Quadrant II – Transcript and Related Materials

Programme	:	**Bachelor of Science (Second Year)**
Subject	:	**Geology**
Paper Code	:	**(DSC) GEC – 103**
Paper Title	:	**Earth's Dynamics and Structural Geology**
Unit	:	**2**
Module Name	:	**Earthquake: Intensity (Mercalli Scale)**
Module No	:	**23**
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Notes

Earthquake Strength (Size and Severity)

All seismic waves represent means of energy released and transmission; they cause the ground shaking that people associate with earthquake. There are various ways of describing the size of the earthquake. The two parameters most commonly used are ***magnitude*** and ***intensity***.

Earthquake Magnitude

The strength of an earthquake is expressed by calculating the amount of energy released at the earthquake's focus. In practice this is done by measuring the height (***amplitude***) of one of the wiggles on the seismogram. The larger an earthquake, the more the ground vibrates. After measuring a specific wave on a seismogram, and correcting for the type of seismograph and the distance from the quake, scientists can assign a number called the **magnitude**. It is a measure of amount of energy released during the earthquake. The **Richter scale**, devised by the C.F.Richter, is a numerical scale of magnitudes from **0** to **8.6**, the higher numbers indicating larger earthquakes. The largest quake measured so far is **8.6**, but because larger quakes might be measured in the future, **8.6** is **not** the upper limit of the Richter scale. It seems probable, however, that values near **9** represent a limit of elastic strength beyond which rocks will break. Therefore, earthquakes larger than magnitude **9** are unlikely.

Because the Richter scale is logarithmic, the difference between two successive whole numbers on the scale means increase of **10** times in the amplitude of the earth's vibrations. It has been estimated that tenfold increase in the size of the earth's vibrations is caused by an increase of about **31.5** times in terms of energy. A quake of magnitude **5**, for example, releases 31.5 times more energy than one of magnitude **4**. A magnitude **6** quake is almost **1000** times (**31.5 X 31.5**) more powerful in terms of energy released than a magnitude **4** quake.

Although a seismograph is required to measure magnitude, this measure has many advantages over intensity as an indicator of earthquake strength. A world-wide network of standard seismograph stations now makes determining magnitude a routine matter. A single magnitude number can be assigned to a single earthquake, whereas intensity varies for a single

earthquake, depending on local damage. Magnitudes can be reported for all quakes, even those in distant uninhabited areas where no property is harmed.

Earthquake Intensity

Second method is to find out how much and what kind of damage the earthquake has caused. This determines the **intensity**, which is the measure of an earthquake's effect on people and buildings (*i.e.*property). Intensities are expressed as Roman numerals ranging from **I** to **XII** on the **modified Mercalli scale;** proposed by Italian seismologist, Mercalli (Table 1); higher numbers indicate greater damage.

Table 1: Modified Mercalli Scale of 1931 (Abridged)

