UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

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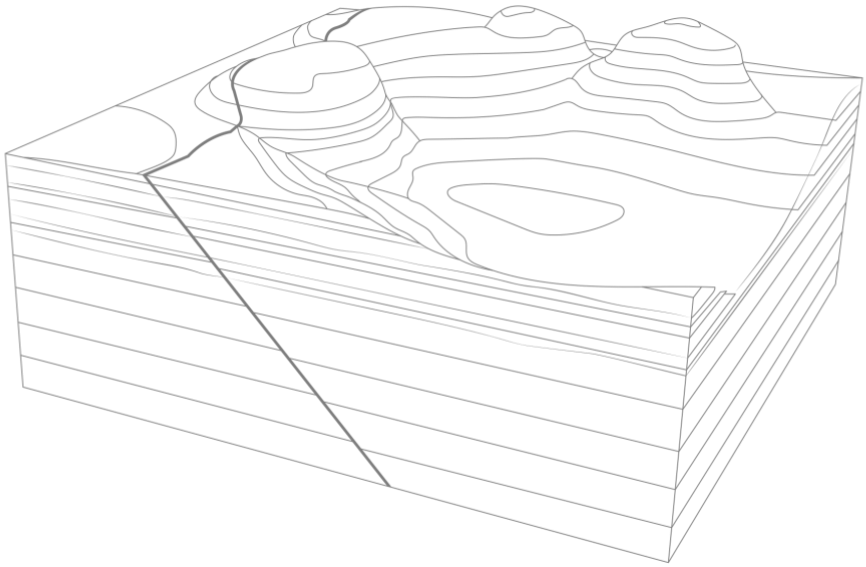

Lesson plan

Geological layers: Superposition, tilted beds and strike and dip

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Learning objectives:

- Apply the law of superposition to identify the youngest and oldest rocks in a layered sequence
- Identify the strike and dip of a tilted planar surface
- Represent the strike and dip of a geological layer on a map using symbols

Key Visible Geology skills:

- Add new geological layers to a block model
- Apply a lilt angle to layers
- Add decals to represent the strike and dip

Timelines:

- Workflow 1 – 6: ~30 mins
- Questions & exercise: ~30 mins

Glossary:

- See page 6

VisibleGeology

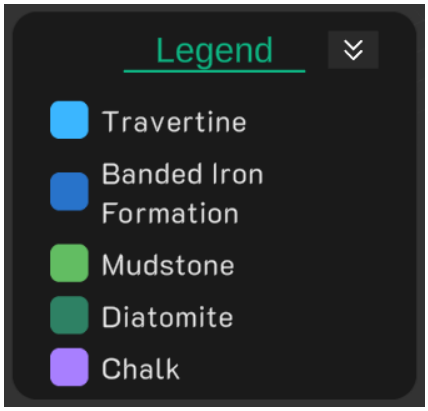
Geological layers: Superposition, tilted beds and strike and dip

Workflow

1. First of all, using Geology Explorer, let's add layers until the block model is completely covered.

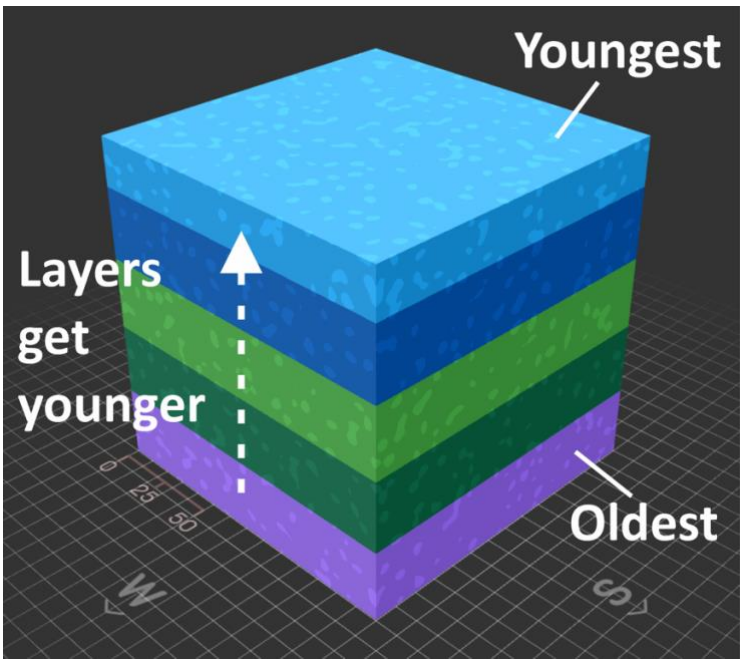
   Layers -> '+' until the block is completely filled with coloured layers.

