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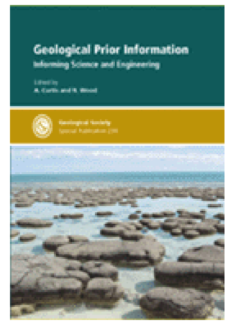
Geological Prior Information—Informing Science and Engineering, edited by A. Curtis & R. Wood, 2005. Geological Society Special Publication 239. The Geological Society Publishing House, Unit 7, Brassmill Enterprise Centre, Brassmill Lane, Bath (Summerset), England BA1 3JN. Hardback, 229 pages. Price GBP 80.00. ISBN 1-86239-171-8.



The title seems novel and somewhat baffling. This may be because this discipline represents an emerging field within the geosciences, where methods and applications are still developing. The use of Bayesian analysis and prior information has long been established in the sciences and the humanities, but in the geosciences there is a concentration only in geophysics.

The book is divided into five parts: Introduction and Reviews (2 papers), Capturing Field Data (3 papers), Geological Process Modelling (2 papers), Methods (4 papers) and Applications (3 papers). The editors contribute an introductory chapter in the first part and offer some diverse examples of how specific geological information has been transferred to other domains where it helps to solve applied and theoretical problems. These include:

- How information about typical geological architectures in a particular environment allows subsurface properties to be established away from drilled observation wells in order to assess hydrocarbon or water reservoir potential.
- How assessments of predicted geohazard risks contribute to the pricing of life and property insurance, citing the famous 2003 work of Rosenbaum and Culshaw.
- How the distribution of ancient reef corals, combined with the relationship between coral growth and sea level, allows prediction of both past sea-level oscillations and how future sea-level change might affect the distribution of modern reefs.
- How historical knowledge of slope stability in different geological environments allows proposed building projects to include appropriate remedial action against such risks, citing Selby's work from New Zealand where such considerations are very important.

- How estimates of regional tectonic stability contribute to allowing toxic waste to be stored underground with minimal risk of future leakage. A problem of increasing importance as the nuclear-waste disposal challenge becomes steadily more urgent.

For each of these problems, geological information is not only provided as an ‘a priori’ component of the solutions, but is central to their creation. This information existed before the formation of the solution, and so in this context is termed “geological prior information” (or GPI). Wood and Curtis construct a Bayesian probabilistic framework that precisely defines GPI. They then define the various components of information that must be either assembled or assumed in order to solve problems using GPI, and demonstrate how uncertainty in such assembled information propagates to create uncertainty in the solutions found.

The papers in the book offer a range from very fundamental studies to complex practical treatments. Cyril Pshenichny from St. Petersburg offers an exploration of the applicability of classical logic in assessing and reducing various kinds of uncertainty. To approach this goal, it is necessary to (1) give an overview of known sources and measures of uncertainty; (2) investigate how logic can cope with uncertainty; (3) discuss the role and place of logic among other uncertainty-reducing methods. He quotes from Frodeman several times; the most striking piece is: “If the energy crisis is defined as a problem of supply (‘we need more oil’), we will find a different set of facts and a different range of possible solutions than if it is defined as a problem of demand (‘we need to conserve’).”

R.A. Bowden of Quintessa considers confidence building in geological models. Nowhere is this more important than in the radioactive-waste disposal sector, where the selection and characterization of a site for deep underground waste disposal is required to demonstrate that the chosen site will remain geologically stable, ensuring the integrity of the waste packages, for tens to hundreds of thousands of years. Geological processes and events that threaten the integrity of a waste repository are greatest for those countries that happen to be located close to plate-tectonic boundaries. Japan is a good example, being located in the circum-Pacific orogenic belt close to the boundaries of four tectonic plates and in one of the most tectonically active areas in the world. Japan, in 2002, began a volunteer process for the selection of a site for high-level radioactive-waste disposal and this makes a very relevant case history; a GPI model is useful.

Stephenson, Gallagher & Holmes from Imperial College look beyond kriging and deal with discontinuous spatial data fields using adaptive prior information and Bayesian partition modelling. Their model space is explored using a Markov chain Monte Carlo approach and a Bayesian framework, so that each iteration will either move, remove or create one partition. The prior information is fairly loosely defined, through hyperpriors on the mean level of the variables and regression variance within a partition, and the hyperpriors are adapted as the algorithm proceeds. Their figure 7 is an example of a Voronoi tessellation—it is always reassuring when a Voronoi tessellation turns up.

Nicky White from Bullard Laboratories considers using prior subsidence data to infer basin evolution. One of the most important risks in hydrocarbon exploration is the thermal evolution of sedimentary basins or continental margins. This risk can be addressed by developing quantitative thermal and structural models which are based on prior information about subsidence histories. The cornerstone of the White approach is to use inverse theory to extract strain-rate histories from subsidence observations. These observations are subject to differing degrees of uncertainty and it is important that such uncertainties are incorporated into any modelling strategy.

This is a book about uncertainties, but mostly about Bayes. If the application of Bayesian approaches may be helpful in solving your particular geo-problems, you should read it. It's a dense fourteen paper package, with a huge contribution from Schlumberger, but it is just possible that the Bayes approach may seem uncomfortably subjective. The starting point in Bayesian analysis is the 'prior' probability, which represents the odds that a researcher would place on a particular hypothesis before considering new data. This prior probability is combined with new data using Bayes theorem, resulting in a 'posterior' probability. Bayes shows that the posterior probability of a hypothesis is given by the product of the prior probability derived from all relevant background information and the relative likelihood of the data having been recorded if the hypothesis were true.

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