SOUTH DAKOTA EARTHQUAKES

What Is An Earthquake?

An earthquake is the result of a sudden release of energy due to an adjustment in the earth's crust. This adjustment causes the ground to tremble and produces vibrations that radiate out from the *focus* of the quake. The *focus* is the location of the "point" within the earth where the energy of the earthquake is released. The location of the "point" on the surface of the earth, directly above the *focus*, is called the *epicenter*.

What Causes Earthquakes?

Earthquakes can be produced by sudden natural processes such as volcanic explosions and meteorite impacts. However, earthquakes are primarily caused by a sudden release of stress built up over time in rocks below the earth's surface. In South Dakota, the most likely causes of this built up stress would be from plate movements along faults and *isostatic* (glacial) *rebound*.

The earth's crust bends and folds. In this process rocks break into blocks along zones of weakness. When two rock bodies or blocks slide by one another (horizontally and/or vertically), this motion is called *faulting*. The process of *faulting* may be a very large-scale or a small-scale phenomenon. Although some surface fault lines have been mapped in South Dakota, they appear to be old and inactive. The quakes we have experienced in South Dakota have been low intensity ones in which the fault movement is limited to the subsurface, with no displacement occurring along fault lines. The hypothesis that faulting has caused earthquakes in our state is based on data from places where it has been shown that these mechanisms have caused quakes.

Isostatic rebound, is another cause of earthquakes. The eastern half of South Dakota was covered by glaciers; the last glacier retreated from the state approximately 10,000 years ago. It has been estimated that the ice was 500 to 1000 feet thick at the southernmost edge of the glacier, along the present-day Missouri River valley. The weight of the glacier caused the underlying rocks and sediments to be compressed and pushed downwards. After the ice retreated, the rocks gradually rebounded upwards. This will continue until equilibrium of pressure in the earth's crust is attained.

How Are They Measured?

Seismic vibrations produced by an earthquake are recorded by a special instrument called a seismograph. Readings from a minimum of three seismographs in different locations must be measured to locate the *focus* of an earthquake and its *epicenter*. Seismographs also can be used to measure the magnitude of an earthquake.

The magnitude of an earthquake as derived from a seismograph is given a value on the *Richter scale*. The *Richter scale* is a *logarithmic* measure. This means that a quake of a magnitude of 3 has 10 times greater ground motion than a quake having the magnitude of 2.

The intensity of an earthquake may be measured or rated in everyday human terms and experiences, using the modified *Mercalli scale*. This scale relates the intensity of an earthquake at a particular location to its effect on people, our structures, and the earth's surface (see Table 1). On the right hand side of Table 1, the *Richter scale* magnitude is also given for comparison with the maximum intensity values of the Mercalli scale.

How Many Earthquakes Have Been Recorded In South Dakota?

Earthquakes are measured in South Dakota as a part of the United States Geological Survey (USGS) national seismograph network. The Golden Colorado office of the USGS monitors the seismograph stations in our region. Since the midwestern states are relatively stable in terms of earthquake activity, only a few seismograph stations are located in the area. The only one in South Dakota is in Rapid City and that has only been in operation since August 1991. Other stations near South Dakota are in Golden, Colorado and French Village, Missouri. There is also some equipment, which can sense earth movements, at the dams along the Missouri River

Between 1872 and 1991, at least 65 earthquakes have been recorded with epicenters in South Dakota (Hammond, 1992). As illustrated in Figure 1, the earthquakes occur primarily on the eastern and southern parts of the state. The numbers used to identify the location of each *epicenter* are in chronological order, from map listing 1 which occurred in 1872 to map listing 65 which occurred in 1991.

An individual listing of each South Dakota earthquake since 1872 is given in Table 2. This table includes the date and time of each event, its location as determined by latitude and longitude, and its intensity on the modified *Mercalli scale*. Most of the earthquakes in South Dakota are relatively weak, the strongest ones reported with intensities of VI on the modified *Mercalli scale* (Hammond, 1992). There has been no known major rerouting of streams or other major *physiographic* change in the state as the result of earthquake activity.

Table 1: Approximate Comparison of Maximum Modified Mercalli Scale Values and Richter Scale Values

