Block Diagram of Nebraska Geology
<table>
<thead>
<tr>
<th>Era</th>
<th>Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cenozoic</td>
<td>66 Ma</td>
</tr>
<tr>
<td>Mesozoic</td>
<td>251 Ma</td>
</tr>
<tr>
<td>Paleozoic</td>
<td>542 Ma</td>
</tr>
<tr>
<td>Precambrian</td>
<td></td>
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</tbody>
</table>

**Day 0**

**Smooth Rock**
- Round shaped rock marks
- Hand span across, some see pristine cut
- Gray/brown color, all light brown spots
- Brilliant greenish streaks - a bit mucky from the surf

Looks like a bit of xeromorphic, light gray rock
- Fine veins all over, looks like streaking and breccia, they are ambers/yellows out colored all day, just on the surface.
- The size is a bowling ball, but past 12-15 lbs.

**Rock**
- Rough, lighter for its size, size of an auction broadleaf

Why are there some solid gray play, looking parts?
- Some parts so big?
- What makes it so heavy?
- What are the streaks?
- What accounts for the colors? The metal-like pieces?

**Rock**
- What’s with the layers perching, leaning, cut down angle? Are they fossil?
- What are the cracks from? How many different rock types are in there?
- Why is the rock “smooth” vs others not?
- Dry it still feels moist – so must have carbon in it (goss)

**Rock**
- Why is it covered in sand and gravel? What makes them stick? Why so many small rocks stuck together?

**Big Question**
- What am I seeing?
- How did it get here? How did it form?
- What has happened to it since it formed?
Becoming an inquiry teacher requires creating and sustaining reflection and discourse with other teachers. — Nevellyn

My ideal self, the kind of teacher I want to be:
- Motivating
- Foster students' curiosity
- Caring
- Make connections with my students

"The Guide on the Side" not "Sage on the Stage"

A mineral is:
- Naturally occurring
- Inorganic
- Crystalline solid (Ice is a mineral!)
- Has a relatively consistent composition
- Has ordered internal structure
- Has a specific chemical composition (Ice specific formula: like NaCl)

Rocks are made of minerals and minerals are made of elements.

Clastic rocks — typically formed in a high-energy environment
- Has distinct pieces of rock (clasts) derived from older, weathered rocks
- Weathering and erosion of rocks
- Most clastic rocks form in relatively shallow environments

Crystalline rocks
- Typically formed in a low-energy environment
- Made of mineral crystals
- Weathering and erosion of rocks
- Most crystalline rocks form in deeper environments

What is INQUIRY?

Day 1
6/10/12

Start defining a question. How do I explain inquiry?
How many views on this exist? Is everyone’s response equally true? Mind the inquiry stages of curiosity, wondering, thinking, and formulating. What is the origin of the origin? Why are the axes labeled x and y?

And then, do I? What would the 4th axis look like? What would you call it? What is the nature of time and space? How do you know (fill in the blank)? What makes us who we are? What’s inside vs. outside of us? Does collective intelligence make us wiser or the whole, or lead us astray? Who decides? How many? How much? Which came first? What is the cause? Is the effect another cause in a series? Are effects always just new causes?
Inquiries

How long has this river been here?
Are the breaks (sand bars etc) in the river random? What causes a break in 1 place and not another?
Rock type/composition may factor in...
Chaos....

Stop 1  Day 1  San Juan
Reach above Platte looking NW
(see map A ground pit)

Wing

water

Shallow less than knee deep
BRIDGE
*slow current, about 1 foot/sec
I think water moves small stuff more than large stuff. Largest stuff 1/3 size of water intake. Larger stuff settles out more and moves less. Small stuff floats more and can move. Will splash about when wave moves. Larger stuff settles to bottom and small stuff floats up.

There is some size of rock where there is wind erosion by liquid water, but wind erosion of rock is small. Rock is not moved by liquid water alone.

The river flow
- small stuff moves
- big stuff doesn’t
- the small stuff fills in around the big stuff

Laying out deposited horizontally
What gets put what depends on current conditions:
- floods (or no floods)
- presence of objects (trees, posts, etc.)

Day 1 Step 1

- whole

25 yards from river: larger rocks on top, bigger than golf balls, smaller than baseballs (cobbles)

3 layers of these larger rocks alternating w/ sand

5 yards from river: 5th layer: large, 4th layer: big rocks as above, get bigger, coarse sand + fine sand mixed

Big rocks:

- When a stream or river enters a standing body of water, such as an ocean or lake, its current slows, which causes much of its sediment to spread out and be deposited.”

4 Major Causes of Physical Weathering:

- Mechanical
  - Surface fracturing
  - Frost and Mineral wedging
  - Thermal expansion (wildfucks or sun)
  - Biological activity (roots into fractures, transported by animals, etc.)

Chemical Weathering:

- Dissolution
- Oxidation
- Hydrolysis
- Biological reactions
Did you know: You'd weigh more in Pomeroy City due to being on a denser place. You can measure the differences in miligals.

