a classroom discussion.

IV. **Creation of Module**

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- A. **Software used** – Movies for this module were created and rendered (as bitmap image sequences) using Bryce 5.0. The images were then imported into VR Worx to create QuickTime VR movies. The layout of the module was developed in FrontPage 2000 using a menu-driven design to allow greater flexibility of navigation and teacher or student control of content coverage.

- B. **Computer requirements** for creating your own – The movie files and html codes were created on PC's. The basic software programs needed to begin are Bryce 5.0 (to generate movies), VR Worx (to convert to QTVR files), Microsoft's FrontPage 2000 (to create web pages), QuickTime 5.0, and Adobe Acrobat 5.1.

V. **Research and Evaluation**

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- A. **Assessment** – A spatial geology content test was developed for use as an evaluation tool to assess the effectiveness of this module and a module covering topographic maps. The items included on this assessment emphasized the spatial skills necessary for interpreting topographic maps and subsurface geology.
- B. **Research** – This geologic blocks module and a topographic maps module were evaluated during a college-level summer course using control (no module) and treatment (using the module) groups. A summary of this research project (below) provides a description of findings and implications for how we found this module to be most effectively used.
- C. **Summary**

The complete details of the evaluation of the Hidden Earth project have been described in separate publications (Piburn et al., 2002; Piburn et al., in press). Consequently, we will include here only the most important details and results.

The evaluation was completed in four introductory geology laboratory sections taught during a summer session. Two were scheduled from 7 to 9 a.m. and two from 11 a.m. to 1 p.m. Each section was taught by a different teaching assistant. One section from each time was chosen as a control group and the other as an experimental group.

Students were pre-tested with two measures of spatial ability and with a geospatial test that was created to match the contents of the introductory laboratory manual. The experimental group interacted with the geologic block computer module and a topographic map computer module, but the control group did not. At the end of the five-week summer session, students in both the control and the experimental groups were tested again on all three instruments.

Both the control and experimental groups improved in their mastery of the laboratory material as evidenced by their scores on the geospatial test. However, there was a significant difference between those students who had completed the Hidden Earth computer modules and those who had not, with the performance of the experimental group exceeding that of the control group.

One indication of the difference between these groups is a comparison of normalized gain scores. Normalized gain is computed by dividing the amount of improvement (post-test minus pre-test) by the total room for improvement (total score minus pretest). Mean gain scores in the experimental group were 60%, while those in the control group were only 45%.

There were also important differences between the performance of males and females in the laboratories. There were significant initial differences between the genders on all instruments on the pre-test, with males more successful than females. However, by the end of the experiment scores of the two groups were identical. When gain scores were compared, females improved by 56%, while males only improved by 48%.

The spatial measures used in this study were the Cube Comparisons Test and the Surface Development Test, both taken from the Kit of Factor-Referenced Cognitive Tests published by Educational Testing Service (Ekstrom, et. al., 1976). In the first instrument, students were asked to rotate, in their mind, a cube with symbols on the sides. It is a measure of spatial orientation. In the second they were asked to fold a planar view of a figure into a three-dimensional figure. It is a measure of spatial visualization.

The Hidden Earth modules had no demonstrable effect on performance on the Cube Comparisons Test. However, there was a significant difference between control and experimental groups on the Surface Development Test, with the experimental group improving significantly over the control group. In a regression equation which included both measures, only the Surface Development Test explained a significant portion of the increased performance of the experimental group on the geospatial test.

VI. Dissemination

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This module was originally developed for web-based distribution and later adapted for CD-ROM distribution (where internet connection is not required). The module was developed in Microsoft FrontPage, and is an executable, stand-alone program. Only QuickTime 5 (<http://www.apple.com/quicktime/download/>) is needed to play the movies in the module and Adobe Acrobat 5 (<http://www.adobe.com/products/acrobat/readstep2.html>) to open the worksheet PDF files.