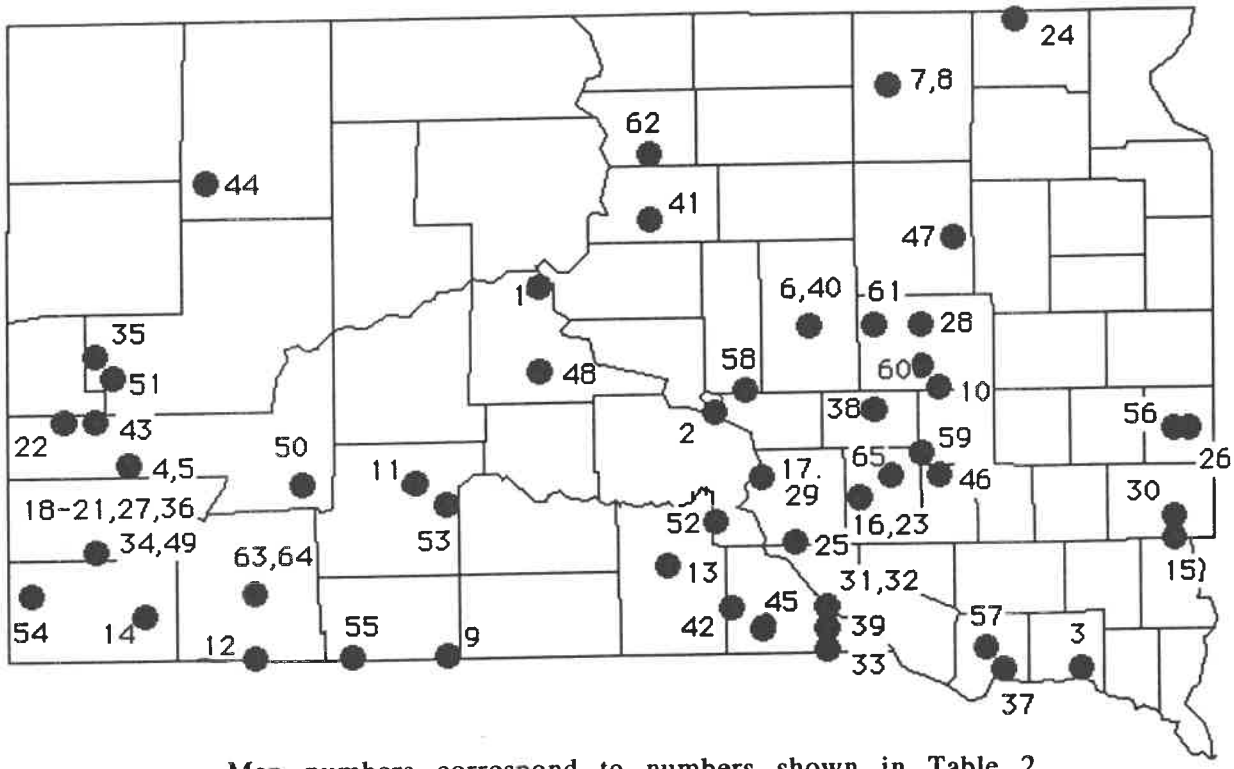
(from Burchett, 1979)

MODIFIED MERCALLI SCALE		RICHTER SCALE: MAGNITUDE
INTENSITY	EFFECT	
I	*Not felt except by a very few under especially favorable conditions.*	1.5
II	*Felt only by a few persons at rest, especially on upper floors of buildings. Delicately suspended objects may swing.*	2
III	*Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibration similar to the passing of a truck. Duration estimated.*	2.5
IV	*Felt indoors by many, outdoors by few during the day. At night some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.*	3 3.5
V	*Felt by nearly everyone; many awakened. Some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop.*	4
VI	*Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight.*	4.5
VII	*Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken.*	5
VIII	*Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture moved.*	5.5 6
IX	*Damage considerable in specially designed structures, well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.*	6.5
X	*Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent.*	7
XI	*Few, if any, (masonry) structures remain standing. Bridges destroyed. Rails bent greatly.*	7.5
XII	*Damage total. Lines of sight and level are distorted. Objects thrown into the air.*	8.0