Lake Ogallala View from Camp

Types of natural cement:
- calcite, silica, clay minerals, iron oxides, gypsum etc.
- CaCO₃, SiO₂, etc.
- in sandstone, etc., forms
- easily rehydrated
- strong cement
- precipitated from H₂O
- as a natural cement, commonly give sediment a reddish color

Non-plastic sedimentary rocks:
- sand, limestone, chalk
- dolomite, pent coal

Day 1 Step 3: Lake Ogallala ➝ Campplace Bluffie

Plan for today:
- Lake McConaughy wind systems
- Spillway, outlet conditions
- Act of Congress
- Stratigraphic principles
- Courthouse & jail rocks, infer a history of events

Day 2: Lake Ogallala
- Cows on one side, lake on the other
- Cottonwoods, honey locust (?) sand
- Some jumper
- A vast area of sand

12
Day 2, Stop 1: Lake McCowry

Pic 102

Big sky
It's windy

This symbol (in the water) indicates partially submerged dead trees; they look relatively small and slender

A 90° view

Grassy land but dry
Lots of brown + twisted, green + groups of trees here + there

Grassy with + trees + sparse

Sand

Water

Grassy + sand

Sand + grasses

Sand + grasses

Sand + grasses

Sand + grasses

Sand + grasses

Sand + grasses

Sand + grasses

Sand + grasses

Sand + grasses

Sand + grasses

Sand + grasses

Sand + grasses
Day 2 Stop 1

Compare sand @ top of sand dune  w/ sand near the lake... (see previous page)

No! It's a reservoir

Did the beach sand come from the dune?

At one time the water was way up here (on the dune)

River  Wind  
both make waves & ripples
riverbed sand was a bit more coarse
darker color
sand is less uniform

Lake sand top has very fine sand
lighter color
sand is more uniform

Laybugs everywhere on the plants on this dune! 🐝
The ultimate/immediate source of this beach sand:
Day 2 Step 2 6/11/12
Spillway

- Bed - sed. structures of individual beds - different rock layers. Horizon.

- Small channel splits rock judging out

- Boulder (see front)

- The boulders here are very porous, rough, jagged, and break over a smaller white stone. Sprinkled in it looks like the most important rock of the day (see page 13). See sample 2-2-A.

- Two is the South Face.

- Big cobble sample from left-hand boulder reacts to HCL on the point in the center that looks smooth-ish and matte - light tan color.

- Small channel patterns (microscopic) dark brown. The outline resembles the most important rock of the day (see p 13).

- Law of Original Horizontal (things tend to lay down flat horizontally)

- Law of Superposition - older things layer down first.
Day 2 Stop 2 6/11/12
Formation near Lake McTavish & Spillway

Unspecified black areas contain grassy, sparse vegetation.

Mostly grey

Sandy looking patches in it. This indicates a sandy patch.

[Diagram of geological formations with labels such as 'shadow', 'redish-grey', 'redish', 'top of some expanding mantling flint'.]

Grasses, vegetation.
Principle of Lateral Continuity

Uniformitarianism - if it happened in the past, it happened again.
(natural laws → uniformity)

Principle of Cross Cutting Relationships

"See it or remove it.
If a surface cuts across a surface, it is younger.

We are looking at the Ash Hill Formation of the Ogallala Group (late Miocene), 5-14 million years ago.
- Fossil deposit filled with "white stuff" - calcareous algae.
- Colonia, wind, alluvial river, lacustrine lake, colluvium, gravity/flows, paludal: "Swamp".

Chaplain Formation - sandy, then broke, fire.
At Ash Hollow (part of Oregon Trail)

Formation (near the town of Brule)

the Whitney member of the Brule, 2-3.4 ma. The white rocks are from Cretaceous age.

the Whiteny member of the Brule, 2-3.4 ma. The white rocks are from Cretaceous age.

Some wind deposited siltstone beds are mixed there.

maybe a lunatia lark

has resistant ledges

a smaller formation to the Ash Hollow

but look at chart on previous page

Time is missing!

DISCONFORMITY — a gap in the stratigraphic record

clay will stick on your fingerprint; silt won’t

7 or 8 million years

this is the Whitney member

at this ledge is the disconformity

the missing time

28 million years

3 poles in sketch at top of sketch

Native Americans were here 900 years ago
Clay particles may become shale when lithified
Mud has both silt & clay — can make mudstone or mudrock — rounded pieces
Shale has particles too small to see w/ a hand lens — it has thin beds & will split into thin flakes or chips — easily breaks into pieces
Windblown silt was esp. abundant during periods of glaciation
Floodplains of meandering rivers are dominated by silt & fine-grained sand
Rivers preferentially carve their channels into shale & siltstone
Day 2 Stop 4 Courthouse Rock & Jail Rock (bigger)
(122-123) "Steep Steps" — see 2-40
Firing No. furnace; peeled stones
Lower rock is Bone
Silty clay test (cracker)
(124) See 2-4A & 2-4B
Bones can be introduced into fluvial (river) deposits in a variety of ways. They may be buried on the floodplain or eroded from the cut bank and reburied (A), transported overland and during high water events and buried on point bars as the flood recedes (B), or represent an animal that has fallen directly into the channel (C) (after Behrensmeier, 1982).

The classic point-bar model for deposition in meandering stream channel from Allen, 1958: At a river bend sediment is eroded from one side (cut bank) and deposited on the opposite side as a point bar.
So... a river laid down these layers of cross-bedding is indicated.

Cross-bedding

If you had a raging river, you'd expect to see boulders.

However, in this cut we see small particles of which the purple pebbles were largest (marble-sized or so at largest).

Hypothesis: the purple layer had faster-moving water. More uniform particles suggest it's moving faster.

The cut side of a river moves faster than the point. 

