Experts can predict the areas likely to experience large magnitude earthquakes. Discuss (33)

Measuring earthquakes

Aims:
To know about the characteristics of the Richter and Mercalli scales
To know how they are represented graphically
To be able to identify strengths and weaknesses of the scales
Outline the causes of earthquakes (8 marks)

Plan
General
Constructive
Destructive
Collision
Conservative
other
Richter Scale

• Invented in 1935 by Charles Richter (avid naturist), it measures the magnitude of an earthquake

• Logarithmic scale

• Measure using a seismograph that produces a seismic trace
Seismic Trace

A Living Graph approach to learning about seismic traces.
As an individual, pair or small group:
1. Study the earthquake trace and the 13 labels.
2. Place the labels at the most appropriate places on the trace.
3. Explain why you put the labels where you did.

4. Mark on pre shocks / main quake / after shock

5. Also P and S waves
As an individual, pair or small group:
1 Study the earthquake trace and the 13 labels.
2 Place the labels at the most appropriate places on the trace.
3 Explain why you put the labels where you did.

1 THE CITY BREATHES A SIGH OF RELIEF
2 BUILDINGS COLLAPSE IN DOWNTOWN LOS ANGELES
3 THE RURAL AREA AROUND LOS ANGELES HAS AN UNEARTHLY QUIET - THERE IS NO NOISE FROM BIRDS AND ANIMALS
4 MRS LOTHAM FALLS TO HER DEATH AS THE STAIRS IN HER HOUSE FALL AWAY UNDERNEATH HER
5 A BASEBALL STADIUM FULL OF PEOPLE STARTS TO CRACK, PEOPLE ARE INJURED AS A STAMPEDE STARTS
6 THE MILLIONAIRE, J.J. BANNISTER, MOURNS THE LOSS OF HIS PAIR OF MING VASES
7 EMERGENCY SERVICES ARE PUT ON RED ALERT
8 THE PRICE OF WATER AND ELECTRICITY GOES UP
9 MR LEE, A TELEVISION STORE OWNER, LOSES A LOT OF MERCHANDISE DUE TO LOOTING
10 FIRES BREAK OUT IN THE SUBWAY
11 A HEADTEACHER ALERTS HIS STAFF IN SAN JOSE PRIMARY SCHOOL TO PUT THE EARTHQUAKE DRILL INTO PRACTICE
12 BURGLAR ALARMS GO OFF ALL OVER THE CITY
13 MRS WILLIAMS GETS HER CHILDREN TO SHELTER UNDER A TABLE IN CASE THEY ARE INJURED BY FALLING WALLS
Emergency services are put on red alert. I put this at the start because there had been some small tremors so the emergency services would need to get ready in case there was a big earthquake. I put it before the animals becoming quiet as this would happen just before the main earthquake.

Extension activity Think of a statement of your own for each section of the trace.
**Questions**

i. Mark on each trace on figure 2 when the P and S waves arrived at each station.

ii. Work out the time difference between P and S wave arrival AT each station.

iii. Work out the time difference between P and S wave arrival BETWEEN each station.

ii. Which station was closest to “Quake 1” and why?

iii. Which city is likely to suffer the most damage from this earthquake and why?
Mercalli Scale

- Invented by vulcanologist Giuseppe Mercalli in 1883
- The scale measures the intensity of an earthquake
- Qualitative scale
- 12 categories
THE MERCALLI SCALE

This is the scale of Earthquake Intensity, i.e., the effects of an earthquake.

Rearrange the following descriptions into the correct order to show Earthquake Intensity.

A Most large buildings collapse; bridges destroyed; large gaps appear in the ground
B Many houses collapse; cracks in the ground become wider
C Felt by people walking around; windows and doors rattle
D Chimneys fall, walls crack; difficult to stand up
E Furniture moves, objects fall, plaster begins to crack
F Some houses collapse; underground pipes crack
G Severe structural damage to buildings
H Felt by most people sitting down, like the rumble of heavy traffic
I Suspended objects swing; sleeping people are wakened
J Noticed only by very sensitive people
Study Figure 1 which shows the relationship between shaking intensity (measured by the Mercalli Scale) and different types of building structure.

