

Badlands and Dinosaurs: Killer Craters

Subject/Grade: Science 4, 7 & Earth Science 30

Lesson Title: Badlands and Dinosaurs: Killer Craters

Stage 1: Identify Desired Results

Outcome(s)/Indicator(s)

Grade 4 Science

RM4.3 Analyze how weathering, erosion, and fossils provide evidence to support human understanding of the formation of landforms on Earth.

Indicator(s)

- b) Examine the effects of natural phenomena (e.g., tidal wave, flash flood, hurricane, tornado, earthquake, mudslide, forest fire, avalanche, and meteor impact) that cause rapid and significant changes to the landscape.
- h) Predict the effects of weathering on various landforms (e.g., butte, cliff, cave, valley, river, waterfall, and beach) in Saskatchewan.
- n) Pose new questions about Saskatchewan landforms based on what was learned.

Grade 7 Science

EC7.3 Investigate the characteristics and formation of the surface geology of Saskatchewan, including soil, and identify correlations between surface geology and past, present, and possible future land uses. [DM, SI]

Earth Science 30

ES30-LS1 Analyze surface geography as a product of weathering, erosion and mass wasting.

ES30-AH1 Correlate major changes in Earth's atmosphere over geologic time with corresponding changes in the biosphere and other components of the geosphere.

Can make connections to any 'space' unit - Grade 7/8 Science and Grade 9 Science

<p>Key Understandings: ('I Can' statements)</p> <p>I can... explain what causes craters to be formed.</p> <p>I can... explain and model the process of how craters are formed.</p> <p>I can... explain the impact that craters have on the stratigraphy of the earth.</p> <p>I can... describe and demonstrate what influences the size and shape of an impact crater.</p> <p>I can... pose new questions based on what was learned.</p>	<p>Essential Questions:</p> <ul style="list-style-type: none">● Why are craters formed?● How are craters formed?● How does the impact of a meteorite cause significant changes to the landscape?● What influences the size and shape of an impact crater?● How did the dinosaurs become extinct and what does that have to do with Saskatchewan?
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Teacher Background

Background Info – The information below is from the website

https://www.lpi.usra.edu/education/explore/shaping_the_planets/impact-cratering/

What are craters?

Craters are roughly circular, excavated holes made by meteoroid impacts. The circular shape is due to material flying out in all directions because of the explosion upon impact, not a result of the impactor having a circular shape (almost no impactors are spherical). Craters are the most common surface features on many solid planets and moons—Mercury and our Moon are covered with craters.

What happens when an impactor hits?

When an impactor strikes the solid surface of a planet, a shock wave spreads out from the site of the impact. The shock wave fractures the rock and excavates a large cavity (much larger than the impactor). The impact sprays material — ejecta — out in all directions. The impactor is shattered into small pieces and may melt or vaporize. Sometimes the force of the impact is great enough to melt some of the local rock. If an impactor is large enough, some of the material pushed toward the edges of the crater will slump back toward the center and the rock beneath the crater will rebound, or push back up, creating a central peak in the crater. The edges of these larger craters may also slump, creating terraces that step down into the crater.

What are the major parts of a crater?

- Floor – The bottom of a crater, either bowl-shaped or flat.
- Central peak – A peak formed in the central area of the floor of a large crater.
- Walls – The interior sides of a crater, usually steep. They may have giant stair-like terraces that are created by slumping of the walls due to gravity.
- Rim – The edge of the crater.

- Ejecta – Rock material thrown out of the crater area during an impact event. It is distributed outward from the crater's rim onto the planet's surface as debris. It is loose materials and forms a blanket of debris surrounding the crater, thinning at the outermost regions.

What influences the size and shape of a crater?

- Velocity -The faster the incoming impactor, the larger the crater. Typically, materials from space hit Earth at about 20 kilometers per second. Such a high-speed impact produces a crater that is approximately 20 times larger in diameter than the impacting object.
- Mass - The greater the mass of the impactor, the greater the size of the crater.
- Geology of the surface
- Planet size - Smaller planets have less gravitational "pull" than large planets; impactors will strike at lower speeds.
- Angle of Impact - Craters most often are circular. More elongated craters can be produced if an impactor strikes the surface at a very low angle, less than 20 degrees.

Why does the Moon have so many craters while Earth has so few?