Table 2: Chronological Listing of South Dakota Earthquakes: 1872 - 1991

Map Listing	Date	Time of Event (UTC)	Latitude	Longitude	Intensity (Modified Mercalli)
1	02/09/1872	---	44.7	100.7	III
2	08/17/1876	05:25	44.1	099.6	IV
3	12/29/1879	06:30	42.9	097.3	V
4	10/11/1895	23:55	43.9	103.3	IV
5	10/12/1895	01:25	43.9	103.3	V
6	12/06/1899	12:00	44.5	099.0	IV
7	03/14/1900	03:00	45.6	098.5	III
8	03/14/1900	05:00	45.6	098.5	III
9	05/10/1906	00:27	43.0	101.3	VI
10	06/02/1911	22:34	44.2	098.2	V
11	10/23/1915	06:05	43.8	101.5	V
12	02/24/1916	04:30	43.0	102.5	III
13	06/29/1916	07:45	43.4	099.9	III
14	07/14/1920	23:00	43.2	103.2	III
15	03/16/1921	23:45	43.5	096.7	III
16	09/24/1921	00:30	43.7	098.7	IV
17	01/02/1922	14:50	43.8	099.3	VI
18	12/30/1924	22:10	43.5	103.5	IV
19	12/30/1924	22:15	43.5	103.5	IV
20	12/30/1924	22:20	43.5	103.5	IV
21	12/30/1924	22:30	43.5	103.5	IV
22	11/16/1928	13:45	44.1	103.7	V
23	01/17/1931	18:45	43.7	098.7	IV
24	01/29/1934	12:30	45.9	097.7	IV
25	08/30/1934	03:50	43.5	099.1	IV
26	11/01/1935	10:00	44.0	096.6	III
27	10/30/1936	10:30	43.5	103.5	IV
28	01/02/1938	17:05	44.5	098.3	IV
29	10/01/1938	22:15	43.8	099.3	V
30	10/11/1938	09:37	43.6	096.7	V
31	11/04/1938	22:10	43.2	098.9	IV
32	11/04/1938	22:15	43.2	098.9	IV
33	06/10/1939	18:30	43.0	098.9	IV
34	05/25/1941	06:25	43.5	103.5	V
35	03/11/1942	17:55	44.4	103.5	III
36	05/16/1943	20:40	43.5	103.5	IV
37	11/10/1945	09:00	42.9	097.8	IV
38	07/23/1946	06:45	44.1	098.6	VI
39	08/25/1947	14:00	43.1	098.9	IV
40	05/07/1949	14:54	44.5	099.0	III
41	06/03/1949	02:06	45.0	100.0	IV
42	12/14/1949	03:15	43.2	099.5	III
43	11/14/1952	---	44.1	103.5	IV
44	12/21/1953	22:43	45.2	102.8	IV
45	12/31/1953	22:30	43.1	099.3	IV
46	12/03/1957	07:30	43.8	098.2	IV
47	01/12/1959	13:--	44.9	098.1	IV
48	12/31/1961	16:36	44.3	100.7	VI
49	03/24/1964	06:12	43.5	103.5	V
50	08/26/1964	16:58	43.8	102.2	IV
51	06/26/1966	11:59	44.3	103.4	VI
52	11/23/1967	06:23	43.6	099.6	V
53	10/19/1971	21:07	43.7	101.3	IV
54	05/16/1975	05:57	43.3	103.9	IV
55	09/13/1981	22:16	43.0	101.9	V
56	07/11/1982	19:42	44.0	096.7	V
57	11/15/1982	02:58	43.0	097.9	V
58	03/04/1983	06:32	44.2	099.4	VI
59	05/25/1986	07:13	43.9	098.3	IV
60	07/09/1987	22:06	44.3	098.3	III
61	10/15/1987	10:54	44.5	098.6	III
62	11/26/1989	01:06	45.3	100.0	III
63	01/28/1990	04:59	43.3	102.5	V
64	03/02/1990	04:15	43.3	102.5	IV
65	10/25/1990	06:25	43.8	98.5	V
66					

Figure 1: Earthquakes Recorded in South Dakota 1872 - 1991



Map numbers correspond to numbers shown in Table 2.

Glossary

Epicenter - the point of the earth's surface directly above the focus of an earthquake.

Faulting - a fracture or a zone of fractures along which there has been displacement of the sides relative to one another, parallel to the fracture.

Focus - the point within the earth which is the center of the earthquake.

Isostatic Rebound - the land surface rising in elevation, in delayed response to the melting and retreat of ice sheets that once covered the eastern half of S.D.

Logarithmic - usually referring to numbers that are exponents of 10. A 2 in a logarithmic scale means 10 to the second power, or 100. A 3 would be 10 cubed, or 1000.

Mercalli scale - an arbitrary scale of earthquake intensity, ranging from I (detectable only instrumentally) to XII (causing almost total destruction). It is named after Guiseppi Mercalli, an Italian geologist who devised it in 1902. Its adaptation to North American conditions is known as the modified Mercalli scale.

Physiographic - referring to the physical features and phenomena of nature.

Richter scale - a numerical scale of earthquake magnitude, devised in 1935 by the seismologist C. F. Richter. This scale is logarithmic so that a quake of 3 is actually 10 times stronger than a quake of 2.

Seismic - pertaining to an earthquake or earth vibration, including those that are artificially induced.

Glossary terms are adapted from Bates, R. L. and Jackson, J.A., 1987, *Glossary of Geology*, American Geological Institute, Alexandria, Virginia.

References

Hammond, R.H. 1992. Recorded Earthquakes in South Dakota, 1872-1991: South Dakota Geological Survey map.

Selected Resources For Teachers

Await the Quake, board game from Lawrence Hall of Science, Univ. of CA, Berkeley CA, 94720 (grades 1 to adult).

Numerous brochures and pamphlets are available from the United States Geological Survey, Rm. 408, Fed. Bldg. 200 4th Street SW, Huron, SD 57350.

A pamphlet on Earthquakes in South Dakota, by Dr. Val Ansfield, will soon be published by the South Dakota Geological Survey, Akeley Science Center, USD, Vermillion, SD 57069.

Outreach (Resource Agency Personnel)

(See Natural Source Directory for phone numbers.)

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