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| **Lesson Planning Guide** |
| **Develop Lesson Plans for Instruction** |
| Steps in developing [NGSS](https://www.nextgenscience.org/)-/standards-aligned, phenomenon-based lessons that are guided by the [5Es instructional model](https://bscs.org/bscs-5e-instructional-model):   1. Complete the Lesson Plan Overview (Part A) to guide development of lesson plans. 2. Use the Lesson Plan Template (Part B) to create detailed lesson plans. |

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| https://lh4.googleusercontent.com/3nF12fEN5h5hgtv4ZofuvibTcwtHVJ_NWtFhMVgHDmo2KU1R-JQY3ndc2Eo8Bc9pXdnqo8Erfx-JMqcT-KaHxMnFOfqsxBUKLF28abqNdDstymCGzJ6SlLhYSu-KzuetFn1Mts6_yLg | **Lesson Overview Template (Part A)** | | |
| **1.a Select grade level NGSS** [**Performance Expectations**](https://www.nextgenscience.org/search-standards?keys=&type%5B%5D=performance_expectation) **(PEs) or** [**Topics**](https://ngss.nsta.org/AccessStandardsByTopic.aspx)**, or district/state standards that support lesson-based student learning goals.**  For NGSS, PE color coding reflects its 3-dimensional learning components. Search the [Evidence Statements](https://www.nextgenscience.org/evidence-statements) for details on what students should know and do. | | | |
| High School: 9-12 grade  **HS-ESS1-5.** Evaluate evidence of the past and current movements of continental and oceanic crust and the theory of plate tectonics to explain the ages of crustal rocks. | | | |
| **1.b Identify a lesson-based** [**anchoring phenomenon**](https://static1.squarespace.com/static/56ef1da37da24f301fccaacd/t/5aa86e09652dea04982ceb94/1520987659683/NGSS+StorylineTool%231-AnchoringPhenomenon+-+v2.2.pdf) **that builds towards understanding of the PEs/standards, and is engaging and relevant to students.**  See more about [phenomena](https://www.ngssphenomena.com/) and using [phenomena with NGSS](https://static1.squarespace.com/static/56ef1da37da24f301fccaacd/t/581f4bb3e58c62bd0983dd03/1478446005130/Using+Phenomena+in+NGSS.pdf). | | | |
| Rock cycle: its relation to plate tectonics and weathering | | | |
| **1.c Ask a Driving Question, which is authentic and student-focused, that relates to investigating the PEs/standards and phenomenon.**  See more about [Driving Questions](http://www.authenticeducation.org/ae_bigideas/article.lasso?artid=53) and using [Driving Questions with NGSS](http://nstacommunities.org/blog/2013/08/01/essential-questions/). | | | |
| How can we use sand to explore the tectonic history of our area? Where are we limited? | | | |
| **1.d Unpack the** [**3-D learning components**](https://www.nextgenscience.org/three-dimensions) **of the Performance Expectations/standards in the table below.**  For NGSS guidance, see the [NGSS Topic Arrangements](https://ngss.nsta.org/AccessStandardsByTopic.aspx) and [NGSS DCI Arrangements](https://ngss.nsta.org/AccessStandardsByDCI.aspx). Use tools to [unpack](https://ngss.nsta.org/ngss-tools.aspx) each PE separately. | | | |
| [**Science and Engineering Practices**](https://www.nextgenscience.org/sites/default/files/resource/files/Appendix%20F%20%20Science%20and%20Engineering%20Practices%20in%20the%20NGSS%20-%20FINAL%20060513.pdf) **(SEP)**  **(skills)** | | [**Disciplinary Core Ideas**](https://www.nextgenscience.org/sites/default/files/resource/files/AppendixE-ProgressionswithinNGSS-061617.pdf) **(DCI)**  **(content)** | [**Crosscutting Concepts**](https://www.nextgenscience.org/sites/default/files/resource/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf) **(CCC)**  **(connections)** |
| Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science.  Evaluate evidence behind currently accepted explanations or solutions to determine the merits of arguments. (HS-ESS1-5) | | **ESS2.A: Earth Materials and Systems**  Earth’s systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. (HS-ESS2-1).  **ESS2.B: Plate Tectonics and Large-Scale System Interactions**  Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth’s surface and provides a framework for understanding its geologic history. (ESS2.B Grade 8 GBE) (secondary to HS-ESS1-5),(HS-ESS2-1)  Plate movements are responsible for most continental and ocean-floor features and for the distribution of most rocks and minerals within Earth’s crust. | PatternsEmpirical evidence is needed to identify patterns. (HS-ESS1-5)Stability and ChangeMuch of science deals with constructing explanations of how things change and how they remain stable. (HS-ESS1-6)Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. (HS-ESS2-1) |
