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Utah Division of Emergency Management

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Utah Geological Survey Map 277
Utah Earthquakes (1850–2016) and Quaternary Faults

UTAH EARTHQUAKES (1850–2016) AND QUATERNARY FAULTS

by

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2017

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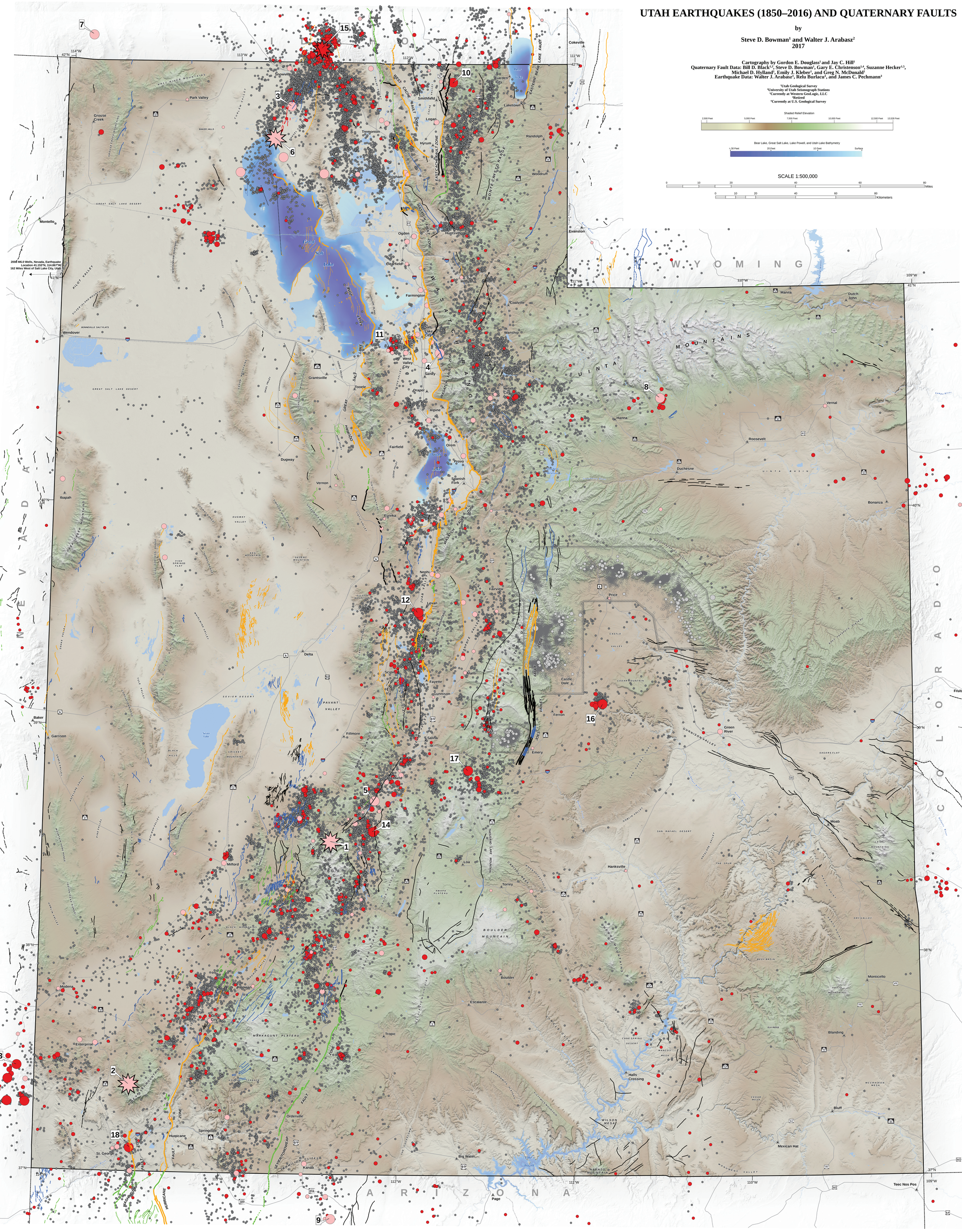

EXPLANATION

This map shows earthquakes known to have occurred within and surrounding Utah from 1850 through December 2016 and mapped Quaternary faults considered to be earthquake sources. The faults shown on the map have been sources of large earthquakes (about magnitude 6.5 or greater) during the Quaternary Period (past 2.6 million years) and are the most likely sources of large earthquakes in the future. Most small to moderate size earthquakes plotted on the map are "background" earthquakes not readily associated with known faults and of a size generally below the threshold of surface faulting (about magnitude 6.5). Buried or unmapped secondary faults are likely sources of much of the background seismicity.

