Interrogation Theory

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The goal of any investigation is to interrogate the state of nature for answers to specific questions. How likely is this volcano to erupt? Does the subsurface contain useful resources, or could it be used for CO_2 storage? What does this person think and why? Background research reveals information discovered previously, an investigation is designed, data are acquired, and an answer is estimated. However, existing methods work within the context of a particular model of the universe which is always approximate and usually is not designed to answer the specific questions of interest, and human subconscious cognitive processes impose biases on solutions. Resources committed to geoscientific decisions are often large, so the absence of an end-to-end theory of investigation risks substantial wastage. We present a theory of interrogation which addresses these pitfalls: forward modelling, design theory, model selection theory, inverse theory and decision theory are combined to create a single methodology that revolves around specific questions. Data are designed in order to best answer the questions (rather than simply to constrain a model); multiple models may be considered, designed and discriminated; parameters pertinent to the questions are constrained; and a decision problem is solved in order to answer the question in the same terms in which the question was posed – usually in plain English. We present tomographic examples answering questions about the size of subsurface bodies, or the thickness of transition zones such as the Moho.