Earthquakes in central Idaho: why, where, and how often

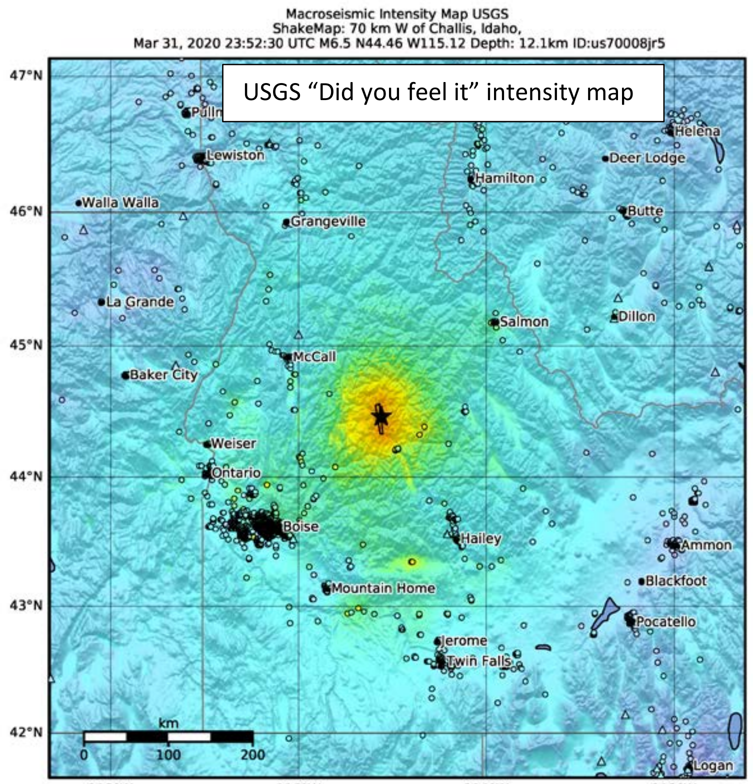
The M_w6.5 March 31, 2020 Stanley Idaho earthquake (5:52 pm local time): little damage – rock fall and avalanches

M_w = moment magnitude - the fault slip **x** the area of the fault surface that slipped - or - the total energy released in the earthquake

Intensity = measure of ground shaking – intensity depends mostly on earthquake distance and local soil or rock conditions.

Epicenter = the ground position above the earthquake *hypocenter* – about 18 miles northwest of Stanley - about 44.465°N, 115.118°W

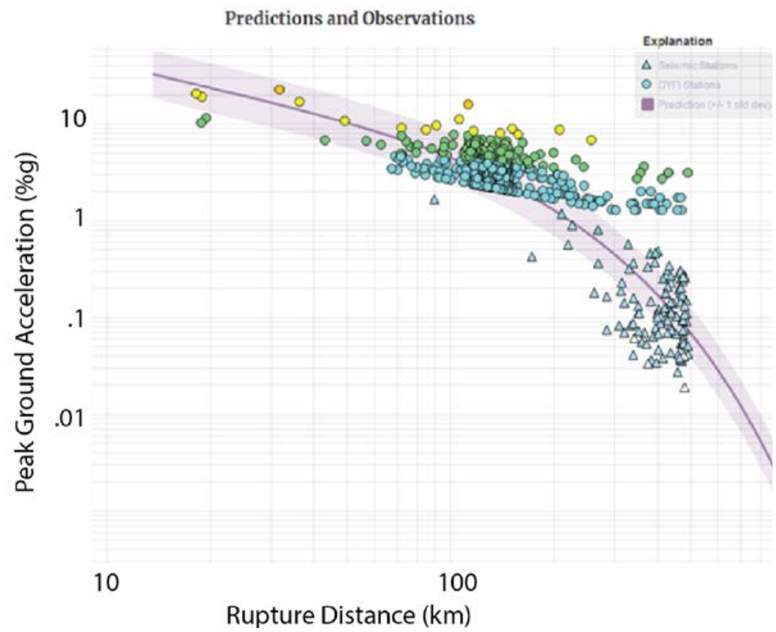
Hypocenter = earthquake depth – about 12 km or 7.5 miles depth



