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Thickness and spatial distribution of veins in a porphyry copper deposit, Rosia Poieni, Romania

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Abstract

A statistical analysis of the vein thickness distributions of veins in the Rosia Poieni porphyry copper deposit, Romania, indicates that vein thickness data conform to a power-law distribution whereas the spatial distribution of veins follows a negative exponential law. A high clustering of the veins is indicated by both the spacing distribution and the C_v values. The similar vein densities observed at the open-pit scale are representative of a saturation level of vein nucleation. Differences in the spacing distribution and in the mean vein thickness are explained by different initial nucleation rates in the deepest and the lowest parts of the porphyry copper. The highly clustered organization of the system is explained by vein linkage processes during their growth and modification of the fluid pressure and local stress during the hydrofracturing.
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1. Introduction

A knowledge of the geometry of fracture networks is essential in several sub-surface geological domains (e.g. engineering for oil reservoirs, mining geology, and waste storage). Discontinuities such as fractures are potential sites for fluid circulation and have important implications for the hydraulic properties of rocks. The matrix permeability of igneous rocks is generally small and, consequently, the overall permeability is mostly controlled by fracture networks. Numerous papers have dealt with the description of natural vein or fracture networks occurring in various environments and focusing on statistical analyses. Several parameters have been studied, the main focus being on the spacing, thickness and length distributions of fractures. Velde et al. (1991) characterized the fractal distribution of fracture patterns in granites. Gillespie et al. (1993) compared different types of statistical and geometrical methods for the characterization of the spatial distribution of fractures in 1D, 2D and 3D. Johnston and Mc Caffrey (1996) established empirical relationships for vein shapes while Clark et al. (1995), Roberts et al. (1998, 1999) and Monecke et al. (2001) demonstrated that the use of statistical approaches is an important clue to understand the relationship between vein geometry and the mechanisms of vein formation. Other contributions based on natural fracture set studies in granites show that the connection of fracture systems is characterized by statistical laws deduced from the fracture extension distributions and that the fact that fluids follow preferential pathways within a fracture network (Bour et al., 2002; Bour and Davy, 1999; Ledésert et al., 1993a,b; Long and Witherspoon, 1985). A number of laws are commonly cited to characterize these distributions, the type of rock fragmentation, its development and maturity. Generally, log-normal, exponential negative or power law distributions are mentioned in the literature (Bonnet et al., 2001).

Johnston (1992) applied a statistical method to systematically characterize the veins that enhance productivity in existing mining areas and to assist the prospecting of new deposits.

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Several other statistical analyses on vein thickness and spacing distributions have been conducted on mineralized vein systems by Sanderson et al. (1994), Mc Caffrey and Johnston (1996), Roberts et al. (1998, 1999), Loriga (1999), Brathwaite et al. (2001) and Monecke et al. (2001). Hence, statistical studies of the geometrical parameters of vein or fracture systems represent a useful way to characterize the spatial distribution and the hydraulic and metallogenic behaviour of fracture networks.

This paper outlines a statistical study of a vein system in a mineralized stockwork from the Rosia Poieni porphyry copper deposit, Romania (Fig. 1). The spatial and thickness distributions of the veins constituting the stockwork are examined and compared with similar distributions proposed in the literature. The evolution of the vein architecture at the open-pit scale is described and the mechanisms responsible for the stockwork formation are discussed.

2. Geological setting

2.1. The Apuseni Mountains and the Rosia Poieni porphyry copper deposit

The southern part of the Apuseni Mountains (West Romania) shows a variety of mineral occurrences (Cioflica et al., 1973; Ianovici et al., 1977; Borcos et al., 1983; Udubasa et al., 1992; Heinrich and Neubauer, 2002) related to Neogene volcanic activity (Lemne et al., 1983; Pecksay et al., 1995; Rosu et al., 1997; Alderton et al., 1998).

The Rosia Poieni porphyry copper deposit, the largest porphyry copper in the Apuseni Mountains, belongs to the metallogenic district of Bucium-Baia de Aries (Fig. 1). The basement here consists of Pre-Mesozoic metamorphic rocks intruded by magmatic bodies and covered by pyroclastics of variable composition (Fig. 1). Two types of igneous rocks, both characterized by intense hydrothermal alteration, are exposed in the open-pit. The host rocks, the Poieni andesite, are intruded by a subvolcanic body characterized by a porphyritic texture, the Fundoaia microdiorite (Fig. 2). Ionescu (1974), Ionescu et al. (1975) and Bostinescu (1984) carried out a mineralogical and petrographic study of the rocks from the Rosia Poieni area. They identified the disseminated character of the copper mineralization and a zoned pattern of alteration. Recent studies (Milu, 1999; Milu et al., 2004) have shown that the Fundoaia subvolcanic body and the Poieni host rocks are characterized by strong hydrothermal alteration spatially related to the Fundoaia intrusion.