The Law of Inclusions.
Day 3, Stop 3
Wildcat Hills like formation
Elev. 4480 ft

Southwest view from up top:
(≈ 400 ft away)
- Jut out
- Look like cobbles all over
- Vegetation throughout and around
- Red, smooth, light tan
- Eroded edges

Northwest view from up top:
(≈ 200 ft away)
- Jut out all over
- Look like cobbles throughout
- Red, smooth, light tan
- Eroded edges
- Boulder
Day 3 Step 3
North view from top:

- Tera intengered crevices
- Vegetation
- Very defined layers

Up top of Wildcat hike - many sizes of rock, possible sandstone?
- Some rounded, some angular
- Reactivity to HCl
- Pumice
- Lot of larger rocks
- Smaller pumice
- Underneath, silstone w/ clay - possibly shale
- Bigger rocks
- Smaller pumice
- Silstone

IMPORTANT Observations:
- We are now seeing layers containing larger rocks (football, basketball size)
- Large rocks are rounded, their layers are cemented by pumice
- Sharp distinctions between layers
- We see deposition + erosion face evidence of cross bedding
Day 3, Step 4

11:47 AM

Elev. 5565 m
Elev. 6630 m
Elev. 8061 m

Vedauwoo WY

Huge piles of huge boulders!
Bloody looking, often rectangular,
Might be stuck in boulders, prisms (ish)

140 - 148

We walked around the boulders on the ground;
They're twice as tall (or taller) than we are.
They are granite w/ lots of pink feldspar

Reflection on Today

Imagination: It's a great way to learn – my knowledge of geology has expanded exponentially already, and it will only increase more. It's challenging for sure and I don't have a ton of background knowledge, so there's a lot I haven't gotten figured out. I am curious and want to keep the answers, so I'm looking at resources and feeling grateful to find information about something I've never learned more about. I like that imagination is valuable in this field...
events on a larger scale: what would it have been like to be a man on the wall, probably speaking, every million years or so? It's true the minutiae can drive you nuts but at the right times, it's so useful to look at a smaller scale. I've felt close to burnout a few times, thinking and re-thinking about these things — but then we take a break or go to bed and then I anticipate what's next. I don't have a unified theory in my head yet about where we've been, what we've seen, but I'm getting it together. It's been a blast so far! Science, yeah.

6/13/12
-Basins have strongly negative gravity anomalies values because the basins are filled with layers of unconsolidated sediments and boulders of sedimentary rocks that are less dense than the igneous and metamorphic rocks in the range.
- A large gravity low in Yellowstone that cannot be caught up by a deep sedimentary basin. The rocks there are lava flows, ash falls, volcanic breccia, other rocks that do not seem at the surface to be significantly less dense than similar igneous rocks that surround them.
- The gravity low may reflect the presence of a low-density plume of hot, partly molten, igneous rock at depth.
- Gravity highs suggest rocks of high density.
Map of major structural elements in Wyoming.
EXPLANATION

Quaternary
SC: Alluvial deposits

Mesozoic
Ku: Cretaceous formations, undivided
Jm: Morrison Formation (Jurassic)
Te: Chugwater Formation and John Formation (Triassic)

Paleozoic
Ph: Forake Limestone (Permian)
P: Shallow Shale (Permian)
Pc: Casper Formation (Pennsylvanian-Permian)

PreCambrian
G: Granite
PC: Undivided metamorphic rocks
P: Fault, arrow indicates relative direction of movement.
S: Sheer zone

Day 4, Stop 1
Elsberry Basin, Wyoming
58-66 mya
- The basin has significant coal deposits and relatively low gravity
- The rock/soil slope descends to the southeast
- Why so much coal here?
- A lot of water would've been caught here - plants would be part of the sediment
- Was this swamp?

Fold-Controlled Groundwater System

Figure 3: Schematic cross section showing (A) Laramie Basin and adjacent ranges and (B) the town of Laramie is built on alluvial deposits of the Laramie. Coal is mined in Wyoming.
6/15/12

How can a river cut through a mountain?
Was the river already there?
A fault or faults caused the cracking?
Uplifts/changes in incline.
Did the canyons in the bedrock facilitate river flow?

One question:
Did it happen like this:
Granite already there
Fault cracks open
Water goes through
Then uplift much later, other layers deposited?

Maybe uplift occurred before Cenozoic?
(see previous page, diagram B.)
Was the river there before the uplift?
No
Does faulting play a part in
Formation of the river channel?
Did the continental

6/13/12

What is going on with the lower gravels in particular areas of Wyoming?

"In Wy. geology, basement refers to the Precambrian igneous and metamorphic rocks that underlie the younger layered sediments. They are the crust of the earth, under which all the younger rocks were deposited."

The basement rocks are... a great variety of igneous and metamorphic rocks... ranging in age from possibly greater than 3.9 billion years old to about 1.9 billion years old.

Some of them have coal.
All have underlying areas of water below 105 F.
Basement rock in these areas tends to be pretty per below the surface 10 to 20 to 30,000 feet.
Often close to a mountain range, consider the uplift.

They're generally basins.
Remote sensing to detect magnetism

Day 4 Stop 2: River Sections WY

[Diagram sketch of river sections and basins]
See sand sample
Fine grain sand, very uniform in size & color, beige mostly

Day 4 Step 2

These are the dolerite deposits

The cracks appear to be at 45° angles, which suggests some kind of uplift event rather than post-erosion.

From which direction did the force come that caused the uplift?