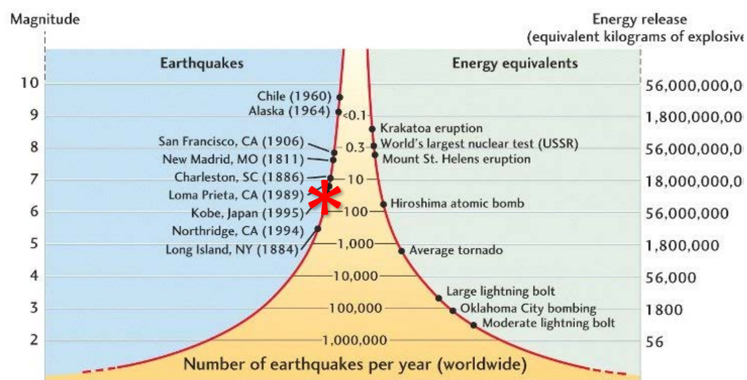
SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
DAMAGE	None	None	None	Very light	Light	Moderate	Moderate/heavy	Heavy	Very heavy
PGA(%g)	<0.0464	0.297	2.76	6.2	11.5	21.5	40.1	74.7	>139
PGV(cm/s)	<0.0215	0.135	1.41	4.65	9.64	20	41.4	85.8	>178
INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

Scale based on Worden et al. (2012) Version 19: Processed 2020-06-07T22:19:32Z
△ Seismic Instrument ○ Reported Intensity ★ Epicenter ▭ Rupture

Did You Feel It? *The USGS received over 40,000 responses*

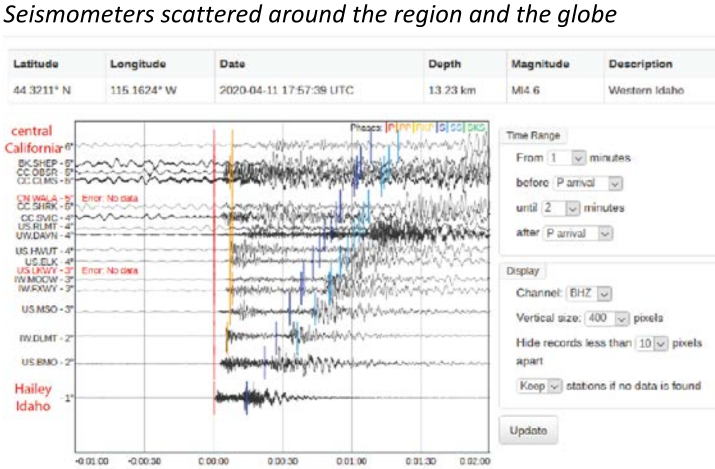


How much energy was released? *More than the Hiroshima bomb*



The earthquake released about 2x the energy that Idaho consumed in 2018

How do we measure earthquake magnitudes and locations?
Seismometers scattered around the region and the globe



Can we predict earthquakes?

Yes, at very long time scales!

…but generally no, not to the year, month, or day.

But, we can predict ground motions from earthquakes, and aftershock patterns.

If… we measure ground properties and ground motions before a large earthquake and during the aftershock sequence (but this costs $).

And if we study other similar earthquakes: the past is the key to understanding future earthquakes.