2. What do the layers represent? Look at the legend on the bottom left of the screen – each coloured layer represents a different rock type! (You can customise what each layer is called, but we don't need to do that now). Notice how the order of the layers in the legend matches the order of the layers in the model, i.e., the uppermost layer in the model is at the top of the legend and the lowermost at the bottom.



ⓘ Learning observation!

If we assume that each layer was successively deposited on top of the previous one, we can assume that the oldest layer is on the bottom and the youngest is on the top. This principle is known as the **law of superposition** and we can use it to infer the order in which different rock types were deposited.



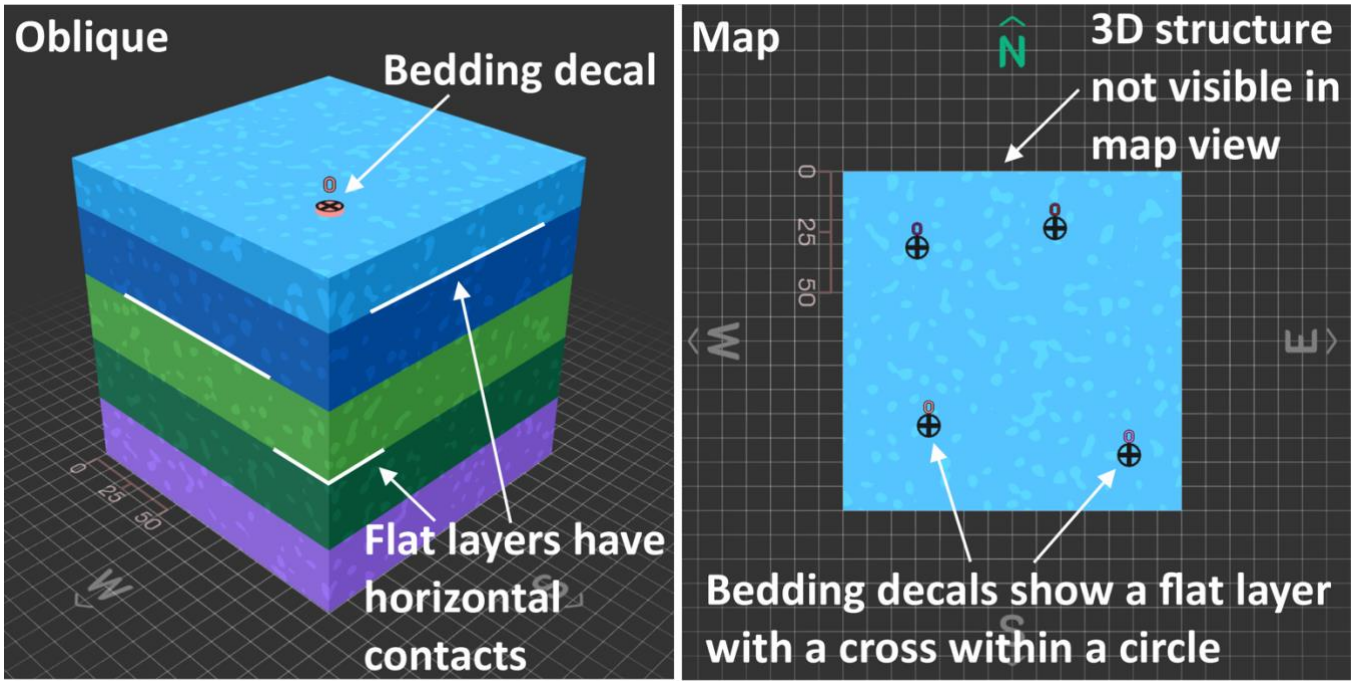
This is useful when we are trying to reconstruct the **geological history** of a place: if we know the conditions needed to form a certain rock type (e.g., limestones form in shallow warm seas and mudstones in deeper oceans), and we know the order that they occurred in (e.g., a limestone layer below a mudstone layer) then we can start to tell the story of what happened here long ago (e.g., an area of shallow warm sea was progressively covered by more water, possibly due to global sea level rise as the climate warmed, until it was at the bottom of a deeper ocean).