| 1.e Determine students’ prior knowledge about the lesson concepts. (e.g., pre-test, class discussion, exit ticket, 1-minute report, KWL chart, survey, etc.) | | | |
| Two items are critical for students to know: (1) plate tectonics and the three plate boundaries, and (2) the three rocks and rock cycle. The first 15 mins of the course devoted to refreshing memory and gaging prior knowledge.  Class discussion on plate tectonics and the rock cycle. I will use a figure for both to refresh their memory.  <https://oceanexplorer.noaa.gov/facts/media/plate-boundaries-800.jpg>  <https://opentextbc.ca/geology/chapter/3-1-the-rock-cycle/>  There should be general consensus from the class that they know the following:  Three types of plate boundaries and mechanisms of each (plates either slide, dive, or diverge).  The three rock types and mechanism of cause (mountains, volcanos). | | | |
| **1.f Identify Lesson Topics and Learning Goals:** List main lesson concepts related to grade level PEs/standards that support student learning goals in figuring out the anchoring phenomenon; revise as needed. | | | |
| * + - 1. Observations of existing rocks can indicate their plate tectonic origin (HS-ESS1-5; ESS2.B)       2. Sand is a powerful tool to indicate rock origin, and thus the plate tectonic history (HS-ESS1-5; ESS2.B)       3. Appearance of sand alone is not a great indicator of rock origin or tectonic history (SEP Skills)       4. Weathering of sand and maturity levels of sand (HS-ESS1-5; ESS2.B) | | | |
| **1.g Select Lesson Resources:** Identify resources to develop lessons that address the PEs/standards and investigate the anchoring phenomenon through a variety of sequenced activities; revise as needed (include title and URL). | | | |
| <https://www.scienceofsand.info/>  DK Rocks and Minerals Handbook (Pellant Editions)  Onondaga Lake sand sample  Magnifying glass | | | |

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|  | **Lesson Plan Template (Part B)** | | | | | |
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| **Grade and Subject** | 9th Grade | | | | **Instructional Time**  (min.) | 90 mins (assuming an every other day schedule) |
| **Lesson Title (Topic)** | Plate tectonics, the rock cycle, and sand | | | | | |
| **Anchoring Phenomenon**  (copy from 1.b) | Plate tectonics  Rock cycle  Weathering | | | | | |
| **Driving Question**  (copy from 1.c) | How can we use sand to explore the tectonic history of our area? Where can we accept its limitations? | | | | | |
| **Lesson Overview** | | | | | | |
| **Lesson Summary**  (description) | | | **Lesson Topics and Student Learning Goals**  (copy from 1.f) | | | |
| The theory of plate tectonics is the unifying theory in Earth Science. The recognition that crust is divided into plates that move over the asthenosphere forms the basis of the theory. Volcanic activity, earthquakes, and active movement circumference the boundaries of the plates.  Plates either separate, dive under, or slide against each other. The rock cycle is a general understanding of rocks as they are created, destroyed, or changed. Igneous and metamorphic rocks are strong indications of plate tectonics and present/past boundaries.  Sedimentary rocks or weathered materials are composed of minerals that can hint to their rock type, and hence their plate tectonic origin.  Sand has limitations (quartz tells a limited story, quarts and feldspar can tell more). Weathering of sand can indicate local processes and the age of sand.  Discuss rock formations in the Onondaga Lake area and associated minerals. Have students look at Onondaga Lake sand sample with magnifying glass, and explain what they are seeing. If they do not seem encouraged, link up for them what grains and likely what minerals. If they seem encouraged, let them get there themselves.  Compare Onondaga Lake sand against Crescent Maine sand: We know the metamorphic and igneous rocks found are associated with subduction zones. They look very different but share the same tectonic history. Generally one is metamorphic weathered materials and the other is igneous/sedimentary weathered materials. Both samples support the theory of plate tectonics and subduction along the eastern coast.  