On Earth, impact craters are harder to recognize because of weathering and erosion of its surface and recycling of the earth's surface by plate tectonic activity. The Moon lacks water, an atmosphere, and tectonic activity, three forces that erode Earth's surface and erase almost all but the most recent impacts. Approximately 80% of Earth's surface is less than 200 million years old, while over 99% of the Moon's surface is more than 3 billion years old. The Moon's surface has not been modified since early in its history, so most of its craters are still visible. Most of the Earth's surface is much younger than the moons and therefore it hasn't had time to be hit by many impacts.

Focusing on Saskatchewan

Note: Some information for this section was paraphrased with kind permission from A. R. Sweet who wrote the paper *Plants, a Yardstick for Measuring the Environmental Consequences of the Cretaceous-Tertiary Boundary Event*, Geoscience Canada, Vol. 28, No. 3, September 2001.

One of the inevitable questions that arise when discussing dinosaurs focuses on their extinction. Dinosaurs and many other species became extinct as the result of a huge meteorite that crashed into the Yucatan Peninsula in Mexico 65 million years ago, creating a huge, *impact crater*. An impact of this size would have thrown up a huge amount of material into the atmosphere. Eventually that material fell out of the atmosphere. Some ended up in the swamps and ponds that covered southern Saskatchewan at that time. Tiny beads of melted rock settled out first and eventually ended up as a 1–1.5 cm thick layer of kaolinite clay. Over about three months after the impact, dust and aerosols continued to rain down on the land and were compressed into a 1 cm layer of satiny claystone. After this catastrophic event regular geological processes returned and after about 10 years, plants (ferns) had recovered enough to provide material for the formation of coal.



Photos courtesy of Emily Bamforth

The *Cretaceous-Paleogene (K-Pg) boundary*, which marks the extinction of the dinosaurs and the end of the Mesozoic Era, is clearly visible in the strata at Grasslands National Park (East block, pictured above left). The extinction of dinosaurs, 65 million years ago, coincides approximately with 1-centimeter thick layer of iridium-rich clay derived from beads of melted rock ejected by the impact. The pale orange clay layer sits within layers of coal (pictured above right, close-up).

The K-Pg boundary is not the only evidence of impact craters in southern Saskatchewan. On the northern flank of the Cypress Hills, near the town of Maple Creek, a meteorite hit the earth about 75 million years ago and created an impact crater 6 km in diameter. It is buried beneath younger rocks, but drill holes in the area have provided confirmation of the central uplift in this structure.

Impact events are probably more common than you think. Approximately 140 impact craters have been identified on earth and these are mainly in populated areas that have been explored. Other impacts have occurred in the oceans, in remote land tracts, or have long since been hidden under sediments or recycled through plate tectonics. Just about all craters have deep central depressions, raised rims, and a radiant ring of ejected material surrounding them. Many of the larger ones also have a raised uplift in their centre. Craters have a characteristically round shape that makes them easy to spot on satellite images. When they are found, scientists are called in to study them. Geologists are becoming more interested in them because some have been found to be associated with valuable ore deposits.

In Saskatchewan there are five impact craters. Go to GeoExplore Saskatchewan - <https://skgeolhighwaymap.maps.arcgis.com/apps/MapSeries/index.html?appid=a845cbb370f7401597806887318e2676> under tab Geo 101 and subtab Meteorite Impacts for more information on meteorites and for Saskatchewan examples.

Stage 3: Build Learning Plan

Class periods needed: 1-2

Teacher Prep time: 10 minutes

1. Sprinkle flour over the bottom of each of three pans to a depth of about 3 cm. Gently shake and tap the pans to make sure the surface is even and smooth.
2. Using the sieve, sprinkle a thin, even layer of the cocoa or tempera paint over the entire surface.
3. Have a sifter of sieve with cocoa or dry tempera for resurfacing the tub after an impact if necessary.
4. Copy *student worksheets and project GeoExplore Saskatchewan website on board.*



Set (Warm-up, Focusing the Learning): Time: 5-10 min

Hook - Depending on grade level -

- Ask students - What is a shooting star? Have you ever wished on a shooting star?
- Ask students - What killed the Dinosaurs?
- Doodle - Have students draw their answer to what killed the dinosaurs.
- Show news video - <https://www.youtube.com/watch?v=gRrdSwhQhY0>
- Show images of craters on the Moon and Mars. Ask students what these are and if Earth has them. https://www.lpi.usra.edu/education/explore/shaping_the_planets/impact-cratering/

1. Describe to students the background information on impact craters - what they are, how they are formed, etc.
2. Then, discuss the first page of the student worksheet. Saskatchewan has one of the world's best-preserved pieces of evidence of the impact that killed off the dinosaurs.