3. The law of superposition is easy to see when the layers are flat. We can see the layers are flat because Visible Geology gives us a 3D view of the block. However, if you rotate your view so you are looking straight down on the block, you are in 'map' view. All you see now is the colour of the youngest block with no indication of whether that layer is flat or tilted to one side! To help with this, we can use 'decals' (a.k.a. bedding labels) to a map to represent the angle of the layers. Add decals to your block to show that the layers are flat.

   Decals -> New Strike & Dip Decal -> you can adjust the location of the decal by dragging it with your mouse -> Apply

ⓘ Learning observation!

For horizontal layers, the **dip** (i.e., the angle of tilt from **horizontal)** is 0° and is represented by a cross within a circle. The number located next to a bedding decal is the dip angle of that layer.

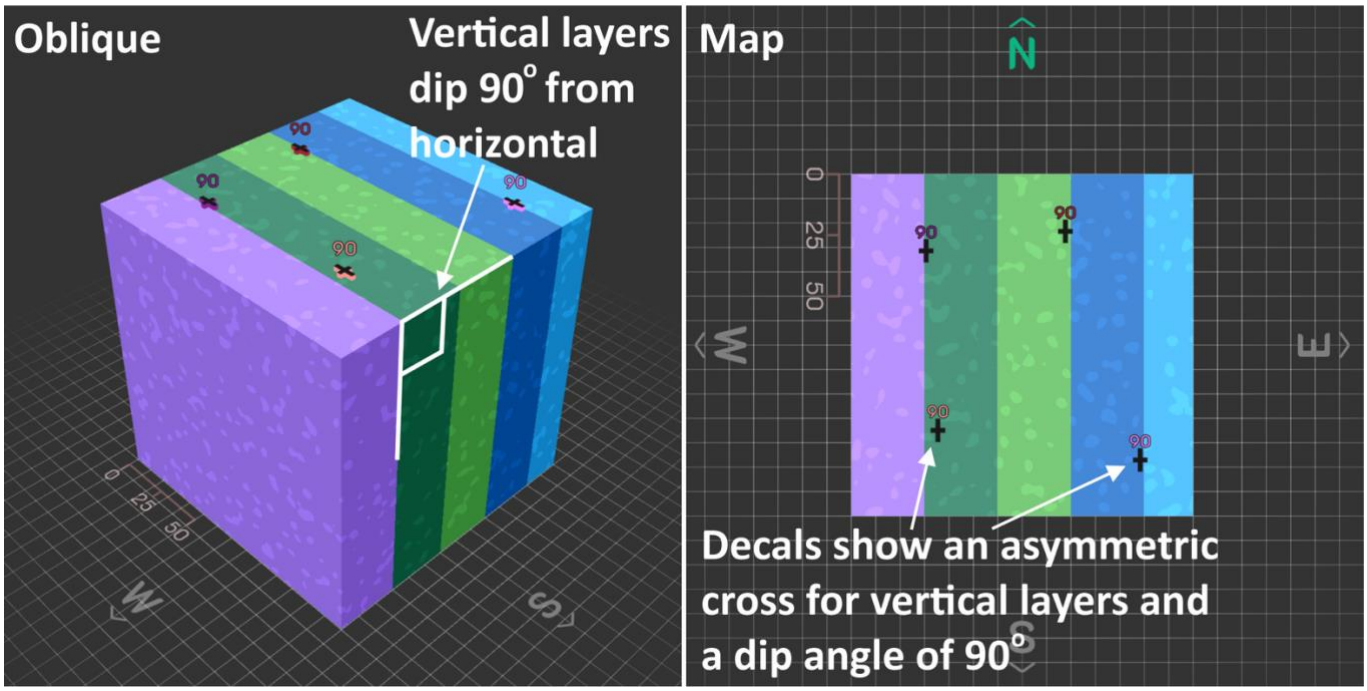


4. But what happens when the layers become tilted to one side? Let's explore this by first tilting the layers until they are vertical! Note: we call the tilt of a layer the 'dip' of that layer, but more on that below!