See Reynolds p. 323, 306, 201, 489

River must resist

Felsic
Oceanic crust, eroded easily, pre-gneissed shale

Folds - set of environmental or sedimentary features (recurring) that reflect processes

Day 4 Step 3
Sand Dunes (Shirley)
Very dry, very windy
More mobile than those at Lake McLaughling
Higher up the dune, we were sandblasted
Edson Y. Sullivan

Rocks closest to the lighter sand can be very large, move under plate of least resistance, driven by gravity
Hey - what are metamorphic rocks?
How are they identified?

Metamorphism - temp + pressure can cause rearrangement of existing material + the formation of new minerals + new structural features.

- Foliation - a general term for any planar metamorphic fabric, including cleavage, but commonly is reserved for more strongly metamorphosed rocks. Foliations form as a result of differential stress that is expressed in a variety of ways. (e.g., cleavage, schistosity).
- Cleavage - parallel orientation of flakes or other plates, typically in foliated rocks. Flakes of deformed objects, like pebbles + a metamorphic conglomerate.

- Gneissic alternating light + dark bands of different proportions of light & dark minerals.
- Mica Schist - Flattened + smooth out mica grains

Linear feature - a linear feature in metamorphic rocks

<table>
<thead>
<tr>
<th>Slate</th>
<th>Sandstone</th>
<th>Limestone</th>
</tr>
</thead>
<tbody>
<tr>
<td>quartzite</td>
<td>fine crystalline marble</td>
<td>greenschist marble</td>
</tr>
<tr>
<td>phyllite</td>
<td>coarse quartzite</td>
<td>greenschist schist</td>
</tr>
<tr>
<td>schist</td>
<td>coarse marble</td>
<td>greenschist schist</td>
</tr>
<tr>
<td>gneiss</td>
<td></td>
<td>greenschist greyschist</td>
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</table>

<table>
<thead>
<tr>
<th>Basalt +</th>
<th>Andesite</th>
<th>Phyllite</th>
<th>Plutonic Rocks</th>
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</thead>
<tbody>
<tr>
<td>Deformed</td>
<td>Greyschist</td>
<td>greyschist schist</td>
<td></td>
</tr>
</tbody>
</table>

Day 5 Stop 1: Alcove River Canyon

- Red layers
- Chugwater Fm

- BOAT ride
- Lots of cross bedding - bigger rocks
- Trees
- From boat: hiking + West - Goose egg - Smooth surface

286 mya - Pennsylvanian
Entering Tensleep

81 ft of water under us
How can I bring Inquiry into my classroom?

Engage - get students interested - they are naturally curious - tap into that

Use National Science Ed. Standards on Inquiry -
- make observations
- pose questions
- explore books + other resources
- use tools to gather, analyze, and interpret data
- propose answers, explanations, predictions
- communicate results

For math classes -
- Have students keep a log of their observations + discoveries + questions
- Have resources available for students to use
- Use hands-on materials, like tile blocks to represent numbers
- Have students record data on numbe blocks, esp. those all fractions & decimals
- Instead of giving them direct answers, use "20 Questions" approach - students can ask yes or no questions of me (when applicable)
- Have students present their findings to the class
- Have students reflect on their thinking process

Some things may not easily lend themselves to inquiry-type lessons. However, students can always investigate why a math operation worked the way it did. Why does \( \frac{1}{2} \div \frac{1}{4} = \frac{1}{2} \cdot \frac{4}{1} \)?

Students can find out by working in groups, using drawings, etc.
Thoughts:

So on 6/13 we climbed Alcova and made observations of what we found. The next day, we took a boat ride and 'traveled back in time.' This gave us a visual 3-D understanding of different formations, and our imagination helped supply the 4th dimension, time.

Then we climbed the Alcova Dinosaur Trail a 2nd time, this time using a marked trail. Lots of explanations for what we had seen the day before—very gratifying to have already discovered some facts and good to learn some things we hadn't known about what we'd observed (i.e., that crystalline, soft white layer was gypsum. Where did that come from? Need to read text for more info).

Inquiry based learning:
I've made and recorded observations.
I've asked questions about my observations.
I've talked with peers about what we observed and how it got there.

Notice the brighter veins in the granite:
- Layers go down left to right
- light banded color
- single (boudiers)
- Thin layers without go up left to right—evidence of sand layers.

Canyon, water
Above limerick

[Diagram of a geological cross-section with layers and formations indicated]
Laramide Orogeny
- Occurred in Rocky Mtns -
  - Raised mountains high in piedmont basins low
Higher gravity areas include mountains
Basins are a catching point for sediments
Uplift also causes erosion
The more the mountains rose, the more erodible they are
  (cracking + freezing, etc)
Steep gradient = rivers run faster

As a piece rises, erosion happens + lowers elevation
  so it can float even higher and cycle recurs
  (isostasy)

Fold = thrust belt - cause of the severe orogeny
  (other than the Laramide orogeny)

Day 6, Step 1
Tonto Creek

6/15/12
In what type of environment were these sediments transported + deposited? Have you seen modern deposits like these?