Development:

Time: 30 min

1. Go through the *Meteorite Impacts* page of the GeoExplore Saskatchewan website with students. Have students use arrows to match the image of the meteorite crater to the examples on the second page of their worksheet.
2. Tell students that they are going to be experimenting with impact craters. This activity will be done as a whole class,

Materials/Equipment:

Projected website to guide students through - GeoExplore Saskatchewan Link in teacher background.

Each Student

- Killer Craters Student Handout/ worksheet (4 pgs.)

Tubs

- 3 large tubs (not glass) at least 25 x 30 x 8 cm. Aluminum turkey roasting pan is just about right.
- 10 kg bag of flour
- 6 cups cocoa or dry tempera paint
- Sifter or sieve
- Old newspapers

Other

- 1 small solid ball (should be bigger than a marble since these are very difficult to pick out without damaging the crater. A golf ball works well. If you can't find different sizes you can try using different masses like a heavier golf ball versus lighter ping pong ball)
 - 1 medium solid ball
 - 1 large solid ball
- Ruler
- Metre stick
- Safety glasses

Note: make sure the balls are not bouncy

Safety Considerations:

- Safety glasses for students to protect eyes

Possible Adaptations/ Differentiation

- Allow students to respond to post-experiment questions: verbally, through video or presentation.

with volunteers coming to the front to do the tests. If you have enough supplies, students can also do this in groups.

3. Set up the testing area in front of the class. Place newspapers under the tubs in case there is a bit of splatter. Set the first tub out.
4. To make the craters, students will use the metre stick and drop the balls from a height of 40 cm and then 80 cm. Another student will then measure the dimensions needed for the *Effect of Projectile Size (mass is more important than diameter) and Height on Crater Dimensions* worksheet (depth, diameter, length of longest ray).

Ask for two volunteers – one to drop the ball and one to measure. The first tub will be used to test the smallest (lightest) ball. Make sure that both students have goggles on. The “dropper” holds the metre stick beside the tub and uses it to place the ball 40 cm above the surface over the centre of the tub. The ball is then dropped. The “measurer” reads out the data so that class members can fill in their worksheet.



5. Ask for another two volunteers who will repeat, only dropping the ball from 80 cm this time.
6. Continue calling students up, using different tubs for each ball size. Remind students using the largest ball that they should try and get the impact closer to the center since the rays may be cut off if too close to the edge.

Note: you might want to test ahead of time and make sure you have the flour deep enough so that the largest (heaviest) ball doesn't hit the bottom of the pan. If that does happen it will create wonky data, so get the students to explain what happened.

Learning Closure:

Time: 15 min

1. When all of the tests are completed, leave the tubs intact so that students who did not get to come up have a chance to create a crater if there is time.
3. Students then complete the graph, comparing the diameter of the crater for each of the different tests. Remind students to think carefully about scale, and to include a legend for their data. This will be a triple line graph.
4. Have a closing discussion, going over the graph and big idea of the lesson.

- Have students do individual experiments focusing on one variable at a time in the form of a POE (Predict, Observe, Explain). Have each group share their experiments and findings with the class.

Questions to ask...

What are your observations? Write student observations on the board.

Why does the ejecta pattern form the way it does?

How did the crater size change when balls of different masses were dropped at the same height?

How does drop height correlate to crater size? What is drop height actually representing? (velocity)

How does this experiment model Newton's Second Law?
 $Force = Mass \times Acceleration$

How does the angle of impact affect the crater shape?

How does the volume of the meteorite affect the crater impact?

In summary:

- The higher the ball's starting point, the greater its velocity at impact.
- The greater an object's velocity, the larger its impact crater.
- When dropped from a given height, the greater the mass, the larger the crater.
- When dropped from a given height, the greater the volume, the larger the crater.

Stage 4: Determine Evidence for Assessing Learning

- **Formative** - closing discussion about the graph and big ideas of the lesson.
- Could collect the data charts and graphs to assess data recording and graphing skills.
- Could create an experiment question sheet that students write responses to ...
 - Using extrapolation on your graph, what crater diameter would you expect when a golf ball is dropped from a height of 120 cm? (depends on the data)
 - What do you think has the most effect on an impact crater — the mass of a projectile or the height it is dropped from? Explain by providing evidence from your data. (depends on the data)
 - Why do you think the moon and Mars are covered with impact craters whereas they are relatively rare on the surface of the Earth? (Hint: What do we have that they don't?) (they have no atmosphere to deflect or burn meteors up, they also do not have plate tectonics, which on earth causes crust to be constantly recycled. Thus, most of the surface of earth is much younger and hasn't had as much time to be impacted, plus the rate of impacts was higher in the past. Water on earth also increases weathering and erosion of craters and deposition of younger rocks on top of older craters)
 - Predict the effects of weathering on a crater. (possible answers could include - crater filling up with water, rim/edges of crater eroding and filling in on itself, crater becomes buried by sediment or vegetation grows).
 - Pose new questions based on what you learned.
 - What was your biggest takeaway of this lesson or the 'big idea'?
- Students could respond to these questions in the form of a flipgrid (video response)

