Geoscape Ottawa-Gatineau

Grade 9 - 11 Lesson Plans to accompany the Geoscape Ottawa-Gatineau poster and website

J. Weatherhead and J. Aylsworth

Theme 10 : EARTHQUAKES : IN OTTAWA !

OVERVIEW

- Students understand the role that earthquakes have played in the geologic evolution of the Ottawa-Gatineau Geoscape and relate local fault features to the theories of plate tectonics and continental drift
- Students calculate the epicentre of an earthquake given information from seismograph stations.
- Students assess the degree of risk of earthquake damage in the local area relative to other regions of Canada and the world

DURATION 155 minutes (2 periods)

ACTIVITY

Note: The Urban Geology of the National Capital Area website http://gsc.nrcan.gc.ca/urbgeo/natcap/his_introduction_e.php has a history of plate movement, maps of bedrock and of faults, and cross-sections through bedrock layers across many faults. The Earthquakes Canada website http://earthquakescanada.nrcan.gc.ca/index_e.php is an excellent source of information on seismic facts, recent and historical events, data archives, eastern Canada seismicity, how hazard is determined, and what to do during an earthquake.

1. Using a bedrock or fault map, students map the major fault lines on to a blank outline map of the Ottawa-Gatineau Geoscape. Label the Ottawa-Bonnechere Graben, Eardley Escarpment, Hogs Back, Hazeldean Fault, Gloucester Fault and Dows Lake. When did the major faulting occur in the Ottawa region? (see Geoscape poster - Deep Time panel)

2. Students analyze and record reasons why evidence of earthquakes is difficult to detect on the landscape of the region. Teacher points out that the very large landslides between Rockland and Bourget, as well as several others, were caused by a large (magnitude 6.8-7) earthquake 4500 years ago. (See landslide map on the Geoscape poster.) Radiocarbon dating of buried trees in these landslides proved that they all occurred at the same time and must have been triggered by a very large earthquake.

3. Students research and note take why earthquakes occur frequently in the Ottawa-Gatineau Geoscape even though the area is not at the edge of a plate boundary. Consult Earthquakes Canada website.

4. Students compare the 2 scales of earthquake measurements (Richter and Mercali), noting what each measures and the usefulness of each.

5. Students indicate the arrival of the compression P wave and shear S wave on the Geoscape seismogram record of the 2000 Kipawa earthquake.

6. Students calculate the epicentre of a 2006 earthquake given information from seismograph stations. Student Worksheet is completed.

7. In teams, students research and report on methods of predicting where, when and how intense earthquakes might be. Can earthquakes be accurately predicted? At the present state of knowledge, earthquakes cannot be predicted, and, in particular, specifying in advance their exact date, time, and location. However, a great deal of research is being conducted to develop reliable prediction methods. Government scientists are

