Computers & Geosciences 78 (2015) 53–62

Contents lists available at ScienceDirect

Computers & Geosciences

journal homepage: www.elsevier.com/locate/cageo

Cell Based Associations: A procedure for considering scarce and mixed mineral occurrences in predictive mapping

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ARTICLE INFO

Article history:
Received 8 September 2014
Received in revised form
28 January 2015
Accepted 29 January 2015
Available online 7 February 2015

Keywords:
Favorability mapping
Grid cell
Classification
Attribute association

ABSTRACT

Cell Based Association is an innovative mineral favorability procedure designed to answer special needs of the mining industry in data wise critical situations where usual favorability methods may not yield satisfactory results. Those situations relate to input data quality (e.g. clustered points, mixed and scarce data, approximate location) or some assumptions that are considered unreasonable (e.g. map areas relevance, conditional independence).

The principle of CBA consists in replacing polygons of geological units with a square cell grid (hence the 'cell-based'). Each cell contains a range of units ('association') that are binary coded in terms of their presence (1) or absence (0) within study area. The loss of resolution inherent to this procedure is compensated by the enriched information contained in each cell owing to the notion of (lithological) association.

Lithological associations are considered as binary spectra and as such are classified using Ascendant Hierarchical Clustering (AHC) thus obtaining a synthetic map of lithological associations. The prospectivity map shows as favourable the cells of the same AHC classes that the ones including mineral occurrences.

It was observed that CBA can distinguish between different ore deposit varieties from a blended mineral occurrences data set. CBA can theoretically include any spatialized data (e.g. geophysics, structural data) as an extra variable to specify classification and narrow favourable areas. Doing so would make it an independent favorability mapping procedure and is still under development.

Cell size in a grid is a critical parameter of the procedure; it must be compatible with the looked-for phenomena and should have a sufficient lithological variability.

In addition to its use for producing favorability maps, a CBA-derived map could help in understanding the background information contained in geological maps. CBA can also be applied to other fields, such as agriculture and urban planning.

1. Introduction

Mineral favorability is a branch of predictive analytics that focuses on designing statistical methods to point out favourable zones in terms of mining potential.

From Carranza (2009): "*The term mineral prospectivity (…) is similar to the terms mineral potential and mineral favourability, both of which imply the chance or likelihood that mineral deposits of the type sought are contained in a region or district under investigation. (…)*

Modelling of mineral prospectivity is a regional- or district scale mapping activity, whether field based or GIS based, which aims to delineate prospective areas for further exploration at the next higher scales of mapping. Notwithstanding the scale of mapping, mineral prospectivity is related to the degrees of presence and degrees of importance of individual pieces of spatial evidence of occurrence of mineral deposits of the type sought. That is, in a region or district under investigation, if there are more important pieces of spatial evidence in an area than in another area, then the former is considered to have higher prospectivity than the latter".

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http://dx.doi.org/10.1016/j.cageo.2015.01.012
0098-3004/

The most basic case relates to measuring the statistical link between a mineral occurrence (MO) data set (points) and a geological map (polygons). This can roughly be translated as finding what makes places where mineral occurrences were observed distinguishable and trying to target similar locations.

End result is often a favorability map that displays the odds of finding something of interest.

Cell Based Association (CBA) is meant to be used during the strategic stages of exploration when available data often does not meet the requirements (independence, representativeness of MO) of usual favorability methods such as Weight of Evidence, Fuzzy Logic, Artificial Neural Networks to be used effectively (Bonham-Carter, 1994; Carranza, 2011; Schaeben, 2011).

Usually the requirements are not met due to poor quality of the mineral occurrence data set.

Indeed, the mineral occurrence data set is normally considered as a unique representative sample of unique elements of a single population (or at least a known number of different populations). This is not always the case as mineral occurrences data sets are most of the time classified according to the (potential) resource observed (e.g. zinc mineral occurrences) which can lead to mixing different types of mineral occurrences that relate to different genesis processes (hence different lithological environments) into a single mineral occurrence data set. Ultimately this means the user will obtain a mixed favorability map that, at best, roughly ranks the different types of mineral occurrences on a single scale that may make no sense because each type should be analysed separately from the others or, at worst, a global fuzzy favorability map that makes even less sense.

Also, when the mineral occurrences data set is too scarce it is impossible to assess if it is representative which is one major assumption/requirement of most favorability methods.