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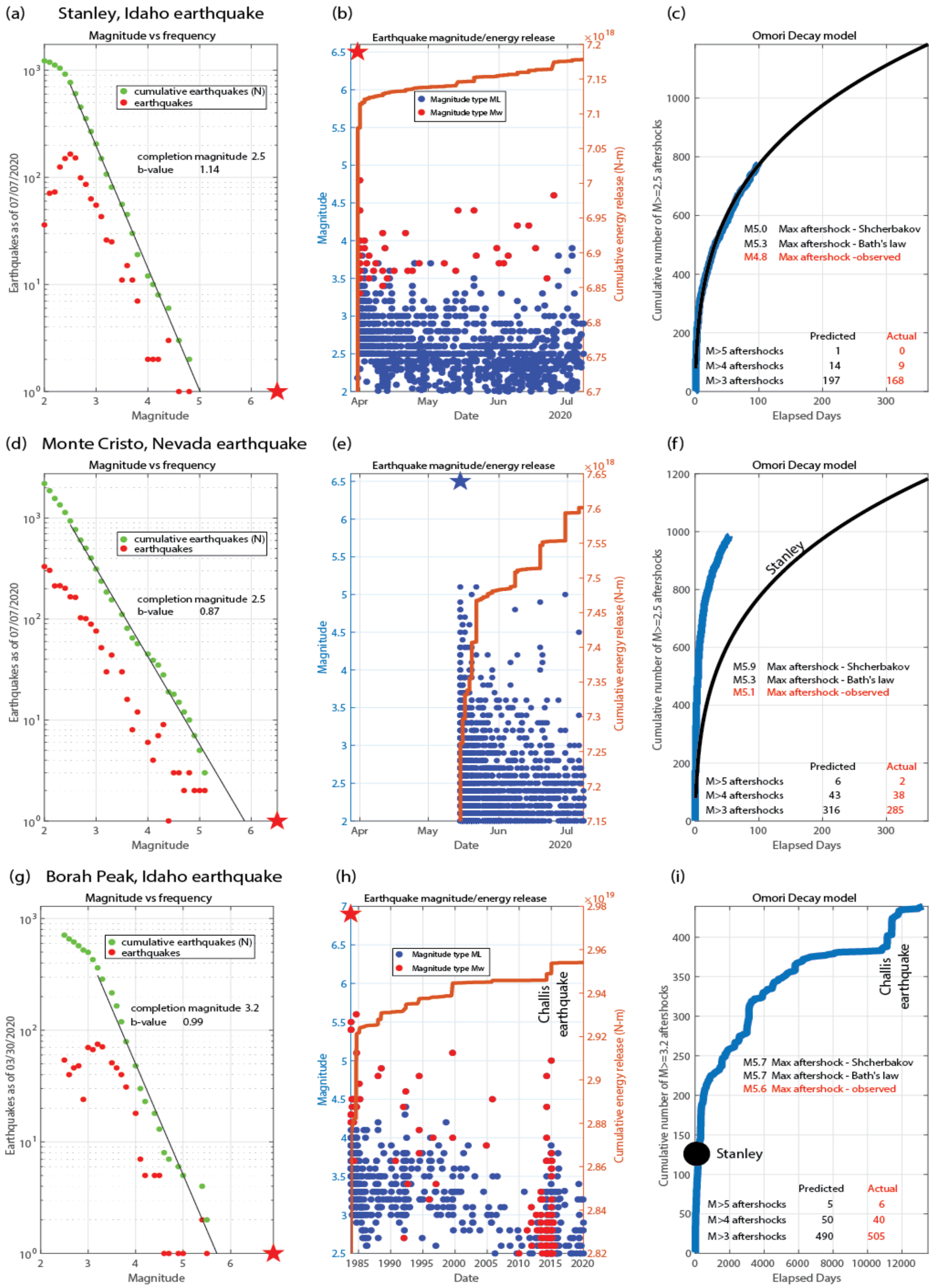
How long will the Stanley earthquake aftershocks last? *Months or years…*

Here is a comparison between 2020 Stanley, 2020 Monte Cristo, Nevada and 1983 Borah Peak earthquakes. The right panel shows the number of M>2.5 aftershocks (blue line) and an aftershock prediction curve (black line). This model predicts hundreds more moderate earthquakes for the Stanley area. The model also predicts a few more M>4 EQ's.



Gutenberg–Richter law: the relationship between earthquake magnitude and total number of earthquakes is predictable (see black line on left plots).

Omori's law: The frequency of earthquake aftershocks decreases with the reciprocal of time after the main earthquake (black line on right plots).

Båth's Law: the difference in magnitude between a main shock and its largest aftershock is approximately M1.2 less than the main shock. Stanley earthquake M_w6.5, largest predicted aftershock = M_w5.3

Other aftershock predictions suggest an M_w5.0 earthquake is possible. The largest aftershocks, to date, were the M_w4.8 on March 31, 2020 (6:30pm) and the M_w4.6 on June 24, 2020 (11:20pm)

Gutenberg-Richter relationships predict **14 M>4 earthquakes**; to date: **we have recorded 9.** Will there be more felt earthquakes? Almost certainly **yes**!

What is a foreshock? any earthquake that is followed by a larger earthquake. The probability of a foreshock for the days or weeks after a large earthquake is about 6%.

Can we expect a large aftershock in the Stanley area? *Let's look at the past*

1) The 1983 M_w6.9 Borah Peak earthquake was followed nine and 10 months later by M5.6 and M5.1 aftershocks. *A M5.7 aftershock was predicted (and instrumentation was not very good)*
2) The 1944 M6.1 Seafoam earthquake was followed about seven months later by a M6.0 earthquake, presumably on the same fault. *This earthquake reportedly "knocked people to the ground" in Custer County.*
3) The 2013 M4.8 Challis earthquake (foreshock??) was followed nine months later by a M5.0 earthquake.