Compare Cyprus sand against Onondaga Lake sand: Both from rocks created from a convergent boundary. However, the Cyprus sand is mafic from oceanic crust, the Onondaga lake sand is felsic igneous/sedimentary. Discuss ophiolites and their strong evidence for plate tectonics. Both provide evidence for plate tectonics, specifically for subduction zones.  Compare Inishmore sand with Onondaga Lake sand: both supposedly have high levels of calcium carbonate, but they look very different. Sand can only tell us so much, especially based on color alone.  Compare Kalama, WA against Onondaga Lake sand: They look alike based on appearance, and they are the most similar. Both are weathered from igneous rocks created at convergent plate boundaries. | | | * + - 1. Observations of existing rocks can indicate their plate tectonic origin       2. Sand is a powerful tool to indicate rock origin, and thus the plate tectonic history       3. Appearance of sand alone is not a great indicator of rock origin or tectonic history       4. Weathering of sand and maturity levels of sand | | | |
| **Lesson Resources Aligned with Standards** | | | | | | |
| **Lesson Resource**  (copy from 1.g, sequenced with titles and links) | | | **Resource Standards Alignment**  (copy from 1.d, standards notated, link optional) | | | |
| <https://www.scienceofsand.info/sand/states/washington/kalama.htm> | | | ESS2.B: Plate Tectonics and Large-Scale System Interactions  Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth’s surface and provides a framework for understanding its geologic history. (ESS2.B Grade 8 GBE) (secondary to HS-ESS1-5),(HS-ESS2-1)  Plate movements are responsible for most continental and ocean-floor features and for the distribution of most rocks and minerals within Earth’s crust | | | |
| <https://www.scienceofsand.info/sand/countries/cyprussand.htm> | | | “ “ | | | |
| <https://www.scienceofsand.info/sand/countries/ireland/inish.htm> | | | “ “ | | | |
| <https://www.scienceofsand.info/sand/states/maine/elizabeth.htm> | | | “ “ | | | |
| **Teacher Preparation** | | | | | | |
| **Student Misconceptions**  (potential student ideas that are problematic when engaging in the lesson) | | | **Scientific Terminology**  (vocabulary named once students “figure out” concepts of lesson) | | | |
| Igneous vs. metamorphic rocks – very common for students to confuse the igneous as metamorphic  Lack of good examples for transform or divergent boundaries and rocks. | | | Felsic = higher silica content, associated with convergent boundaries  Mafic = lower silica content, associated with divergent boundaries | | | |
| **Materials Preparation** | | | | | | |
| **Student Needs**  (activity sheets, data packet, etc.) | | **Group Needs**  (lab equipment, group data packets, etc.) | | **Safety & Technology Needs**  (unsafe materials, websites cued, etc.) | | |
| 1. Observations of existing rocks can indicate their plate tectonic origin  2. Sand is a powerful tool to indicate rock origin, and thus the plate tectonic history  3. Appearance of sand alone is not a great indicator of rock origin or tectonic history  Weathering of sand and maturity levels of sand. | | -- | | -- | | |
| **Supporting Information** | | | | | | |
| **References**  (links to cite sources of data, images, websites, etc.) | | | **Background Reading**  (for teachers and/or students) | | | |
| **Plate Tectonics:** <https://oceanexplorer.noaa.gov/facts/media/plate-boundaries-800.jpg>  **Rock Cycle:** <https://opentextbc.ca/geology/chapter/3-1-the-rock-cycle/> | | |  | | | |

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| **Complete the 5E Instructional Model section(s) that are relevant to the lesson:** |

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| **Engage: *Interest in a concept is generated and students’ current understanding is assessed.***  ACTIVATE interest: Introduce anchoring phenomenon and driving question. |
| * Engages students in the concepts through a short activity or relevant discussion * Connects students’ past and present experiences * Creates interest and generates curiosity * Uncovers students’ current knowledge and misconceptions * Initiates students’ investigation into the anchoring phenomenon based on an observation, problem, or question |
| **Phenomenon-based Driving Questions** (questions students are likely to ask about the lesson topic) |
