Computers & Geosciences 83 (2015) 72–79

Contents lists available at ScienceDirect

Computers & Geosciences

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

# Geometric average of spatial evidence data layers: A GIS-based multi-criteria decision-making approach to mineral prospectivity mapping

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ARTICLE INFO

*Article history:*
Received 20 March 2015
Received in revised form
9 July 2015
Accepted 10 July 2015
Available online 11 July 2015

*Keywords:*
Multi-criteria decision-making
Geometric average
Target generation
Mineral prospectivity mapping

ABSTRACT

Techniques for GIS-based multicriteria decision-making (GIS-MCDM), like mineral prospectivity mapping (MPM), are concerned with combining information from several criteria into a single evaluation model to solve certain problems in the fields of geosciences. In this paper, we introduce the geometric average method for MPM, as a GIS-MCDM approach, and demonstrate its advantage over the expected value MPM method. The comparative analysis shows that the geometric average MPM method yields better prediction of mineral prospectivity and it overcomes the limitation of the expected value method in terms of using spatial evidence values with the same unit.



## 1. Introduction

Multicriteria decision-making (MCDM) problems are important research issues in decision-making (Liu, 2013) under uncertainty when there are some vaguely-known variables (Berger, 1985; Xu, 2007a, 2007b). Techniques for GIS-based MCDM (GIS-MCDM) are widely used to solve certain problems in the fields of geoscience (e.g., Chico-Olmo et al., 2002; De Araújo and Macedo, 2002; Pazand et al., 2011; Lisitsin et al., 2013; Feizizadeh et al., 2014). Because natural resource management is plagued with uncertainties of various kinds (e.g., Nepomuceno Filho et al., 1999; Runge et al., 2011; Carranza, 2014; Ford et al., 2015; Khan and Deutsch, 2015), GIS-MCDM techniques are primarily concerned with combining information from several criteria into a single evaluation model to modulate uncertainty (An et al., 1994; Feizizadeh et al., 2014).

Mineral prospectivity mapping (MPM) is also a MCDM problem because it aims to analyze individual layers of geo-exploration data, which are used to represent different criteria, for creating weighted evidence layers and for integrating such information layers to generate and select target areas for further exploration of a certain deposit-type sought (Bonham-Carter, 1994; Carranza, 2008b). For MCDM problems (e.g., here using different geo-exploration evidence layers for MPM of a mineral deposit type sought), in which attribute weights have been defined vaguely and so there are uncertain variables with no proven weights, group decision-making analyses methods have been developed using expected value or geometric average (Wang et al., 2007; Xu, 2007a, 2007b; Wang and Zhang, 2008, 2009a, 2009b; Wei, 2010; Zhang and Liu, 2010; Liu, 2013).

Recently, Yousefi and Carranza (2015a) adapted the concept of expected value to model uncertainty of portrayed geological features because the problem of modeling evidential attributes that are incompletely known or completely unknown (Xu, 2007a, 2007b) and the relative importance and integration of weighted evidential values can be and has been addressed by using expected value function (Wang and Chin, 2011). For this, Nykänen et al. (2008), Yousefi et al. (2012, 2013, 2014) and Yousefi and Carranza (2014, 2015a, 2015b) assigned weights to continuous-value spatial evidence to avoid the problem of uncertainty due to simplification and discretization of continuous-value spatial evidence into some proximity classes using arbitrary intervals of distance and then assigning the same score to all distances in each proximity class in traditional MPM methods (e.g., Carranza and Hale, 2001; Porwal et al., 2003, 2004, 2006; Rogge et al., 2006; Lisitsin et al., 2013). Although the expected value MPM method treats uncertainty of representing geological evidence, the method has a disadvantage in that it requires conversion of values with different units in every evidential map into the same unit so that the evidence maps can be integrated by addition (Yousefi and Carranza, 2015a); however, data conversion can also alter the statistical structure of the spatial data.