References

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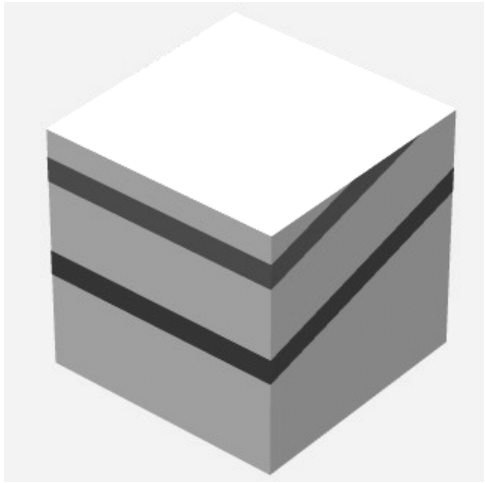
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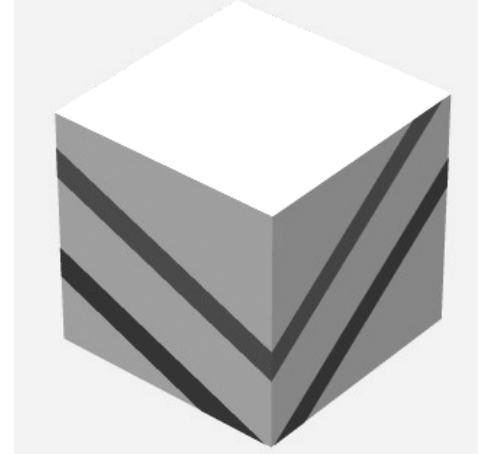
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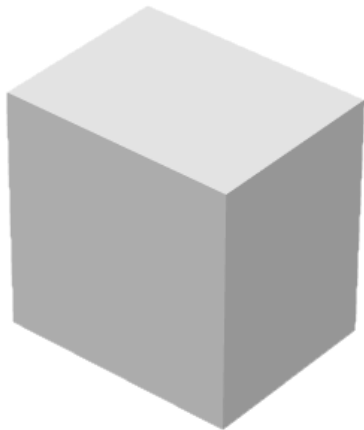
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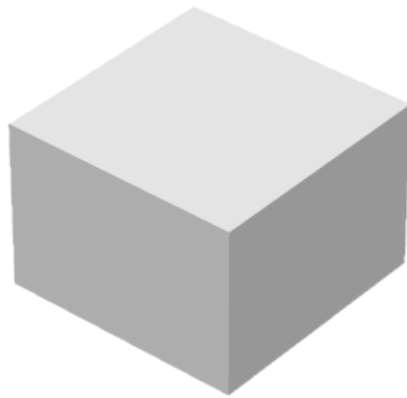
L-2 Sketch