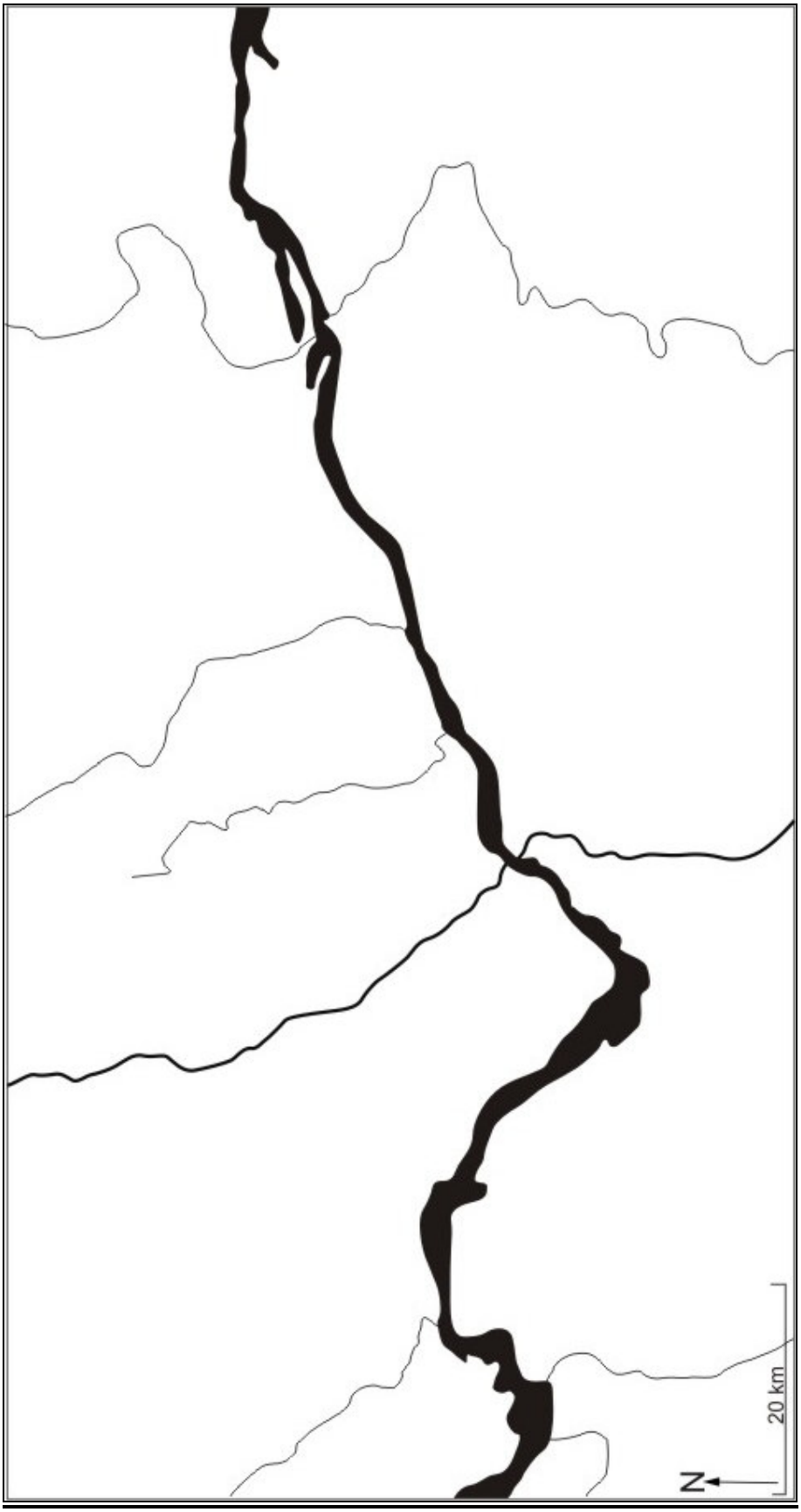
Funding for this project came from Natural Resources Canada and the Ontario government

working to minimize damage and injuries through implementation of new earthquake-resistant standards so that people are protected whenever and wherever an earthquake occurs.

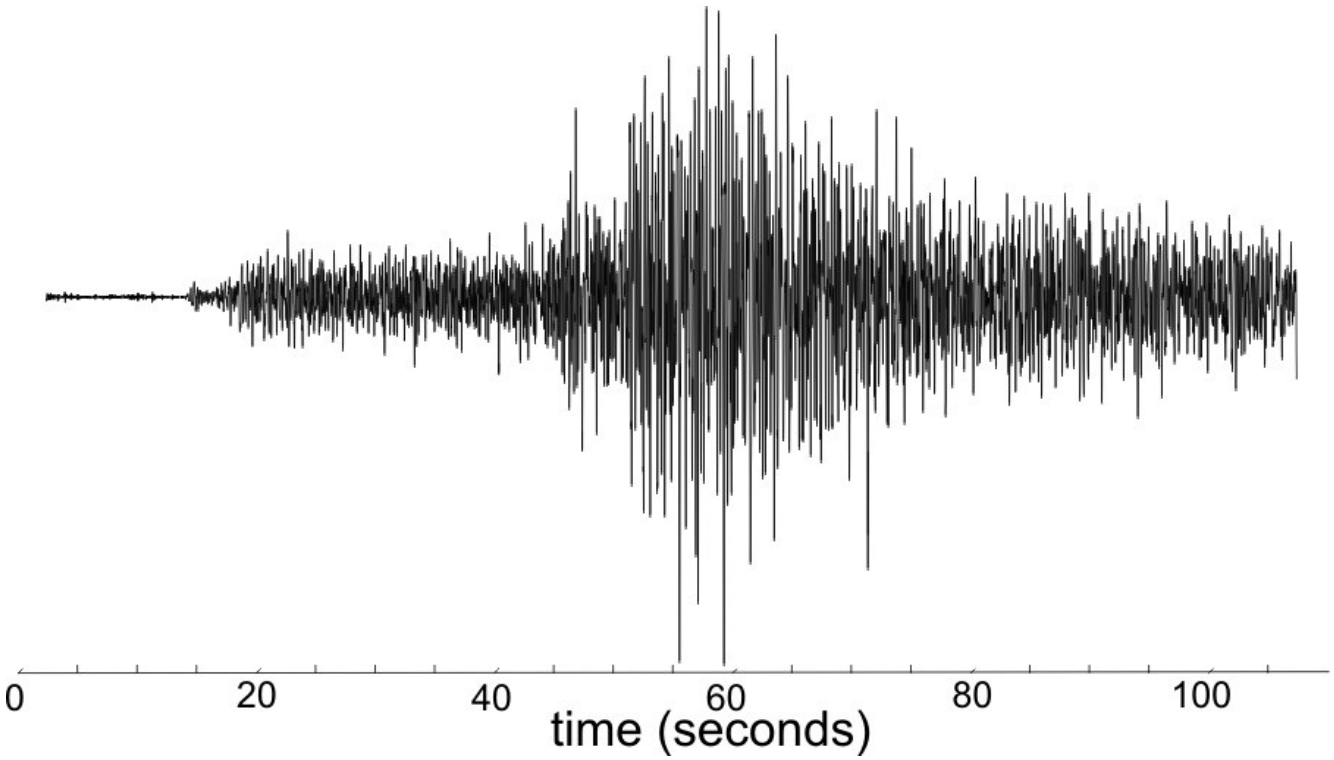
8. Students produce a map of the relative degree of earthquake hazard across Canada using Arcview or Earthquake Canada website. They then explain the differences between regions. The outlines of Canada's physiographic regions can be superimposed on their map.