Describe and comment on the information provided.

(7 marks)

**Figure 1**

<table>
<thead>
<tr>
<th>Type of building structure</th>
<th>VI (Strong)</th>
<th>VII (Very Strong)</th>
<th>VIII (Destructive)</th>
<th>IX (Ruinous)</th>
<th>X (Disastrous)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adobe (baked mud and clay)</td>
<td>8</td>
<td>22</td>
<td>50</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Unreinforced masonry</td>
<td>3.5</td>
<td>14</td>
<td>40</td>
<td>80</td>
<td>100</td>
</tr>
<tr>
<td>Reinforced masonry (non-seismic design)</td>
<td>1.5</td>
<td>5.5</td>
<td>16</td>
<td>38</td>
<td>66</td>
</tr>
<tr>
<td>Steel framed buildings</td>
<td>0.4</td>
<td>2</td>
<td>7</td>
<td>20</td>
<td>40</td>
</tr>
<tr>
<td>Reinforced masonry (seismic design)</td>
<td>0.3</td>
<td>1.5</td>
<td>5</td>
<td>13</td>
<td>25</td>
</tr>
</tbody>
</table>

Source: US Geological Survey

The numbers are the percentages of buildings damaged or collapsed.
<table>
<thead>
<tr>
<th></th>
<th>Richter</th>
<th>Mercalli</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adv</td>
<td>• Help predict based on pre shocks</td>
<td>• Cheap</td>
</tr>
<tr>
<td></td>
<td>• Precise</td>
<td>• Use to identify aid needed</td>
</tr>
<tr>
<td></td>
<td>• Global – understood around the earth</td>
<td>• Easy to understand</td>
</tr>
<tr>
<td></td>
<td>• Use past data to predict where when and size of future eq</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Easy comparison of different EQ</td>
<td></td>
</tr>
<tr>
<td>Disadv</td>
<td>• Skilled people to read and interpret</td>
<td>• Based on opinion, so open to bias</td>
</tr>
<tr>
<td></td>
<td>• Expensive equipment needed</td>
<td>• Qualitative so difficult to compare to previous quakes.</td>
</tr>
<tr>
<td></td>
<td>• HICs or HICs working with LICs e.g. PHILVOLCs</td>
<td>• Some stages quite similar</td>
</tr>
<tr>
<td></td>
<td>• If there isn’t a seismograph in position you can’t measure the</td>
<td>• Doesn’t provide a warning of an eq</td>
</tr>
<tr>
<td></td>
<td>earthquake</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Only tells you the magnitude not the amount of damage</td>
<td></td>
</tr>
</tbody>
</table>
Moment magnitude scale (Mw)

Today, the most common calculation method for magnitude - the amount of energy released by an earthquake at its source - is the moment magnitude scale (Mw).

Developed in the 1970s by Hiroo Kanamori, professor at the California Institute of Technology,

Succeeded several magnitude scales, including the 1930s-era Richter scale, whose model was solely based on the geology of California, where earthquakes are mostly shallow.

By taking into account the actual area of fault line ruptured, Mw gives a more consistent measurement to earthquakes no matter how deep.
Modified Mercalli intensity scale (MMI)

MMI describes earthquakes in terms of intensity. Numbers are used to describe magnitude. Intensity indicates how much shaking is felt and the level of damage in a specific location.

"Many people think high-magnitude earthquakes must result in greater damage, but this is not always the case, it depends on location.

Amod Dixit, general secretary of Nepal's National Society for Earthquake Technology (NSET), says "Magnitude is a scientist's language. You and I are more concerned with the practical implications of an earthquake, "Engineers here [in Nepal] claim to build houses that can withstand magnitude-7.0 earthquakes, but that doesn't mean it can withstand intensity IX?"

