

# An under-recognized mineralization style along the northern margin of the North China craton: Potential for discovery of large-tonnage disseminated and stockwork-style gold deposits

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**Abstract.** Based on recent field investigations of a number of the important gold deposits along the northern margin of the North China craton, it is argued that broad zones of disseminated and stockwork-style mineralization in some of the deposits have far greater importance than previously recognized. On a regional scale, the intersection of the major NNE/NE- and E-W-trending structures, products of Mesozoic Pacific margin oblique subduction and Paleozoic-early Mesozoic craton collision, respectively, is a key to localization of the ores.

**Keywords.** Disseminated and stockwork-style ores, large-tonnage, gold deposits, North China craton

## 1 Introduction

The northern margin of the North China craton has been attracting much attention from both academic researchers and mining industry personnel in the past decade, as it has undergone perhaps the most lengthy, complex tectonic history in China, as well as hosting a resource of approximately 800-900t Au (Zhou 1999; Zhou and Lu 2000; Hart et al. 2002; Zhou et al. 2002). In the past, much of the exploration work in the region has focused on finding gold vein style mineralization; this style of deposit has been well described in various recent research papers (e.g. Miller et al. 1998; Ao et al. 2002; Hart et al. 2002; Zhou et al. 2002; Jin 2003). In the past couple of years, we visited many of the important gold deposits in this region, and have gained extensive and updated geological data through our exploration and mining projects along the craton margin. Our observations indicate a much greater importance for broad zones of disseminated and stockwork-style mineralization in some of the deposits than was previously recognized. We will attempt here to share our experience in developing these newly identified targets with other explorationists, particularly those from western countries who have been actively involved in, or intend to step into, gold exploration and mining in China.

## 2 Broad zones of disseminated and stockwork-style mineralization

The northern margin of the North China craton underwent several orogenic events as the result of the collision

of the North China craton with the Siberia and South China cratons, and subduction of the Izanagi/Pacific oceanic plates. The E-W structures that dominate the area were caused by the convergence between the North China and Siberia cratons from late Paleozoic through Early Jurassic time, with the closure of the Solonkar Ocean occurring between the two blocks. In the eastern part of this area, the E-W structures were overprinted by NNE-NE structures that developed as a result of the NW-directed, oblique subduction of the Izanagi/Pacific plates under the eastern margin of China.

In the western part of the northern craton margin, such as in the Wulashan goldfield (i.e., Hadamengou and Wulanbulang gold deposits, approx. 20 km west of Baotou City, Inner Mongolia), the majority of gold deposits belong to the well-described, gold-bearing quartz veins, which are mostly about 1-1.5 m in width. In some favorable structural intersections and possibly favorable rock types, however, relatively high-grade and wider veins may be found.

From the city of Zhangjiakou (Hebei province) eastwards, an area containing the Dongping and Xiaoyingpan (also called Zhangjiakou) gold deposits, the influence of the NNE-NE structure is significant. Importantly, broad zones of disseminated and stockwork-style mineralization have been recently identified throughout this region. For example, a 70- to 130-m-wide zone of disseminated and stockwork style ore was found to average 5-6 g/t Au near the contact of a middle Paleozoic alkalic intrusive complex and Late Archean gneiss/amphibolite at Dongping. Similar looking disseminated and stockwork-style ore zones have also been observed at properties throughout Kuancheng, Qinglong and Pingquan counties, which include parts of eastern Hebei province and adjacent Liaoning province, where the two major E-W and NNE-trending structural corridors intersect. At the Huajian-Niuxinshan deposit (about 200 km northeast of Beijing), underground development intersected an over 35-m-wide disseminated and stockwork style ore zone averaging 4.5 g/t Au, hosted in a silica-sericite-pyrite altered syenite dyke. Additionally, disseminated ores in