Lastly, considering each mineral occurrence as individual leads to an overestimate of the importance of clustered areas that in fact describe a single object geologically wise which is even more critical in the case of mixed mineral occurrence data sets.

To address these problems, we propose a procedure called 'Cell-Based Associations' (CBA).

Using a square grid (of appropriate cell size fixed by user) in which each cell records the presence or absence of lithological

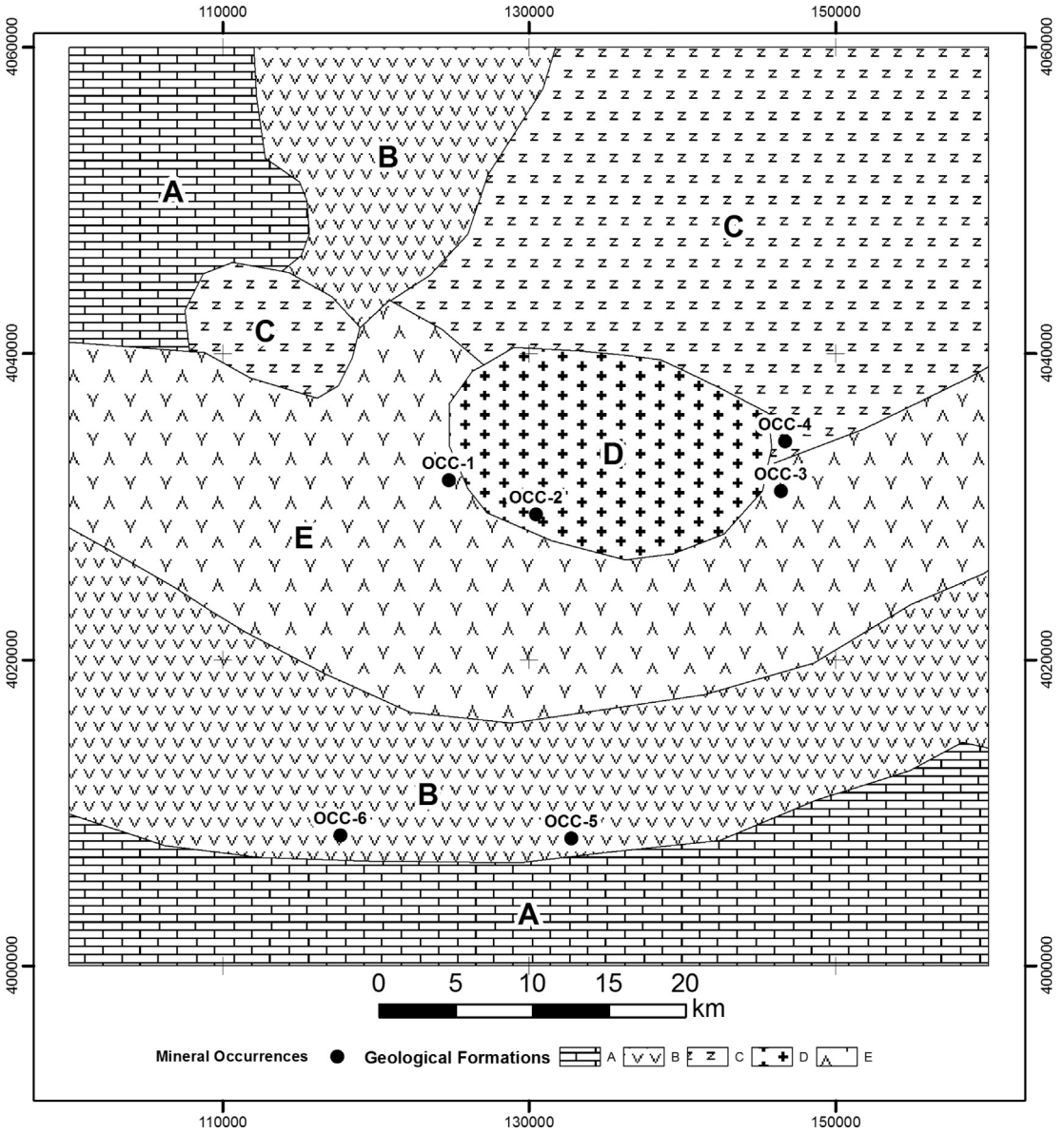

Fig. 1. Geological map and mineral occurrences (theoretical example).