

## Teacher Discussion Material

### To accompany Borah Peak Earthquake Video prepared for Idaho Falls School District

The intention of the video is to provide a starting point for discussion topics related to geography, earthquakes, hydrology, geospatial tools, and human impact of natural catastrophes. The following are some possible starting discussion points for teachers and students.

#### **Geography**

*Where is Mackay located? What major cities and landmarks are nearby?*

Use a map or Google Earth to locate Mackay. Introduce concept of scale and directions.

#### **Earthquake**

The 7.3 earthquake resulted in a 23 mile long scarp at the foot of the Borah Peak Mountain Range, Idaho. The epicenter was near Chilly Butte, Idaho. The fault line had a dip of about 50 degrees. Borah Peak uplift was approximately 0.9 m, while the Lost River Valley subsided 1.5 m. Sand boils, changes in the flow of water in springs, and fluctuations in well water levels were some of the hydrologic impacts of the earthquake.

*What is a fault scarp line?*

Exposure of the earth's surface from an earthquake rupture along a fault (a topographic expression of the earthquake, could be a lateral and/or vertical offset).

*What is an epicenter?*

The vertical projection of the focus (location of where the release of strain energy occurs) onto the Earth's surface.

*What is a Richter scale?*

From Wikipedia:

The Richter magnitude scale, also known as the local magnitude ( $M_L$ ) scale, assigns a single number to quantify the amount of [seismic energy](#) released by an [earthquake](#). It is a base-10 [logarithmic scale](#) obtained by calculating the logarithm of the combined horizontal [amplitude](#) of the largest displacement from zero on a Wood–Anderson torsion [seismometer](#) output. So, for example, an earthquake that measures 5.0 on the Richter scale has a shaking amplitude 10 times larger than one that measures 4.0. Developed in 1935 by [Charles Richter](#) in partnership with [Benio Gutenberg](#), both of the [California Institute of Technology](#), the scale was firstly intended to be used only in a particular study area in [California](#), and on seismograms recorded on a particular instrument, the Wood-Anderson torsion [seismometer](#). Richter originally reported values to the nearest quarter of a unit, but decimal numbers were used later. His motivation for creating the local magnitude scale was to separate the vastly larger number of smaller earthquakes from the few larger earthquakes observed in California at the time.

<b>Richter magnitudes</b>	<b>Description</b>	<b>Earthquake effects</b>	<b>Frequency of occurrence</b>
Less than 2.0	Micro	Microearthquakes, not felt.	About 8,000 per day
2.0-2.9	Minor	Generally not felt, but recorded.	About 1,000 per day
3.0-3.9		Often felt, but rarely causes damage.	49,000 per year (est.)
4.0-4.9	Light	Noticeable shaking of indoor items, rattling noises. Significant damage unlikely.	6,200 per year (est.)
5.0-5.9	Moderate	Can cause major damage to poorly constructed buildings over small regions. At most slight damage to well-designed buildings.	800 per year
6.0-6.9	Strong	Can be destructive in areas up to about 160 kilometres (100 mi) across in populated areas.	120 per year
7.0-7.9	Major	Can cause serious damage over larger areas.	18 per year
8.0-8.9	Great	Can cause serious damage in areas several hundred miles across.	1 per year
9.0-9.9		Devastating in areas several thousand miles across.	1 per 20 years
10.0+	Epic	Never recorded; see below for equivalent seismic energy yield.	Extremely rare

Richter Approximate Magnitude	Approximate TNT for Seismic Energy Yield	Joule equivalent	Example
0.0	1 <a href="#">kg</a> (2.2 <a href="#">lb</a> )	<a href="#">4.2 MJ</a>	
0.5	5.6 kg (12.4 lb)	<a href="#">23.5 MJ</a>	Large <a href="#">hand grenade</a>
1.0	32 kg (70 lb)	<a href="#">134.4 MJ</a>	Construction site blast
1.5	178 kg (392 lb)	<a href="#">747.6 MJ</a>	<a href="#">WWII</a> conventional bombs
2.0	1 <a href="#">metric ton</a>	<a href="#">4.2 GJ</a>	Late WWII conventional bombs
2.5	5.6 metric tons	<a href="#">23.5 GJ</a>	WWII <a href="#">blockbuster bomb</a>
3.0	32 metric tons	<a href="#">134.4 GJ</a>	<a href="#">Massive Ordnance Air Blast bomb</a>
3.5	178 metric tons	<a href="#">747.6 GJ</a>	<a href="#">Chernobyl nuclear disaster</a> , 1986
4.0	1 <a href="#">kiloton</a>	<a href="#">4.2 TJ</a>	Small <a href="#">atomic bomb</a>
4.5	5.6 kilotons	<a href="#">23.5 TJ</a>	
5.0	32 kilotons	<a href="#">134.4 TJ</a>	<a href="#">Nagasaki atomic bomb</a> (actual seismic yield was negligible since it detonated in the atmosphere) <a href="#">Lincolnshire earthquake (UK), 2008</a>
5.4	150 kilotons	<a href="#">625 TJ</a>	<a href="#">2008 Chino Hills earthquake</a> (Los Angeles, United States)
5.5	178 kilotons	<a href="#">747.6 TJ</a>	Little Skull Mtn. earthquake (NV, USA), 1992 <a href="#">Alum Rock earthquake (CA, USA), 2007</a>
6.0	1 <a href="#">megaton</a>	<a href="#">4.2 PJ</a>	Double Spring Flat earthquake (NV, USA), 1994
6.5	5.6 megatons	<a href="#">23.5 PJ</a>	<a href="#">Rhodes (Greece), 2008</a>
6.7	16.2 megatons	<a href="#">67.9 PJ</a>	<a href="#">Northridge earthquake (CA, USA), 1994</a>
6.9	26.8 megatons	<a href="#">112.2 PJ</a>	<a href="#">San Francisco Bay Area earthquake (CA, USA), 1989</a>
7.0	32 megatons	<a href="#">134.4 PJ</a>	<a href="#">Java earthquake (Indonesia), 2009</a>
7.1	50 megatons	<a href="#">210 PJ</a>	Energy released is equivalent to that of <a href="#">Tsar Bomba</a> , the largest thermonuclear weapon ever tested.
7.5	178 megatons	<a href="#">747.6 PJ</a>	<a href="#">Kashmir earthquake (Pakistan), 2005</a> <a href="#">Antofagasta earthquake (Chile), 2007</a>
7.8	600 megatons	2.4 EJ	<a href="#">Tangshan earthquake (China), 1976</a>
8.0	1 <a href="#">gigaton</a>	<a href="#">4.2 EJ</a>	<a href="#">Toba eruption</a> 75,000 years ago; which, according to the <a href="#">Toba catastrophe theory</a> , affected modern <a href="#">human evolution</a> <a href="#">San Francisco earthquake (CA, USA), 1906</a> <a href="#">Queen Charlotte earthquake (BC, Canada), 1949</a> <a href="#">México City earthquake (Mexico), 1985</a> <a href="#">Gujarat earthquake (India), 2001</a> <a href="#">Chincha Alta earthquake (Peru), 2007</a>

