ELATSITE COOPER MINE – AN EXAMPLE OF MAGMA EMPLACEMENT INTO LOCAL EXTENSIONAL DOMAIN OF THE DEXTRAL STRIKE-SLIP KASHANA SHEAR ZONE

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Key words: strike-slip faults, local extensional domains, magma emplacement, transpression, brittle deformation, Elatsite copper mine

Introduction

Porphyry copper deposits of the same type as Elatsite are the world's major source of copper and significant sources of molybdenum and gold. They are associated with the intrusion of magmas of intermediate composition into shallow stocks and are products of subduction-related magmatism. Usually, they are found as part of magmatic arcs worldwide.

Based on the results of new structural field work in the area of Elatsite copper mine, this study attempts at better understanding the tectonic factors controlling the emplacement of magmatic bodies and ore veins in the brittle crust. Furthermore, one of the main tectonic problems connected with magma emplacement – the so called "room problem" (creation of space for magma emplacement) is briefly discussed.

Geological setting

The pre-Upper Cretaceous basement rocks in the area of Elatsite copper deposits comprises Variscan (314±4.8Ma, Kamenov et al., 2002) granodiorites of the Vejen pluton intruded into Lower Paleozoic low-grade (greenshist facies) metamorphic rocks. The latter are contact-metamorphosed to hornfelses adjacent to the granodiorites.

The Upper Cretaceous magmatic rocks in the area of Elatsite mine are represented by a succession of subvolcanic intrusions (U/Pb age 92-91 Ma; Von Quadt et al., 2002) of monzonitic to granodioritic composition (Trashliev, Trashlieva, 1964; Kalaidjiev et al., 1984). They are hosted by the Variscan granodiorites and low-grade methamorphic rocks.

A close spatial relationship has been recognized between the subvolcanic magmatic bodies in the area of Elatsite copper deposits and a crustal-scale dextral strike-slip shear zone – Kashana shear zone (Fig. 1; Ivanov et al., 2003, 2004).The latter is thought to act as migration pathways and sites of magma emplacement.

Regionally, the Upper Cretaceous magmatic rocks in the area of Elatsite copper deposits are situated in the northern part of the Central Sredna gora tectonic unit (Ivanov, 1998) and are interpretated as products of intensive Late Cretaceous island-arc intermediate magmatism (Boccaletti et al., 1974; Hsu et al., 1977). The formation, development and deformation of Sredna Gora magmatic arc are considered to be result of a system of regional deep situated strike-slip fault zones (Ivanov et al., 2001).

Size, shape and contact relationships of subvolcanic magmatic bodies

The Upper Cretaceous magmatic bodies can be divided into two main groups, based on their spatial orientation, relationships with faults, morphology, petrography, age and hydrothermal alteration: (1) monzodiorite porphyries, and (2) granodiorite porphyries (Ivanov et al., 2003, 2004).

The monzodiorite porphyries form a relatively large (about 4 km in length and up to 600-700 m in width) E-W trending elongate intrusive body that has (in cross-section) very complicated "funnel" shape. They are intruded only within low-grade metamorphic wall-rocks. Everywhere from south and north, the intrusion is bounded by steeply dipping E-W trending brittle dextral strike-slip faults (P-shears) that are parts of a regional dextral fault system – Kashana shear zone (Ivanov et al., 2003, 2004). Well-defined intrusive relationships with the metamorphic wall-rocks are found mainly in the southwestern part of the open pit in the sites of overlapping between E-W-trending faults.

The granodiorite porphyries form small subvertical intrusive bodies and dikes with mainly NE-SW trending elongation. They are intruded predominately in Variscan granodiorites but in the southern part of the Elatsite mine they occur also as small dikes within low-grade methamorphic rocks and rarely within the

