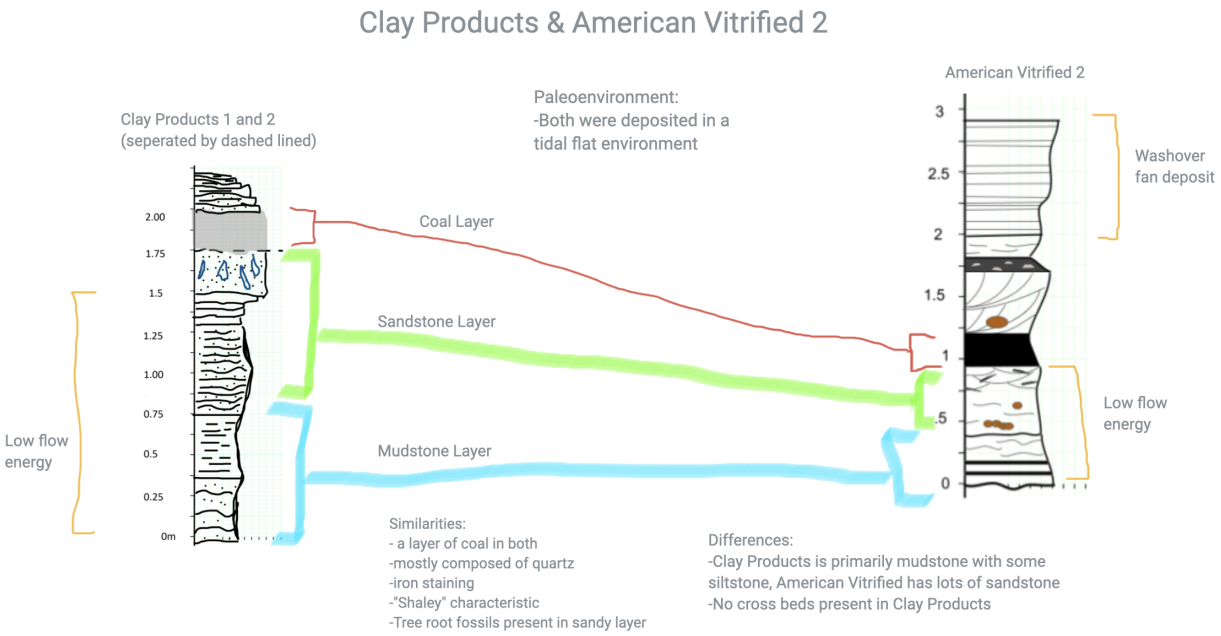

Figure S1: Supplemental example of Part 6 of the Assignment, in which small groups at adjacent localities correlated their sections and explained similarities, differences, and drafted paleoenvironmental interpretations.

Related SLO	Student Feedback and Reflections
1	What I took away from this virtual field trip is how to apply lecture and lab examples to the real world and the typical rock formation I will be presented with in the future will most likely not have a straightforward answer.
1	One of the things this project taught me was how to form hypotheses about the depositional environments that can form outcrops of sedimentary rocks. It also helped me refine how I take field notes and make outcrop sketches.
1	I learned how to apply ideas and skills that we have been learning in class to real-world situations, like using QFR diagrams, viewing hand samples, reading and applying published literature, and more.
1	I liked how the lab was on a local site here in Michigan. It makes it more relevant to us because it is an area we may be familiar with or can easily visit versus a random location across the globe.
1	...and when it came to the sketch and the field notes, I thought it would be a piece of cake, but then I realized that there was much more critical thinking that came around in it as well, it became more challenging and definitely more interesting to work on.
1	Normally I dread doing big assignments but I enjoyed this one a lot more than I had anticipated. This activity was great practice for me to do if I were ever going to work in the field of geology.