Quaternary Faults and Folds

The Utah faults and folds shown on this map are from the *Utah Quaternary Fault and Fold Database* developed by the Utah Geological Survey (UGS, 2017). Faults in Nevada are from the *Quaternary Faults in Nevada* map database (dePolo, 2008), and faults in Arizona, Colorado, Idaho, and Wyoming are from the *Quaternary Fault and Fold Database of the United States* (U.S. Geological Survey [USGS], 2006). The major fault in Utah is the 240-mile-long Wasatch fault zone that extends from north of Malad City, Idaho, south through the Wasatch Front to near Fayette, Utah, and is considered to be capable of producing up to a magnitude 7.7 earthquake (Working Group on Utah Earthquake Probabilities, 2016). Other major hazardous faults include the East and West Cache, Hurricane, Joes Valley, Oquirrh–Great Salt Lake, Sevier/Toroweap, and Washington fault zones, and the Eastern Bear Lake fault. These fault zones are composed of many individual fault traces (often subdivided and named) and are shown on the map using a wider colored line. The other faults shown on this map are also potential sources of future earthquakes. Faults may be shown terminating at a state boundary due to incomplete mapping in some areas. Additional faults may exist that have not been mapped, may not have surface exposures, or were mapped subsequent to the publication of this map. The folds shown on this map are restricted to those involving a component of Quaternary faulting (fault-related folds). Refer to the *Utah Quaternary Fault and Fold Database* for more information on these structures.

During an earthquake of about magnitude 6.5 or greater, fault rupture may break the ground surface, creating a vertical offset or scarp; surface breaks along a fault sometimes occur over a zone tens of feet wide. Some communities in Utah have adopted ordinances that generally prohibit constructing buildings across or directly adjacent to a hazardous fault to reduce the risk of collapse or severe damage during an earthquake. Detailed 1:24,000-scale (1 inch equals 2000 feet) surface-fault-rupture hazard maps of selected areas in Utah are available at http://geology.utah.gov/map-pub/maps/geologic-hazard-maps/. Guidelines for performing surface-fault-rupture investigations, that may be needed before development, are available at http://geology.utah.gov/about-us/geologic-programs/geologic-hazards-program/for-consultants-and-design-professionals/recommended-report-guidelines/. Additional information on Utah faults or how to download the fault GIS data is available from the UGS at https://geology.utah.gov/apps/qfaults/index.html.

Age of Most Recent Movement

Faults

- <150 years, well constrained
- <15,000 years, solid where well constrained, long dashes where moderately constrained, short dashes where inferred. The fault traces beneath Great Salt Lake and Utah Lake, which were mapped primarily from seismic reflection data, are solid where they displace the lake bottom and short dashes elsewhere
- <130,000 years, solid where well constrained, long dashes where moderately constrained, short dashes where inferred
- <750,000 years, solid where well constrained, long dashes where moderately constrained, short dashes where inferred
- <2.6 million years, solid where well constrained, long dashes where moderately constrained, short dashes where inferred

Folds

- Anticline, <2.6 million years, solid where well constrained, short dashes where inferred
- Monocline, <2.6 million years, solid where well constrained

Earthquakes

The earthquake epicenters on this map are primarily from a Uniform Moment Magnitude Earthquake Catalog developed for the Utah region by Arabasz and others (2016) for the period 1850 through September 2012. For this map, the catalog was extended through December 2016 and expanded to include earthquakes smaller than magnitude 2.9 and coal-mining-induced seismicity. The database for the seismicity plotted on the map, together with explanatory information, is provided in Arabasz and others (2017). Gray hachured boundary lines delineate two areas in east-central Utah within which seismicity consists predominantly (more than 90%) of mining-induced seismicity caused by underground coal mining (see Arabasz and others, 2017). Moment magnitude, a modern seismological measure of the physical properties of the earthquake source, is the best indicator of an earthquake's true size (an improvement over the Richter local magnitude scale) and has become the preferred size measure for seismic hazard and earthquake engineering applications. The table to the right lists the largest earthquake mainshocks (moment magnitude 4.9 or greater) in the map area since 1850.