Day 6, Havrest left campsite yet
Freemont Canyon / Ancient History

Rocks around here are over 2 billion years old
  (granite)

Igneous intrusion under continental crust
  
  Light phases melt off first (Al, silica)
  and rise up as molten material, then start to cool
  - Intrusion of magma + solidification (2 billion yrs ago)
  - Then intrusion of light lies, their crystals are growing
  - Cracking occurs - lots of vertical, some in other directions
EVENTS - Erosion of sediment resistant layers stand out - Then uplift happens & it's all fitted (local uplift) - horizontal fractures - stress related
- Clovery (bottom of which is Lakota Fm)
- Morrison
- Sundance
- Chugwater - red
- Goose egg - trace fault in white w/ red
- Tensleep - full of crossbeds - sandstone - decays
- Amherst - sandstone (clayey sandy; sea level would've fallen)
- Phase of sediment or sand into caves
- Sea level must fall & expose the Madison Ls to form caves
- Deposition Madison Ls
- Discontinuity - No deposition or erosion occurred
- Deposition of something well bedded, similar in color to rock below - Flattened sandstone
- Erosion - Rich in iron & magnesium - a different type of igneous body
- Black intrusions
- Fracturing - dominantly vertical
- Intrusion of light dikes
- Magma intrusion + cooling
- Older rocks - present

Erosion cut away smoke silhouette
Clovery
Lakota Fm
Morrison
Sundance
Chugwater - RED
Goose egg
Tensleep
Amherst
Interior Seaway
- This bed marks a B1G tectonic event
- Lakota Fm
- Morrison
- Jurassic
- Sundance
- Alcoa limestone
- Chugwater - RED
- Flathead

Alcoa limestone
Lakota
Morrison
Sundance
On the Granite Mts
we see NO
Fluted, Madison above
(The Granite Mts are newer)
We went through Seminoe Mts to get to Alcova.
Why do the Granite Mountains have such a low relief?
- We are in a higher gravity area.

See Byrnell text p. 300-301

"Regional mtn ranges are... large enough that they can only be explained by major variations in the thickness and temperature of the crust & lithosphere. Most ranges occur near convergent plate boundaries, or where there has been large scale movement of material in the mantle.

"As a rain belt forms, uplift is commonly faster than erosion, and the mountain becomes higher & more rugged over time." Weathering & erosion begin to wear down &手脚, contributing sediment to streams & rivers.

Then there's less weight holding down the thick crustal root
- isostatic rebound

"Erosion & isostasy cause rocks deep in the crust to be uplifted and exposed at the surface... many with better exposed metamorphic & plutonic rocks. Through simultaneous erosion & isostasy, the mountains are eroded down & the thick crustal root is gradually reduced in size. Material eroded from the mtns spills into adjacent basins, increasing the crustal thickness beneath the basins."
"Regional elevations relatively low for regions with thicker crust, and relatively high for regions with thinner crust. Rule of thumb: increasing the thickness of the crust by 0.6 km will result in an increase of elevation of 1 km."

Water shoots into the limestone cavern 100-500 cubic ft/sec depending on time of year. After going into the 'Sink', the water disappears underground and shows up again 2 mi later. It takes 2 hours to go through so there must be a complicated network of tunnels, large and microscopic, that moves the water longer paths to travel taking more time.

The whole explanation is still a mystery — but limestone, easily forms caves, and over time you can imagine that the force of the water flow has worn down limestone and pushed/graded holes in it that became tunnels, and the water comes out again at the Rise. The Sinks are likely an Ice Age feature, thousands of years ago.

At the Rise, the water comes out of over 182 and you can see sand bubble up (it's cloudy)

ENDWIRE trout ward for 25 cent food

"Limestone can be dissolved by carbonic acid and water, reaction to form acid created by the combination of water and CO2. This acid dissolves the limestone at continued H2O movement will create channels in the stone." - park sign
The Persistence of Fossils

The Tonsleap (resistant unit) looks the same as the Sink (granite Mtn) as it did at Alconia.

See Sample of Sand & Madison Limestone from the Sink.

Sand size varies poorly sorted, ranges from very fine gravel to this size.

It's slightly pitted all over, the grains look clay-like, no signs of crustacean fossils.

Rin Lake (bonus stop) Shoshone Petroglyphs

Limestone & other rocks rich in calcium carbonate or magnesium carbonate are soluble in water and in acids. They dissolve & form pits and caverns.

The most common weak acid in surface water is Carbonic acid, produced when rainwater reacts with CO2 in the atmosphere, soil, and rocks. The chemical reaction for the dissolution of calcite in carbonic acid is:

\[ \text{CaCO}_3 + \text{H}_2\text{O} + \text{CO}_2 \rightarrow \text{Ca}^2+ + 2\text{HCO}_3^- \]

Calcite Carbonic Acid Calcium Bicarbonate Ion in Solution.

A weak acid in water produces a weak H+ ion, which is important in a balanced ecosystem & is available to make other chemical bonds.

Wind River Mountains Bull Lake Stop A Day 7 Step 2

Vegetation:
- Above tree line
- Mesic - Mixed, leading to more
- Dry grass tree
- Grass, dry vegetation
- Underfoot - a mix of poorly sorted rocks, clay, silt mixture, most rocks look smooth on the surface, also boulders to sit on
Question: Is this true? 
Glacier valleys are V-shaped 
River valleys are V-shaped

Look:
- Hill in water, cut face
- Water cut face

Ball Lake:
- A glacial valley
- As it gets wider, it makes a flat area
- As it narrows, it makes a small, rounded area
- Many boulders
- Rocks
- Water

Wind River Mt.

What processes formed the landscape?
The landform changes created the mountains and valleys. I would guess rivers cut through to create the valley. The ground water has flushed out the water from the past layer of the rounded stones.

