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Typomorphic characteristics of pyrite: Criteria for 3D exploration targeting in the xishan gold deposit, China

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ABSTRACT

This paper describes 3D modeling of exploration criteria derived from typomorphic characteristics of pyrite in the Xishan quartz vein-type gold deposit (China). The methodology consists of five steps: (1) modeling of orebody thickness and grade using ordinary kriging in longitudinal section; (2) analysis of major/trace element content of Au-bearing pyrite from each ore paragenetic stage; (3) analysis of thermoelectric parameters of Au-bearing pyrites and estimation of ore-forming temperatures and comparison with homogenization temperatures from fluid inclusion analysis; (4) 3D modeling of orebodies using surface geological mapping, mining tunnels in different levels, and a borehole dataset; and (5) 3D modeling of thermoelectricity coefficients and estimated temperatures from Au-bearing pyrites for exploration targeting via discrete smooth interpolation and concentration-volume fractal modeling. The results indicate that: (1) Au-bearing pyrites from four ore paragenetic stages record gradually decreasing temperatures from the earliest to the latest stages, and the frequencies of occurrence of pyrite crystal combination forms and element components are closely correlated with P-type values of pyrite; (2) orebodies Nos. 108–1 and 107 are continuous at depth and potential exploration targets of their continuations extend more than 700 m downward from their present mining levels; whereas orebodies Nos. 55 and 108–2 discontinue at depth.

1. Introduction

Mineral deposit models, which contain information on geological, geochemical, geophysical, genesis, grade and tonnage of specific deposit types are useful in regional-scale exploration and resource assessments as well as in three-dimensional (3D) district-scale geological modeling for exploration targeting (Cox and Singer, 1986; Dagbert and Harfi, 2002; Fallara et al., 2006; De Kemp et al., 2011; Wang et al., 2011, 2013, 2015; Mejía-Herrera et al., 2014; Vollgger et al., 2015). Deposit-scale exploration targeting has also benefitted from 3D modeling of surface and subsurface geochemical datasets (Jackson, 2010). The cited case studies of 3D geological modeling are mostly concerned with targeting for porphyry–skarn or VMS deposits across a range of scales from regional- to deposit-scales and commonly have sufficient multiple geoscience datasets. However, 3D geological modeling for exploration targeting of vein-type mineral deposits is even more challenging because uncertainty in 3D modeling of complex geological systems, such as mineral deposits, is difficult to eliminate (Fallara et al., 2006; Lindsay et al., 2012, 2013a, 2013b).

In this paper, we address the question "How can we construct a 3D exploration targeting model using typomorphic features of pyrites in complex and irregular quartz-vein hosted gold in the Xishan deposit, China"? The targeting criteria that we use are derived from hydrothermal pyrite, which contains significant amounts of minor and trace elements, and provides a record of hydrothermal fluid evolution in an ore system (e.g., Deditius et al., 2011; Reich et al., 2013). For example, pyrite in gold-bearing quartz veins provides information on the potential source and timing of gold and related fluid processes responsible for mineralization (Large et al., 2009; Thomas et al., 2011; Cook et al., 2013). Typomorphic features of pyrite in different ore-forming stages or different ore bodies in a mineral deposit have been analyzed in metallogenic studies to support mineral prospecting (e.g., Chen et al., 1989; Meng et al., 2001; Shen et al., 2013; Xue et al., 2014). Typomorphic characteristics of pyrites, such as crystal type, chemical composition, and thermoelectricity, have been shown to be closely related to the physicochemical environment of their formation (e.g., Li et al., 1994, 2012; Shen et al., 2013).

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In this paper, we describe 3D deposit-scale modeling for exploration targeting based on typomorphic thermoelectric property of pyrite (Li et al., 2012), 3D models of orebody based on Au grade and vein geometry, and knowledge of metallogenesis of the Xishan gold deposit.

