UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

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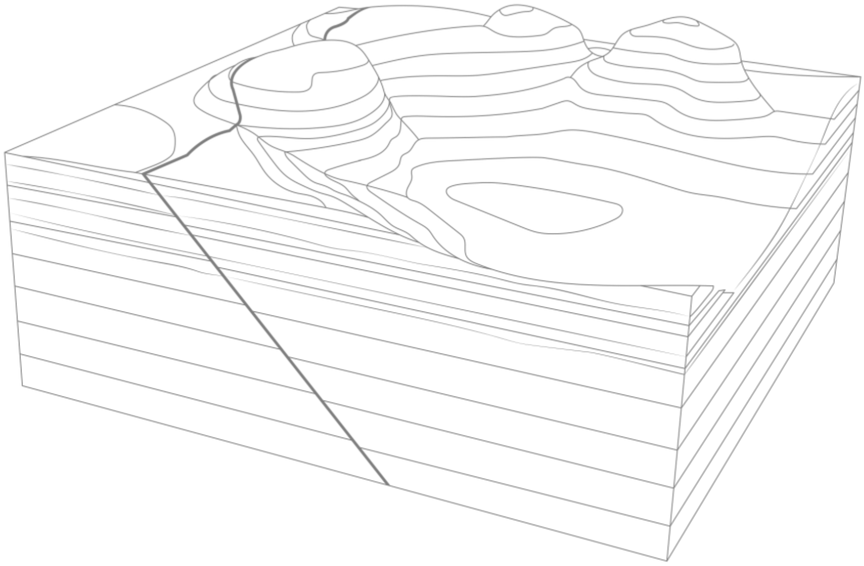

Lesson plan

Igneous intrusions: dikes, sills and plutons

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Learning objectives:

- Distinguish dikes, sills and plutons based on their shape, orientation and contact with host rocks
- Use cross-cutting contacts to identify age relationships between intrusions

Key Visible Geology skills:

- Apply dikes and change their orientations
- Create sills using the dike feature
- Create plutons and change their dimensions

Timelines:

- Workflow 1 – 5: ~20 mins
- Questions & exercises 6 – 7: ~30 mins

Glossary:

- See page 5

VisibleGeology

Igneous intrusions

Igneous intrusions are volumes of magma that cooled and solidified *within* the crust. Magma travels upwards through vertical **dikes** and laterally though horizontal **sills**. If magma stalls and begins to accumulate in one place, it forms a **pluton**! We call all of them intrusions because they *intrude* the pre-existing rocks surrounding them (a.k.a., the **host rock** or **country rock**). This means the magma must have arrived *after* the host rocks formed and therefore must be *younger* than the host rocks. The contact between an intrusive body and the host rock is called an **intrusive contact** (for more on different types of contacts, see the 'Unconformities' module!). Igneous intrusions are responsible for significant mineral deposits around the world, so being able to identify and map their features is very important!