9. Risk is the likelihood of occurrence of a hazard **AND** the societal impact should the hazard occur. Students offer explanations of why eastern cities figure prominently in the current list of urban earthquake risk in Canada : Vancouver, Victoria, Montreal, Ottawa, Quebec City, Toronto.

10. Students conclude with a written analysis of the goals of earthquake monitoring here as well as elsewhere in the world.

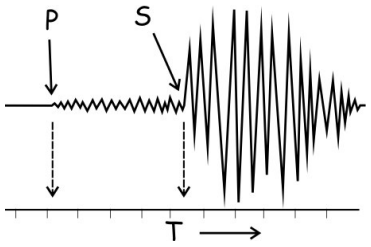

20 km
N

seismogram record of the 2000 Kipawa earthquake



Student worksheet: **LOCATING AN EPICENTER OF AN EARTHQUAKE**

When an earthquake occurs, seismic waves are generated. Direct compressional waves (**P-waves**) are faster moving and shear waves (**S-waves**) are slower. Each type appears as a unique signature on a **seismograph**.



At the recording station, the **difference in arrival time** of the direct P-waves and S-waves is used to calculate the **distance to the epicentre** of the earthquake. Using triangulation, the calculated distances from several different seismic recording stations can be plotted to locate the epicentre.

In eastern Canada, P-wave velocity = 6.2 km/s and S-wave velocity = 3.65 km/s
Difference = 2.65 km/s

1. time taken by P-waves to travel a distance (D) from the epicentre to a seismic station : $T_P = D / 6.2$
2. time taken by S-waves to travel same distance from the epicentre to a seismic station : $T_S = D / 3.65$
3. difference in arrival time (lag time) between P- waves and S-waves is : $\Delta T = T_S - T_P$
   $= D/3.65 - D/6.2$
   $= 2.65\ D / 22.63$
4. distance from the epicentre to the seismic station is: $D = 22.63\ \Delta T / 2.65$

1. a. How long would it take P waves to travel 100 km? _____
   b. How long would it take S waves to travel 100 km? _____
   c. What is the lag time between the arrival of P waves and S waves over a distance of 100 km? _____.
   d. If the difference in arrival time of P and S waves was 20 seconds, what is the distance between the epicentre and the seismograph location? _____

2. Four separate recording stations measured the time between the arrival of P-waves and S-waves. Identify the arrival of the P and S waves on the seismograms. Calculate the distance to the epicentre from each station.

