Geophysical Research Abstracts
Vol. 17, EGU2015-488, 2015
EGU General Assembly 2015

Quantifying and predicting interpretational uncertainty in cross-sections

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Cross-sections are often constructed from data to create a visual impression of the geologist's interpretation of the sub-surface geology. However as with all interpretations, this vision of the sub-surface geology is uncertain. We have designed and carried out an experiment with the aim of quantifying the uncertainty in geological cross-sections created by experts interpreting borehole data. By analysing different attributes of the data and interpretations we reflect on the main controls on uncertainty.

A group of ten expert modellers at the British Geological Survey were asked to interpret an 11.4 km long cross-section from south-east Glasgow, UK. The data provided consisted of map and borehole data of the superficial deposits and shallow bedrock. Each modeller had a unique set of 11 boreholes removed from their dataset, to which their interpretations of the top of the bedrock were compared. This methodology allowed quantification of how far from the 'correct answer' each interpretation is at 11 points along each interpreted cross-section line; through comparison of the interpreted and actual bedrock elevations in the boreholes. This resulted in the collection of 110 measurements of the error to use in further analysis.

To determine the potential control on uncertainty various attributes relating to the modeller, the interpretation and the data were recorded. Modellers were asked to fill out a questionnaire asking for information; such as how much 3D modelling experience they had, and how long it took them to complete the interpretation. They were also asked to record their confidence in their interpretations graphically, in the form of a confidence level drawn onto the cross-section.

Initial analysis showed the majority of the experts' interpreted bedrock elevations within 5 metres of those recorded in the withheld boreholes. Their distribution is peaked and symmetrical about a mean of zero, indicating that there was no tendency for the experts to either under or over estimate the elevation of the bedrock.

More complex analysis was completed in the form of linear mixed effects modelling. The modelling was used to determine if there were any correlations between the error and any other parameter recorded in the questionnaire, section or the initial dataset. This has resulted in the determination of both data based and interpreter based controls on uncertainty, adding insight into how uncertainty can be predicted, as well as how interpretation workflows can be improved. Our results will inform further experiments across a wide variety of geological situations to build understanding and best practice workflows for cross-section interpretation to reduce uncertainty.