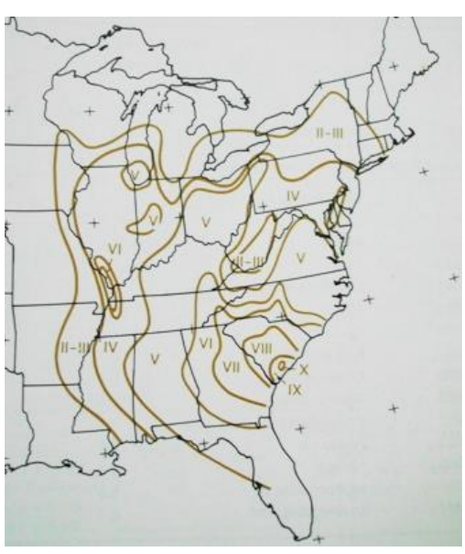
Intensity	Description of characteristic effect
I	Not felt except by a very few under especially favorable circumstances. Detected only by seismographs.
II	Felt only by a few sensitive people mostly at rest, especially on upper floors of buildings. Delicately suspended objects may swing.
III	Felt quite noticeably indoors, especially on the upper floors of buildings, but many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibration like passing of truck. Duration estimated.
IV	During the day felt indoors by many, outdoors by few. At night some awakened. Dishes, windows, doors disturbed; walls made cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.
V	Felt by nearly everyone; many awakened. Some dishes, windows etc. broken; a few instances of cracked plaster; unstable objects overturned. Disturbance of trees, poles, and other tall objects sometimes noticed. Pendulum clocks may stop. Bells ring.
VI	Felt by all, many frightened and run outdoors. Some heavy furniture moved; a few instances of fallen plaster or damaged chimneys. Damage slight.
VII	Everybody runs outdoors. Damage *negligible* in buildings of good design and construction; *slight* to moderate in well-built ordinary structures; *considerable* in poorly built or badly designed structures; some chimneys broken. Noticed by persons driving motor cars...
VIII	Damage *slight* in specially designed structures; *considerable* in ordinary substantial buildings with partial collapse; *great* in poorly built structures. Panel wall thrown out of frame structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. Sand and mud ejected in small amounts. Changes in well water. Persons driving motor cars disturbed.
IX	Damage *considerable* in specially designed structures' well designed frame structures thrown out of plumb; *great* in substantial buildings, with partial collapse. Buildings shifted out off foundations. Ground cracked conspicuously. Underground pipes broken.
X	Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations; ground badly cracked. Rails bent. Considerable landslides from river banks and steep slopes. Shifted sand and mud. Water splashed (slopped) over banks.
XI	Few, if any, (masonry) structures remain standing. Bridges destroyed. Broad fissures in ground. Underground pipelines completely out of service. Earth slumps and land slips in soft ground. Rails bent greatly.
XII	Damage total. Waves seen on ground surface. Lines of sight and level distorted. Objects thrown upward into the air.

From Wood and Neumann, 1931, *Bulletin Seismological Society of America*

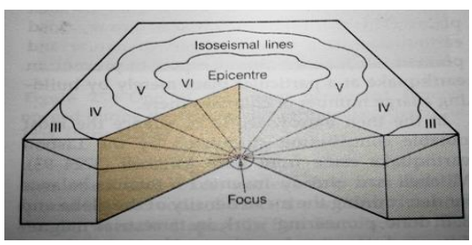
Intensity has for many years been expressed by reference to an arbitrary scale from **I** to **XII**. The adjectives used to describe the intensities are given below are purely descriptive, lacks quantification and thus unscientific!!

Intensity	Adjectives used
I	Instrumental
II	Feeble
III	Slight
IV	Moderate
V	Rather strong
VI	Strong
VII	Very strong
VIII	Destructive
IX	Ruinous
X	Disastrous
XI	Very disastrous
XII	Catastrophic

Although intensities are widely reported at earthquake locations throughout the world, using intensity as a measure of earthquake strength has a number of drawbacks. From the human point of view damage depends on population density, building standards, distance from the epicenter, and the nature of ground etc. Because damage generally lessens with distance from a quake's epicenter, different locations report different intensities for the same earthquake. Moreover, damage to buildings and other structures depends greatly on the type of geologic material on which the structure was built as well as type of construction and its standard. Houses built on solid rock (strong!) normally are damaged far less than houses built upon loose sediment (weak!) such as delta mud or bay fill. Damage estimates are also subjective: people may exaggerate damage reports consciously or unconsciously. Intensity map can be drawn for a single earthquake to show the approximate damage over a wide region.

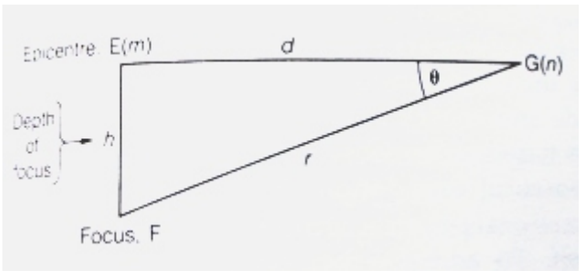


But such maps indicating isosiesmal lines or zones cannot be drawn for uninhabited areas (the central ocean, for instance), and so not all quakes can be assigned intensities. The one big advantage of intensity ratings is that no instruments are required.