| But how do we know XYZ rock is associated with a certain boundary?  Why is quartz found in most the samples?  Why does a granitic rock form in one area but an andesitic rock in another?  What about rocks associated with transform margins or divergent margins? |
| **Lesson Activities** (experiment, demonstration, video, visualization, reading, etc., coherently sequenced to help build understanding of PE/standard)  For each activity, provide details of the procedure including timing, teacher guidance, student prompts, strategies for discussions and differentiation, etc. |
| Review (~10 mins): The theory of plate tectonics is the unifying theory in Earth Science. The recognition that crust is divided into plates that move over the asthenosphere forms the basis of the theory. Volcanic activity, earthquakes, and active movement circumference the boundaries of the plates. Plates either separate, dive under, or slide against each other (Figure 1). The rock cycle is a general understanding of rocks as they are created, destroyed, or changed. Igneous and metamorphic rocks are strong indications of plate tectonics and present/past boundaries Sedimentary rocks or weathered materials are composed of minerals that can hint to their rock type, and hence their plate tectonic origin.  (Figure 2).  Discuss rock formations in the Onondaga Lake area and associated minerals (15 mins). Have students look at Onondaga Lake sand sample with magnifying glass, and explain what they are seeing with regards to weathering. If they do not seem encouraged, link up for them what grains are likely what minerals. If they seem encouraged, let them get there themselves. Encourage them to look up rock formations in their Pellant Rocks and Minerals guide.  Compare Onondaga Lake sand against Crescent Maine sand (15 mins): We know the metamorphic and igneous rocks found are associated with subduction zones. They look very different but share the same tectonic history. Generally one is metamorphic weathered materials and the other is igneous/sedimentary weathered materials. Both samples support the theory of plate tectonics and subduction along the eastern coast. Show pictures, a rock and minerals list.  Compare Cyprus sand against Onondaga Lake sand (15 mins): Both from rocks created from a convergent boundary. However, the Cyprus sand is mafic from oceanic crust, the Onondaga lake sand is felsic igneous/sedimentary. Discuss ophiolites and their strong evidence for plate tectonics. Both provide evidence for plate tectonics, specifically for subduction zones. Show pictures, a rock and minerals list.  Compare Inishmore sand with Onondaga Lake sand (15 mins): both supposedly have high levels of calcium carbonate, but they look very different. Sand can only tell us so much, especially based on color alone. Show pictures, a rock and minerals list.  Compare Kalama, WA against Onondaga Lake sand (15 mins): They look alike based on appearance, and they are the most similar. Both are weathered from igneous rocks created at convergent plate boundaries. But very different in age. Show pictures, a rock and minerals list.  Discussion with remaining 5 mins. |
| **Formative Assessment** (activity sheet, Venn diagram, summary, exit ticket, think-pair-share, etc. to check for understanding of lesson concepts) |
| As homework, ask them to complete at least two Venn Diagrams (two samples each) showing what these samples have in common (mineralogy, parent rocks, weathering, and plate boundaries) and what is different.  This will meet the standard of applying concepts/being able to explain the evidence for existing theories. |
| **Consensus Discussion** (claims, evidence, and reasoning on what students figured out in this lesson) |
| Rock formations are evidence of plate tectonics  Limitations of sand to determine tectonic history |
| **New Questions and Next Steps** (student-driven questions, ideas on what to investigate in the next lesson and how to investigate it, etc.) |
| Next steps would be to look at rocks associated with transform margins and divergent boundaries |

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|  | **Step 4: Lesson Instruction and Reflection** |
| **Lesson Notes During Instruction** | |
| To be completed after lesson.  Students will be frustrated with lack of understanding of rocks formed/changes at divergent boundaries or transform. | |