The Silicate Structures: Chalkboard Demonstration

Activity developed by:

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Bentley College
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The following pages include information for instructors and the original assignment.

For Instructors:

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Activity Description & Benefits: This assignment is designed to introduce the silicate structures, and their significance to mineral properties, to undergraduate non-science majors in an introductory physical geology course. Three-dimensional, magnetic representations of SiO tetrahedra and cations are manipulated on a chalkboard to create five basic silicate structures. Students are expected to complete a worksheet accompanying the exercise, which addresses silicate structures, bond types and strengths, physical properties (e.g. fracture, cleavage), Si:O ratio and introduction to vocabulary such as "felsic" and "mafic," and mineral formulae. The worksheet and chalkboard demonstration are designed to simplify silicate structures from complex ball-and-stick models typically used in textbook figures, and to grant students a visual, three-dimensional, manipulable, perspective on what tends to be a confusing concept. This exercise may simplified or expanded to suit timeframe and the needs of the audience. This activity is a tactile, collaborative, classroom demonstration that, when used in conjunction with a standard lecture introduction, provides such benefits as reinforcement of lecture concepts, broad appeal for a student group with multiple learning styles and degrees of knowledge, and strengthened understanding of the silicate structures.

Assignment Context: This assignment is lecture activity/demonstration used with non-science majors in an introductory physical geology course at Bentley, a (primarily) undergraduate business college. The four-credit course meets twice a week; once for a single period used for lecture, and again for a double period used primarily for lab activities. There is no geology major at Bentley; few students elect a broad liberal studies major in "Earth, Environment & Global Sustainability."

Required Skills: Students complete this exercise during the second week of a course on physical geology. Students will have completed a first lab on mineral properties, and so will be familiar with the physical properties of minerals, including fracture, cleavage, and hardness. This class exercise follows a lecture on the rock-forming minerals, which includes introduction to mineral bonds (ionic vs. covalent) and the Si tetrahedron.

Activity Goals: The goal of this activity is to develop and reinforce practical understanding of the importance of the silicate structures to the properties of silicate minerals. Content-specific goals include: 1.) Students will learn to differentiate (visually and through written description) the differences between five basic silicate structures. 2.) Students will study the relationships between fracture/cleavage and bond strength and structure (arrangement). 3.) Students will study the relationship between Si:O ratio and structure and will discuss the differences between felsic, mafic, and ultramafic minerals. 4.) Students will relate mineral composition (formula) to mineral structure. Higher-order thinking skills goals: Depending on the audience and how the instructor chooses to use this activity, goals for higher-order thinking skills will vary. This activity may be used simply as visual reinforcement for lecture concepts, or may be expanded to include hypothesis-building. Other skills: This activity is used to encourage student participation, and may be used to encourage group work, presentation skills, and discussion.

References & Resources:

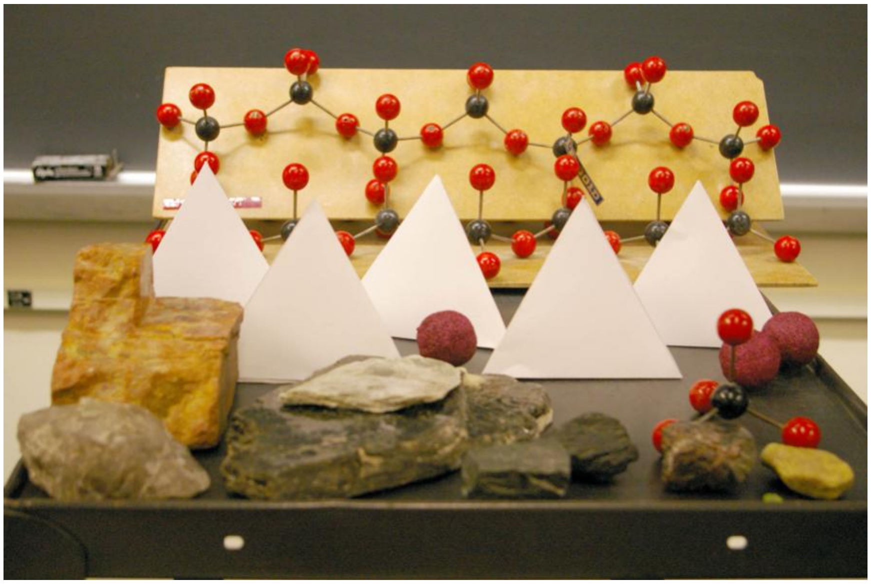
- Course Textbook: Tarbuck and Lutgens, 2008, Earth: An Introduction to Physical Geology, ninth edition: Pearson Prentice Hall, Upper Saddle River, New Jersey, 714 p.
- Klein and Hurlbut, 1993, Manual of Mineralogy, twenty-first edition: John Wiley & Sons, Inc., New York, 681 p.
- Tetrahedron Pattern: Enchanted Learning: Make a Tetrahedron, from http://www.enchantedlearning.com/math/geometry/solids/Tetrahedrontemp.shtml

Activity Evaluation: The activity itself is not evaluated. Students are expected to describe and recognize the five basic silicate structures and to describe the cleavage and Si:O ratio associated with each structure. This knowledge is evaluated during quizzes and/or on a midterm exam.