Recording Station	Difference in arrival time	Distance
ALFO (Alfred)		
GAC (Glen Almond)		
OTT (Ottawa)		
TRQ (Tremblant)		

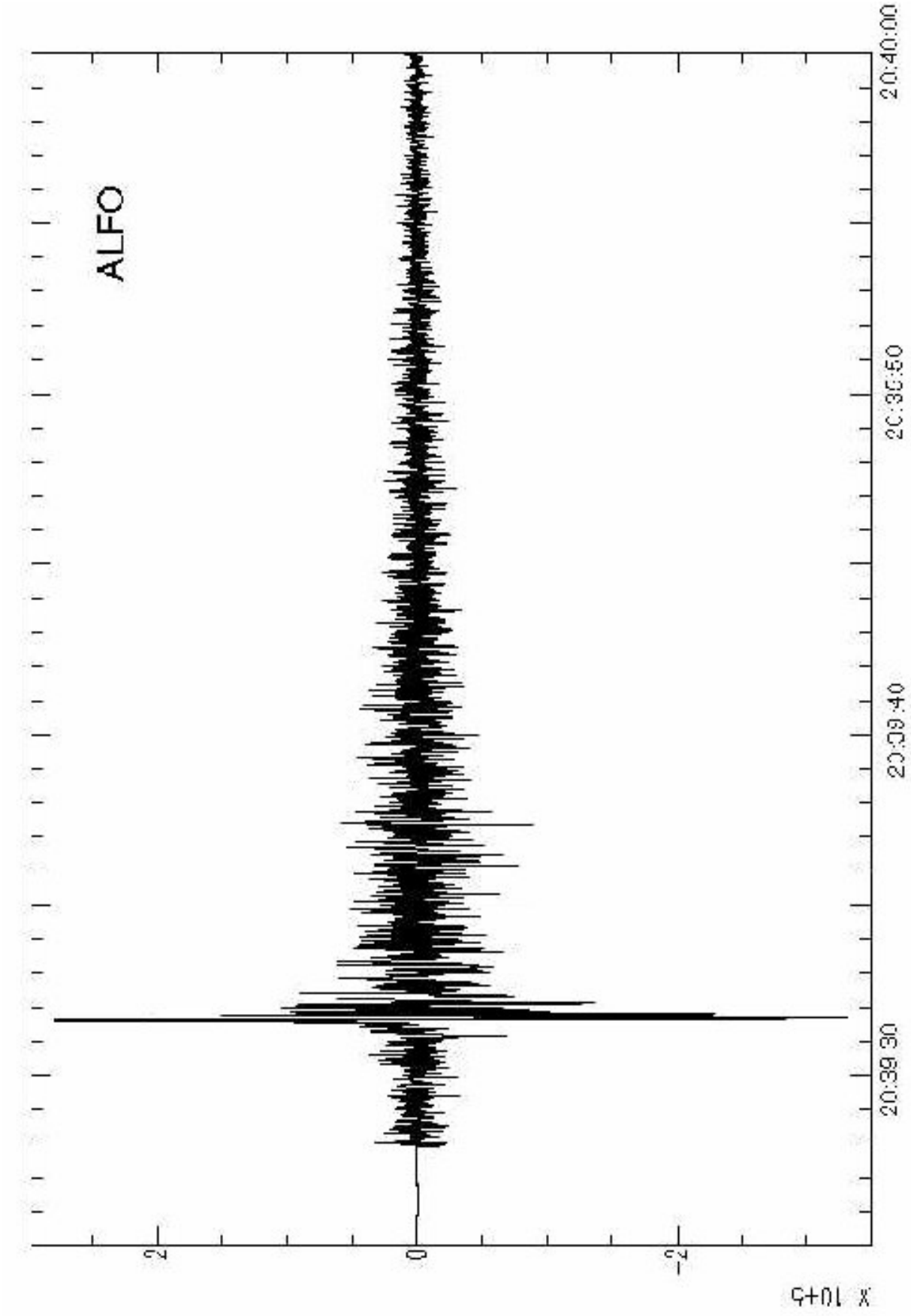
3. Calculate the epicentre: On a map of eastern Canada, inscribe a circle with a compass, such that the point of the compass is on the location of the recording station and the radius of the circle is equal to the calculated distance to the epicentre. Repeat for the other stations. The epicentre of the earthquake is located near the point at which the circles approximately intersect.

