

Landslide activity 4: **Landslides in Eastern Canada: Earthflows**

Description: This lesson consists of a presentation of how and why landslides occur in sensitive clays of Eastern Canada, followed by a choice of activities where students can complete a vocabulary game, label a diagram of an earthflow, or identify the zone at risk of landslides and decide where to locate a new hospital.

Materials: Overheads of 1) Champlain Sea
 2) Sensitive Clay
 3) Failure Sequence
 4) Landslides in Leda Clay of the Champlain Sea
Student worksheets (Vocabulary game, Label the earthflow diagram, Identify the zone of hazard)

Other resources: **Atlas of Canada: Landslides** [PDF] - included as part of these resources

http://geoscape.nrcan.gc.ca/ottawa/landslides_e.php

Duration: Two periods.

Teacher Instructions:

Part A. Teaching lesson (first period)

1. Use overheads 1, 2 and 4 (Champlain Sea, Sensitive Clay and Landslides in Leda Clay). Most of the landslides in Eastern Canada occur in the very sensitive marine clays (Leda Clay) of the Champlain Sea. It is important that the teacher emphasize the unique geological conditions that occurred in the Ottawa-St. Lawrence valleys (rapid deposition in a temporary sea [Champlain Sea] at the edge of an ice sheet) and that most landslides in this region occur in the sensitive marine (Leda) clay of this sea. These landslides are influenced less by gravity and more by the unstable particle structure and high moisture content of the clay. If disturbed, these clays may lose physical strength and liquefy (see overhead 2). This type of landslide is called an earthflow.
2. Explain to the students why the clay is unstable: Leda clay is composed of clay- and silt-sized particles of bedrock that were finely ground by glaciers and washed into the Champlain Sea. As the particles settled through the salty water, they were attracted to one another and formed loose clusters that fell to the seafloor. The resulting sediment had a loose but strong framework that was capable of retaining a large amount of water. Following the retreat of the sea, the salts that originally contributed to the bonding of the particles were slowly removed (leached) by fresh water filtering through the ground. If sufficiently disturbed, the leached Leda clay may lose physical strength and liquefy.
3. Using overhead 3, Failure Sequence, explain each step involved in a Leda clay earthflow. After an initial failure removes the stiffer, weathered crust, the sensitive clay liquefies and collapses, flowing away from the scar. Failures continue in a domino-like fashion, rapidly eating back into the flat land lying behind the failed slope. Driven by its own weight, the flowing mud may flow out for great distances.
4. Discuss the impact of landslides on buildings, humans, wildlife and on river systems.
5. Ask students: "What would you do if a scientist told you that your house is built on Leda clay?"
Note: Not all the clay is unstable. The site must be tested.
6. Present overhead 4, map of Landslides in Leda Clay of the Champlain Sea.
7. Point out the rivers, towns, cities and landslides (earthflows).

8. Ask students if they see a pattern of where landslides tend to occur.

Possible patterns:

- in area covered by Champlain Sea,
- near rivers, although they can occur on other slopes.

9. Have students suggest reasons why they tend to occur near rivers.

Possible reasons:

- erosion of the riverbank, slope of land, etc.

Part B. Activity (second period)

The teacher can choose between activities A, B and/or C.

Activity A: Vocabulary game

- Distribute the worksheet and have students match the word to the corresponding definition.

Vocabulary game answers

1. catastrophic	C	13. clay	M
2. framework	K	14. dam	W
3. unstable	N	15. susceptible	P
4. sensitive clay	I	16. infrastructure	Q
5. geologist	T	17. landslide	U
6. debris	D	18. erosion	R
7. siltation	A	19. infiltrate	G
8. cluster	E	20. bonding	F
9. Leda clay	H	21. silt	L
10. slope	V	22. underlie	O
11. bedrock	S	23. liquefy	B
12. excavation	J		

Activity B: Label the earthflow diagram

- Distribute the worksheet and have students label the diagram with the numbers corresponding to each step in the failure.