Additional Notes for Instructors:

Materials for Activity:

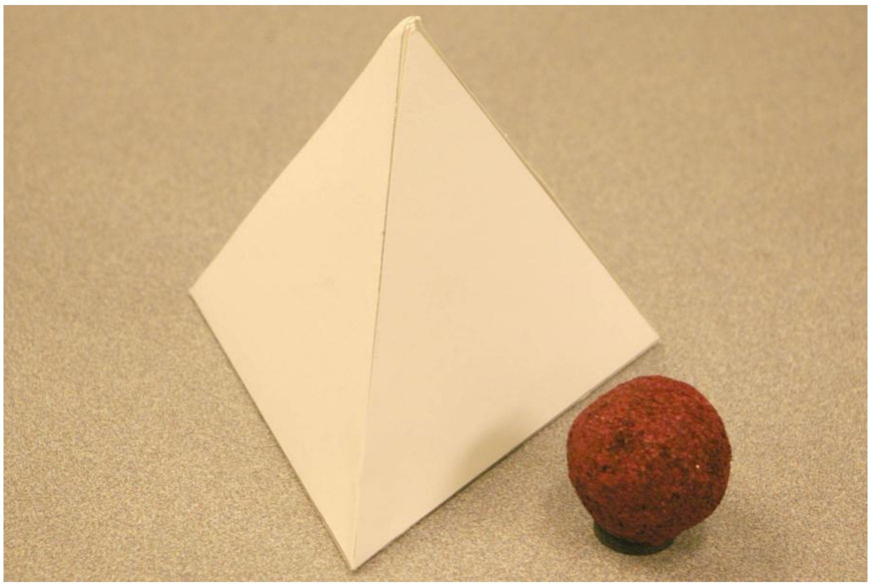
- SiO tetrahedra models (cardstock, tape or glue, magnets) ~12
- Cation models (polystyrene balls, knife, glue, magnets) ~12
- Colored chalk
- Mineral samples (olivine, garnet, pyroxene, amphibole, micas, quartz, feldspars)
- Ball-and-stick silicate models – optional
- Magnetic surface (e.g. chalkboard)



Materials used for classroom demonstration.

Creating Magnetic Models:

- Use a pattern or template for a tetrahedron, such as that found with this exercise (see also http://www.enchantedlearning.com/math/geometry/solids/Tetrahedrontemp.shtml).
- Create approximately a dozen tetrahedra on heavy cardstock paper. Tape a magnet inside the model before sealing up. Note: as magnets are taped inside the SiO tetrahedra models, I have placed a small sticker on the tetrahedral face so as to quickly find the magnetic side.
- To make cations: Cut a small polystyrene ball to create a flat base. Use superglue to attach a magnet to the flat side. Paint the ball a bright color.



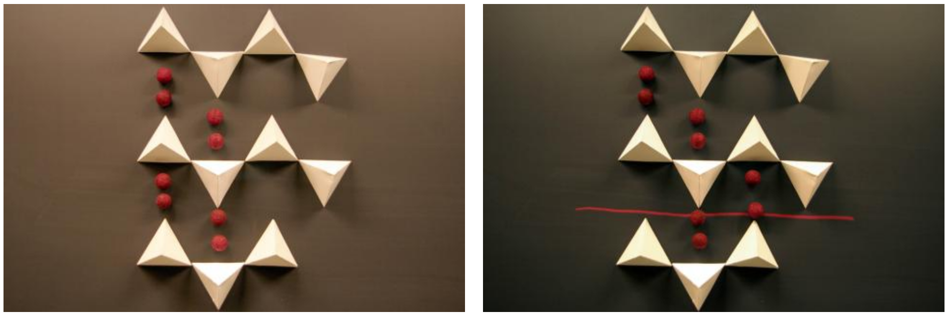
Example of magnetic tetrahedron and cation models.

Classroom Demonstration:

- Arrange tetrahedra into "independent tetrahedra" structure. Discuss arrangement. Add cations. Discuss locations of covalent (within tetrahedra) and ionic bonds. Discuss lack of cleavage, determined by lack of particular planes of weakness within mineral structure. Discuss Si:O ratio – note that all tetrahedra contain 1 Si and 4 O – therefore this structure's ratio is 1:4. Show example mineral samples.

Silicate structure – Independent Tetrahedra

- Rearrange tetrahedra to single chain structure. Discuss arrangement, add cations. Again, discuss cleavage patterns, Si:O ratio.



Silicate structure – Single Chain – Cleavage plane in chalk.

- Repeat for remaining silicate structures.
- Ask students to consider the compositions (formulae) of some common silicate minerals – can they detect the pattern between the formula and the Si:O ratio? Challenge them to figure out the pattern in the plagioclase composition (Al substitution for Si).

<u>Alternative Exercise</u>: Give students the link for the tetrahedron pattern, or give them a scaled-down photocopy, and ask them to make a half-dozen (or so) of their own models to bring to class. Students can then work in pairs or small teams to create their own silicate structures in class and to complete the worksheet on their own.

<u>Additional Notes</u>:

- I generally allow a half-hour for this exercise. The time required varies from class to class.
- One of the biggest challenges here is discussing the two-dimensional cleavage planes of the inosilicates. For this, I use purchased ball-and-stick models and I refer students to figures from their textbook (also included in lecture slides).
- Generally, by the time we have reached the double chain structure, students have the hang of determining cleavage planes and Si:O ratio (although double chains pose their own challenge…). The discussion tends to proceed more quickly at this point.
- Some information given on the worksheet is beyond the scope of a classroom discussion for non-science majors. While the structures are represented as accurately as the cartoon schematics allow, I do not engage my students in a discussion of the finer details. For example, certain tetrahedra are shown with dashed lines, indicating that the apices of these tetrahedra point downward. Additionally, cations are represented in approximate locations, but are not differentiated (different sites, octahedral coordination, etc.).
- The worksheet is created using Adobe Illustrator. The PDF can be opened into Illustrator for modification.