			<a href="#">Sichuan earthquake (China), 2008</a> (initial estimate: 7.8)
8.5	5.6 gigatons	<a href="#">23.5 EJ</a>	<a href="#">Sumatra earthquake (Indonesia), 2007</a>
9.0	32 gigatons	<a href="#">134.4 EJ</a>	<a href="#">Lisbon Earthquake (Lisbon, Portugal), All Saints Day, 1755</a>
9.2	90.7 gigatons	<a href="#">379.7 EJ</a>	<a href="#">Anchorage earthquake (AK, USA), 1964</a>
9.3	114 gigatons	<a href="#">477 EJ</a>	<a href="#">Indian Ocean earthquake, 2004</a> (40 ZJ in this case)
9.5	178 gigatons	747.6 EJ	<a href="#">Valdivia earthquake (Chile), 1960</a> (251 ZJ in this case)
10.0	1 <a href="#">teraton</a>	<a href="#">4.2 ZJ</a>	Never recorded by humans.
13.0	10 <sup>8</sup> megatons = 100 teratons	5x10 <sup>30</sup> ergs = <a href="#">500 ZJ</a>	<a href="#">Yucatán Peninsula impact</a> (causing <a href="#">Chicxulub crater</a> ) 65 <a href="#">Ma</a> ago. <sup>[8][9][10][11]</sup>

## **Hydrology**

*Why was the hydrology changed during and after the earthquake?*

Some locations below and near the surface of the earth experienced an increase in pressure that resulted in squeezing out more water. Conversely, some locations below and near the surface of the earth experienced a decrease in pressure. For example, springs stopped flowing.

Other examples include:

- Water in wells near the quake's epicenter near Borah Peak went up about 10 feet initially, but has since receded.
- Flows from springs at the Hagerman National Fish Hatchery, 150 miles southwest of Mackay, dropped 10 percent hours after the earthquake, and fluctuated again two days later.
- A hot-water spring south of Challis dried up completely after the earthquake, but reappeared and was flowing at more than triple its original flow, flooding houses in a subdivision.
- The 95-degree spring that flowed on the Will Ingram ranch (where in relation to epicenter?) dried up within hours of the quake. The spring was used to irrigate 1,300 acres and water 2,300 head of cattle, and hydrologists offered little hope that the hot water spring would come back. But water began reappearing Nov. 10. [Post-Register; November 28, 1983]

## **Geospatial Tools**

*How can Google Earth or LiDAR (explain LiDAR) help us better understand earth processes?*

Google Earth uses remote sensing imagery from satellites and airplanes to provide a large picture view that is different than the perspective one might see on the ground. LiDAR remote sensing can provide digital elevation models (DEMs) or topographic information that help explain the topography of the earth and even changes in the topography over time.

*What is LiDAR data?*

LiDAR is the acronym for light detection and ranging, also known as laser altimetry. LiDAR technology uses a laser mounted on a tripod on the ground, an airplane, or a satellite. In the case of this video, the LiDAR was mounted on an airplane. The round trip travel time of the laser pulse provides precise elevation information where the laser pulse hits the ground, vegetation, buildings or other structures. LiDAR allows the reconstruction of the earth's surface (including vegetation) to within 15 centimeters or less in the vertical direction. LiDAR data provides a more precise elevation model than what is shown in Google Earth. The LiDAR 3D tour of the Borah Peak earthquake scarp provided information about the shape of the land surface and the height offset of the scarp line from the earthquake.

## **Human Impact**

*How could people protect themselves?*

Build earthquake safe structures. Understand the hydrology of the area and whether they are in an area that could be impacted by a change in hydrology (e.g. springs and flooding)

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