PROSPECTIVITY OF TUNGSTEN IN SOUTH-WEST ENGLAND USING BAYES' THEOREM

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Bayes' theorem of conditional probabilities is used to evaluate the potential for tungsten mineralisation in the granites and surrounding country rocks of the southwest peninsula of England. The approach uses the distribution of known tungsten mineralisation in relation to geological controls that can be mapped, to calculate the probability by unit area of as yet undiscovered mineralisation. It permits the evaluation of the efficiency of the chosen exploration criteria one by one and in combination. The method indicates areas of up to 20 km^2 where the posterior probability of a square kilometre containing tungsten mineralisation approaches unity, located in a discontinuous zone extending from the east side of the Godolphin Granite in the south, through the eastern margins of the Carn Marth Granite to St Agnes and Cligga Head with small outliers elsewhere on or close to the outcrop of the southwest granites.

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INTRODUCTION

The southwest peninsula of England has been an important source of metals since ancient times. Tin was the main commodity sought for most of this time and by the late 19th Century accounted for half the world production (Dines, 1956, p.21). Mining of copper also has ancient origins but did not become important until the 19th Century when for a short time in the 1850s Devon and Cornwall supplied 40 per cent of world production. Since those times, there has been a decline such that at the present time, there are no working base metal mines in the region. There is however in the current world market conditions, renewed interest in tin and tungsten mineralisation. Most notably, planning and environmental permits to reopen the tungsten-tin mine at Hemerdon Ball have been negotiated and finance raised, and redevelopment of the mine is now under way with production expected in the third quarter of 2015.

Tin and tungsten mineralisation in the region are genetically and spatially related to the intrusion of the Cornubian granites (Figure 1). The following sections attempt to use the wealth of mineral distribution and geological data for this area to draw conclusions about where further occurrences of tungsten might be sought. The method used is based on Bayes' theorem of conditional probabilities (Bernardo and Smith, 1994), applied to mineral exploration by Bonham-Carter and colleagues at the Geological Survey of Canada in the 1980s (Bonham-Carter *et al.*, 1988) and has subsequently been used by others for mineral exploration applications (Barr, 1990; Raines, 1999; Deng, 2009; He *et al.*, 2010; Pazand and Hezarkhani, 2013).

METHOD

Bayes' theorem relates the odds or probability of an event given that it satisfies some condition, to its unconditional probability through other parameters that can be measured. Expressed algebraically:

$$P(A|B) = \frac{P(B|A)P(A)}{P(B)} \qquad (1)$$

where P(A|B) is the probability that A occurs, given that condition B is satisfied, P(B|A) is the probability that B occurs given that condition A is satisfied and P(A) and P(B) are the unconditional probabilities of A and B respectively (Bonham-Carter *et al.*, 1988). Applied to mineral exploration, the relationship may be restated as:

'the probability that a unit area is mineralised on condition that it satisfies some aspect of relevant mineral exploration data, is given by the product of the proportion of unit areas where this condition holds that are mineralised (P(B|A)) and the unconditional probability of mineralisation (P(A)), divided by the proportion of the whole exploration area where the condition applies (P(B))'.

P(A) is referred to as the prior probability of mineralisation, i.e. the probability before considering any exploration data. P(A|B) is the posterior probability given that the area identified satisfies some criterion of the exploration data B. P(B|A) is not known for sure unless every mineral occurrence has been identified, in which case the exercise would be pointless, but it can be estimated from the distribution of known mineral occurrences.