Ball Lake Stop B
1st of rocks
- rock at zero feet
- Water
- Slow, shallow
- Water falls
- Water

View to the South
- Green, broad, long grasses
- Stream of water
- Rocks
- Waterfall
- Water

A boulder in my foot partially buried

A rock in my foot partially buried
- Very defined, thin layer
- Large crystals
- Likely granite
- Many veins inside granite (??)

3 feet
I was thinking about my experience as an exchange student in Japan. Talk about total immersion! I knew I had phrases/questions in Japanese upon arrival, so I was very anxious about how it would be with the language barrier. I took Japanese language class at a university, along with classes dealing with Japanese culture/history. I lived with a host family, and I speak some English. There were frustrating times, like taking the wrong bus and not knowing how to get back. There were more times that were personally rewarding when I figured things out, like learning to read Japanese characters and starting to converse with my little host sister in Japanese. I learned so much during those 6 months in Tokyo.
What's a maraime? - Reynolds p. 9, 904

Day 8 Stop 3
Whiskey Basin

Day 8 Stop 1
Tensleep
desert picture - red colored rock
What Framework are we in? The red rock
is fine-grained & sandy & light in color inside,
surrounded by a darker, thin covering with
some white
dark breccia or outside
light color
light sand
broken side

Shoshone 2

Petroglyphs most face down valley, warning signs
to scare away the Crow

Shoshone ate a lot of sheep

1 real permanent dwellings - would

approx. mile up the steep, we're able to see
the Crow

Thin walled godess
+
1 animal

Rocky end of the hillside

Harry Chapin - So Many Clogs in the Rain

Day 9 Stop 2
Wind River Mtn. Valley Area

Layers of rocks

Many trees

Boulders

Day 8 Stop 3 - working our way out of the valley
compared: SE & NW view

SE see sketch below left

NW

Sample at

boulder pile

150 ft across?

Very Craggy

solid, angular, gray, pieces

Matrix fine

actual size

Some trees

Sparse timber

Trees red

No trees
Day 8 Step 4: Working our way out of the valley.

How did this area form? Glacial

Compare to Alcove.

Setting on a boulder facing N:

Choppy or angular

see pic

of student

knee

This is all

One piece jutting out

Evidence of bedding

Huge

Another piece jutting out

Flattened out and weathered (see pic of hand in it)

2 different types of rock

Icdp line radiating streaks of mud

Basement Rock: Precambrian

Rocky shore looking west

West side, rocky but not A U-shaped valley

How do you explain what we've been seeing?

Sequence of events:

Laramide Orogeny

Absaroka Upliftation

Interformational Conglomerate

The Gallatin Formation (Limestone)

Marine environment, earthquakes, storms occurred, reforming itself, the shale beneath.

Day 8 Step 5: Spotted Cobble Stop 6/17/12
Day 10 Step 10 Greyfish Creek

The waters are warm due to geothermal activity - usually you wouldn't find greyfish here in this elevation.

Accretionary lapilli - accretionary particles of ash grow concentrically, stick together like its hard when they break off in balls.

- Obsidian Springfall
- Water exits the hot spring at this location.
- The falls generate a large amount of mist.

Day 10 Step 11 Lewis Falls

Water is flowing over the rim of the caldera.

Day 10 Step 12 Old Faithful

Magma rises a few miles beneath the Earth's surface.
- 21 yrs
- 13 yrs
- 60,000 yrs
- Volcanic eruption
- Holocene active for at least 1.6 million years

- The processes of Yellowstone are active in a heat source, abundant hot springs, and active volcanism that are kept open by frequent earthquakes.

- Shallow bodies of water heat adjacent rock. Hot rock transfers heat to sediments to groundwater that has percolated down from the surface, precipitating them.

- Convection - movement of heated fluids in a convection current, transfer of heat from one solid surface to another.

A geyser always loses a point of connection. Since water is dissolved by superheated water, it develops clays.
Rhyolite - a common volcanic rock
- felsic, silica-rich, iron-rich minerals
- composed of quartz, feldspar, and alkali feldspar
- rich in silica (silicic) and potassium (potassic)
- dark red or pink in color

Sinter - rock crust that forms around the openings of many hydrothermal features
- can have siliceous sediments
- iron sulfide = black
- iron oxides = brown
- iron sulfates = yellowish

Fumaroles - steam vents

Microbial mats
- ADP-2mol yellow
- cream
- red-greenish
- jade-yellow-orange
- brown

* Inquiry - the kids’ area is the best for educational inquiry
- study/observe various hydrothermal features and compare
- observe what color bacterial community is hottest or coolest
- watch a simulation of a geyser (watch in cylinder, etc.)
- also the area at the base of a cone where boiling water
- couple, bison tracks, scale, etc. - the question used:
- How much evidence if life do you observe?
- The elephant gives clues - will mostly answer:

What can happen when groundwater is heated? GYSGRS
- What features are present at an active, volcanic site?
- fumaroles
- mudpots
- hydrothermal vents
- hydrothermal springs
- geysers

Symposium
- Glacial-Interglacial changes
- Lakes provided a climate archive
- A meteorite impact may have filled up sediments
- Snake River Plain shows where the hotspots were
- Currently it is at Yellowstone (continent is shifting SW)

Fold + Thrust Belt - Sierra Nevada
- Cause internal seawall
- impacted by Laramide orogeny
- Sedimentary archive that holds a record of climate change

M. hemisphericus found at ~1.8 mya
Day 10: Stop 4. Prismatic Pool

Where do the minerals come from that form the rock deposits around the pools? Inside, the melted rock is unique. The orange color protects the microorganisms from the sun.