Isoseismal line**

A line drawn through all the places with the same intensity is an isosiesmal line. Each one normally encloses circular or elliptical area. From the intensities (measured by accelerometers) at the epicenter E and at point G on an isosiesmal line at a known distance from E, R.D.Oldham showed, at least in principle, how the depth of focus could be estimated as below,



From the focus the **intensity** (expressed in terms of acceleration) theoretically **decreases** outwards inversely as the **square** of the **distance**. Thus to a first approximation we have $\mathbf{n/m = {}_h^2/r^2 = (\sin \theta)^2}$. The angle θ being thus determined, **d tan θ = h= the depth of the focus**

* The text and the illustrations are from the book titled, **Physical Geology** by Charles C. Plummer and David McGeary; Fourth Edition; Wm C. Brown Publishers Dubuque, Iowa.

** The text and illustrations from the book titled, **Holmes' Principles of Physical Geology**, Edited by P.McL.D.Duff; fourth Edition; ELBS.

Supplementary Readings

Physical Geology by Carla W. Montgomery; Second Edition; Wm. C. Brown Publishers.

Intensity - Modified Mercalli Scale

From: USGS National Earthquake Information Center (NEIC) Website, 1998

The effect of an earthquake on the Earth's surface is called the **intensity**. The **intensity scale** consists of a series of certain key responses such as people awakening, movement of furniture, damage to chimneys, and finally - total destruction. Although numerous intensity scales have been developed over the last several hundred years to evaluate the effects of earthquakes, the one currently used in the United States is the **Modified Mercalli (MM) Intensity Scale**. It was developed in 1931 by the American seismologists Harry Wood and Frank Neumann. This scale, composed of 12 increasing levels of intensity that range from imperceptible shaking to catastrophic destruction, is designated by Roman numerals. It does not have a mathematical basis; instead it is an arbitrary ranking based on observed effects.

The **Modified Mercalli Intensity value** assigned to a specific site after an earthquake has a more meaningful measure of severity to the nonscientist than the magnitude because intensity refers to the effects actually experienced at that place. After the occurrence of widely-felt earthquakes, the Geological Survey mails questionnaires to postmasters in the disturbed area requesting the information so that intensity values can be assigned. The results of this postal canvass and information furnished by other sources are used to assign an intensity within the felt area. The maximum observed intensity generally occurs near the epicenter.

From: Noson, Qamar, and Thorsen, Washington State Earthquake Hazards, 1988, Washington Division of Geology and Earth Resources Information Circular 85

Intensity:

The **intensity of an earthquake** is a measure of the amount of ground shaking at a particular site, and it is determined from reports of human reaction to shaking, damage done to structures, and other effects. The **Modified Mercalli Intensity Scale** is now the scale most commonly used to rank earthquakes felt in the United States. If **magnitude** is compared to the power output of a radio broadcasting station, then the **intensity** of an earthquake is the signal strength at a particular radio receiver. In practice, an earthquake is assigned one magnitude, but it may give rise to reports of intensities at many different levels. The magnitude 6.5 April 29, 1965, Seattle-Tacoma earthquake produced intensity VII to VIII damage near its epicenter, intensity V damage 150 kilometers from the epicenter.

Intensity Scales:

A measure of severity of shaking at a particular site. It is usually estimated from descriptions of damage to buildings and terrain. The intensity is often greatest near the earthquake epicenter. Today, the **Modified Mercalli Scale** is commonly used to rank the intensity from **I** to **XII** according to the kind and amount of damage produced. Before 1931 earthquake intensities were often reported using the **Rossi-Forel scale**.

Modified Mercalli Intensity Scale:

I. Not felt except by a very few under especially favourable circumstances.

II. Felt only by a few persons at rest, especially on upper floors of buildings. Delicately suspended objects may swing.

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 truck. Duration estimated.

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.

V. Felt by nearly everyone; many awakened. Some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop.

VI. Felt by all; many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight.

VII. Damage negligible in building 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. Noticed by persons driving motor cars.

VIII. Damage slight in specially designed structures; considerable in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned.

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.

X. Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent.

XI. Few, if any (masonry) structures remain standing. Bridges destroyed. Rails bent greatly.

XII. Damage total. Lines of sight and level distorted. Objects thrown into the air.