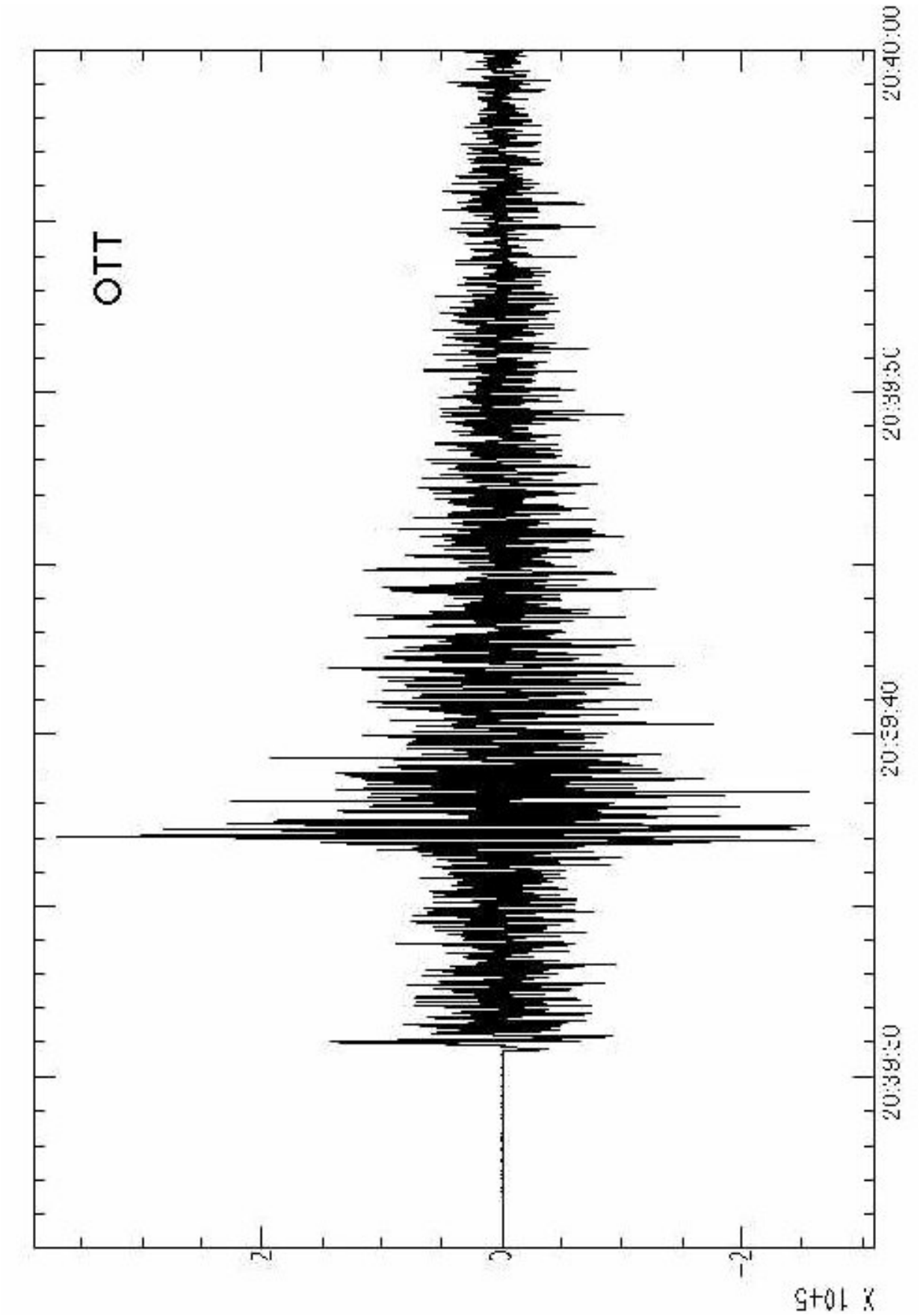
   Where is the epicentre of this earthquake? _____
   What is the minimum number of stations that are necessary to find an epicentre? _____