Answers:

3. Quick-clay (sensitive clay) zone

7. Weathered crust

1. Firm weathered crust is eroded by river or weakened by ground shaking and a small landslide happens at the slope

5. Sensitive clay underneath the initial failure liquefies and is no longer able to support itself and flows away from the landslide scar

4. This triggers a "domino effect" causing many "slices" to fail, one after another. The original flat land gets "eaten away" as the ground turns into flowing mud

2. Solid blocks of ground may be carried away on the flowing mud

8. The flowing mud moves far away from the landslide scar and the mud may fill the valley

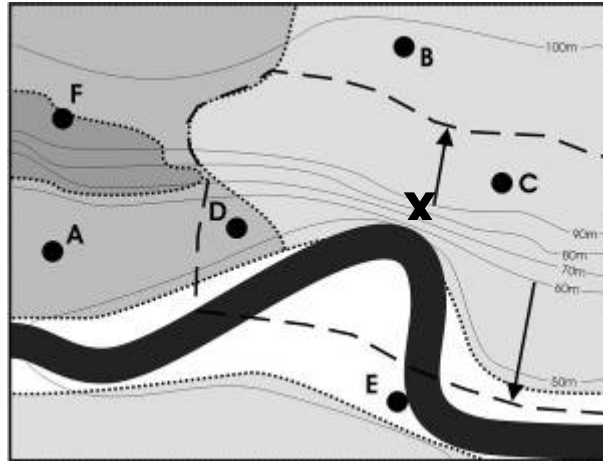
6. Landslide mud (debris) dams (blocks) rivers, causing flooding in the valleys.

Activity C: Identify the zone of hazard

Using a geology map, students must identify the zone at risk of landslides and decide where to locate a new hospital.

- Distribute worksheet and have students follow the procedure.

Answers:

