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Delineation of gold mineralized zones using concentration–volume fractal model in Qolqoleh gold deposit, NW Iran

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ABSTRACT

The aim of this study is to delineate and recognize the different gold mineralized zones based on surface and subsurface lithogeochemical Au data utilizing concentration–volume (C–V) model in the Qoloqoleh gold vein deposit, NW Iran. C–V modeling outlined six geochemical populations and four mineralized zones for Au element based on log–log plot which was correlated with the mineralized veins from geological data. Extremely mineralized veins are higher than 14.12 ppm in Au grade, which are correlated with surface weathered zone by oxidized pyrites. The main phase of gold mineralization where Au grade typically ranges between 3.98 and 14.12 ppm is associated with thick quartz veins. Moderately and weakly mineralized zones ranging from 0.354 to 3.98 ppm Au derived by C–V model were correlated with narrow quartz veins that contain minor sulfides in the deposit. Barren host rocks obtained by C–V modeling were correlated with barren quartz veins in the deposit. The results were compared with a geological model, showing a strong positive correlation between mineralized zones and quartz-sulfide veins hosted by meta-volcanic rocks and sericite schist. Results examined via the C–V fractal model illustrate that the interpreted zones based on the fractal model, mineralogical, SEM and EPMA analyses have strong correlation with highly and moderately silicic mineralized veins consisting of sulfides and Au. To certify this, a logratio matrix was employed to validate the C–V fractal model for Au and two lithological units namely meta-volcanic rocks and sericite schists indicating the overall accuracy of 0.56 and 0.58 respectively.

1. Introduction

Classification and delineation of mineralized zones from barren host rocks are important in economic geology, mineral exploration, resource evaluation and mine planning. Investigation of ore mineralogy and paragenetic sequence provides useful data on ore-forming processes in deposits, because the typical characteristics of various types of ore deposits are reflected by their mineral assemblages (Craig and Vaughan, 1994; White and Hedenquist, 1995). Conventional methods to differentiate mineralized zones in hydrothermal deposits are based on mineralogical, petrographical and geochemical investigations including alteration assemblages and ore mineral recognition utilizing X-ray Diffraction (XRD), Electron Probe Micro Analyzer (EPMA), Scanning Electron Microscopy (SEM) and Portable Infrared Mineral Analyzer (PIMA: e.g., Berger et al., 2008; Chouinard et al., 2005; Hedenquist et al., 2000; Hoefs, 2009; Hudson, 2003; Jensen and Barton, 2000; Pirajno, 2009; Pirajno and Bagas, 2002; Richards, 1995; San Shen and Yang, 2004; Sillitoe, 1997). Fluid inclusion and stable isotope studies are other methods for the outlining of different mineralization phases based on thermometric and isotope element parameters along with other geological particulars (e.g., Boyce et al., 2007; Faure et al., 2002; Wilson et al., 2007).

Fractal geometry (Mandelbrot, 1983), is an important branch of nonlinear mathematical sciences applied in various fields of geosciences since the 1980s. Bolviken et al. (1992) and Cheng et al. (1994) have shown that geochemical patterns of various elements have fractal dimensions. Several fractal models have been developed and applied to geochemical exploration by separating various geochemical (including mineralized zones and phases) populations, e.g., concentration–area (C–A) by Cheng et al. (1994), concentration–distance (C–D) by Li et al. (2003), concentration–volume (C–V) by Afzal et al. (2011) and number–size (N–S) by Mandelbrot (1983) and Agterberg (1995).

Fractal analysis assists in describing relationships of geological, geochemical, and mineralogical settings with spatial information derived

