Comparison of grade modelling methods at Blackpool china clay pit, Cornwall

L.W. Palmer and H.J. Glass

Palmer, L.W. and Glass, H.J. 2015. Comparison of grade modelling methods at Blackpool china clay pit, Cornwall. *Geoscience in South-West England*, **13**, 454-458.

Two methods of estimating grade data are compared: implicit modelling (using Radial Basis Functions) and explicit modelling (using Ordinary Kriging). Residuals are defined in order to improve the comparison between the different models. As a case study, these methods are applied to a kaolin resource at Blackpool Pit, St Austell, Cornwall. Although Blackpool pit is not currently in operation, the area could be developed in future. The two estimates produced are globally very similar but the residuals identify areas of significant difference, likely due to the highly variable nature of the kaolinisation at these locations. Residuals can be used to identify areas that warrant further sampling and can be used to delimitate the error attached to an estimate.

Camborne School of Mines, College of Engineering, Mathematics and Physical Sciences,
University of Exeter, Penryn Campus, Penryn, TR10 9FE, U.K.
(E-mail: L.W.Palmer@exeter.ac.uk)

Keywords: resource estimation, Kriging, implicit modelling, kaolin, industrial minerals.

Introduction

Modelling the geology and interpreting grade data is an essential part of modern mining operations with a variety of different software tools available. Traditionally, geological models were constructed entirely manually by creating volumes that only contained what was deemed to be geologically similar material. This process had certain advantages: for example, each drillhole could be evaluated individually and mistakes are often easy to spot. However, it was also a time-consuming process. More recently, less manually intensive ways of constructing grade shells have been developed using radial basis functions first described by Cowan *et al*. (2003). The uptake of this type of modelling has been particularly strong in Australia (e.g. Hill *et al*., 2014; Rawling *et al*., 2006). While it is now starting to gain global acceptance as an alternative to traditional orebody modelling, it can also complement the traditional techniques. See, for example, Knight (2006) and Kentwell *et al*. (2006).

Comparisons between Radial Basis Function Modelling (RBFM) and Ordinary Kriging (OK) are often based on theoretical considerations and use relatively simple datasets (Stewart *et al*., 2014). Alternatively, RBFM and OK are compared after OK has been constrained within user-defined domains (Kentwell *et al*., 2006). This study aims to apply and compare RBFM and unconstrained OK in the case of a kaolin deposit.

Kaolin, known locally as china clay, has been mined in the St Austell area for the last 250 years (Bristow, 1993). The deposit was formed by kaolinisation of the granite pluton which outcrops to the north of St Austell, forming part of the Cornubian Batholith (Scrivener, 2006). The exact driver of kaolinisation is still unclear; it is possibly linked to both hydrothermal alteration along structures (mineralised in conjunction with the alteration and due to later fluid flow) and chemical weathering of the granite during geological periods of high rainfall and humidity (see Alderton and Rankin, 1983; Bristow, 1993; Sheppard, 1997; Psyrillos *et al*., 1998). Blackpool pit (Figure 1) lies within the central area of current clay mining. The pit is not currently in operation and has been allowed to flood.

Methodology

The practice of Kriging has become widely accepted as the method of choice to produce estimates of grade data from drilling or other sampling techniques (Isaaks and Srivastava, 1989). Kriging forms the integral part of the geostatistical package of techniques, where the spatial variability of a variable across a deposit is computed using the variogram. The variogram considers the variance between samples at different sample distances, based on the assumption that at a certain distance there will be no relatedness between samples. The basic workflow to produce an estimate by Kriging is as follows. Firstly, an experimental variogram is computed from the sample data. A mathematical model is then fitted to the experimental variorgram, following the shape produced by the experimental variorgram as closely as possible, so as to reflect most accurately the spatial variability seen in the data. The area to be estimated is then divided up into a series of blocks and Kriging then estimates the variable in each block from the known data points by applying a weighted average, with the weights derived from the variogram model. Kriging is optimised through various Kriging outputs which give a measure of how unbiased the estimates are. A good overview of the process of Kriging and how it is used by resource geologists is provided by Clark (1979).

Radial Basis Function Modelling uses a mathematical function as an interpolator to produce an estimate of a variable across an area. As in the case of Kriging, a model is fitted to the data, but for RBFM the fitting is normally done mathematically. A weighted average, with weights derived from the Radial Basis Function, is then used to estimate unknown points. The unknown points estimated can then be averaged into regular blocks to be used in further mine planning. An overview of how RBFM operates is provided by the producers of Leapfrog software by Aranz Geo (2015).

For the purpose of resource exploration and resource definition, Imerys Minerals Ltd. and previous companies have gathered a large dataset across in Blackpool pit. The data are distributed irregularly across the area and were obtained from