   Events -> Tilt -> strike = 000, dip = 90

ⓘ Learning observation!

For vertical layers, the **dip** (i.e., the angle of tilt from horizontal) is 90° and is represented by an asymmetric cross decal. The **strike** of the bed is parallel to the **lateral orientation** of a vertical bed.

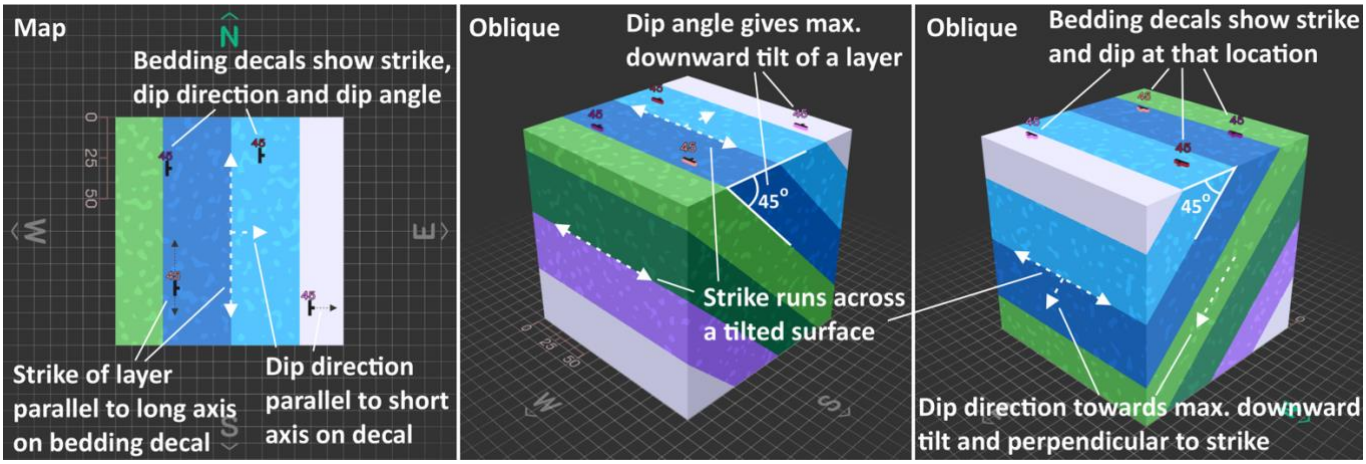


5. Now, let's tilt the layers at an angle between horizontal and vertical (keeping the oldest layer on the bottom).

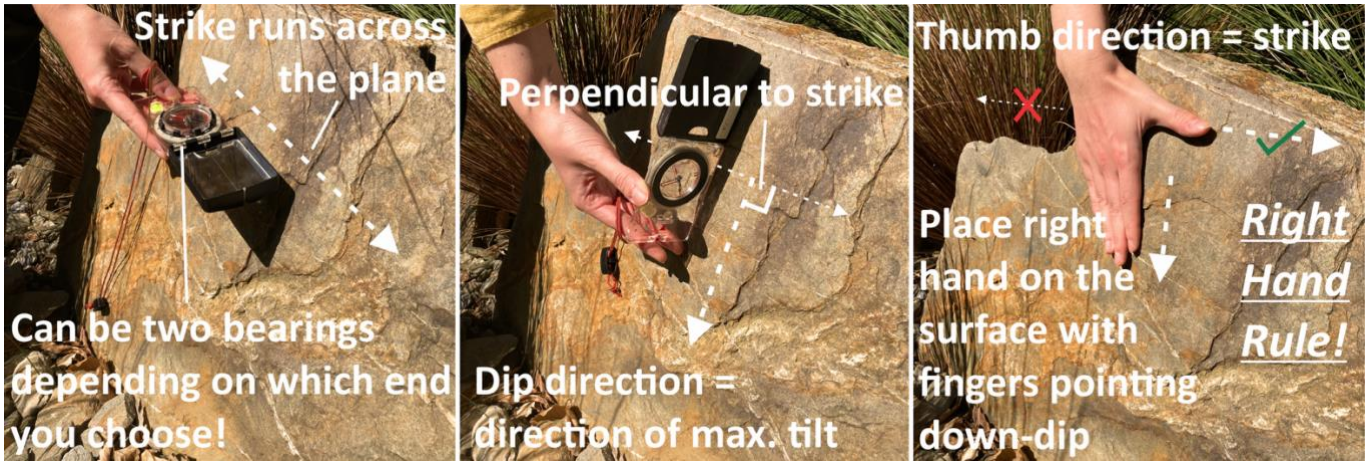
   Events -> Tilt -> strike = 000, dip = 45