Workflow

1. Let's start by adding some more layers to your block model until the whole cube is filled in.

   Layers -> add layers -> Apply

2. Next, add a steeply dipping dike.

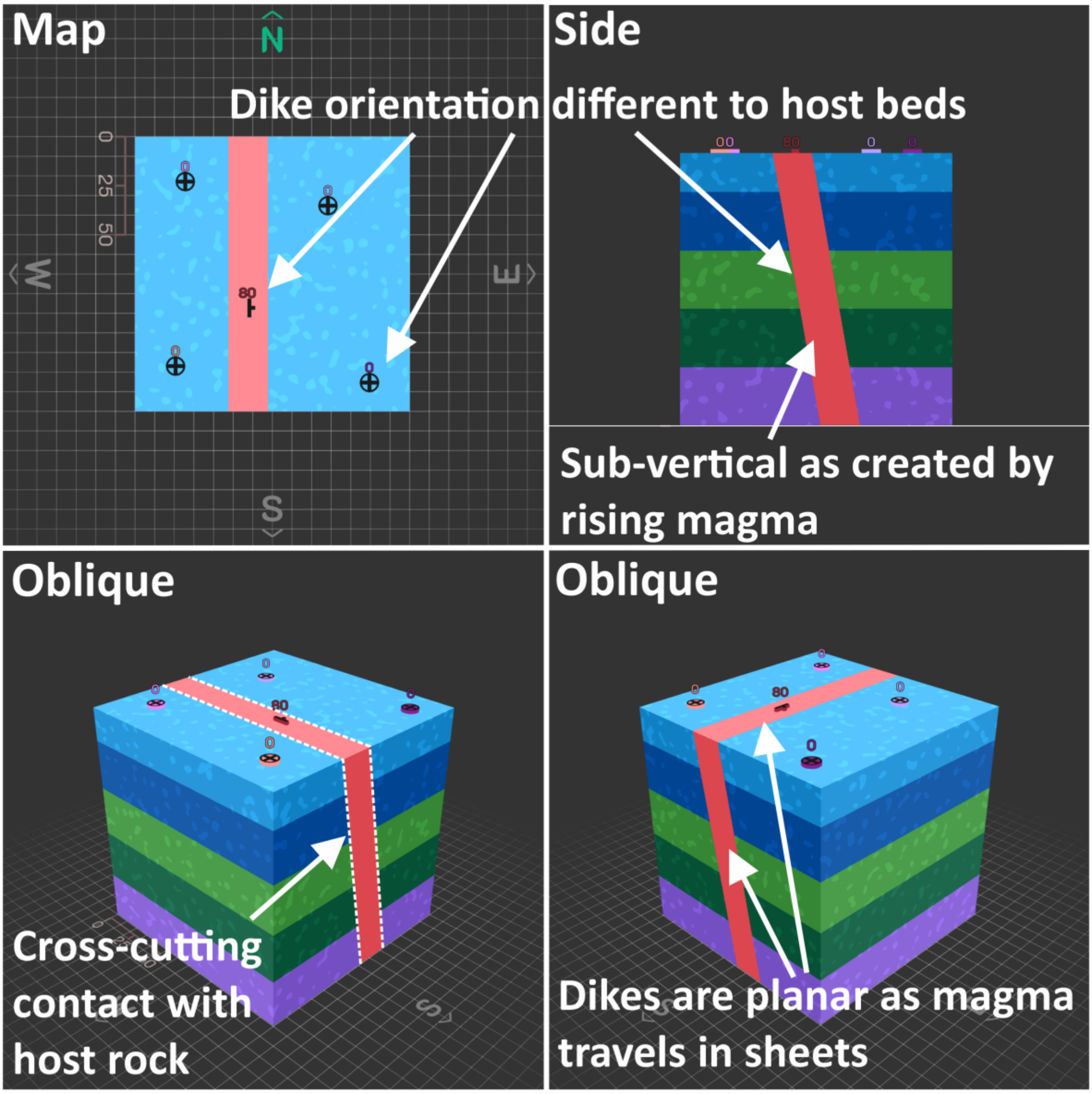
   Events -> Dike -> dip = 80 -> Apply

3. Now, add some bedding markers to highlight this.

   Decals -> add new decals with at least one within the dike and several others across the host rocks

ⓘ Learning observation!

Dikes are the vertical pathways magma takes at it rises up through the crust. In 2D (i.e., on only one side of your VG model) they can look like narrow pipes. However, in 3D, we know they are planar features as magma travels in sheets (essentially a long magma-filled crack!). Notice how the dike cuts across the layers of sedimentary rocks hosting it. We call this a **cross-cutting relationship**, and these are incredibly useful as they show us the age relationships between rock types! As the dike cuts across the sedimentary layers, it must be younger than them (matching the order we created them in).