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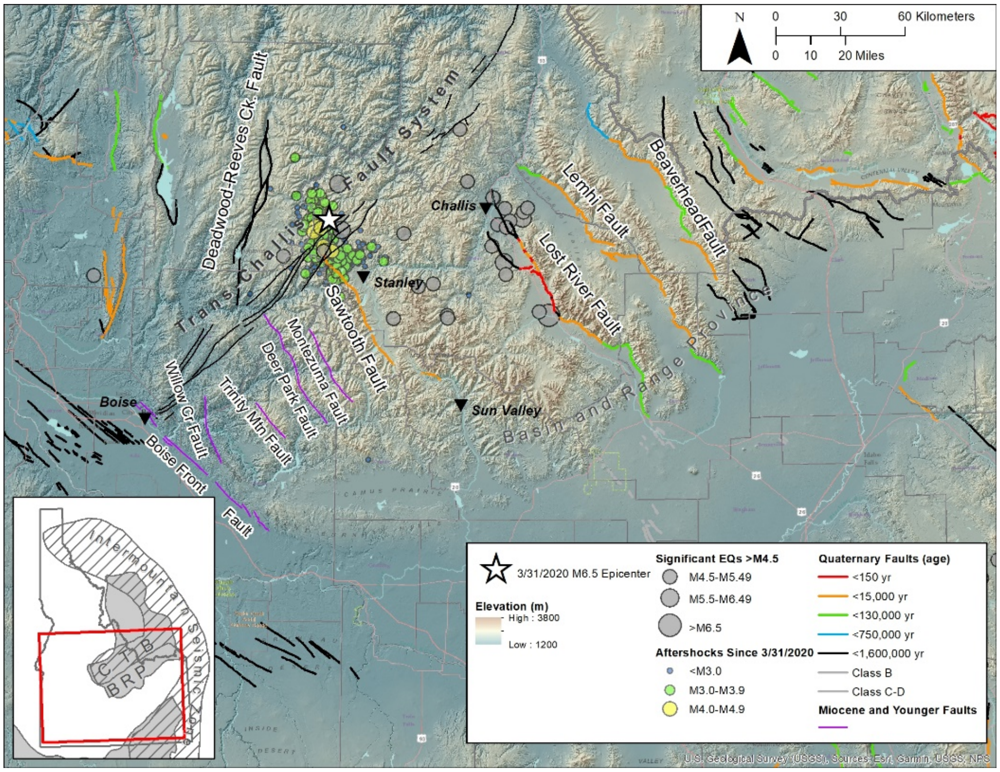
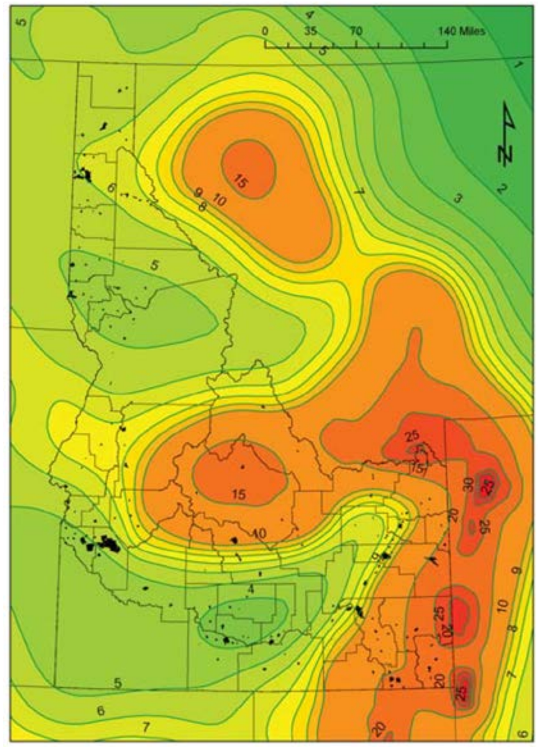
Where in Idaho do earthquakes occur? Mostly eastern and central Idaho.

Why? *Two reasons*

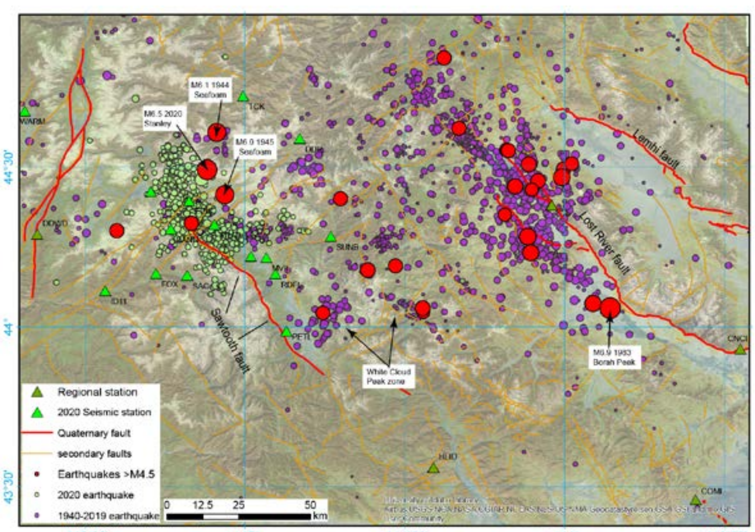
1) *Active faults (weaknesses in the earth's crust) accommodate different plate motions. For example, the Snake River Plain crust moves westward at a different rate than the central Idaho crust.*
2) *The Yellowstone Hotspot passage (Snake River Plain) has inflated, then deflated the crust through time. The "cool" brittle crust of central Idaho will produce more earthquakes than the "hot" ductile Snake River Plain crust.*

The Stanley earthquake occurred along the Sawtooth fault. We know that this fault has been active in the past and will continue to be active in the future.

