# The Characteristics and Growth Process of the $FeS_2$ Alternating Bands in the Laozuoshan Gold Deposit, NE China

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Pyrite, marcasite, and pyrrhotite are widespread in the Laozuoshan gold deposit, Heilongjiang, NE China. Pyrrhotite is particularly abundant along the direction of cleavage. The formation of alternate bands of pyrite and marcasite has attracted much attention. This phenomenon can contribute to revealing the process of sulfide metasomatism and the ore-forming fluid environment.

There are two metallogenic periods, magmatic-hydrothermal forming skarn mineralization and later hydrothermal mineralization. The pyrrhotite mainly formed during the skarn mineralization period, whereas the pyrite and the marcasite within alternate bands formed during superimposed hydrothermal mineralization. The genesis of the $FeS_2$ bands has not been previously studied.

The pyrite and marcasite banding occurs in the sulfide-rich ore formed during the hydrothermal mineralization period. In backscattering images, the bandwidth of $FeS_2$ alternating bands is between 3 and ~10 μm, with the primary phases being pyrite and marcasite. There are three types of mineral associations: (1) pyrite + marcasite + chalcopyrite ± pyrrhotite, (2) pyrite + marcasite + chalcopyrite, and (3) pyrite + marcasite. The amount of fine and anhedral pyrrhotite is small, and it is distributed in the gap between the $FeS_2$ bands. Chalcopyrite is anhedral and banded in the same direction as the $FeS_2$ alternating banding. Compared with the ideal $FeS_2$ mineral, Fe ranges between -0.93~ +4.79 wt % and S ranges between -5.33 ~ +0.67 wt % in the $FeS_2$ bands based upon EPMA data. Both pyrite and marcasite display a characteristic high Fe content and low S content. Some element concentrations (As, Zn, Cu, Ag, Au) are mostly below the detection limit. The Au content is high in the first two mineral paragenetic assemblages but decreases in the late pyrite-marcasite event. Raman spectrum peaks for the marcasite banding are 332.76~336.13$cm^{-1}$ and 370.76 ~ 399.26 $cm^{-1}$. From the micro-band to the coarse band in the marcasite, the Raman shift spacing decreases, peak strength increases, and FWHM decreases, indicating the crystallization degree of the marcasite increases from the micro-band to the coarse band.

Due to the physical and chemical conditions causing fluid changes, pyrite and marcasite replaced early pyrrhotite through the dissolution-reprecipitation mechanism. In the process of replacement, the volume of material was reduced, and the spaces are commonly filled with siderite and other carbonate minerals. The occurrence of marcasite indicates the pH was acidic during the late mineralization. The $FeS_2$ alternating banding recorded the fluid flow replacement process.