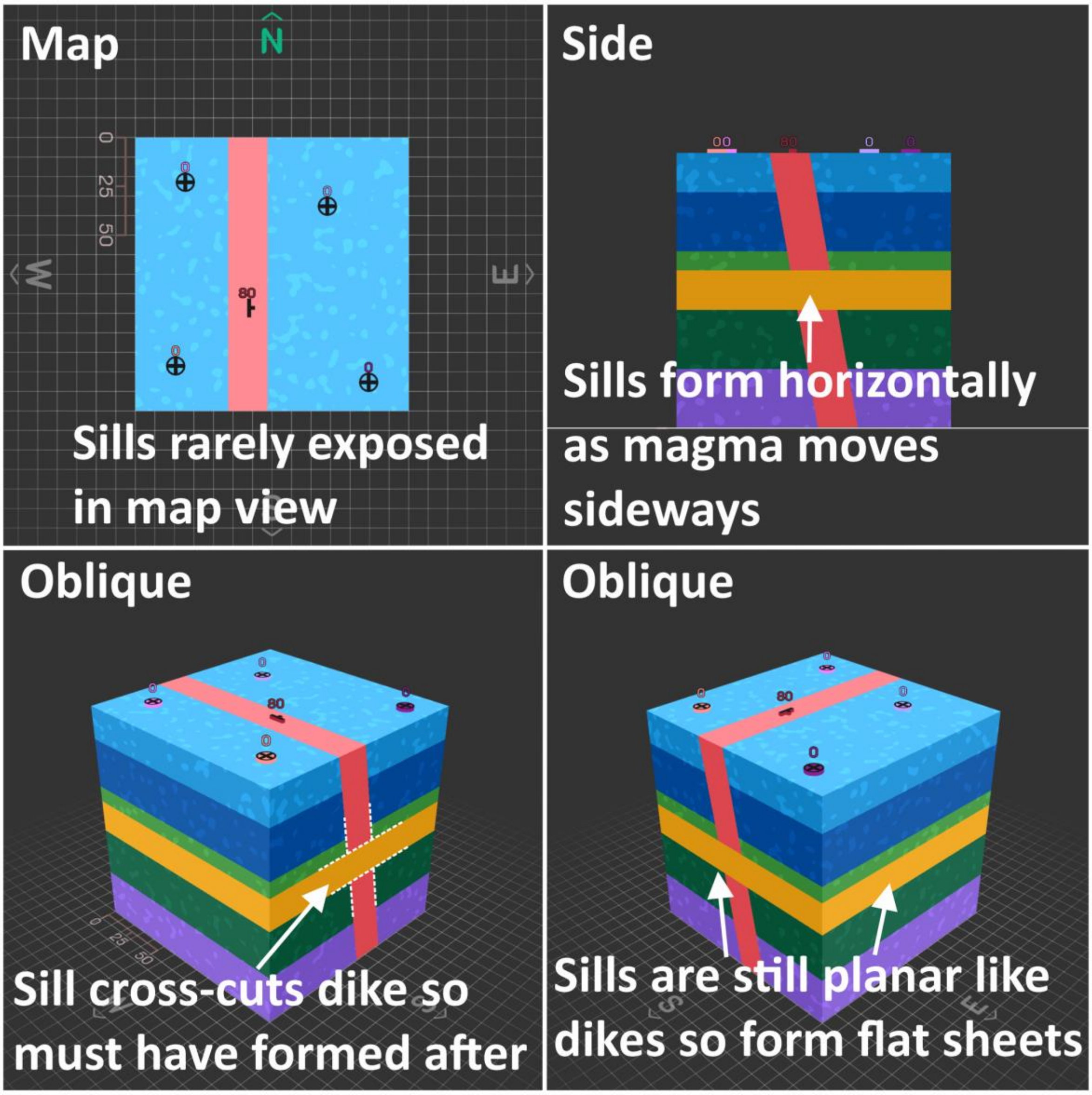


4. What happens if magma was flowing sideways, rather than up? Add a horizontal dike and let's see!

   Events -> Dike -> dip = 0 -> Apply

ⓘ Learning observation!

Horizontal intrusions are called **sills**! They show where magma was travelling sideways through the crust, usually because rising magma reached a hard layer above that stopped it from rising any further. They are planar features like dikes and often follow the contacts between two different rock types (e.g., the horizontal layers in our model).