2. Geological setting

The Jiaodong Peninsula along the southeastern margin of the North China Craton (NCC) is the most important gold producing province in

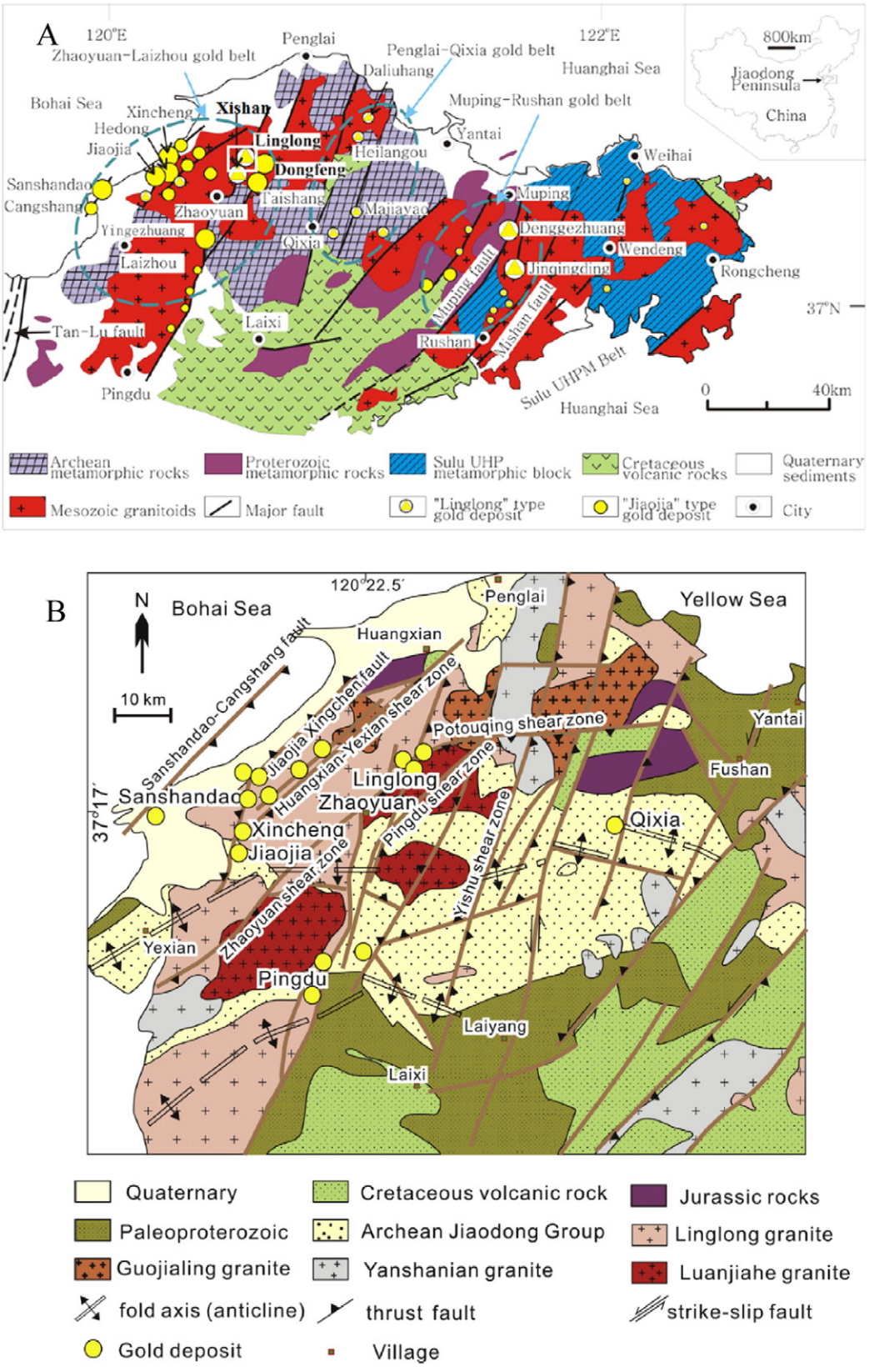

Fig. 1. Gold deposits and geological map of Jiaodong Peninsula, China (A: modified from Wen Wen et al., 2015; B: modified from Goldfarb and Santosh, 2014).