Correlation between boreholes

Illustrating uncertainty in ground investigations using Lego™

The role of a professional geologist is to predict subsurface structure and conditions to reduce uncertainty, when knowledge of what is underground is needed. This can be for a variety of reasons such as engineering, resource location or geothermal energy development. Drilling boreholes is a standard way of investigating what lies beneath our feet but the cost of drilling often seriously limits the amount of borehole data available. To overcome these data gaps geologists apply knowledge and understanding gained from the study of similar geological situations elsewhere. The ability to predict what is in the subsurface as accurately as possible, while working with limited data, is a key part of a geologist's job.

The recovery of an intact cylinder of rock from the borehole provides the material for the geologist to work on. This type of sample is known as a core and once the borehole has been finished with, the core sample should be deposited with the British Geological Survey so other geologists working in the area can use it. While the core sample provides a great deal of information on the point where the borehole was drilled, it is up to geologists, using their professional knowledge, to interpolate between the boreholes and predict what will be found.

Figure 1: A typical core sample used in geology teaching at the University of Leeds (*P Murphy*)

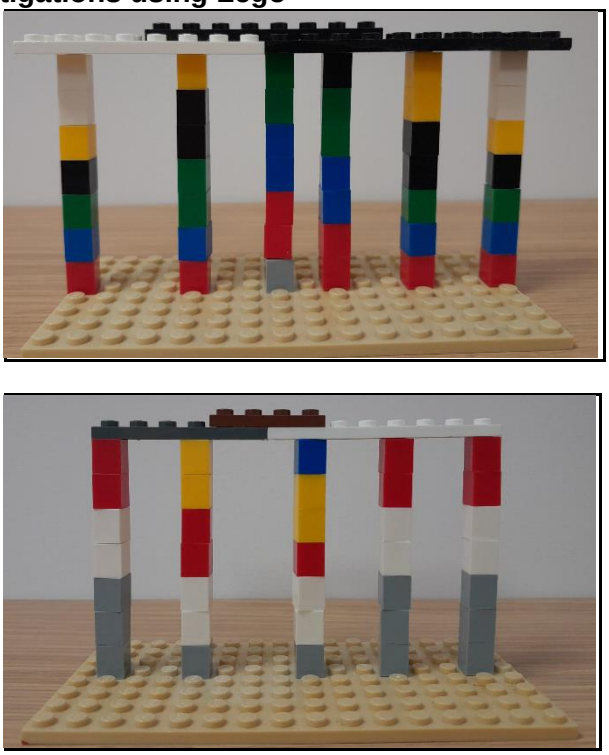

Figure 2: The vertical columns represent boreholes. *(P Murphy)*

This exercise is a simple illustration of the shortcomings of borehole data. Vertical columns of single blocks of Lego™ or other building block systems represent the boreholes. The colours represent different stratigraphic units, in the order and relative thickness encountered while drilling into the ground.

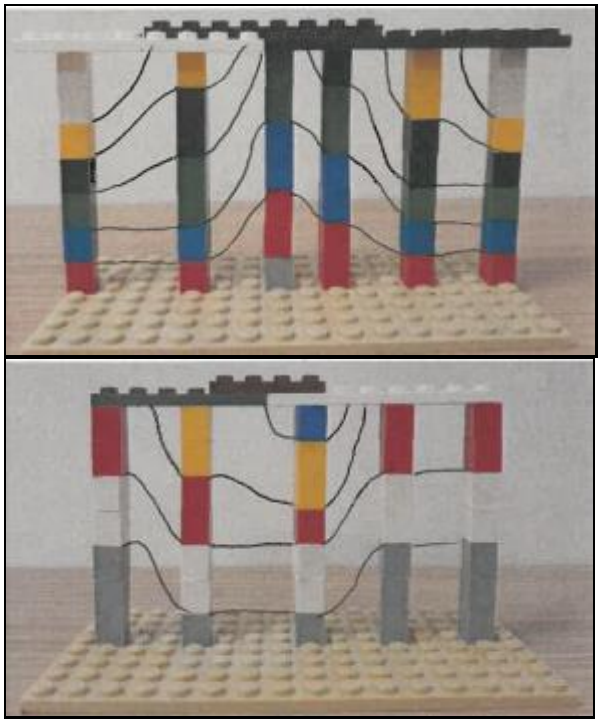

Figure 3: A student's correlation/interpolation between the boreholes in Figure 2. How does this compare to Figure 4? (*P Murphy)*

Once the various interpretations have been collated, the best interpretation can then be shown as a complete representation of the sub surface.
This often leads on to discussions about what is needed to give a more accurate answer – a typical student response is *more boreholes,* which leads onto what factors dictate how much sampling takes place. Other options are for the deployment of geophysical techniques between the boreholes. This might lead to a discussion around the advantages and disadvantages of different geophysical techniques and may also be extended to a wider discussion about the role of the geologist and potential career pathways.
The two situations shown here are simple folds but situations that are more complex can easily be created.

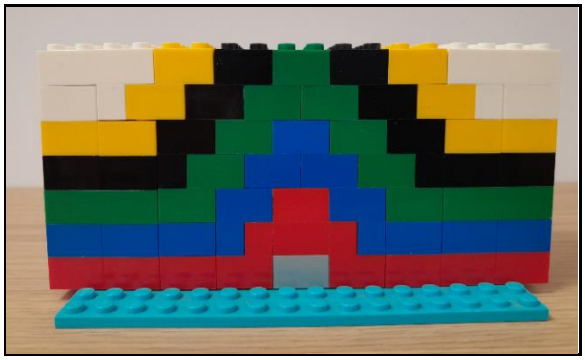

Figure 4: The geological cross sections created using Lego ™ *(P Murphy)*

The back up

Title: Correlation between boreholes

Subtitle: Illustrating uncertainty in ground investigations using Lego™

Topic: An illustration of problems posed by limited data, when trying to understand the complexities of the sub-surface

Age range of pupils: 15 years +

Time needed to complete activity: 20 minutes+

Pupil learning outcomes: Pupils can:
- explain that boreholes only sample a limited amount of the subsurface;
- show that limited data allow for a range of possible interpretations;
- demonstrate that an understanding of similar situations, where more data are available, helps to ensure the most accurate answer.

Context: This simulation illustrates the challenges a geologist faces when trying to understand the geological structure beneath our feet from borehole data alone. It illustrates how important fieldwork is, so that a geologist's wider experience can contribute to providing most accurate possible answer.

Following up the activity:
Students make further Lego models (2D or even 3D) to show different structural situations (e.g. fault, unconformity or facies change)

Underlying principles:
- Boreholes are a standard way of sampling the geology beneath our feet.
- Core samples are the usual way a geologist gets to handle the rocks being studied.
- A geological study is often hampered by a limited amount of data being available.
- A wider understanding of geology and geological processes help ensure a geologically valid answer.

Thinking skill development: Students need to construct a valid model for the geology, using only limited data. Metacognition through discussion requires the development of bridging skills between the simulation and fieldwork and cross section development activities.

Resource list:
- A selection of Lego™ blocks or other building block systems.

Useful links:
British Geological Survey core store at
https://www.bgs.ac.uk/geological-data/national-geological-repository/ngr-facilities/
https://www.earthlearningidea.com/PDF/411_Walthers_law2.pdf

Source: Written by Dr. Phil Murphy, School of Earth and Environment, University of Leeds.