1	Sometimes I feel as if I get the gist of what I am being taught but the exercise pushed me to see the bigger picture at all times- instead of me just following a set of directions and not taking anything away from it.
2	While doing this project I learned how to make detailed field notes, informative stratigraphic columns, and accurate QFL diagrams. I had worked on these various methods in other settings but doing them for this project really enhanced my understanding and confidence when dealing with data collection and observation.
2	The main thing that I learned from this lab was how to approach an outcrop and interpret its environment. When observing the layers there were small clues to the type of environment such as way bedding and the root traces that other outcrops had. Putting these together helps understand more specific details about the type of marine environment.
2	One thing that I would say I took away from this experience is there is no way to know the story of a rock face with 100 percent accuracy. It's more a series of hints or clues that are found in a subject area that help you piece together a puzzle of what most likely happened based on our understanding of known geological processes.
2	Having so many pictures and resources for the Grand Ledge site was really helpful and made it feel more like we were working on an actual field project rather than just looking at photos of rocks online.
3	I was also able to learn more about how the different rocks responded to weathering.
3	I also learned that certain features in the rock record can be post-depositional, which can sometimes confuse the record.
3	During the field trip I used geological skills to draw outcrop images, stratigraphic columns, and diagnose rock types from thin sections. I learned how to better those geological skills along with determining what kind of bedding styles and sedimentary structures are within the outcrops and identifying fossils.
4	One of the biggest things I learned from the Virtual Field Trip was how to get interpretations from an outcrop and transform that into a stratigraphic column.
4	It was not easy by any stretch of the imagination, but it really challenged me to really look for details and specifics to create the most accurate profile of the stratigraphic column.
4	While doing this project I learned how to make detailed field notes, informative stratigraphic columns, and accurate QFL diagrams.
5	I also learned that when considering an outcrop, determining its history is not as straightforward and simple as I would have thought because depositional environments are complex and often difficult to interpret.

5	This experience did help boost my morale about this class and show me that I can actually understand geology and bring more than one concept together, which is something I feel like I have been frustrated with in the past because I haven't felt like I have connected any geology thoughts for a while now.
5	Working collaboratively with the whole class to combine what we learned went fairly well, and I appreciated how each group actively contributed to the discussion. However, my group had some difficulties with miscommunications about what outcrop we would focus on, which set us back at first.
5	I also enjoyed learning about what my field notes actually should look like, and what makes good field notes, and how important they actually are. There were many times when I was working on my interpretations, that I would look at my field notes and then have to go back and look at the outcrop because I missed something. I was glad in that way that we were doing this virtually so that I could do that.
5	The depositional environment predictions that we came up with as a class, were well thought out and, I believe, viable answers to the question posed towards us.
5	I really enjoyed the problem solving aspect of this experience. I also enjoyed the process of collaborating with a fellow geologist as they can offer hypotheses of the origin of a sedimentary face that I would not have come up with myself.
6	After reading *The Ledges of the Grand River, Michigan*, I noticed that I was not looking at the big picture enough even after our class discussions. ... Seeing how you take the general environment, analyze your outcrop, make your outcrop stratigraphic sequence based on data collected- then double back and expand on the previous environment was a huge realization moment for me.
6	I learned the importance of being cautious and humble about my ideas in the field and willing to listen and learn from my classmates and colleagues.
6	This project was also very beneficial for working in a team setting. The collaboration and focus towards a similar goal was helpful for me to problem solve whenever we came to unknown sections of the work.
6	Our group's final interpretation did not support our initial hypothesis that the outcrop was directly formed from glacial melt. However, our findings support the additional hypothesis that channelization may have formed the upper sandstone layers
6	When discussing as a whole group it was interesting to see how every layer in the stratigraphic columns match up. The layers may not be even, and they may be at different heights, but you can at least make a connection between the layers (drawing a line between all the coal layers).

Table S1: Student feedback and reflections on the VFT.

Grand Ledge Virtual Field Trip Stratigraphy Project Assignment

Student Instructions

You will be assigned a group of 2-3 to work with. Although the virtual field trip will be done in groups, this is for discussion and idea-sharing purposes. You will be responsible for turning in your own work (do **not** replicate your group members' products).

Upon successfully completing this project, students will be able to:

1. Apply their course knowledge to analyze the stratigraphic characteristics of a real-world field site through a virtual field experience
2. Identify and describe lithologies from a combination of outcrop photos, 3D models, and thin sections.
3. Recognize and describe bedding styles and geometry from outcrop photos and 3D models.
4. Create a detailed, (litho)stratigraphic column using data from objectives 2-3 and additional strat column resources.
5. Develop an interpretation of the depositional environment(s) for the stratigraphic column.
6. Present final products and discuss observations and the strengths and weaknesses of different interpretations.

Part 1: Background and Framework

Each group will be assigned 1 outcrop from the **Grand Ledge Field Localities**.

[NB: While you will initially be in a small group of 2-3, after your initial outcrop investigations, your group will have the opportunity to collaborate with 1-2 groups tackling neighboring outcrops. This will be a chance to compare and share data, and figure out how your sections are related (i.e., correlated).]

