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Uncertainty in geological linework: communicating the expert's tacit model to the data user(s) by expert elicitation.

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The boundaries mapped in traditional field geological survey are subject to a wide range of inherent uncertainties. A map at a survey-scale of 1:10,000 is created by a combination of terrain interpretation, direct observations from boreholes and exposures (often sparsely distributed), and indirect interpretation of proxy variables such as soil properties, vegetation and remotely sensed images. A critical factor influencing the quality of the final map is the skill and experience of the surveyor to bring this information together in a coherent conceptual model.
The users of geological data comprising or based on mapped boundaries are increasingly aware of these uncertainties, and want to know how to manage them. The growth of 3D modelling, which takes 2D surveys as a starting point, adds urgency to the need for a better understanding of survey uncertainties; particularly where 2D mapping of variable vintage has been compiled into a national coverage. Previous attempts to apply confidence on the basis of metrics such as data density, survey age or survey techniques have proved useful for isolating single, critical, factors but do not generally succeed in evaluating geological mapping 'in the round', because they cannot account for the 'conceptual' skill set of the surveyor.
The British Geological Survey (BGS) is using expert elicitation methods to gain a better understanding of uncertainties within the national geological map of Great Britain. The expert elicitation approach starts with the assumption that experienced surveyors have an intuitive sense of the uncertainty of the boundaries that they map, based on a tacit model of geology and its complexity and the nature of the surveying process. The objective of elicitation is to extract this model in a useable, quantitative, form by a robust and transparent procedure.
At BGS expert elicitation is being used to evaluate the uncertainty of mapped boundaries in different common mapping scenarios, with a view to building a 'collective' understanding of the challenges each scenario presents. For example, a 'sharp contact (at surface) between highly contrasting sedimentary rocks' represents one level of survey challenge that should be accurately met by all surveyors, even novices. In contrast, a 'transitional boundary defined by localised facies-variation' may require much more experience to resolve (without recourse to significantly more sampling).
We will describe the initial phase of this exercise in which uncertainty models were elicited for mapped boundaries in six contrasting scenarios. Each scenario was presented to a panel of experts with varied expertise and career history. In five cases it was possible to arrive at a consensus model, in a sixth case experts with different experience took different views of the nature of the mapping problem.
We will discuss our experience of the use of elicitation methodology and the implications of our results for further work at the BGS to quantify uncertainty in map products. In particular we will consider the value of elicitation as a means to capture the expertise of individuals as they retire, and as the composition of the organization's staff changes in response to the management and policy decisions.