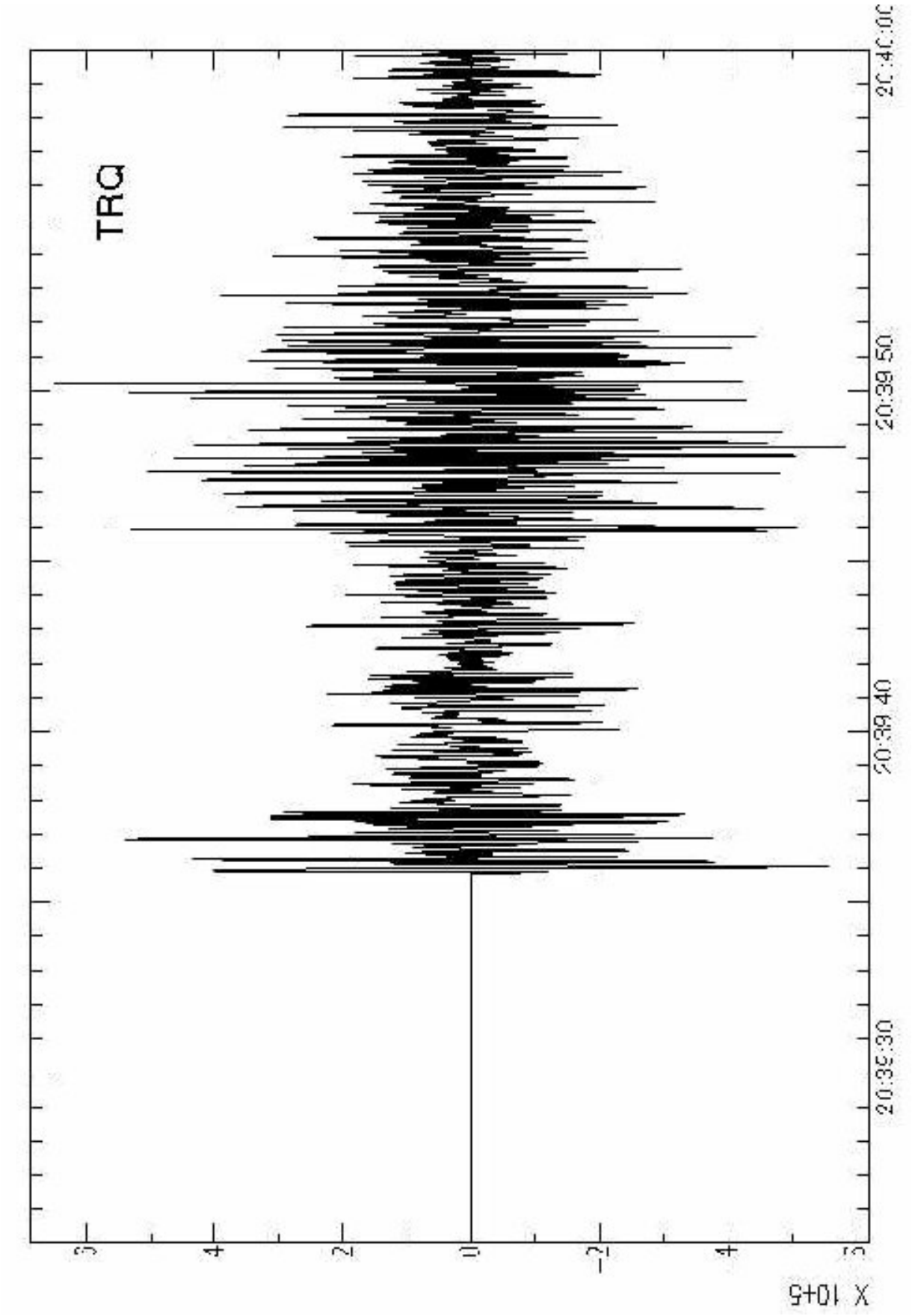
4. The **magnitude** of this earthquake was 4.5. Some felt reports are attached here. Using information from the web (http://earthquakescanada.nrcan.gc.ca/index_e.php), what would be the **intensity** of this earthquake in the Ottawa area? _____