ⓘ Learning observation!

For tilted beds the maximum **dip angle** is measured from horizontal and is always between 0 and 90°. The direction of downward tilt is recorded as the **dip direction**. The **strike** runs along a line across the surface with a dip of 0°: imagine walking across a hillside so that you don't go uphill or downhill at all but just travel straight across – this is the strike of a plane! The strike is **always** 90° (perpendicular) to the dip direction.



The strike is given as a bearing – a compass direction between 0° and 360°. As you might have noticed, the strike is a line and therefore can give two different bearings (directions) depending on which way you look! When recording strike and dip measurements from a plane, we take the strike bearing 90° **anticlockwise** from the dip direction. This is also known as the **right-hand rule**: if you place your right hand on a plane with your fingers pointing straight down the surface in the direction of dip and extend your thumb out to the side, you take the strike bearing in the same direction as your thumb!



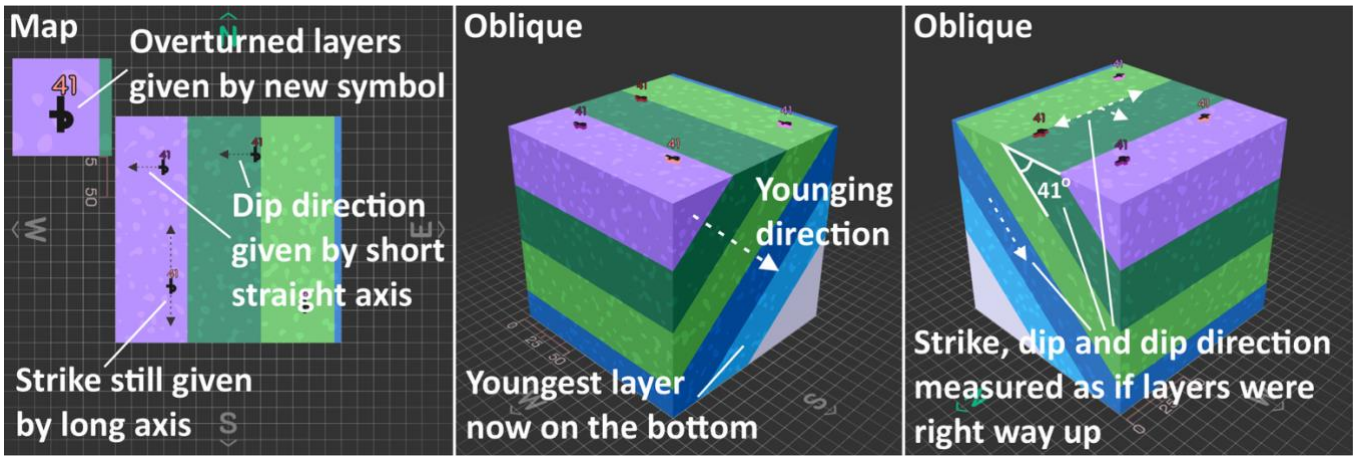
When recording strike and dip measurements in the field, or importing data into Visible Geology, the strike reading of a plane is given as three digits (e.g., 020, 116, 003) and the dip just two (e.g., 43, 26). As a back-up test to check we've used the right-hand rule correctly, we can also note down the dip direction (e.g., NW, S, SSE) when recording strike and dip measurements in the field: if your recorded dip direction is 90° clockwise from your strike, you've nailed it! If your dip direction is 90° anticlockwise from your strike, you've probably recorded the other strike bearing..! (you can quickly correct this by just adding 180° to the value you recorded).

