Mineral. Deposita 21, 271–277 (1986)

MINERALIUM DEPOSITA

Metamorphic imprints upon sulphide mineralisation at Boksputs, Northern Cape, South Africa

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Abstract. A small stratiform Fe–Cu–Zn mineralisation has been examined from Boksputs within the metavolcanic Areachap Group (1.5 Ga), along the eastern boundary of the Namaqua Province. Distinctly deformational and metamorphic features within the mineralisation can be separated into an early and a late fabric; the former is related to an early prograde metamorphism (M1) and also to a subsequent mild retrogression (M2) which can be regionally distinguished in the silicate mineralogy, whilst the latter fabric is derived during a severe retrogressive event (M3) that is concentrated especially in shearzones that cut the mineralisation. A release of secondary sulphur-bearing fluids during M3 is evidenced by new growth and redistribution of sulphides and by local replacement of pyrrhotite by pyrite.

Introduction

Disseminate and semi-massive Fe–Cu–Zn mineralisation occurs on the farm Boksputs in the Northern Cape Province, South Africa along strike from the much larger and better-known deposit at Copperton (Prieska Copper Mines, cf. Middleton 1976; Theart 1985; Wagener 1985). The Boksputs deposit is hosted by chlorite gneisses, amphibolites, amphibole gneisses and garnet-biotite gneisses of the lowermost Jannelsepan Formation of the Areachap Group. This latter lithological unit has a wide regional distribution (see Fig. 1 of Geringer et al. 1986) and has been variously dated at between 1.5 Ga and 1.3 Ga (Cornell 1978; Barton and Burger 1983; Theart 1985). Locally the host rocks are collectively known as the Boksputs Formation but it is considered that these lithotypes are strongly correlable on lithological, tectonic and chemical grounds to the Jannelsepan Formation (Humphreys 1985; Stowe 1983; Geringer 1983; Sacs 1980).

The host rocks have been subjected to four phases of folding and a subsequent phase of regional dextral shearing although some of these tectonic imprints are stronger than others (Table 1). In the mineralised areas (Fig. 1, this paper) the strongest fabric is derived from the dextral shearing that cuts the mineralisation. Accompanying the deformation is a series of metamorphic episodes which belong, with the deformation to the Namaqua Orogeny (1.1–1.0 Ga, Nicolaysen and Burger 1965).

Mineralisation

The mineralisation at Boksputs consists of a series of small, disc-shaped pyrite-magnetite-chalcopyrite bodies up to 200 m×300 m and up to 3 m in width (Theron 1979). The distribution of the ore minerals is predominantly disseminated although in places, massive sulphide lenses occur; the disseminate nature of the deposit together with its low tonnage (1.7 Mt) has made it uneconomic.

Table 1. Deformational patterns in the Eastern Namaqua Province (after Stowe, 1983 and Humphreys, 1985)

Event	Nature	Effects
F1	Isoclinal folding NW trend	Transposed foliations and crenulation cleavage in schists, S_1
F2	Tight-closed folding NW-NNW trend; upright or slight SW vergence	S_2 crenulation foliation and a widespread L2 mineral lineation
F3	Open folding; NE-ENE trend	Dome-and-basin interference pattern with F2; deforms L2 into clear girdles
F4	NNW trending chevron folds; normally asymmetric	S_4 crenulation cleavage rarely developed
F5	Dextral, NNW-trending shears and faults	Tightening of adjacent folding; S_5 mylonitic foliation; anastomosing shearzones through Boksputs mineralisation and host rocks

