part 1) How did landscape evolve and where do “clay” minerals come from?

part 2) How were they deposited in Lake Vermont/Champlain Sea?

part 3) Can we predict the distribution of “clay” thickness? (…can we compare prediction with what people observe)
~500,000,000 years:
Sediments of “Champlain Valley Sequence” deposited on shoreline of ancient ocean

~460,000,000 years:
Collision of island arc causes thrusting + metamorphism
Champlain Thrust:
- Exposed at Snake Mtn + Mt. Philo
- Delineates boundary between “low” and “mid” grade metamorphic rocks
- Marbles pf middlebury syncline folded along back of thrust
Topography of Addison County reflects erodibility of bedrock:

- **T1**: lower surface: “low grade” sedimentary rocks below thrust (e.g. shale)
- **T2**: upper surface: “mid grade” meta-sedimentary rocks above thrust (e.g. marble)

*Green Mountains* = “high grade” metamorphic rocks (e.g. schist and gneiss)
Part 2: How were clays deposited in Lake Vermont and the Champlain Sea?

500,000,000 years

~96,000 - 20,000 years (i.e. yesterday...):
Champlain Valley sat below 1-3 km of ice

Today

Soils and clay minerals from previous inter-glacial cycles were stripped by advancing glaciers

Rocks were ground into “clay size fraction” and trapped under ice
retreating glacial ice withdrew from Champlain Valley between ~14-13 kyr
Many depositional features in Champlain Valley record ice retreat

- Layers of “basal till” deposited beneath ice sheets (coarse, angular, poorly sorted debris)

- Meltwater streams flow between glacier and hillslopes

- Sedimentary deposits accumulate, leaving ‘kame terraces’ when glacier retreats
Lake Vermont had 2+ stages:
**Coveville**: Ice dammed in So. New York
- Shoreline elevations: ~170m

**Fort Ann**: Overflowed at Fort Ann, NY
- Shoreline elevations: ~120m

**Key point**: extremely turbid lake?
- no fish or ecosystem?
As ice retreated from valley, ocean water rushed in from St. Lawrence river, creating the **Champlain Sea**

**Champlain Valley was below sea level...**

**Crust had undergone “isostatic subsidence”- sinking into Earth’s mantle under the weight of the ice sheets**
Lake Vermont, Champlain Sea, Lake Champlain sediments deposited atop each other in the deepest parts of Champlain Basin.

Question: How are properties of clays different from one another?

Answer: I have no clue... didn't look into it....
...except Champlain Sea “quick clays” in Quebec are famous....

Radar image of Lake Champlain bed - taken in open lake.
Part 3: What should spatial distribution of clays look like in Champlain Valley?

A few key ideas:
- Coarser sands and silts must be deposited in shallow water
- Thicker deposits closer to river mouths (deltas)

**Question:** Do we expect clays to be thicker near deltas, or same everywhere?
**Question:** Do we expect clays to be thicker near deltas, or same everywhere?

**Three considerations:**

1) **water depth in Lake/Sea**

2) “fetch” of open water + wave size (larger in bigger lakes)

3) **settling velocity of clay particles:** theoretical = 0.000064 cm/sec
   (should takes months to settle!!!)

**Answer:** probably thickest where water depth drops below wave base around delta
- Clays probably settle in days-weeks by aggregation + flocculation once reach deep water

“wave base”: depth below which waves do not disturb sediment: 6-12 m in Lake Vermont??

Where is water deep enough to deposit lake Vermont and Champlain sea clays?

Odd, 1982
Preserved shoreline features and deltas allow us to estimate water depth.

- Shorelines of Champlain Sea and Lake Vermont rise to north due to isostatic rebound.

**Key point:** Champlain sea clays become more spatially extensive as you go north.
Lake Vermont (Coveville)

Cover upper “T2” surface:
Monkton, New Haven, Middlebury, Salisbury, Leicester

Champlain Sea extent

Cover lower “T1” surface:
Ferrisburgh, Panton, Addison, Bridport, Shoreham

Key point: when working in “T1” towns, expect to deal with Champlain Sea clays...

A different beast?
prediction 1: clay should be thicker within 5-10 km of deltas?
   - **Thinner on ridgelines**: water was shallower + sub-surface currents stronger
     - Post Champlain Sea redistribution

prediction 2: clay should be thicker in local valleys + hollows
   - water is deeper + protected from sub-surface currents stronger

**Question**: What is role of landscape processes in redistributing clays after deposition?

**Closing Question**: What do practicing geologists, septic designers, and excavators know about thickness?

Need data to test ideas....
Summary of key differences between Lake Vermont and Champlain Sea:

**Lake Vermont:**
- Freshwater
- Relatively short lived (< 1000 years)
- Larger extent + Deeper water
- Higher sediment Load

**Champlain Sea:**
- Marine salt water
- Long lived (several thousand years)
- Smaller extent + Shallower water
- Lower sediment load