Appendix II-2

A New Type Gold Deposit, the Greatwall—Its Characteristics and Exploration Potential in Eastern Hebei Province, P.R. China

by

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INTRODUCTION

A new type gold deposit has recently been named as "the Greatwall" in the Lengkou basin. These deposits are different from Carlin-type and other types gold deposits currently known on the world both in geology and geochemistry. The Lengkou sedimentary basin is located over the five counties of Qinglong, Kuancheng, Qianxi, Qianan, and Lulong in eastern Hebei Province, P.R. China (fig. 3-2-1). It is about 5 to 15 km wide, more than 60 km long, trending northwest, and consists of rocks belonging to the late Proterozoic (Sinian system) Great Wall and Jixian systems (fig. 3-2-2). The characteristics of the ores in these deposits is a simple mineral composition, no visible sulfides, no carbon, low toxic elements (As, Hg, Sb Tl), loose texture and widespread mineralized zones. These properties make this deposit type open pit mining, and to direct heap leaching with high recovery rates.

These deposits have been found in Ca- and Mg-carbonate rocks of the upper Gaoyuzhuang group of the Great Wall system, and lower Yangzhuang and Womishan groups of the Jixian system, and are present in stratabound breccia zones with weak alteration. This deposit type was first discovered in 1988 by the 5th Geological Team, Hebei Bureau of Geology, and small mining activities have been conducting in this area since that time.

GEOLOGIC CHARACTERISTICS OF THE GREATWALL DEPOSITS

Orebodies are hosted by layered, stratabound breccia zones, which contain economic gold contents and are present along stratigraphic horizons (fig. 3-2-3). They usually trend NW 290° to 310°, dip to SW approximately 50° to 80°, and vary locally with the host strata. The orebodies are 30 to 40 m wide, several tens m long, and parallel each other. They locally comprise mineralized zones up to 200 m wide. There are not clear boundaries between the orebodies and host-rock (breccia—dolomitic limestone). Their extension on the surface and underground has not been constrained by geologic engineering measurements; however, some individual open pit mines made by local farmers are about 40 to 50 m wide and 25 to 50 m high.

Ore Types

Breccia ore is the main ore type in the Greatwall deposits, but three additional ore types are silciceous, thin marl, and unconsolidated mud-sand ore types. Unconsolidated mud-sand types are contained in modern unconsolidated sediment and are similar to placer deposits.

(1) Breccia ore, the main ore type, consists of carbonate breccia with muddy, lime cement, and is about 80% of total ore. The content of gold in this type of ore depends on the amount of interstitial cement, while the general assay varies from 1 to 5 ppm Au, and locally up to 10 to 30 ppm Au in some rich ore blocks, with large cement components.

(2) Siliceous ore types are common in the #II breccia zone and consist of white, brecciated jasperoidal stratabound stringers similar to quartz, which are 1 to 20 m thick, with stratabound veins, and local irregular shapes, along the bedding of the host rocks. There are no visible sulfide minerals and the assays vary from 1 to 5 ppm Au. This type ore comprises about 10% of the total proven ore in the Greatwall deposits.

(3) Thin marl ore types consist of yellowish gray to pinkish gray argillaceous limestone, dolomitic limestone, and dolomite. The ores are brecciated and argillized and contain weak silicification and no visible sulfide minerals. The assays of this ore varies from 0.2 to 2 ppm Au, and locally up to 3 to 5 ppm Au. It is about 5% of total proven ore.

(4) Unconsolidated mud-sand ore types are strongly brecciated and weathered and consist of yellowish green or purple, loose mud, sand and rock debris. The ores are present at the D open pit in #V breccia zone, and are about 5% of total proven ore. The mineable individual orebody is 4– to 5–m-thick with an average assay of between 50 and 60 ppm Au. (Assay varies from 20 to 85 ppm, up to 140 ppm Au).

Alteration

Silicification, ankeritization (?) and limonitization (geothite) are the main hydrothermal alteration and mineralization styles in the Greatwall deposits. Generally, hydrothermal alteration is weak in the deposits. Limonitization is most common and easy to identify in the field by its purple-red color, and it locally changes into a light brownish green color by leaching and oxidization near the surface, and is an indication of strong mineralization. Locally, chloritization can is present in some samples from the orebodies. Limonitization and ankeritization are more common than silicification, although some irregular lenses or nodular zones of silicification are locally present. On the surface, the alteration zones are not clear because, but are recognized by unmineralized breccia zones that serve as a markers for exploration.