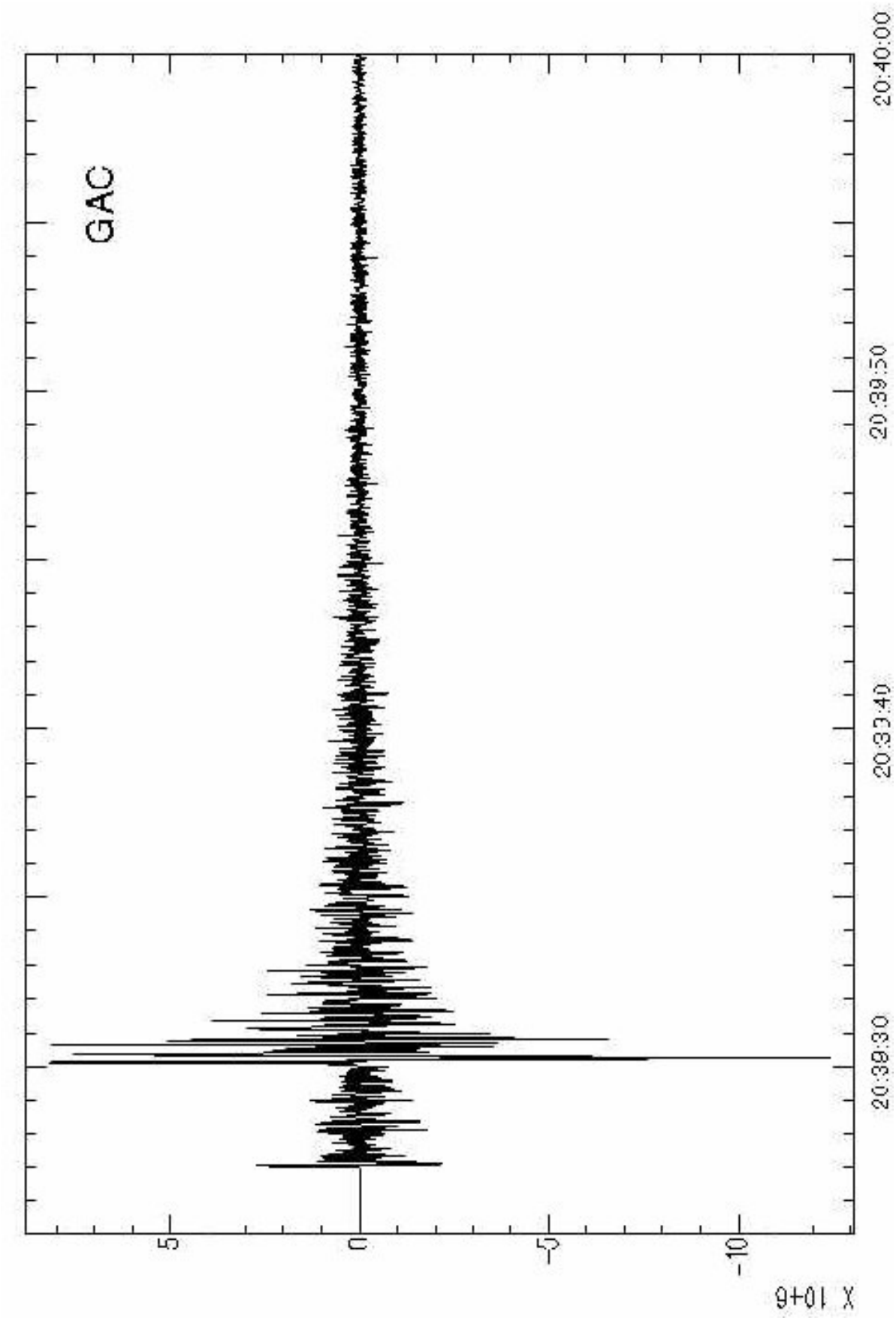
Felt Reports

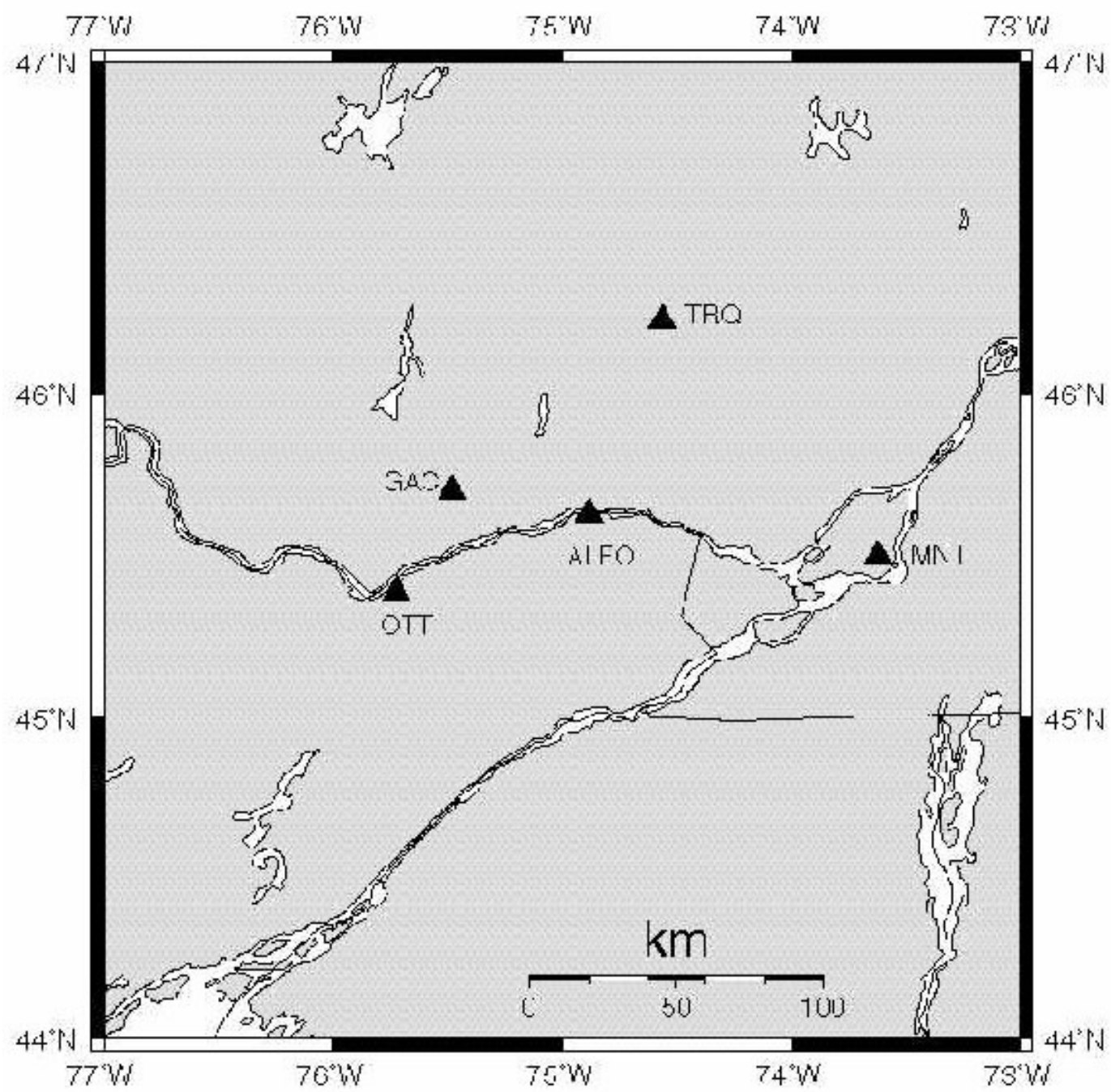
Town	Heard	Felt	Saw	Damage
Carp	Sounded like rumbling of heavy equipment driving through our lot, or like distant thunder. Heard rattling of dishes.	Felt the house shaking	Saw nothing move	No
Rockland	Outside, trees were cracking, I heard the ground growl. Inside, the dishes were rattling, especially the glass and crystal.	Child was not awaken, but the house definitively shook. The outside deck and the floor were shaking. I had trouble getting the door knob and walking straight.	Deck and house shaking. Birds which are normally sleeping at this time of the night, were quite agitated outside. They were flying out of the cedar bushes. My cats went down to the basement and hid for a while. Glasses were displaced in my buffet	No
Hammond	Sounded like earth moving machine starting from rear of property towards the front.	Entire house shook. Lasted 15 seconds. Felt like there were heaving ocean waves under the floor the entire time.		No