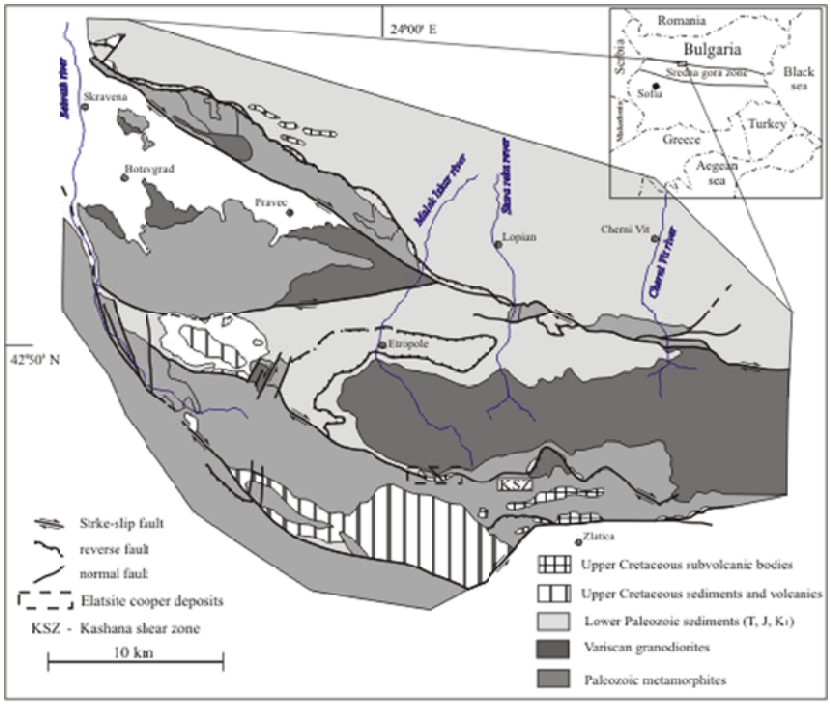

Fig. 1. Geological sketch map of the area of Etropolska Stara planina mountain (Ivanov et al., 2004) based on the geological map of Bulagaria M 1: 100 000

monzodiorites. Usually, they are limited by steeply dipping NE-SW trending brittle sinistral strike-slip faults and fractures (R' shears) that are (similarly to the dextral P-shears) considered as antithetic faults within the Kashana shear zone (Ivanov et al., 2003, 2004).

Kashana shear zone

The Kashana shear zone forms an up to 1 km wide NW-SE trending zone in the area of Elatsite copper mine. It comprises a large number of second-order brittle strike-slip faults that are genetically connected, but have different orientation and kinematics. These faults are subdivided into 4 main groups: dextral NW-SE group (R-shears, "Elatsi – 1"); dextral E-W group (P-shears, "Elatsi-2"); antithetic sinistral NE-SW group (R'-shears) and tensional N-S group (Ivanov et al., 2003, 2004). Each of these fault groups forms typical "flower" structures that can be observed at different scales (from the scale of a separate outcrop to the scale of the shear zone). These fault structures appear to have been used by the intruding magmas and hydrothermal veins. Furthermore, traces of oblique and vertical movement of the surrounding crustal blocks can be found together with typical strike-slip displacement. In a planar view of the Elatsite mine, the Kashana shear zone has sigmoid shape and well-development pattern of faults broadly conforming to Riedel's R and R', and P fracture directions, segmenting the area into diamond-shaped blocks, each roughly parallel to the overall orientation of the shear zone.

Emplacement mechanism and the "room problem"

The analysis of the orientation and kinematics of the separate fault planes, the contacts of the magmatic bodies with their host rocks and the relationships between the shape and size of the intrusions and fault groups show that the subvolcanic intrusions in the Elatsite cooper deposits were emplaced passively into an area of overlapping of the en echelon array of the E-W group of faults ("P-shears") associated with Kashana strike-slip shear zone. It provides a fairly continuous zone of local extension in the bridges between active "P shears".

In cross-section view, the "funnel" shape of the monzodiorite intrusion reflects the "flower" structure geometry of the Kashana shear zone. It is well known that every single fault in the flower structure has individual kinematics. In that sense, the space in the brittle crust was created mainly by simultaneous lateral, oblique and vertical wall-rock translation in the range of the active strike-slip shear zone.

On the basis of experiments and field observations, P-shear arrays and funnel shape of shallow intrusions, appear to be common in transpressional regimes, in oblique convergent-arc settings (Tikoff, Teyssier, 1992; Benn et al., 1998).

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МЕДНО НАХОДИЩЕ ЕЛАЦИТЕ – ПРИМЕР ЗА ВНЕДРЯВАНЕ НА МАГМА В УЧАСТЪК НА ЛОКАЛНА ЕКСТЕНЗИЯ В КАШАНСКАТА ДЯСНООТСЕДНА ЗОНА НА СРЯЗВАНЕ

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Настоястоящето изложение има за цел да представи в обобщен вид някои от резултатите от проведените през последните 4 години теренни изследвания в района на медно-порфирно находище Елаците. Целта на изследванията бе да се изяснят тектонските фактори, оказали влияние върху внедряването и разпределението на горнокредните магмени тела в областта на находището и съседните му територии. Събраните структурни данни показаха, че вероятно разпределението на субвулканските интрузии се е контролирало от Кашанската дяснооотседна зона на срязване. Внедряването се е извършило в условията на локална екстензия в участък на застъпване (тензионен мост) между отделните разломни нарушения (синтетичните P-срязвания) в обхвата на зоната на срязване. Анализът на геометрията на зоната на срязване показа, че в разрез тя представлява структура „цвете", характерна за отседните системи, формиращи се във високите корови нива. Вероятно тази структура е контролирала внедряването на субвулканските интрузии, на което се дължи и тяхната сложна, „фуниевидна" (стесняваща се в дълбочина) форма, наблюдаваща се ясно в минната изработка на находище Елаците. Формирането на подобни P–срязвания с участъци на локална екстензия между тях в обхвата на отседните системи, а също така и внедряването на интрузии с подобна форма и размери са характерна черта за регионално проявените транспресионни геодинамични обстановки. Посочените особености дават допълнително основание да се счита, че тектоно-магматичната еволюция и в тази най-северна част на Средногорската тектонска зона е била причинена от проявата на регионални дяснооотседни зони на срязване.