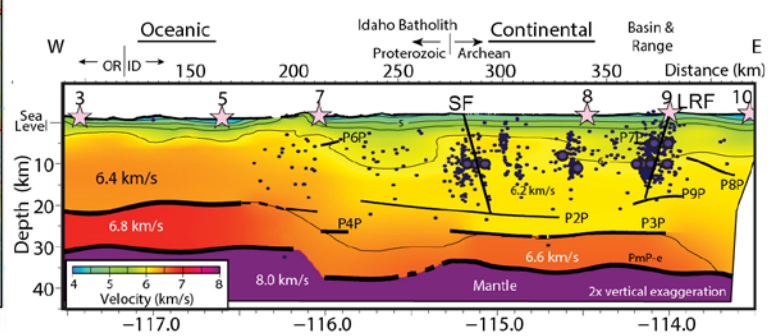




(left) Stanley earthquake, aftershocks and large historic earthquakes. Also shown are the active faults (colored by age of last earthquake. (right) **Peak Horizontal Acceleration** (%g) 50 year prediction with a 10% probability of exceedance (Data Source: USGS). Orange and red colors represent higher earthquake hazard regions.



Are the Borah Peak and Stanley earthquakes related?
Maybe… the area between faults shows similar extension rates. And, UU scientists have predicted a 100+ year aftershock sequence for the Borah Peak earthquake.



(left) Central Idaho earthquake map. Red circles represent earthquakes >M4.5, green circles are the Stanley aftershocks, purple circles are older small earthquakes. Red lines represent mapped active faults. Green triangles are the Boise State earthquake monitoring stations. (right) Cross section of the earth's crust across the Sawtooth fault (SF) and Lost River fault (LRF). Earthquake hypocenters show clusters of earthquakes between the two mapped faults.

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What are we doing to better understand the Stanley earthquake and other earthquakes in Idaho?

Active faults and earthquakes in central Idaho are poorly understood. We (Boise State, the Idaho Geological Survey, and the Idaho National Lab) have deployed seismometers and microphones to monitor aftershocks. The poor cell coverage in central Idaho means little real-time information.

In addition to seismic monitoring, scientists will map the ground surface (ground mapping and airborne Lidar) throughout the Sawtooth area to identify changes in the earth's surface from this earthquake or from past earthquakes.

From the seismic recordings and related work, we will:

1) Better locate each recorded aftershock. Why? *To locate active faults and understand how they moved.*
2) Some earthquakes add stresses to adjacent regions. *Knowing the earthquake distribution and energy release will help predict where aftershocks may occur.*
3) We can examine how ground motions change with each earthquake. This help us determine how the seismic energy dissipates with distance and with time. *This can provide a predictive tool to anticipate structural damage and landslide/avalanche potential.*
4) Better understand the properties of the Sawtooth fault to shed light on other Idaho faults. *When may we expect a large earthquake? How often do large earthquakes occur?*
5) Small earthquake occurrences provide a predictive tool for larger earthquakes. Once we know an accurate distribution of earthquakes less than M5, we can "predict" how often a M6 or M7 earthquake may occur.
6) The Stanley earthquake did not offset the ground surface near the epicenter. This suggests other similar pre-historic earthquakes also did not imprint a permanent record on the earth's surface. This observation tells us that scarp-forming earthquakes (like the Borah Peak earthquake) were all likely larger than M6.5.
7) An earthquake scarp mapped near Redfish Lake suggests that the Sawtooth fault is capable of supporting a ~M7 earthquake.

Recommended reading/web pages:

Idaho Geological Survey web site, https://www.idahogeology.org/stanley-earthquake

"Putting down roots in earthquake country", Printed by the Idaho Bureau of Homeland Security, 2009, https://adacounty.id.gov/emergencymanagement/wp-content/uploads/sites/39/eqcountry.pdf

US Geological Survey Earthquake Hazards web page, https://earthquake.usgs.gov/earthquakes/

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Lin Gray, Executive Director, Sawtooth Interpretive & Historical Association

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