Extensions

1. Do some research on the Chicxulub crater in Mexico and the Maple Creek crater in southern Saskatchewan. Compare the two in terms of size and learn more about the effect of the Chicxulub impact. Based on your findings, infer what affect the meteorite creating the Maple Creek crater had on this region when it hit.
2. Design your own impact crater experiment and test for a variety of different variables, including angle of impact, mass of projectile, type of surface, etc.
3. Find satellite images on the internet that show impact craters and map them. Can you see any patterns? If so, propose a possible explanation for your observations.

Continue to explore GeoExplore Saskatchewan - Digital GeoScience Highway Map (DGHM) of Saskatchewan for further information and a deeper understanding of the local context:

Main Website

<https://skgeolhighwaymap.maps.arcgis.com/apps/MapSeries/index.html?appid=a845cbb370f7401597806887318e2676>

Geology 101:

- **Sub tab: Meteorites:**

Name: _____

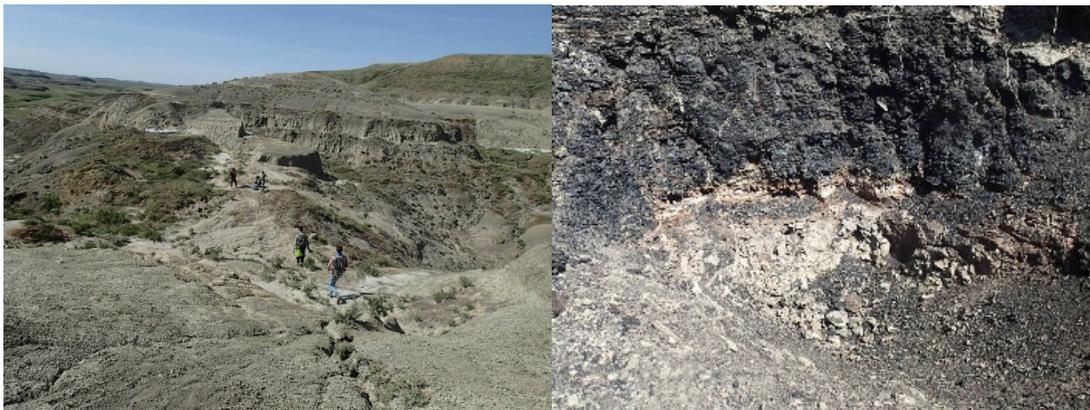
Killer Craters



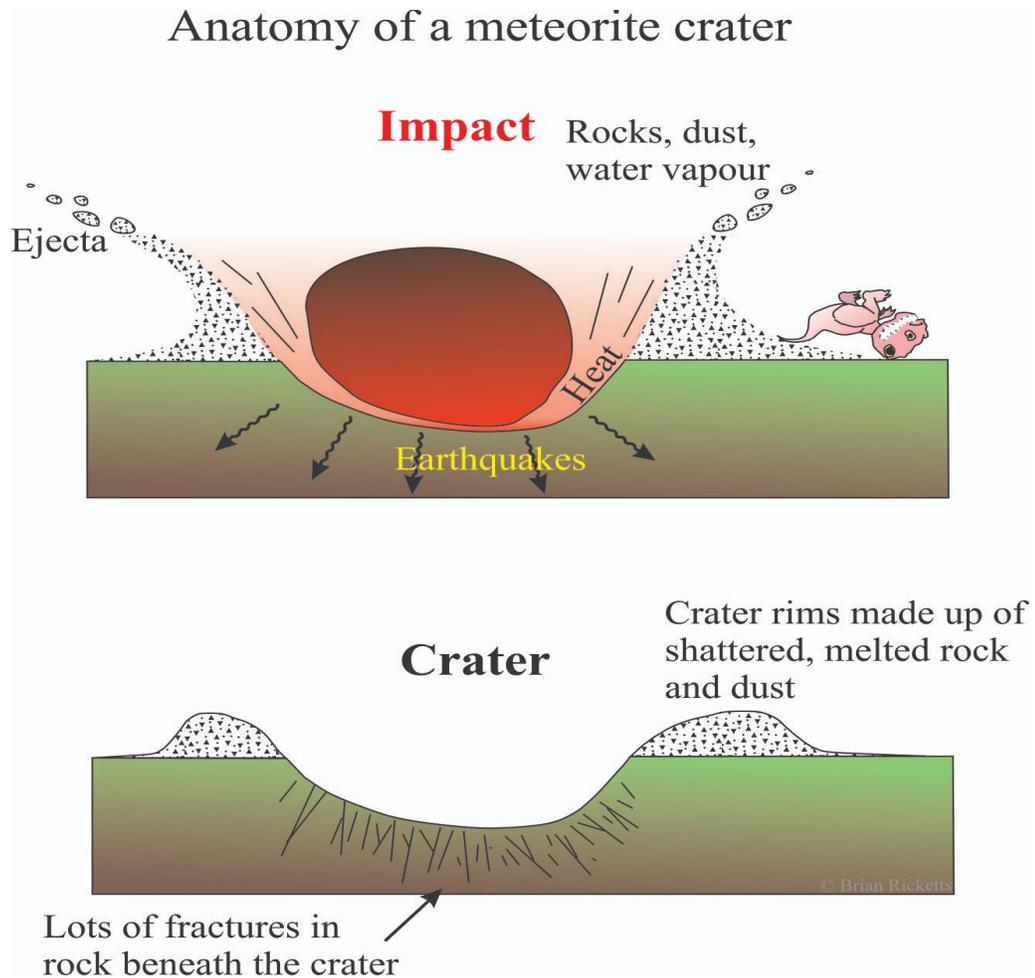
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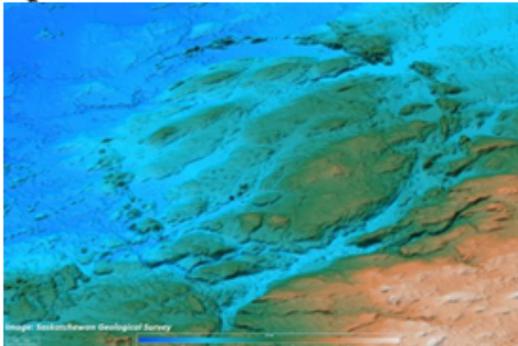


Saskatchewan Meteorite Impacts



Carswell Meteorite Impact Crater

With a diameter of 35 km, the Carswell impact crater is Saskatchewan's largest. It formed about 478 million years ago by a meteorite 0.5 to 1 km in diameter.