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http://dx.doi.org/10.1016/j.cageo.2015.07.006
0098-3004/

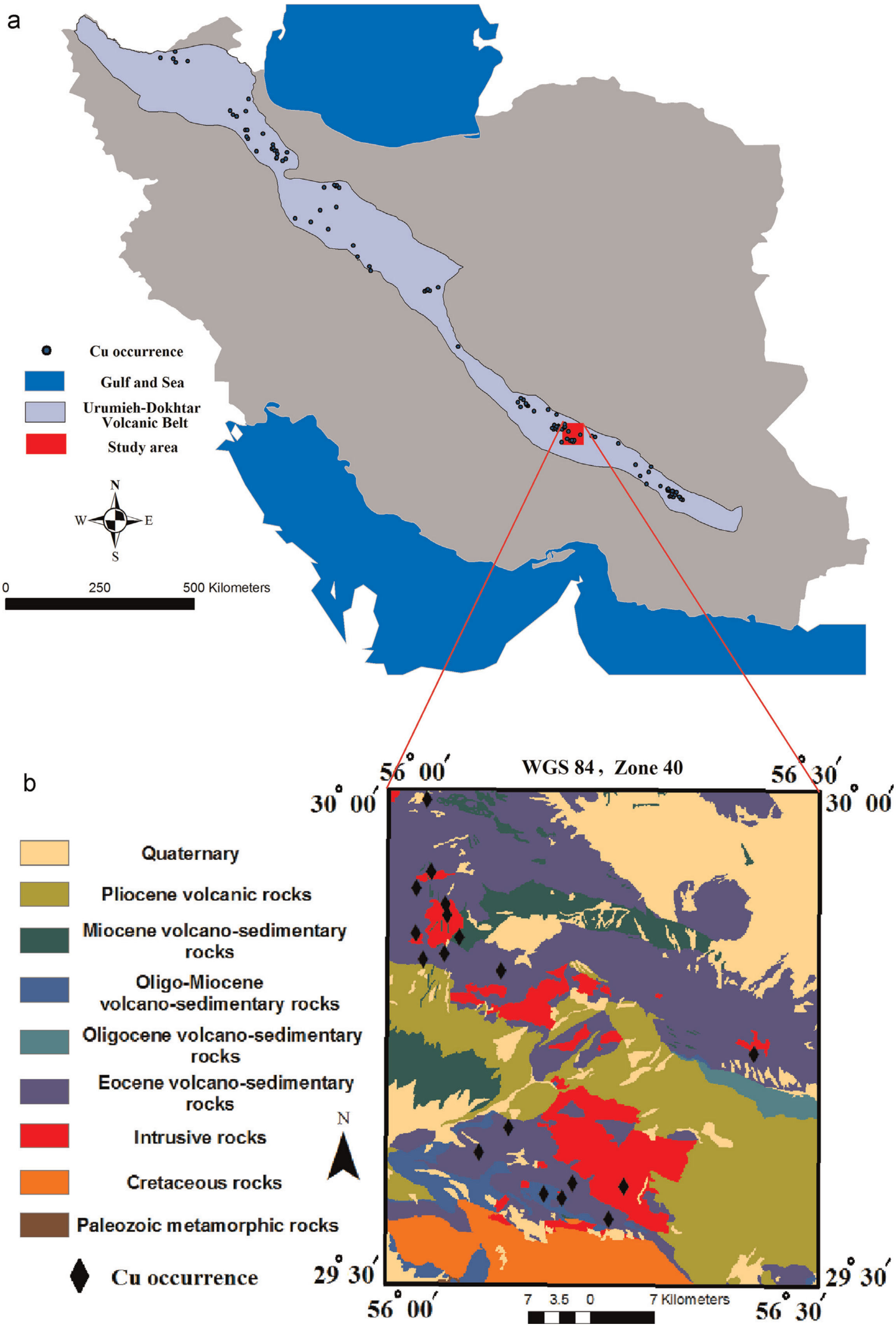


**Fig.1.** Location of the study area in the Orumiyeh-Dokhtar volcanic belt of Iran (a) and geological map of the study area (b).