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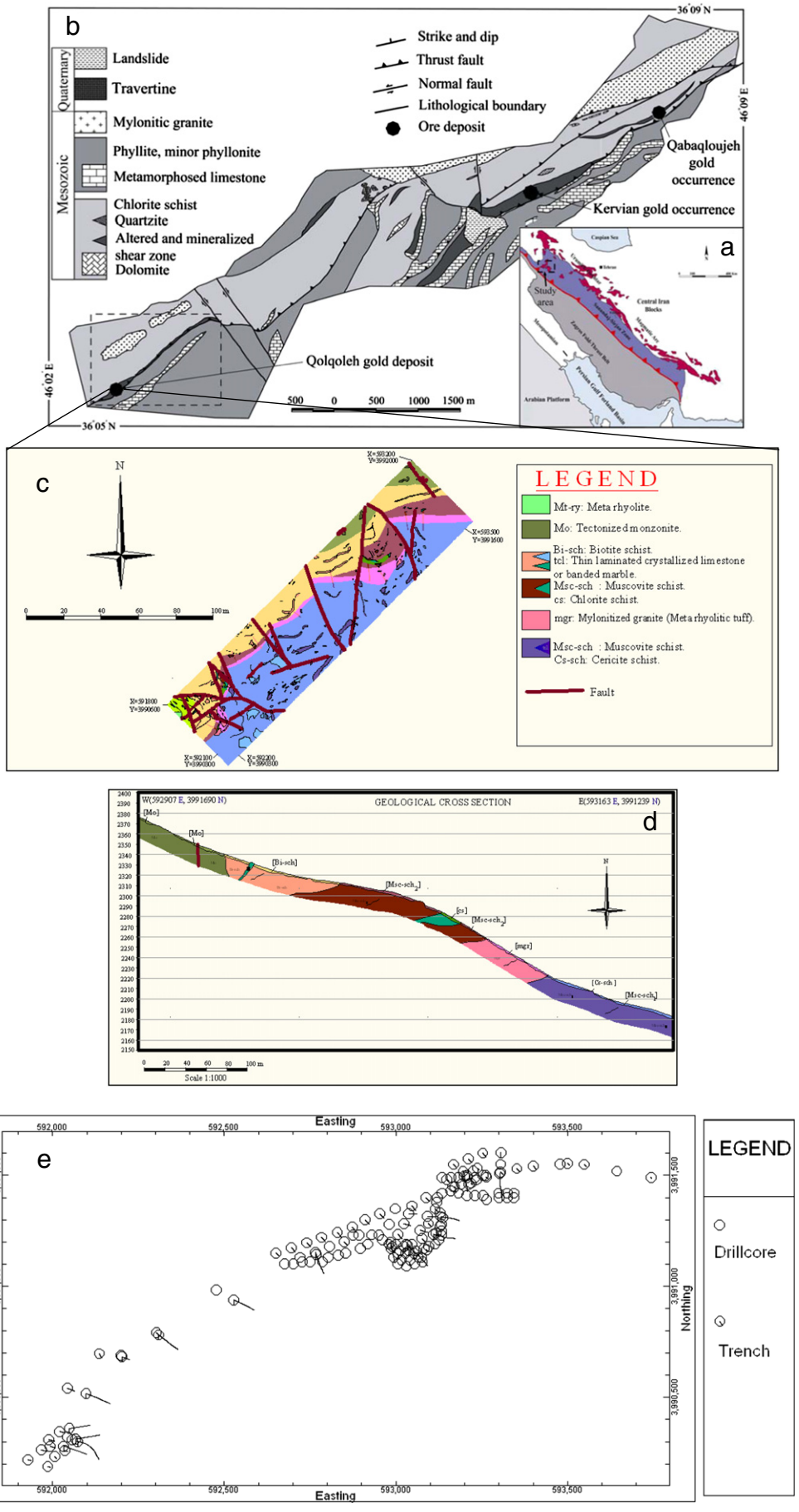
b
Quaternary
Landslide
Travertine
Mesozoic
Mylonitic granite
Phyllite, minor phyllonite
Metamorphosed limestone
Chlorite schist
Quartzite
Altered and mineralized shear zone
Dolomite
Strike and dip
Thrust fault
Normal fault
Lithological boundary
Ore deposit
Qabaqloujeh gold occurrence
Kervian gold occurrence
Qolqoleh gold deposit
36°09 N
36°05 N
46°02 E
46°09 E
500 0 500 1000 1500 m
a
Study area
Central Iran Blocks
Arabian Platform
c
N
0 20 40 60 80 100 m
LEGEND
Mt-ry: Meta rhyolite.
Mo: Tectonized monzonite.
Bi-sch: Biotite schist.
tcl: Thin laminated crystallized limestone or banded marble.
Msc-sch : Muscovite schist.
cs: Chlorite schist.
mgr: Mylonitized granite (Meta rhyolitic tuff).
Msc-sch : Muscovite schist.
Cs-sch: Cericite schist.
Fault
d
GEOLOGICAL CROSS SECTION
W(592907 E, 3991690 N)
E(593163 E, 3991239 N)
[Mo]
[Bi-sch]
[Msc-sch1]
[cs]
[Msc-sch2]
[mgr]
[Cs-sch]
[Msc-sch3]
Scale 1:1000
e
Easting
Northing
592,000
592,500
593,000
593,500
3,991,500
3,991,000
3,990,500
LEGEND
Drillcore
Trench