Fig. 2 presents a schematic reconstruction of the Rosia Poieni volcanic structure and shows the concentric pattern of

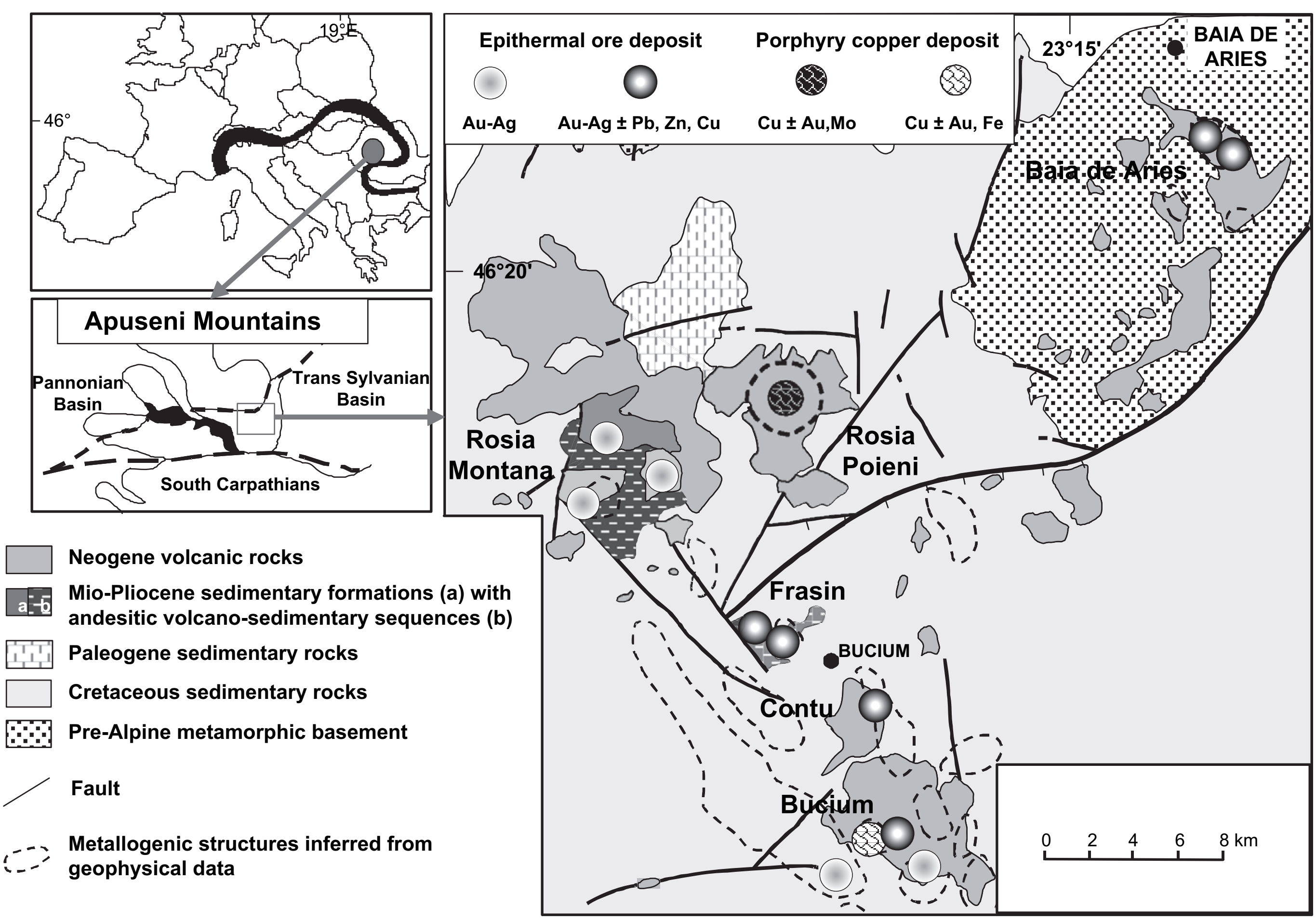

Fig. 1. Geological map of the Bucium-Baia de Aries metallogenic district located in the Apuseni Mountains, Romania (modified from Borcos et al., 1983).