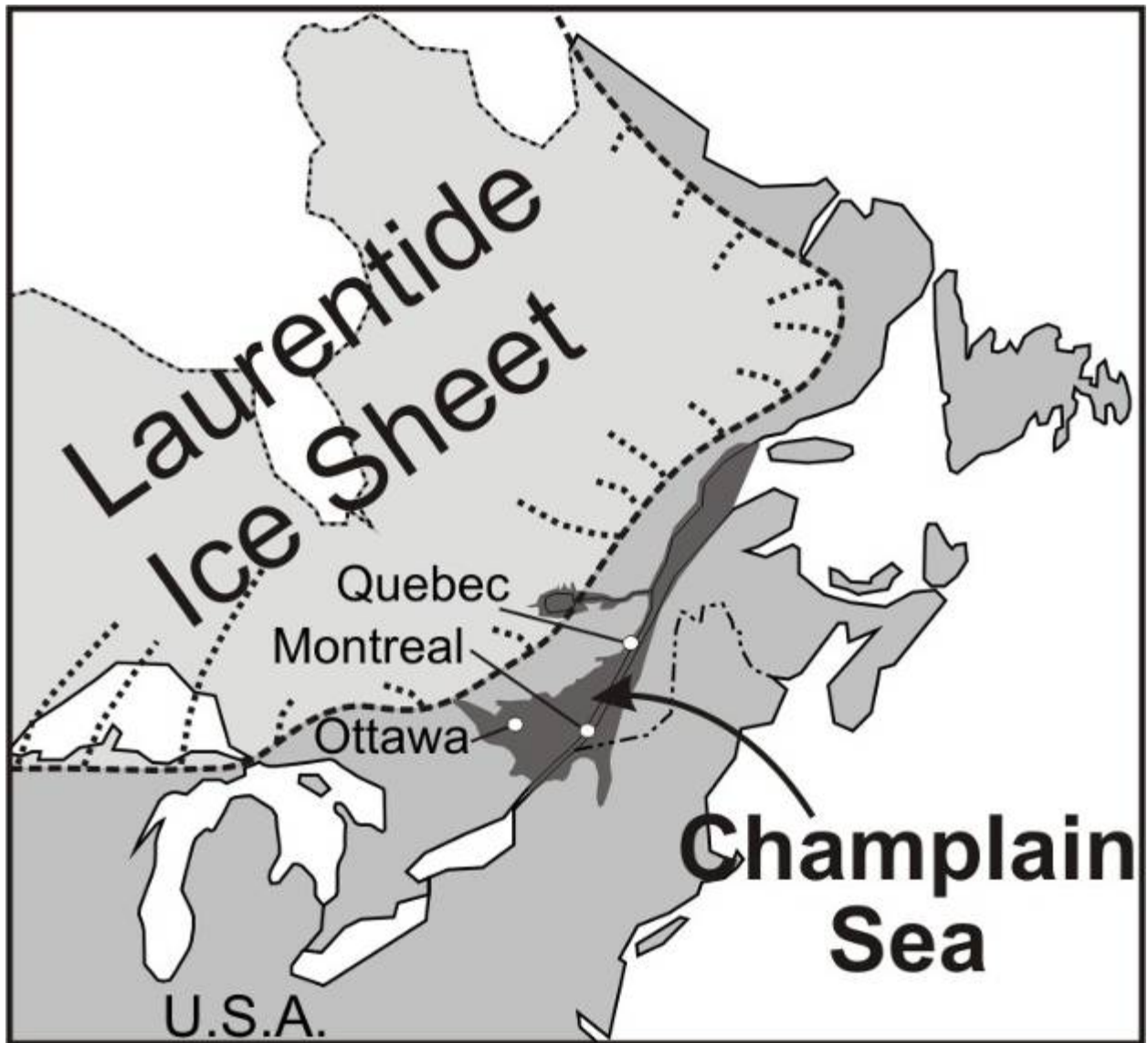


b.

SITE	YES/NO	WHY
A	Y	Not on clay and far from clay slope
B	Y	On clay but outside the hazard zone
C	N	On clay and inside the hazard zone
D	N	Not on clay but inside the hazard zone. Could be buried.
E	N	Not on clay and outside hazard zone, but very close to river – danger of flooding
F	Y	Bank is bedrock.

- c. Landslide is most likely to occur near the bend in the river because the river may be eroding the bottom of the slope.