The microbe:
- Stabilize processed rocks
- Make medicines/cosmetics
- Break up pesticides

Day 10 Stop 4. Firehole Canyon

Floods, ash falls, contact metamorphism

This blew up ± also blew up other lava flow

Day 10 Stop 5. Inspiration Point. Yellowstone

Seism: Origami earthquake

Fold & Thrust Belt

Pressure from the west pushing the sedimentary rocks into folds (not the basement rocks) "then shared tectonics" in contrast to lava rock structures

Deep crystal folds/thrusts start after pushing went in a SW direction, building up & over the sedimentary layers

Nasaraka volcanoes (50 mya)

Hole at 15 or 16 million years of eruptions;
Snake River Plain is where the hotspot was.
Day 11 Step 3
River bend by nature trail
- West face of anticline
- Looks again like siltstone

Day 11 Step 4
River under highway 120
- Look at outcrops same as above
- Flat, calm water; mainly controlled by climate cycles

Day 11 Step 5
Cobble

Day 11 Step 6
Overview of valley
- Solid siltstones
- The Shoshone came in from the west (to east)

Day 12

Caly Unconformity
- Observe + sketch the stratigraphic relationships + explain how it formed
- Is there any time missing between the 'ages' you know? What evidence do you need to determine how much time is missing?

Caly Landscape
- Observe + collect information to develop a history of how the river helped change the city
- Handled the river influence the Geomorphic landscape + urban development

Caly
- Paleohorizon? Glacial till?
- Slant up west down east
- What direction are slants going?

June 20/12
Day 11

6/20/12
Day 11

Caly Unconformity
- Observe + collect information to develop a history of how the river helped change the city

Caly Landscape
- Observe + collect information to develop a history of how the river helped change the city

Seeds of Big Horn
- Alt is Plnt
- Big Horn Basin

Poudre River Basin
- Linear deposits of oil + gas

6/20/12
Day 11
How does organic material turn into oil and gas?

- Process takes millions of years

1. Accumulation of organic material perhaps in mud
   "source rock"
   "It's still red, uncrushed @ temps @ or near earth's surface"

2. Organic material must be preserved before it can decompose
   " deposited in O2 poor conditions & buried under other layers of sediment; when buried to shallow depths & heated to less than 60°C, the organic starting material is converted into kerogen"

3. Source rocks get buried by more sediments becoming heated as the temp increases with depth
   - When heated to ~60°C~120°C, long hydrocarbons chained in a benzene ring break down into heavy + light oils
   - At these & higher temps (up to ~200°C), the oily hydrocarbons convert into natural gas

   A thick layer of kerogen is formed over time.

   Sources of the organic material:
   - Plants
   - Fungi
   - Marine organisms
   - Most organic remains come from trees

   Petroleum - oil or natural gas - forms extensively when sediment rich in organic material is deposited, buried, & heated to several degrees of elevated temp.

   - It's composed of carbon + hydrogen + smaller amount of other elements

   "primary rock is sandstone & shale"
Day 12 Stop 6: Jewel Cave
Gypsum can grow in dry areas of caves. Aragonite can make "needles." Calcite may look like popcorn. Daybook Sports Quartz Fossil Stalagmites
Stalactites Nullclay Spur Over 161 miles of caves: We go down 240 ft; a breather cave; it tries to match the pressure outside. Lithograph: Compass + Null Point, 1 mile. Changes are on top of the caves.

6/22/12 Make observations of Jewel Cave map

Rough Sketch

A lot of the lines look like y = x. They seem to run NE to SW.

Start like the same way but from a different angle.

The map shows a small area around the bulk of different cave elev.

Highest point in cave: 5398 ft
Lowest point in cave: 4817 ft

Compare Jewel Cave to Wind Cave

Differences:
- Both sets of caves have a stream in the middle of the cave. Jewel Cave has a stream in the middle, and there is a surface that the stream flows through. Wind Cave has a stream in the middle, but there is no surface that the stream flows through.
- Jewel Cave is older than Wind Cave. Jewel Cave is over 150,000 years old, while Wind Cave is only 41,000 years old.

Similarities:
- Both caves have a stream in the middle of the cave.
- Both caves have a north-south trend in the stream's direction.
- Both caves have a diagonal trend in the stream's direction.
- Both caves have a "blab" of cave toward the surface.
- Both caves have a surface that the stream flows through.
Day 13 Step 1:
Different Road Cut in Crater

- Huge sheets of rock
- Quartz, Feldspar, black crystals
- Sun pic near man
- Black stuff is mineral angle
Questions regarding caves: 6/22/17

What holds up the roof? 1st Spring?
Where is the water table in relation to Wind Cave + Jewel Cave?
Does the Popo Agie make caves along the Sierra to the Rise?
How do different formations occur in caves even though it's all "the same stuff"? Celtics etc. Caves form a pattern around the Black Hills?
Guiding Question: How does underground water other rocks + how are they pressure different? Those that appear on the surface?

Did the cave form only once? (Remember, it's Mobilion Fan Night?)
Did the wind & the Black Hills control the formation of the cave? Yes. Then how?

Dier's Place
1) Did the cave form only once?
2) How many different kinds of cave formations are there?
3) Is the cave still forming now. Cavers can't see through in.
4) How did the Langford Orgy determine the structure of the cave?
5) Why are there no caves in the middle of the Black Hills?