1. Get oriented to your outcrop location, and where that is within the Michigan Basin:
    a. Locate your outcrop on the field trip maps found on the **Field Localities** page. You can also download the .kmz file to open in Google Earth, which will allow you to explore the area of Grand Ledge, around the outcrops.
2. Explore the **Background Geology** page, investigating the context of Grand Ledge, Michigan in geologic time and within the context of the rest of the Michigan Basin.
3. Reflect on the two sets of bolded questions posed within the **Background Geology**. Write down your hypotheses and ideas about these in your notes. You might not have definite answers to these yet, but this is the time to start brainstorming about them. This is a useful practice before going into the field anywhere – establish context, and know when, where, and what is above and below you.

Part 2: Outcrop Reconnaissance

Access your assigned site (under the Field Localities and Outcrop Models tabs), visit and carry out reconnaissance of your outcrop 3D model and panoramic photos, hand sample models, close-up photos, and thin sections. (Read the notes that are included with some imagery):

1. Using the 3D outcrop model AND the outcrop photos (full-resolution versions are linked below the photos), make an **outcrop sketch**. This is the first thing to do as a geologist when approaching a new site – take in the big picture.
2. Through sketching the overall geology of your outcrop, **define distinct units** (layers with different lithologies; how many? You may want to number or letter them from base to top of outcrop.). Building upon your geological sketching skills,

focus on the geometry of bedding, sedimentary structures, and changes in lithology (which may be reflected in the weathering profile).

   a. Look past and ignore any weathering stains, fractures or joints, lichen, vegetation, or rubble! Focus on the original, primary sedimentary features.

3. **Label and annotate** your sketch. Make this a data-rich resource.
   a. This is also a time to note some hypotheses or questions in your annotations that you know you want to investigate further.

Part 3: Lithologies

On the virtual field trip site, focus in on the close-up photos (which are tied to annotations on the 3D outcrop model!), hand sample models, and thin sections (which were made from the hand samples). Read the notes that are included with some imagery:

1. Write a **rock description** for each unit. You will at least have as many units as there are hand samples for your outcrop, and potentially more. While you started defining your units in Part 2, it's okay if you want to revise this original assessment. (See examples of full, formal rock descriptions from your sandstone and conglomerate labs.)
   a. To properly name your rocks (especially sandstones) you will need to determine both the texture and composition using the **thin sections** and other imagery. Use the standard charts for visual estimations of percent composition, and plot your results on a **QFR** to determine the rock name. Provide both the QFR percentages and the rock name in your description, along with all textural descriptors.
2. Draft hypotheses for your interpretations of the specific types of depositional environments for the lithologies you have described. (You will be revising these as you gather more data, and you might want to look back in your book for ideas.)

Part 4: Bedding style and Sedimentary Structures

Using your outcrop and close-up photos and 3D model for your locality:

1. Use the Jacob's staff (10-cm increments; or scale bars with 1-cm increments) in the photos as your reference to:
   a. Measure and record bed thicknesses in your outcrop (add these to your sketch).
   b. Assess any trends up-section (make notes of these).
2. Identify and carefully describe any sedimentary structures (e.g. cross-beds) or fossils (e.g., root traces), add these to your notes. Make sure you include them in your outcrop sketch.
3. Revise your environmental interpretations. Focus on thinking about how the environment (flow energy, sediment supply and type, life present, etc.) changed over time, based on the succession of units present.

Part 5: Stratigraphy

Using your data from parts 2, 3, and 4:

1. Draft a detailed stratigraphic column (also called a graphic log). Use the provided logging sheet to draft your section. Please use **0.25 m per tick mark** on the vertical scale for consistency. *You can annotate the **pdf** file in pdf viewing software, or insert the **png** file into Word, PowerPoint, or a Google Slide to draw upon.*
   a. All students must complete and submit a **stratigraphic column** – this is your most refined product, and what you would present in a professional context.

Key features to include for this strat. column:

- Thicknesses of beds
- Lithologies and texture information: Lithology is indicated by a pattern or a note beside the column. Grain size is indicated by the width along the X-axis, expressed with a ragged or smoothed edge as it changes
- Sedimentary structures (physical and biogenic) -- include symbols on the column and describe them at the side.
- Fossil content and clasts
- Nature of contacts (sharp? erosional features? relief?)
- Weathering style of individual beds (note changes in color, or if a unit is more recessive vs. more ledgy or resistant)

2. Write your interpretation of your strat. column/graphic log, making your concise notes alongside your column. Include:
    a. Paleoenvironmental interpretation – be detailed and precise! [i.e., not just "coastal" but specify "upper shoreface"]
    b. Notes on relative sea level changes, ideas about the climate, etc.
3. Work as a group to assemble a short set of Google Slides that include a map pinpointing your locality, an outcrop sketch, a stratigraphic column, and your interpretations. [**Every** student will turn in their **own** products, but choose **one** of yours to present – *one group member will present their outcrop sketch, the other group member will present their strat. column*.]