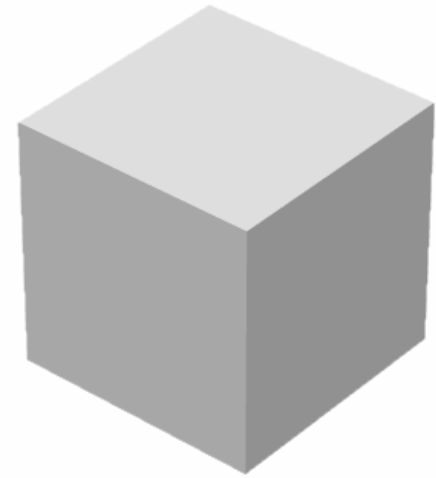
L-3 Sketch



L-4 Sketch

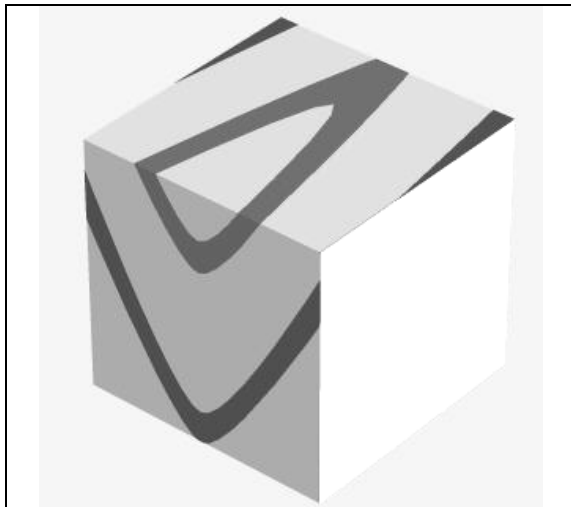


L-5 Sketch

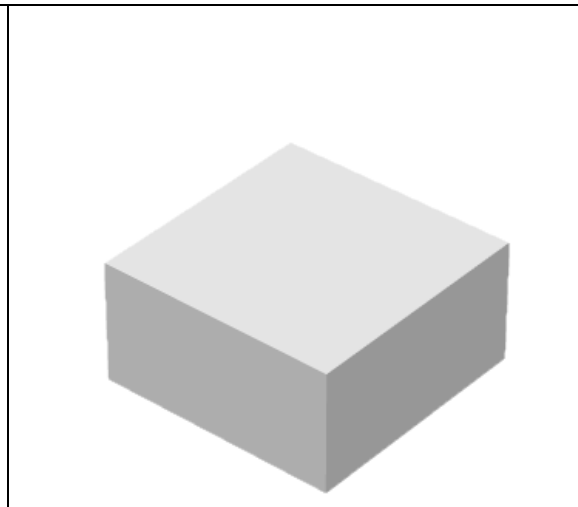


L-6 Sketch

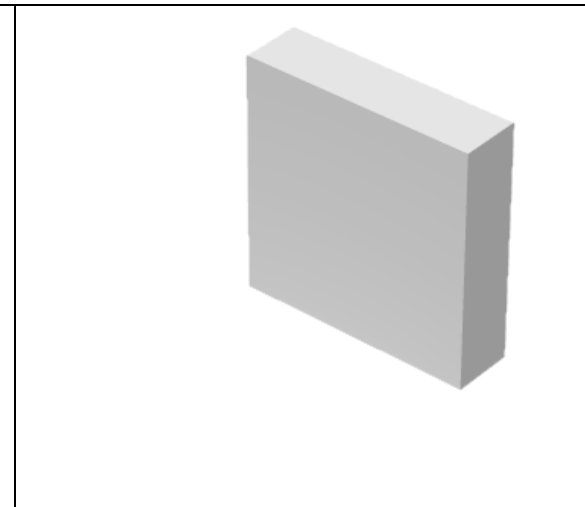
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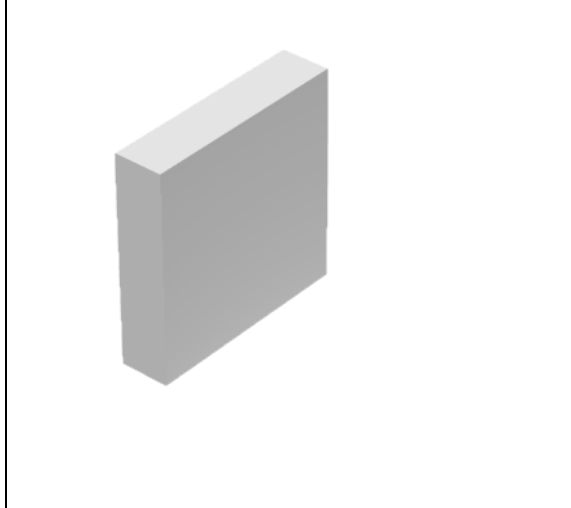
Fo-1 Sketch