sericite-pyrite altered Mesozoic granite, with grades as high as 7.5 g/t Au, are mined by local workers from several adits driven into the Niuxinshan granite. The extent of the gold mineralization in the granite is still unknown. Only about 20 km north of the Huajian-Niuxinshan deposit, gold mineralization at the Yuerya deposit occurs as both quartz veins and disseminated/stockwork style ores within the Mesozoic Yuerya Granite. Most mineralization occurs near the contact of the granite and Middle Proterozoic carbonate rocks. The disseminated/stockwork ores have accounted for almost 25% of the production to date. Recent underground exploration identified a 30-m-thick disseminated/stockwork ore zone averaging 4 g/t Au. Further to the north, the Dongliang deposit and its extension within Pingquan county (Liaoning province) are characterized by similar high-grade zones of stockwork and disseminated style gold ores over widths of 10-20 m. Further east, at the Baizhangzi deposit, a broad zone of disseminated/stockwork ores, 20- to 50-m-wide and with a grade >5-6 g/t Au, has been identified along the margin of a Mesozoic granite that intrudes Middle Proterozoic metasedimentary rocks.

Although local controlling factors for these broad zones of disseminated and stockwork style ore require further investigation, a regional control appears to be the intersection of major NNE- to NE-trending structures with the older E-W structures. In these areas of intersection of structural domains, the competent margins of Paleozoic-Mesozoic igneous bodies are particularly favorable hosts for development of gold-rich stockworks and disseminations. These areas within the northern margin of the North China craton are the key targets for western companies who are seeking large-tonnage gold deposits in China.

### 3 Issues relating to remaining resource/reserve in existing gold mines

To correctly assess the remaining resource/reserve in existing gold mines, one must first fully understand the common practices in the Chinese exploration and mining industry. Traditionally, geological brigades under various ministries of the State Council were assigned to conduct regional geological and geochemical reconnaissance surveys, followed by preliminary and detailed exploration projects that included trenching, limited underground development, and some drilling. Generally, the footage of each drill hole was in the range of 100 to 200 m, with only a few extending to depths of 300 m or more, and the majority of the drill holes were sub-vertical. By the end of a detailed exploration project, each brigade would submit a geological report with indicated and inferred resource (in Chinese categories C and D, but occasionally B), and all data would be transferred to the mining sector representatives, who were usually administered by dif-

ferent government organization. Once mining commenced, workers usually tried to extract the already recognized and easily accessible ores as thoroughly as possible, and neglected the importance of further exploration, particularly drilling to depth to enlarge the resource. In fact, the majority of the mines in the region had never been subjected to any underground drilling since the mining operations started. As a result, after a few years of mining activities, a mine was quite often defined as "the mine in crisis" due to apparent depletion of the remaining resource. However, many mines have been revived after new underground exploration and subsequent identification of additional resources. For example, the Dongping deposit was given the status of "mine in crisis" before May, 1999. However, further underground development guided by experienced mine geologists has identified significant new gold resources at depth. As a result, the Dongping deposit today remains as one of largest active gold mines in China. Similar experiences have characterized development of many existing mines including the Yuerya, Baizhangzi, and Niuxinshan deposits.

It is also worth noting that the broad zones of disseminated and stockwork-style gold ores usually do not appear in outcrop and often occur solely in the subsurface. Above these broad ore zones, mineralization may occur as narrow, auriferous quartz veins, e.g., at Dongping, Baizhangzi and Niuxinshan. Therefore, during due diligence review for acquisition of mining projects in China, explorationists from the western countries may need to realize when considering the remaining resource numbers that these may be somewhat deflated, and they should not under-estimate the potential for finding more resource at depth in many of the already active gold mines across northern China.

### 4 Concluding remarks

The northern margin of the North China craton is one of the major gold provinces in China. However, most exploration and mining companies from the western countries appear to be perplexed when it comes to exploration in this area, as the deposits there were traditionally described as narrow gold-bearing quartz veins, normally only 1- to 2-m-wide, and, therefore, would not be suitable for large-scale mining. Our recent work suggests that significant potential exists for the discovery of broad zones of disseminated and stockwork-style gold mineralization in the subsurface beneath known vein systems. On a regional scale, the intersection of the major NNE/NE- and E-W-trending structures, products of Mesozoic Pacific margin oblique subduction and Paleozoic-early Mesozoic craton collision, respectively, is a key to localization of the ores. This particularly characterizes the North China craton margin to the east of Zhangjiakou. Because these broad zones of disseminated and stockwork style gold ores typi-

cally occur at depth, and giving the common practices in the Chinese exploration and mining industry, one should not under-estimate the significant potential in finding multiple Moz gold resources during evaluation of exploration properties and existing gold mines.

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