Part 6: Collaborate

After each small group has tackled their individual outcrop and its details and assembled a basic presentation, you will meet with the other 1-2 small groups with adjacent localities (your "pod") to collaborate and share ideas to refine your ideas and work.

1. Rotate through and briefly have each small group present their site and interpretations.
2. Merge your Google Slides, and add a new slide: insert all 2-3 strat. columns for your pod here, using the locality maps to determine their approximate lateral placement. (You will want to crop everything from the logging sheets except the actual sketched columns for this part. Keep the columns all at the same scale/size!)
    a. As a group, do you see any clear similarities or differences? On the slide, try sketching any contacts you think can be traced across the columns (which beds might be similar, aka "marker beds").
    b. Compare and contrast your interpretations of the environments and their changes through time. Work together as a group to refine your paleoenvironmental story and add that to your slide with all columns (keep your original slides!).

Part 7: Disseminate Knowledge

The final part of this virtual field exercise focuses on sharing what we have each learned in different localities to piece together a full picture of the region's geologic history.

1. Export your strat. column (choose **one** from your small group) as a **jpg** or **png**.
2. Each small group will add their strat. column to our class Google Jamboard (make sure to include your locality name! Do crop out the rest of the logging sheet)

3. Each small group (in sets of pods) will present their outcrop, stratigraphy, and preliminary interpretations to the full class, using brief slides. Each pod will elect a representative (or two) to present their correlated stratigraphy with revised interpretations.
4. As a class, we will then arrange and annotate everyone's strat. columns on the Jamboard, generate a cohesive set of hypotheses about the depositional system (including changes in energy, sediment supply, sea level, climate, life, etc.), and revisit original hypotheses.
5. As a wrap-up, everyone will complete a short, assigned reading on published interpretations of the area.
6. Each student will submit a **final written reflection**. 1-1.5 pages, double spaced, 12 pt. Times New Roman font. Include:
    a. Summary of what you learned overall
    b. Reflections on our interpretation accuracy and class discussion of the depositional system (refer to your original hypothesis). Differences with published interpretations?
    c. Things that went well or things to change about this exercise.

Deliverables from each student:

Save each of these items as a separate (single, compiled) **pdf** and deposit in the appropriate Moodle assignment link on each due date (see Moodle):

1. Copies of "field" notes (annotated outcrop sketch, rock descriptions, etc.) and original hypothesis
2. Your stratigraphic column with interpretations (single completed logging sheet)
3. Final written reflection

Keep your work organized at all stages, and submit a professional product.

Virtual Field Trip Assessment (70 pts total)

"Field" Notes: 20 pts

General notes (8 pts):

1: Date, who with, weather.

1: Description of geographic location

2: Written description of outcrop

2: Hypothesis (should be distinct from other notes and questions)

2: Additional notes/ideas/questions (can be on sketch)

Sketch (12 pts):

2: Major features of outcrop represented

2: Defined and labeled geological units: rocks types, etc.

1: Horizontal and vertical scales

1: Cardinal directions

2: Labels and annotations; and/or key/legend

2: Detail!

2: Neatness, inking

Stratigraphic Column: 20 pts

1: Vertical scale (1 sheet of paper), including total thickness of all units; metric

1: Left side straight, right side reflects grain size

2: Appropriate lithologies/facies represented with standard symbols or notes

2: Sedimentary structures represented

2: Nature of contacts

2: Weathering style of individual beds

2: Horizontal scale represents grain size

2: Key/legend

1: Mark any offsets

2: Interpretations (paleoenvironmental, sea level changes, climate, etc.)

1: Detail!

2: Neatness, inking

Final Reflection: 20 pts.

Content (15 pts)

5: Summary of what you learned overall

5: Reflections: On our interpretation accuracy and class discussion of the depositional system (refers to your original hypothesis). Discuss differences with published interpretations

5: Concluding thoughts

English Composition (5 pts)

2: Clarity

2: Length (1.5 pages + double spaced)

1: Spelling

Participation and Presentation: 10 pts

5: Peer evaluation and presentations

5: Self-evaluation and attendance