Gow Lake Impact Crater

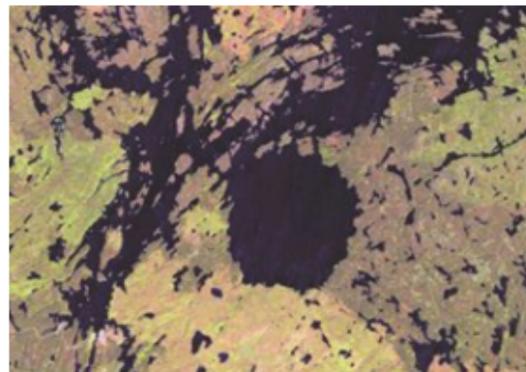
With a 5 km diameter, the Gow Lake impact crater is one of the smallest in Canada to have a central uplift—the island in the middle of the lake. This impact crater is believed to be 210 million years old.

Deep Bay Impact Crater

This striking impact crater, found near the southern end of Reindeer Lake, formed nearly 100 million years ago. This crater is 13 km across with an outer rim that rises up to 100 m above the lake and an impressive depth of 220 m.

Maple Creek (White Valley) Impact Structure

Approximately 23 km east-southeast of Maple Creek is a buried impact structure, 1300 m below the surface. The impact structure is about 7.5 km in diameter and is the youngest in Saskatchewan, impacting Earth about 75 million years ago.



Viewfield Impact Structure

North of the town of Viewfield, is a buried meteorite impact structure, about 1000 m below the surface. This structure is about 2.5 km in diameter and occurred approximately 190 million years ago.

Meteorite Impact Crater Experiment

Effect of Projectile Size and Height on Crater Dimensions				
Test (projectile and height)	Depth of crater (mm)	Diameter of crater (mm)	Longest ray length (mm)	Description of Crater
Small at 40 cm				
Small at 80 cm				
Medium at 40 cm				
Medium at 80 cm				
Large at 40 cm				
Large at 80 cm				



Draw an Impact Crater from the experiment...

