Deposit modelling techniques and data handling

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To try to forecast developments in computer technology more than two or three years ahead is a waste of time. Provided that the world economy is not in a state of permanent deep recession over the next 15 years, however, it is certain that significant advances will be made in the computer hardware that is available by the year 2000. Most notably, improvements in the price:performance ratio will match those of the last 15 years, and the miniaturization of key components, such as memory and mass storage, will continue. It is likely that good, true, high-resolution flat-screen colour displays will be available. The Cray computer of today is likely to be matched by much smaller and cheaper computers in 2000, in the way that the Atlas of 1970 is now matched in power by many microcomputers. Thus, ample raw computing power will be available to handle much larger and more complex tasks than can be undertaken now. An attempt will be made here to identify development trends and to relate them to the requirements and research and development capabilities of British industry.

Underlying all real computer applications (as opposed to demonstrations and pilot projects) in the future will be the development and maintenance of large databases that contain varied and complex exploration data sets. Because of the variety of the projects that it will have to handle the database will be managed in a very general and flexible way. The only candidate for this is the relational database management system, several of which have already been developed. It is likely, however, that on account of the well-defined logical theory of relational systems they will be implemented in hardware rather than software. The ICL contents-addressable file store (CAFS), which was developed some years ago—though little used so far—shows what can already be achieved technically. It is probable that the significant database developments will take place in mainstream computing rather than in mining-related industries, but some important applications areas are specific to mining.

One of these is deposit modelling. This requires a combination—which is unique to geology—of large data volumes, complex three-dimensional geometry and statistically intractable data. The only parallel is with petroleum reservoir modelling and, indeed, it is probable that the two related fields will develop together, with much cross-fertilization of ideas.

There have been many different strands of development in spatial modelling over the past 20 years, but they have generally remained relatively pure, with applications in specific areas. For example, finite-element analysis has been widely applied in geotechnical studies, geostatistics (the statistics of spatially correlated data)—mainly in metalliferous mine evaluation—trend analysis in petroleum exploration and filtering in image processing and pattern recognition. A trend that should and will develop over the next few years is towards the integration of these separate areas and techniques. For example, finite-difference and finite-element modelling will probably be applied to the simulation of ore genesis. Many of the appropriate techniques for this have already been developed in connexion with studies of radioactive waste disposal and the modelling of solute diffusion processes.

An increasing variety of robust statistical techniques that are intended specifically for geological applications has been developed, particularly in the last five years; this trend is expected to continue, the application of such techniques supplanting the theoretically 'pure' geostatistics in many modelling applications.

Pattern recognition, which is now considered an important branch of artificial intelligence studies, has been applied widely in robot vision experiments, and its usefulness for image enhancement has already been recognized for geological remote sensing applications. Recent work at the BGS and elsewhere, moreover, has shown the similarity in principle between remotely sensed data and regional geochemical reconnaissance data. It is possible that these techniques could also be developed for application to prospect modelling and mine evaluation. One particular use for three-dimensional image enhancement is the delineation of orebody boundaries.

The use of multivariable drill-hole data that include both assays and down-hole physical measurements is at present limited, though the geostatistical technique of cokriging (predicting values of one variable from another on the basis of a small 'training' set) has found some applications. This will probably be a very important growth area, however, as the cost of drilling is likely to remain high compared with that of data processing, and it will be essential to extract the maximum information from available drill-hole data. For this it is already possible to choose from a very large body of multivariate techniques, including factor and cluster analysis, multidimensional scaling and multiple regressions. The selection itself of appropriate techniques is not simple in any particular application; it is probable that multivariate data handling is an area that will yield readily to the development of 'learning' systems. Even existing 'expert' systems will be of potential relevance in the selection of techniques.

The interplay of three-dimensional deposit geometry and multivariate data sets will pose problems that are technically severe, but deposit modelling, however well done or elegantly handled, will not yield any direct economic benefits to the mining industry, and the development of a range of such techniques (however satisfying academically) will not be of interest to the industry without corresponding advances in two other fields. These are mine planning, which includes both mine design and production scheduling (with strong emphasis on the financial aspects), and mineral processing, where the variety of options is so great that an 'expert' system will need to be at the core of any new process-plant design and simulation software.

It is not possible to divorce the future development of computer software for deposit modelling from the requirement of mining companies to use their deposit models effectively. The development of modelling must go hand in hand with the development of mine planning applications. The tasks may be modularized, however, within a generally agreed framework—shared data structures, low-level code or even merely a common programming language. Furthermore, research into techniques need not necessarily lead directly to commercially applicable products, as long as the commitment and the funding to develop the commercially relevant parts of such research are provided. The costs of such development need not be great: experience in Britain has shown that small, dedicated groups with *sufficient* funding can achieve more than large, lavishly funded groups.

Continuity of commitment is more important than the amount of funding that is available. Given a degree of support by both industry and Government, the United Kingdom is well placed to become world leader in this field of technology over the next 15 years: the relevant researchers already move freely between academic, industrial and government environments, and not too many of them have yet been lost to North America or Australia.

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