Mineral Ls is where the caves developed
Mobilion water reaches Ls
Erosion of underlying layers will allow H2O to get to the Ls eventually
Langford Orgy 75-85 yrs. (August 84) - Edits are happen

Pennsylvania strip at Mineral Ls (Cavern) - the Clements has seen mobilion water in those years somewhere

TIMELINE

Boulders

In level cave, the crystals are in the upper layer/levels 9/12 9/19

Day 13 (Sun): Traditional Parking
How were these "tool tools" formed?
The sandstone feel sturdy like concrete.
Very rippled. The rock gives one on the course scale, multicolored...
Everything looks gray brown at a glance. Looking down on a "roll is like looking at a 3-D topographical map"
Day 13 Step 5 (P Smith Hill)

- A dark "cliff". Looks like a place for water?
- We see it up to 1800 feet.
- A few little trees?
- Green grass growing here and there, some grass.
- A thin trail is about the same height as the path.
- It goes through an area of dark, charcoal-colored rocks.
- Some areas have some round, white, and some areas have some dark red dirt, some different.
- Some dark clay, some gray color, some light gray?
- Some dark gray, some grayish color.
- Some dark brown dirt, some grayish color.
- Some dark black.
- A small, black, dark crack.
- A small crack in the dirt.
- A small black crack, dark crack in the dirt, some light color, some grayish color, some red, some gray.
- Some red dirt, some dark red dirt, some grayish color, some dark gray.
- A small crack, some dark gray, some dark red.
- Some dark brown dirt, some grayish color, some dark red dirt, some grayish color.
P. Smith Hill Strata Column

Some effects of clay/silt/sand on bureau. Some vegetation effect.

10 ft

9 ft

8 ft

7 ft

6 ft

5 ft

4 ft

3 ft

2 ft

1 ft

0 ft

Black Hills 10 ft

30 ft

60 ft

90 ft

120 ft

Diagram of stratigraphy with various layers and notes on vegetation and soil characteristics.
Why no sandstone?
Why so much variegation in cobbles?
Why the different colors?

- Red: burnt clay
- Green: moss
- Black: coal

Boulders: slate, shale, chert, rhyolite, granite

1) Base layers: Priory Shale
2) Overlying beds: shales
3) Contact: cobbles

Boulders: slate, shale, banded, post

It turns out that geology is so massive and of the same age, so small in scale - imagine sitting on a processes that created a wave of mountains in a day. We found a piece of sandstone. Identify the particles size. Which is it - big or small?

It's interesting to think of causes and ask more questions about what caused that particular event, and ultimately work your way back to the causes of all causes... We could say Big Bang and call it good, but we still wonder more about that, too.

Why is sandstone red? Because of iron oxides. Because it reflects that particular shade of red out of all possible wavelengths of color that it could reflect. Because we perceive it as red. Because it just is.

The large and small scales of geology are excellent for mathematical ideas and concepts. How much is a million? What does a million grains of sand look like? How can we devise a method of figuring that out?

I once tried "A Million Blades of Grass" activity. I had students cut a one inch square hole in some cardboard, and then we went outside to a grassy area. We pinched the square hole onto the grass to count how many blades of grass come through. The idea was to take the existing # of blades of grass/leaves counted in a square inch, then use this amount to determine what rectangular boundary of the sample yard contained a million blades of grass. Unfortunately, the grass was not at the...
Time, and the cardstock didn't work well. Also, some kids were confused on how it was supposed to work. If I were to give that activity another try, I'd structure it differently based on what I've learned about inquiry. I would write on the concept of large numbers quite a bit in advance and have kids brainstorm in groups the types of scenarios in which really big numbers are required. I'd have students share ideas on how we, as a class, could demonstrate a million in a concrete way. Then we would do it and reflect on our observations and on our thinking throughout.

6/121
Ashfall Missel Bells

Beardog!

Silver toothed deer!

Kangaroo Rat!

Giraffe Camel!

book:

Why are Cudinas so Rare?

-Collins
<table>
<thead>
<tr>
<th>Pedagogy as evidenced in this class (Ideas):</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>KWL</strong></td>
</tr>
<tr>
<td>What do you know?</td>
</tr>
<tr>
<td>What do you wonder about?</td>
</tr>
<tr>
<td>What did you learn?</td>
</tr>
<tr>
<td><strong>Billboard</strong></td>
</tr>
<tr>
<td>Create a poster of your ideas +</td>
</tr>
<tr>
<td>e.g. Presenting in small groups for others to read</td>
</tr>
<tr>
<td><strong>Note cards</strong></td>
</tr>
<tr>
<td>Write one fact you know on an index card +</td>
</tr>
<tr>
<td>and pass it to the next person.</td>
</tr>
<tr>
<td>Continue until you have as many facts on</td>
</tr>
<tr>
<td>the chart as people in the group. Ask</td>
</tr>
<tr>
<td>questions about the facts as needed. Share</td>
</tr>
<tr>
<td>facts with other groups</td>
</tr>
<tr>
<td><strong>20 Questions</strong></td>
</tr>
<tr>
<td>Students ask instructors yes or no</td>
</tr>
<tr>
<td>questions to help get a problem</td>
</tr>
<tr>
<td>solved</td>
</tr>
</tbody>
</table>

*Maps & Geos trip in pocket:
- NC highway map
- US road map
- Routes highlighted*