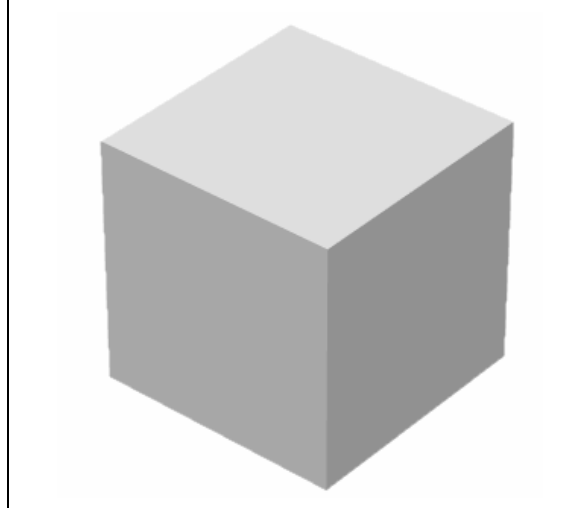
Fo-2 Sketch



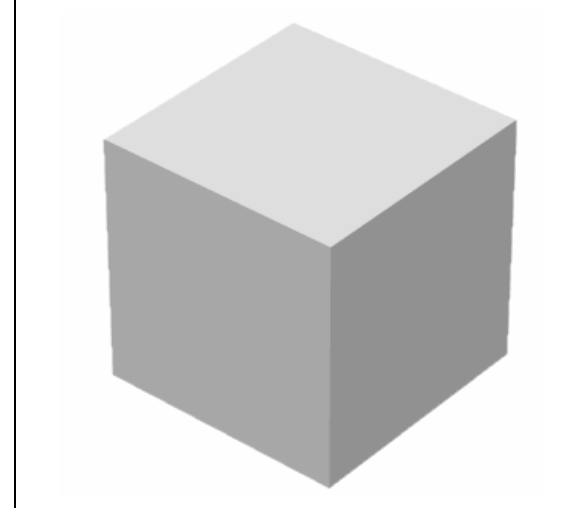
Fo-3 Sketch



Fo-4 Sketch

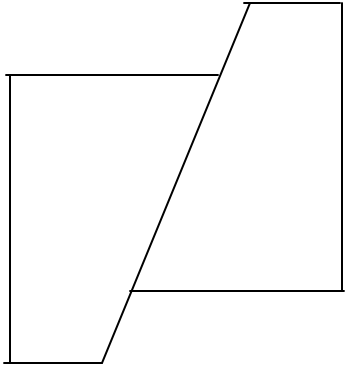
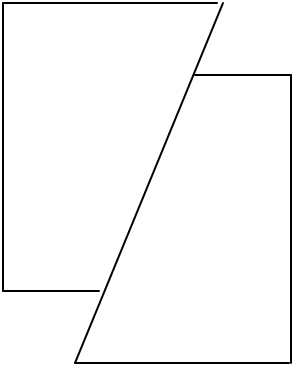
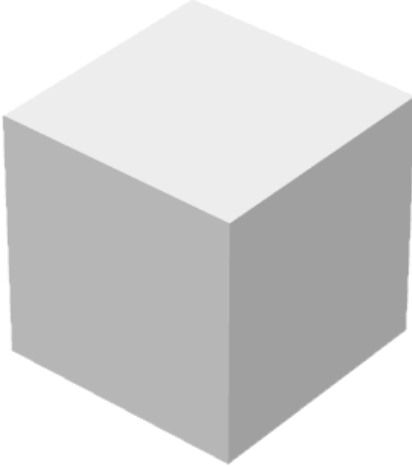
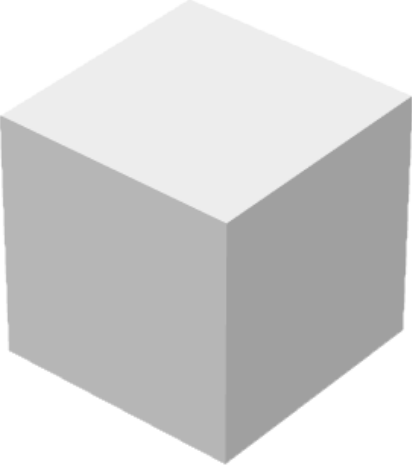