Navan	At first we heard a low rumble that felt like it was coming towards us. Then we felt the whole house shake and there was a loud explosion-like sound	the whole house shook	Some pictures were a little crooked and items were knocked over on a bathroom shelf	No
Gatineau	Sounded like 2 large bangs. First one extremely loud followed by rumbling. Second bang also extremely loud followed by rumbling then easing into decreasing vibrations.	Whole house shook, everything was vibrating.	Lamps swayed and at one point the lights seemed on verge of going out as power was fluctuating.	No
Nepean	Sounded as if something had crashed into house or near it such as an airplane.	Entire house shook dramatically. it was very scary	Nail in the studs of our living room walls are now protruding from the wall. You can see all the heads of the nails just under the paint.	Yes, our living and dining room walls


ALFO
20:40:00
20:39:50
20:39:40
20:39:30
2
0
-2
X 10+5


OTT
20:40:00
20:39:50
20:39:40
20:39:30
2
0
-2
X 1045


TRQ
20:40:00
20:39:50
20:39:40
20:39:30
X 10+5
5
4
3
2
1
0
1
2
3
4
5


GAC
20:40:00
20:39:50
20:39:40
20:39:30
5
0
-5
-10
X 10+6


77°W
76°W
75°W
74°W
73°W
47°N
46°N
45°N
44°N
TRQ
GAC
ALFO
MNT
OTT
km
0
50
100