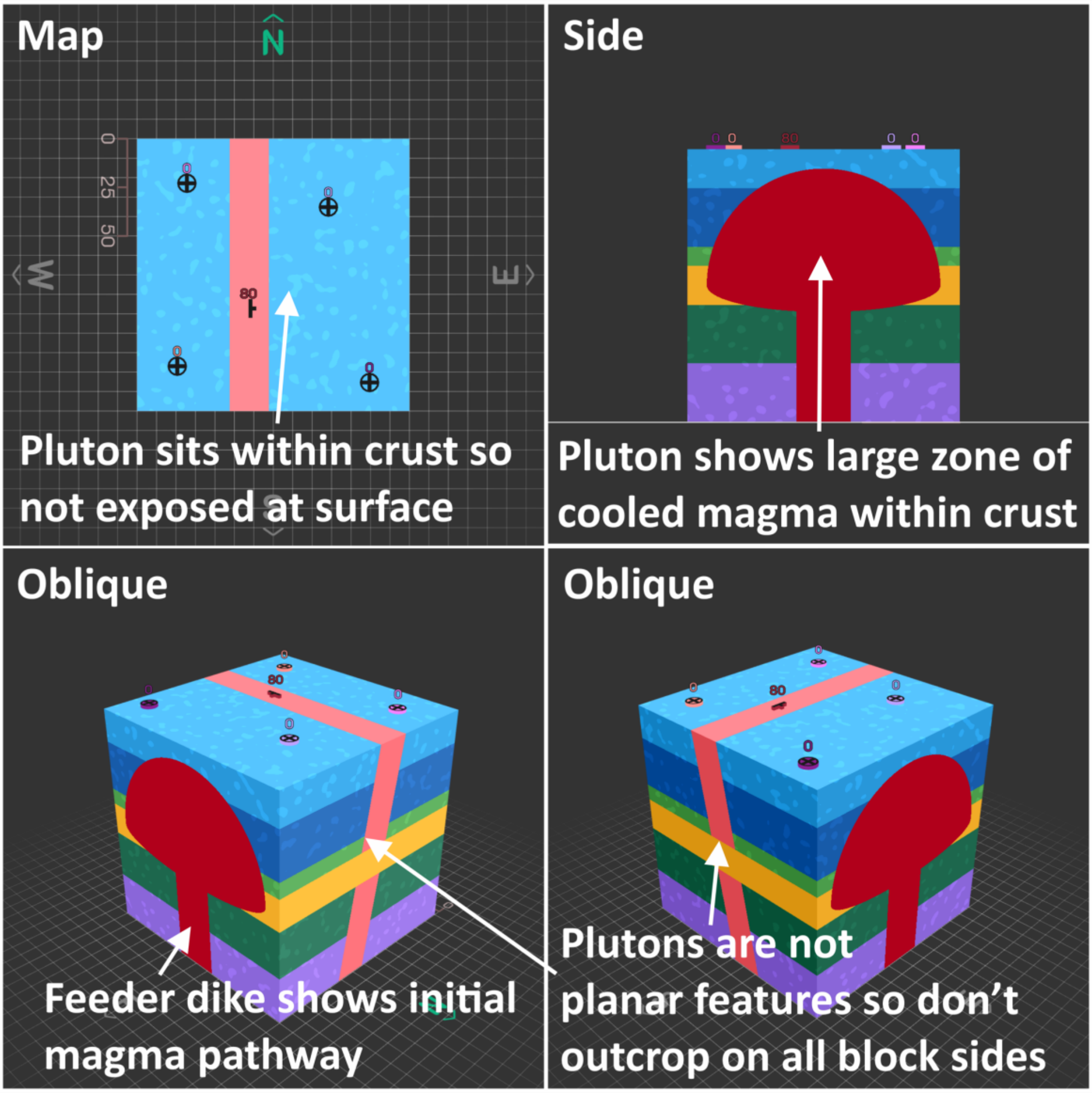
Also notice how the sill cuts across the dike and so must have come through *after* the dike. Note: if sills become so thick they push the overlying rocks upwards into a dome shape, they are renamed laccoliths.

5. Now, let's add a pluton! Try changing its dimensions and move it around to get a feel for its shape in 3D.

   Events -> Pluton -> Edit the dimensions, then return to: Cap radius = 60, Dike radius = 14, Trend = 000, Plunge = 90 -> Apply

ⓘ Learning observation!

Plutons are large storage regions of magma (a.k.a. 'magma chambers!'). They show where ascending magma stalled and cooled within the crust. Because a large region of hot magma takes a long time to cool, crystals can grow to large sizes, so plutons now exposed later at the surface by uplift and erosion show coarse crystalline textures. The main body of a pluton is fed by one or more sub-vertical dikes from below.