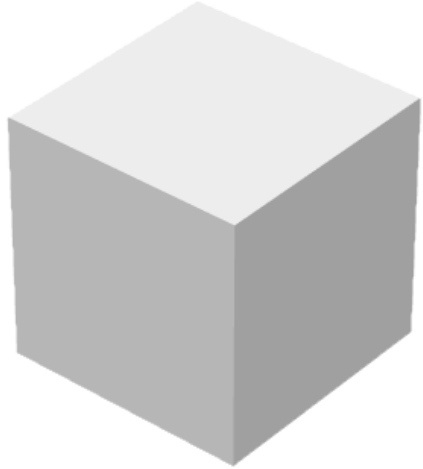

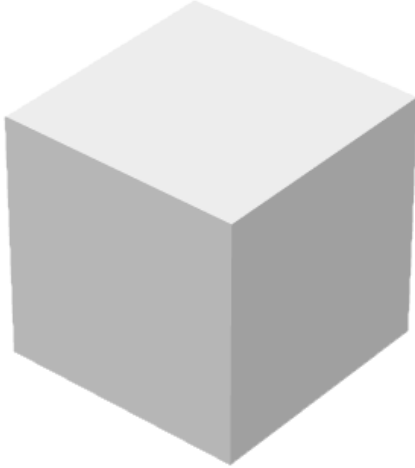
Fo-5 Practice sketch



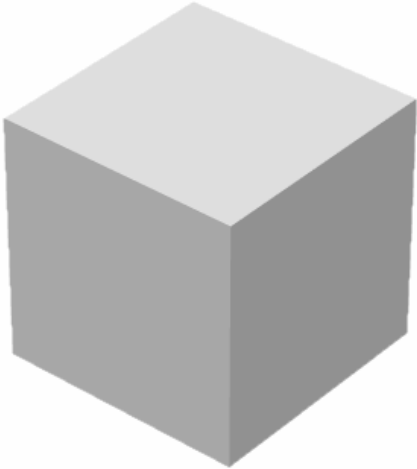
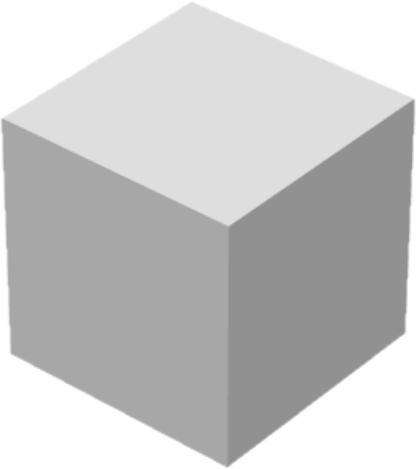
Fo-5 Final sketch