Epicenters

Magnitude Range* (**M**)	Earthquakes: 1850–June 1962	Earthquakes: July 1962–December 2016	Areas of Predominantly Mining-Induced Seismicity: 1928–December 2016
< 2.9		●	○
2.9–3.4	●	●	●
3.5–3.9	●	●	●
4.0–4.9	●	●	●
5.0–5.9	●	●	
6.0–6.9	✸	✸	

* All magnitudes (from Arabasz and others, 2016, 2017) are moment magnitude, **M**, either directly measured, empirically estimated from other size measures, or (for magnitudes of about 2.5 and smaller) inferred from other magnitude scales to be < **M** 2.9. Magnitude ranges are simplified to one decimal place: < 2.9 means **M** < 2.85, 2.9–3.4 means 2.85 ≤ **M** ≤ 3.44, and so on.

The refined earthquake catalog of Arabasz and others (2016) and its extension by Arabasz and others (2017) unifies catalogs compiled by the primary agents of seismic monitoring of the region: the University of Utah Seismograph Stations (UUSS) and the USGS. Authoritative source catalogs used to produce the unified catalog included (1) compilations of historical earthquakes since 1850 documented by USGS and UUSS researchers and (2) catalogs of instrumentally recorded earthquakes resulting from regional seismic monitoring by the UUSS since mid-1962 and from national-scale seismic monitoring by the USGS since 1973 (or in earlier decades by the U.S. Coast and Geodetic Survey).

Earthquake Mainshocks of Measured or Estimated Moment Magnitude (*M*) 4.9 or Greater
(labeled by number on map)

No.	Date (GMT)	Epicenter Location	M
1	11/14/1901	Tushar Mountains	6.6
2	11/17/1902	Pine Valley	6.3
3	10/06/1909	Hansel Valley	5.6
4	05/22/1910	Salt Lake City	5.3
5	09/29/1921	Elsinore	5.5
6	03/12/1934	Hansel Valley	6.6
7	11/19/1937	Idaho-Nevada-Utah border area	5.4
8	01/18/1950	Northwestern Uinta Basin	5.3
9	07/21/1959	Arizona-Utah border	5.6
10	08/30/1962	Cache Valley	5.8
11	09/05/1962	Magna	4.9
12	07/07/1963	Juab Valley	5.1
13	08/16/1966	Nevada-Utah border	5.2
14	10/04/1967	Marysvale	5.1
15	03/28/1975	Pocatello Valley, Idaho	6.0
16	08/14/1988	San Rafael Swell	5.0
17	01/30/1989	Southern Wasatch Plateau	5.2
18	09/02/1992	St. George	5.5

Additional information on Utah earthquakes is available from the UUSS at http://quake.utah.edu. Seismic hazard maps showing the expected severity of earthquake ground shaking for various probability levels are available from the USGS at https://earthquake.usgs.gov/hazards/hazmaps/conterminous/index.php#2014.

Earthquake/Faulting Hazard and Risk Preparedness

This map was developed to illustrate to the public and other stakeholders the geographic extent of earthquakes and faulting in Utah, which indicate widespread hazards and significant risk to Utah's people, property, infrastructure, and economy. This map was a collaborative effort among the three key partners in the Utah Earthquake Program: the Utah Geological Survey, the University of Utah Seismograph Stations, and the Utah Division of Emergency Management.

The Utah Earthquake Program (https://ussc.utah.gov/pages/help.php?section=Utah+Earthquake+Program) is a strong partnership that unites diverse professionals working cooperatively to reduce earthquake losses and risk in Utah. By bringing together professionals with emergency management, engineering, geology, seismology, and public outreach expertise into a collaborative framework, the Utah Earthquake Program leverages a broad array of experience, reduces duplication of effort, optimizes limited funding, and ensures the delivery of consistent, authoritative earthquake-related information for the benefit of all Utahns.

ACKNOWLEDGMENTS

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DISCLAIMER

This map is intended for general purpose viewing and not for project-specific fault and/or earthquake epicenter location. For other uses, see the original data sources: Arabasz and others (2017) for the earthquake database and Utah Geological Survey (2017) for the *Utah Quaternary Fault and Fold Database*.

Although this product represents the work of professional scientists, the Utah Department of Natural Resources, Utah Geological Survey, makes no warranty, expressed or implied, regarding its suitability for a particular use. The Utah Department of Natural Resources, Utah Geological Survey, shall not be liable under any circumstances for any direct, indirect, special, incidental, or consequential damages with respect to claims by users of this product. Map for use at 1:500,000 scale only. The UGS does not guarantee accuracy or completeness of the data.

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Basemap shaded color relief from Shuttle Radar Topographic Mission (SRTM) 75 meter DEM data. Grayscale shaded relief from U.S. Geological Survey 100 meter DEM data set.

Projection: UTM Zone 12
Datum: NAD 1983
Spheroid: GRS_1980

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