Multiple plutons nested together can form very large areas of intrusive rocks. We call these **batholiths**. This typically occurs within volcanic arcs where lots of batches of magma are rising through the same area of thick crust. A famous example of an exposed batholith is Yosemite National Park in the USA!

6. Now, let's explore how plutons might be exposed and mapped at the surface today. Move the pluton laterally so it's completely contained within the block and doesn't appear on any face. Then, take a screenshot of map view (i.e., from above) and add it to a blank word document.

   History -> Pluton -> Edit -> Location tab -> drag on the red arrows to move the pluton into the centre -> Apply

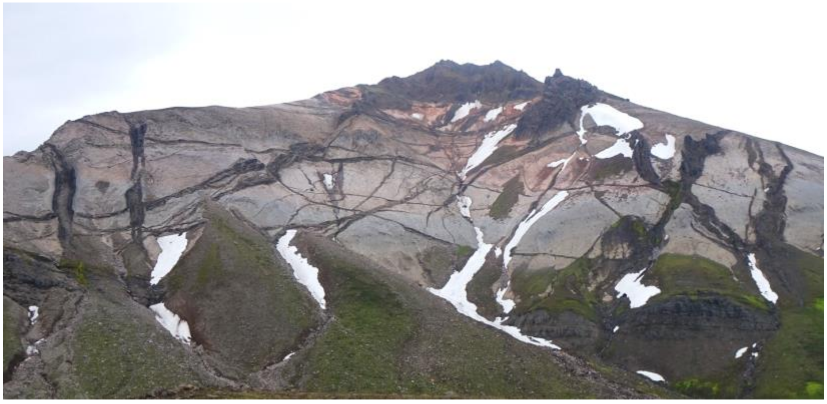
7. Next, introduce the different pre-made topographies within Visible Geology to see how the pluton becomes exposed on the surface. For each topography, take a screenshot of map view and add it to the word document containing the pre-topography screenshot. Compare how the shape of the pluton, dike and sill exposed in map view changes between topography types! Hint: as dykes and sills are planar, you can use the Rule of V's to anticipate how they will outcrop.

   Topography -> Cliff, Hill, Mountain, etc.

Questions

- Based on the contact relationships between the pluton, sill, dike and host rocks in your model, which is the oldest and which is the youngest? Does this match the order you made them in?
- Dykes and sills are planar features formed from the movement of magma. How might measuring their strike and dip be useful when reconstructing the geological history of an area?
- In Visible Geology, the rocks surrounding the intrusion do not visibly change after you introduce a dyke or a sill. Would you expect this to be the case in the real world?
- Metal deposits are often found in the zones around intrusions where hot fluids interact with the country rock. How might your new knowledge of igneous intrusions be useful to a mining company looking for these metal deposits?

Real-world examples



Vertical and sub-vertical dykes (black) exposed cutting up through a mountainside. Hvitserkur, Iceland. Photo: Ben Kennedy

The horizontal Whin Sill (black cliff) exposed on both sides of a valley. High Cup Nick, England. Photo: Henry Hoult

Glossary:

Igneous: rocks formed from cooled magma.

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

Dike: a vertical/subvertical, planar intrusion of magma.

Sill: a horizonal, planar intrusion of magma.

Pluton: an intrusive body of magma within the crust

Laccolith: a sill that deforms the overlying country rock.

Batholith: a series of nested plutons that form a very large body of intrusive rocks.

Host rock/country rock: the pre-existing rocks the magma intruded into.

Intrusive contact: contact between intruding magma and the surrounding host rock.

Cross-cutting relationship: The overprinting contact between two geological units indicating one was created after the other.

The granite walls of Yosemite Valley within the Sierra Nevada Batholith. Yosemite National Park, USA. Photo: Henry Hoult

Batholiths really do make impressive landscapes and often lead to a characteristic steep sided but rounded topography due to the hard crystalline rock, especially if carved by glaciation. In Aotearoa New Zealand, granite batholiths underpin much of the dramatic West Coast of the South Island landscapes, including Abel Tasman National Park (L) and Kōtukuwhakaoka Lake Brunner (R). Photos: Kate Pedley