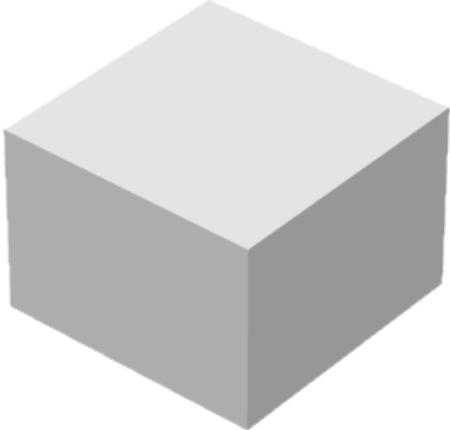
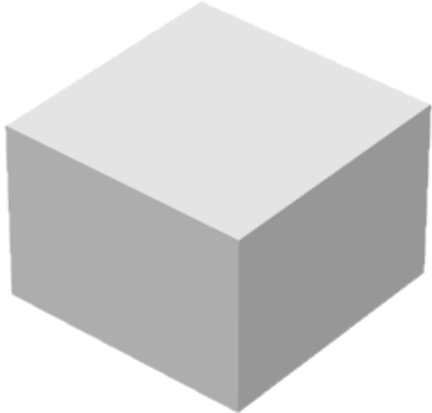
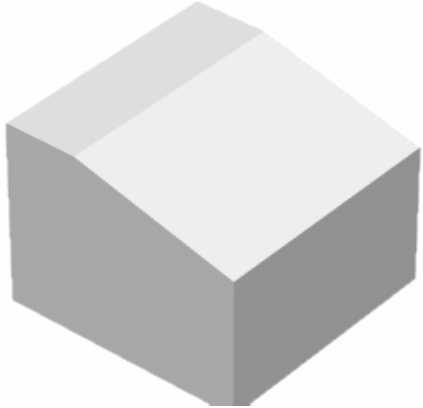
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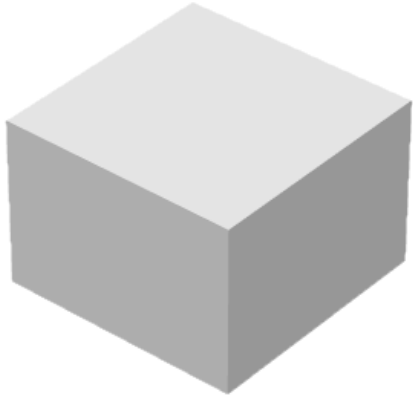
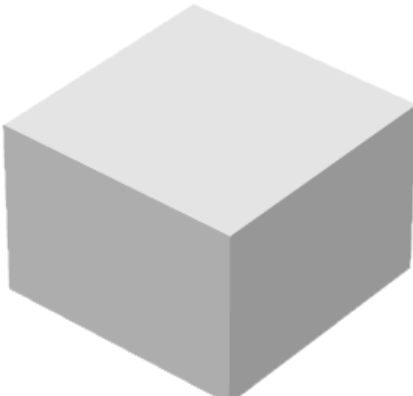
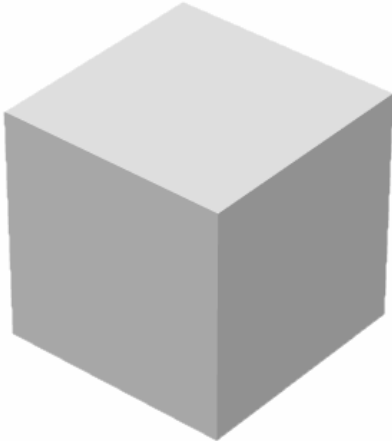
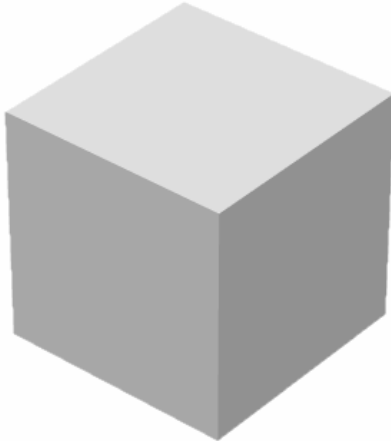
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<p>Ft-6 Sketch</p>	<p>Ft-7 Description</p>	<p>Ft-8 Circle One</p>
<p>Up and Left</p> <p>Up and Right</p> <p>Down and Left</p> <p>Down and Right</p>		
<p>Ft-9 Circle One</p>	<p>Ft-10 Sketch</p>	<p>Ft-11 Sketch</p>

Name _____

		1. 2. 3. 4.
I-1 Describe	I-2 Number and Types of Intrusions	I-3 List Order of Events (old to young)
1. 2. 3. 4.		
I-4 List Order of Events (old to young)	I-5 Sketch Block – Practice	I-5 Sketch Block – Final

	<p>___ Layers Tilted</p> <p>___ Upper Layers Deposited</p> <p>___ Erosion</p> <p>___ Lower Layers Deposited</p>	<ol style="list-style-type: none"> 1. 2. 3. 4.
<p>U-1 Draw Unconformity</p>	<p>U-2 Order Events</p>	<p>U-3 List Events</p>
	<ol style="list-style-type: none"> 1. 2. 3. 4. 5. 	
<p>U-4 Draw Unconformity</p>	<p>U-5 List Events</p>	<p>U-6 Draw Unconformity</p>

Name _____

	<ol style="list-style-type: none">1.2.3.4.5.	
<p>U-7 Identify Layers/Draw Unconformity</p>	<p>U-8 Order Events</p>	<p>U-9 Draw Unconformity</p>
		
<p>U-10 Describe and Order</p>	<p>U-11 Draw Block – Practice</p>	<p>U-11 Draw Block – Final</p>