6. Now that we're comfortable with tilted beds and reading bedding decals, let's have some fun! Rotate the layers and see how the bedding decals change as you do so. What happens to the bedding decals if you tilt the layers so far over that the oldest layer is now above the youngest?

   History -> Tilt -> edit -> click and drag on the red arrow

ⓘ Learning observation!

If beds have been completely overturned the youngest rocks are no longer on the top but are now on the bottom. This is represented on a map by the overturned bedding symbol.



Questions

- What geological processes might cause layers originally deposited horizontally to be tilted?
- How might you be able to tell if beds are still the right way up (i.e., the oldest layer is still at the bottom)?

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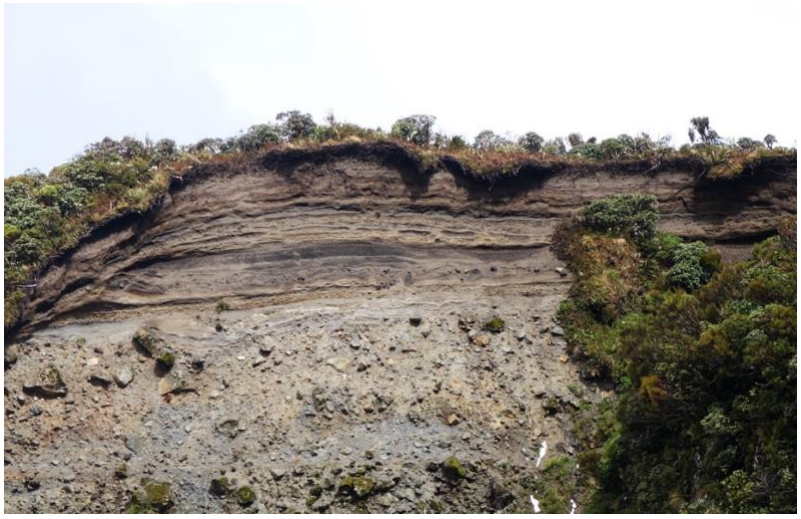
7. Now let's use what you've learned! Below is a table of dip and strike measurements. For each dip and strike reading, draw the appropriate bedding symbol in the table (make sure your symbol is orientated appropriately – if you don't have a compass then just approximate, e.g., if strike = 045 then align your strike NE). Then, adjust your block model in Visible Geology so your layers have the same dip and strike reading. Compare your symbol with the ones in Visible Geology and see if you were right!

Strike	Dip	Symbol
022	45	
264	12	
128	60*	
346	89	
199	06*	

*overturned

Real-world examples



Horizontal layers of explosive volcanic deposits. The law of superposition tells us the layers on the top are from the most recent eruptions, with each layer below being older than the one above. Taranaki Mounga, Aotearoa/New Zealand. Photo: Henry Hoult

Tilted mudstone and sandstone beds dipping south-east. Cape Foulwind, Aotearoa/New Zealand. Photo: Henry Hoult

Glossary:

Bedding: parallel layers within sedimentary/metamorphic rocks of different characteristics.

Planar: forms a flat surface/plane (e.g., geologic bed, contact, fault, laptop cover, car windscreen, chopping board).

Strike: The orientation of a horizontal line (tilt = 0°) along a planar surface (i.e., the direction the plane is travelling in). Will *always* be orientated perpendicular (90°) to the dip.

Dip: The maximum downward tilt angle of a surface from horizontal, measured in degrees. Will *always* be orientated perpendicular (90°) to the strike.

Orientation: direction of a feature in 3D space.

Contact: the interface between two different rock types.

Bearing: An orientation measurement taken from a compass and given between 0° and 360°.

Overturned: Geological layers that have been tilted over until the layer is now upside-down.

Law of superposition: The concept that the oldest layers formed first, and successively younger layers are deposited on top of the older ones.

Younging direction: The direction through a sequence of geological layers that moves from older to younger layers.

Geological history: The sequence of environmental, magmatic and tectonic events that created all the rocks within a given area and lead to their current distribution at the surface.

Right-hand rule: A method to consistently record the strike of a planar surface as the bearing 90° anticlockwise from the dip direction.