Citing the magnitude-6.1 earthquake near Christchurch in New Zealand in February 2011 as an example, Towashiraporn agreed that magnitude alone can be misleading. "A moderate magnitude-6.1 earthquake can still cause significant damage and loss of life if it happens at a shallow depth and is very close to a highly populated area,"
The Japan Meteorological Agency seismic intensity scale (JMA)

The JMA scale measures intensity in the units of "Shindo", and is similar to the MMI.

The only difference is JMA measures intensity from 0 to 7 and the MMI runs from I to XII.

JMA is only used in Japan and Taiwan. Koizumi said JMA gives the world's fastest intensity information.

"The initial estimation comes in 1.5 minutes after an earthquake occurs. Then after a few seconds, a warning is issued to the general public on TV.

Seismic intensity meters have been installed throughout the country, making calculation much faster.
Prompt Assessment of Global Earthquakes for Response (PAGER)

USGS developed this new technology in 2010.

Taking into account the demographics, building types and economic and casualty data collected from past earthquakes, PAGER estimates the shaking distribution, the number of people and settlements affected, and the possible fatalities and economic losses experienced.

PAGER turns the estimates of damage into colour-coded alert levels, so local, national and international agencies know what level of response is needed.

Apart from providing data for post-disaster mitigation, PAGER tops the other scales by generating information that helps prepare for earthquakes. "The PAGER highlights the most vulnerable structures that need improvement. This is especially important for developing countries where people don't always follow building codes," he said.
The effects earthquakes have on landforms and landscapes

1. faulting
2. graben – scarp slopes
Faulting
Faults

• Fractures in the earth’s crust along which rocks have been moved. There are different types of fault such as normal, reverse and transverse faults.
Normal fault

- On a normal fault rocks are moved downwards in the direction of the fault.
Reverse fault

- On a reverse fault the rocks move downwards in the opposite direction. The actual fault plane may not be visible because of slumping from the higher block onto the lower block.
Transverse fault

• A fault that occurs perpendicular to the plate boundary. These are commonly associated with conservative plate margins.
Mid Atlantic ridge
San Andreas Fault
Plenary quiz

1. What does the Richter scale measure?
2. Every time you go up one on the Richter scale how much bigger is the earthquake?
3. What term do we use to describe this?
4. What is the name of the scientific instrument that records measurements on the Richter scale?
5. What is Mercalli’s first name?
6. What does his scale measure?
7. Why is it very useful particularly in LICS?
Describe how seismic waves and earthquakes can be measured.
The magnitude of seismic waves and earthquakes is measured on two scales.

(a) The Richter scale is a logarithmic scale - an event measured at 7 on the scale has amplitude of seismic waves ten times greater than one measured at 6 on the scale. The energy release is proportional to the magnitude, so that for each unit increase in the scale, the energy released increases by approximately 30 times.

(b) The Mercalli scale measures the intensity of the event and its impact. It is a 12-point scale that runs from Level I (detected by seismometers but felt by very few people - approximately equivalent to 2 on the Richter scale) to Level XII (total destruction with the ground seen to shake - approximately 8.5 on the Richter scale).

Seismic records enable earthquake frequency to be observed, but these records only date back to 1848 when an instrument capable of recording seismic waves was first developed.

Candidates may provide details of both scales. Detail of the equipment and technology used, such as seismographs, is also relevant. Credit elaboration of how the technology is used or works.

Mark scheme

Level 1 (1-4 marks) (mid point 3)
Simple references to the scales given above, increasing numbers of the scale, but without any precision in their use; or detailed explanation of one system only, including technology.

Level 2 (5-8 marks) (mid point 6)
Recognition that there is more than one way in which to measure seismicity – by energy levels or by impact or by technology. Some detail is given of more than one system. Also credit commentary on usefulness if given when in this level.
Questions

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Mercalli scale maps

Lituya Bay, Alaska
July 9, 1958 - Magnitude 7.9

Modified Mercalli Intensity

I II III IV V VI VII VIII IX X+ ★ Epicentre

Timiskaming, Quebec
November 1, 1935 - Magnitude 6.2

Modified Mercalli Intensity

I II III IV V VI VII VIII IX X+ ★ Epicentre