Champlain Sea



Sensitive clay



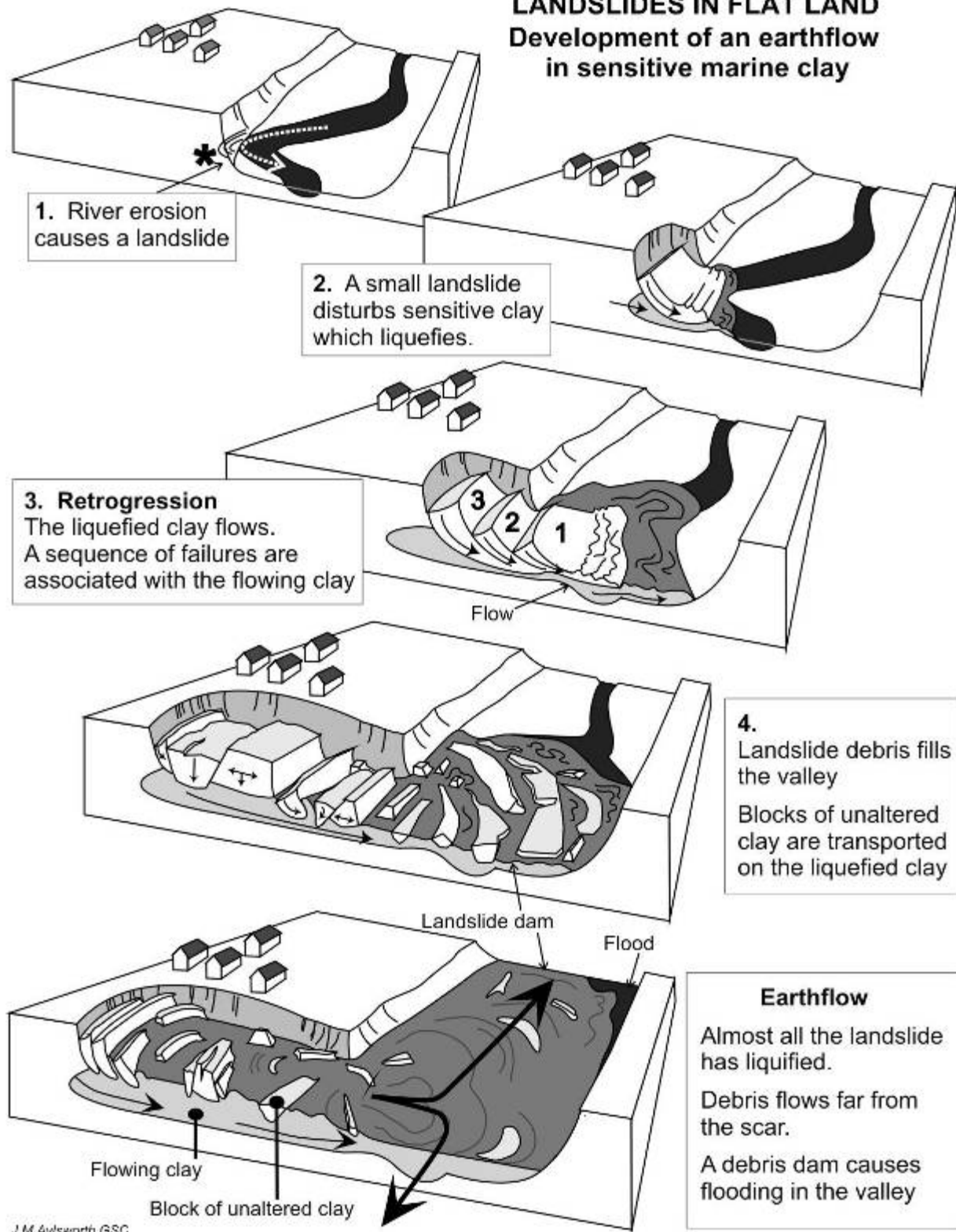
Photo: H. Schade, NRC

The same clay

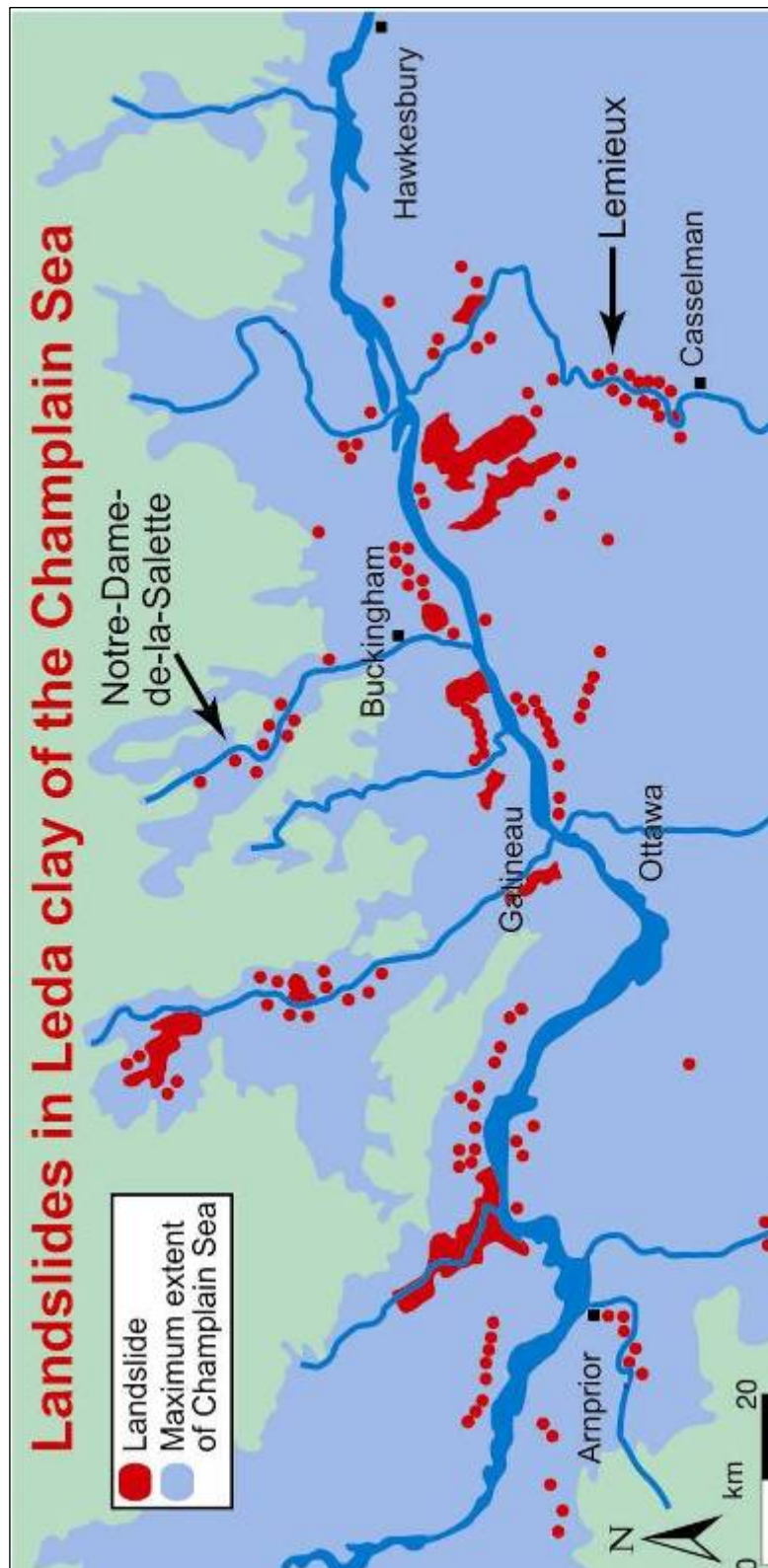
If disturbed, sensitive clay may lose all physical strength and behave like a liquid.

Failure sequence

LANDSLIDES IN FLAT LAND Development of an earthflow in sensitive marine clay



Landslides in Leda clay of the Champlain Sea



Landslides in Canada

Select the correct answer.

1. All Canadian Provinces and Territories have landslides.
True or False?
2. Landslides only occur on mountains.
True or False?
3. The provinces with the greatest number of disastrous landslides are:
 - a) Quebec and Ontario
 - b) Alberta and British Columbia
 - c) Newfoundland and Alberta
 - d) British Columbia and Quebec
4. Most landslides occur in bedrock.
True or False?
5. About 6000 people have been killed by landslides in Canada in recorded history.
True or False?
6. Where was the worst landslide disaster in Canada?
 - a) Hope, British Columbia
 - b) Frank, Alberta
 - c) St-Jean-Vianney, Quebec
 - d) Burin Peninsula, Newfoundland
7. Most landslides are caused by human action.
True or False?
8. A landslide can dam a river and cause a flood.
True or False?
9. An earthquake can cause a landslide.
True or False?

Student Quiz 1 – Pg 2

10. In 1929 an underwater landslide caused a tsunami that hit Newfoundland.

True or False?

11. Damage to buildings during landslides can be caused by:

- a) collision from heavy debris
- b) burial under debris
- c) collapse of ground under the building
- d) flooding upstream of a landslide dam
- e) all of the above

12. People should not build houses on unstable slopes.

True or False?

13. There are a number of ways to protect a community from the danger of a future landslide.

True or False?