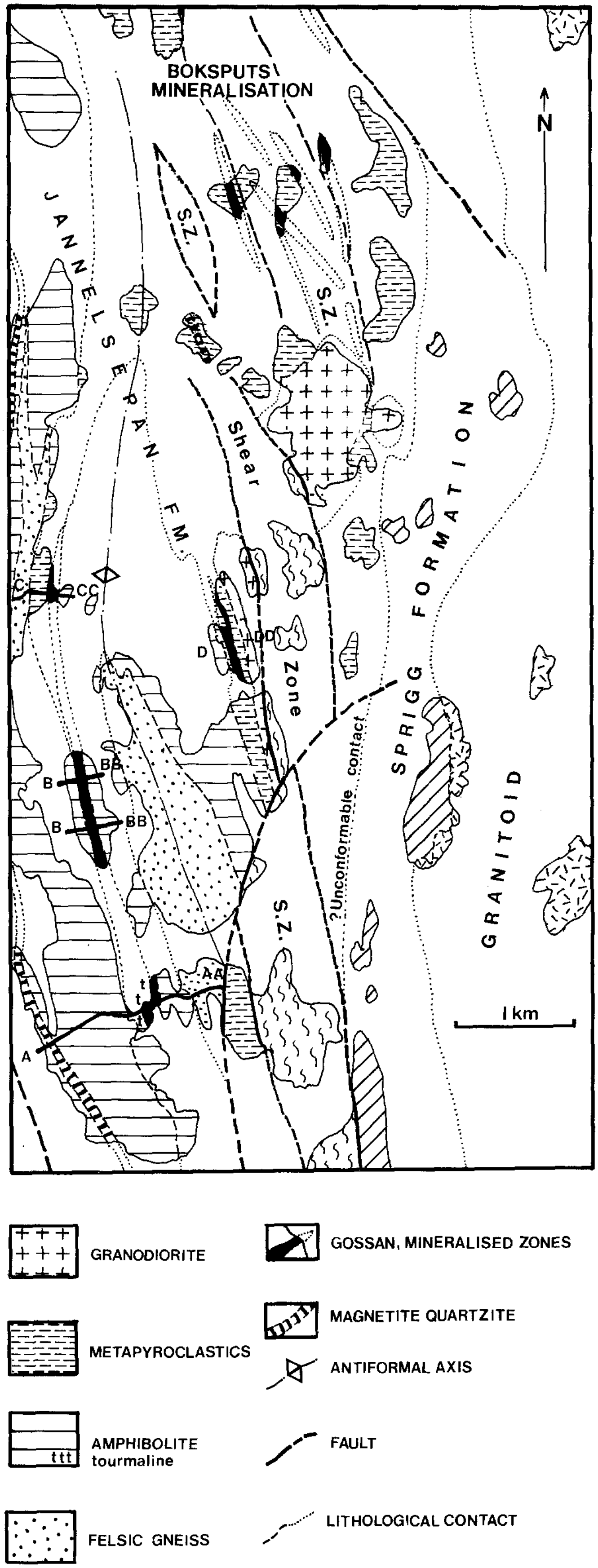

Fig. 1. Geology of the Boksputs mineralisation and host rocks within the Jannelsepan Formation of the Areachap Group. For sections A-AA, B-BB etc., refer to Geringer et al. (1986)

In decreasing abundance the mineralisation comprises pyrite, magnetite, chalcopyrite, sphalerite, pyrrhotite, haematite, chalcocite, covellite, bornite, bismuthinite and reported pentlandite (Geringer 1983). In addition, malachite and cuprite are seen in exploration trenches, and limonite and haematite in gossans. The minerals observed in polished section are described in Table 2. Two types of ore mineral association can be seen (Fig. 2) distinguishable chiefly on the respective proportions of magnetite and sphalerite. The sphalerite-bearing association commonly is dominated by chalcopyrite and contains subsidiary pyrite, whereas the magnetite-bearing association has abundant pyrite, subsidiary chalcopyrite and no sphalerite. The significance of these two ore types, which in any case grade into one another, is not known.

Textural evidence from the sulphides as well as from the silicates reflects a similar metamorphic history for the two mineralogies although it is much better defined in the silicates. This suggests though cannot prove that the mineralisation was syngenetic with the eruption or deposition of the host rocks. Fluid inclusion and isotopic studies currently under way may constrain the origin of the mineralisation further (A.E. Schoch, pers. comm. 1986).

The host rocks, chemical characterization and geological setting of the Boksputs mineralisation are treated more fully by Geringer (1983) and Geringer et al. (1986).

Silicate metamorphism

The metamorphism along the eastern boundary of the Namaqua Tectonic Province (Hartnady et al. 1985) consists of one widespread prograde event (M1) that has been preceded by limited contact metamorphism 15 km west of Boksputs and also by a patchily developed (or preserved) regional event recorded by Theart (1985) and observed by the author at Copperton as a staurolite-producing event. M1 was followed by a retrograde-to-isothermal regional event (M2) that at Boksputs is mildly retrogressive, and then by a severely retrogressive event (M3) which was extensively developed over Eastern Namaqualand though concentrated around planes of weakness offering high porosity.

M1 reached upper amphibolite facies with P–T conditions estimated from mineral assemblages of 4.8–6.2 Kb and 680°–730 °C. In metabasic rocks, diopside and green-brown hornblende are widely developed together with grossular or almandine garnet (depending on composition) and rare grains of orthopyroxene in restricted areas of lower granulite facies metamorphism. In metapelites, assemblages are typified by K-feldspar + sillimanite + plagioclase + quartz, hercynite + quartz, coexistent almandine garnet and cordierite, and additional red-brown biotite. Orthopyroxene-bearing metapelites are found but the grains are strongly overprinted by M1 assemblages; the proximity of a foliated amphibolite with relict olivines (Pretorius 1986) suggests the existence of a pre-M1 high temperature contact event to explain the orthopyroxene in the metapelites. M1 was coincident with early isoclinal folding (F1 – see Table 1) and lasted into F2 deformation whose NNW trend is seen in the antiform in Fig. 1.

M2 was an upper-to-lower amphibolite facies event coinciding with an ENE-NE trending fold phase (F3). It