Gold assays related to breccia type

The assay values of Au-mineralized breccia depends on the texture and the amount of matrix cement. The richer ores are strongly brecciated and contain finely fragmented breccia and larger amounts of cement. Different rank s of ore are identified in the Greatwall deposits that depend on breccia color and the amount of cement. For instance, gold assays in ores with yellowish white or yellowish gray breccias and yellowish gray cement are 10 ppm Au or more (up to 30 to 50 ppm Au) especially if the cement is about 15 to 20%. The Au assay is usually below 10 ppm if the cement is less than 15%; however, if the ore contains black breccia and pink cement (less than 10%), gold assays are below 1 ppm.

Mineral composition

Mineral composition in ores of Greatwall deposits is relative simple, and mainly consists of calcite, dolomite, serpentine, and quartz, as well as small amounts of clay minerals. Trace zircon and barite also are identified in the ore. Ore minerals include native gold, electrum, pyrite, limonite (geothite) and local of chalcopyrite, sphalerite. The geochemical

composition of the ore is high CaO, MgO, CO_2, and low SiO_2, K_2O, Na_2O; Fe_2O_3 varies relative to gold; generally, high Fe_2O_3 accompanies high gold. This is consistent with the observation that native gold is enclosed in geothite. Most native gold occurs in limonite (geothite), while some is present in the fractures of minerals. Sometimes visible gold can be seen in the richer ores in the Greatwall deposits.

GENERAL CHARACTERISTICS OF GREATWALL TYPE GOLD DEPOSITS

This new type gold deposit has some special geological features, such as regional distribution, Au-bearing geologic bodies, ore-control structures, and mineralogic and metallurgical characteristics. The Greatwall deposits were considered as Carlin-type gold deposits before, however, we think that it should be a new type gold deposit with its own geologic characteristics. According to the following characteristics, the Greatwall gold deposits are different from Carlin-type gold deposits and are considered in the general class of sedimentary rock-hosted gold deposits.

Stratabound mineralization zones

Chert-bearing Ca- and Mg-rich carbonate stratigraphic controls of all five breccia zones are contained in the upper Gaoyuzhuang group of the Greatwall system, Yangzhuang group and lower Wumishang group of the Jixian system in eastern Hebei Province. These stratigraphic units consist of the northwest-trending Lengkou gold mineralized zone. Thin marl rocks of the Qingbaikou system lie above the host stratigraphy, and the Dahongyu group of the Greatwall system lies below it. The bottom of the mineralized Gaoyuzhuang group is in contact with argillaceous dolomite, marl, and sandstone, *in* which there are Mn-bearing or Mn lens shaped orebodies.

Uniform and widespread of zones of mineralization

The Lengkou basin, more than 60 km long, lies in Qinglong, Kuancheng, Qianxi, Lulong and Qianan Counties. Breccia zones in the basin control gold mineralization zones. The measurement of the known breccia zone is generally 5 to 15 km, up to 25 to 30 km long. A total of 34 rock chip samples were randomly taken from 4 mining sites, which contain gold assays from northwest to southeast along the breccia zone as 0.044 to 4.5 ppm (avg. 1.65 ppm), 0.20 to 23.03 ppm (avg. 6.24 ppm), 0.04 to 8.82 ppm (2.55 ppm), 0.018 to 85.23 ppm (avg. 11.43 ppm Au). In addition, 10 trench samples were taken from a section south of the #I breccia zone, which yielded gold assays of 2.72 ppm (avg.) in the poor segment, and 7 to 9 ppm in the rich segment (see fig. 3-2). These assays suggest that mineralization in the Greatwall deposits is very uniform and widespread on a district basis.

Structural breccia zones serve as main ore-control

Breccia zones parallel the host stratigraphy and contain breccias fragments from all the host rocks such as dolomitic limestone, mud-siltstone, chert, silicalite. These are commonly cemented by purple to maroon-colored fine-grained, silty to sandy cement. The size of the angular fragments varies from several square meters to several square millimeters. Large fragments usually occur in the center of breccia zone, while smaller fragments are present at the margins. The amount of fragments decreases from the center to both sides of the zones, and gradually grade to normal dolomitic limestone.

Crumpled and compressed structures and curved dolomite lenses in the breccia zones are most common where gold mineralization is strong. Secondary brecciation is commonly cemented again by carbonate, which indicates that these breccia zones may have experienced first extension

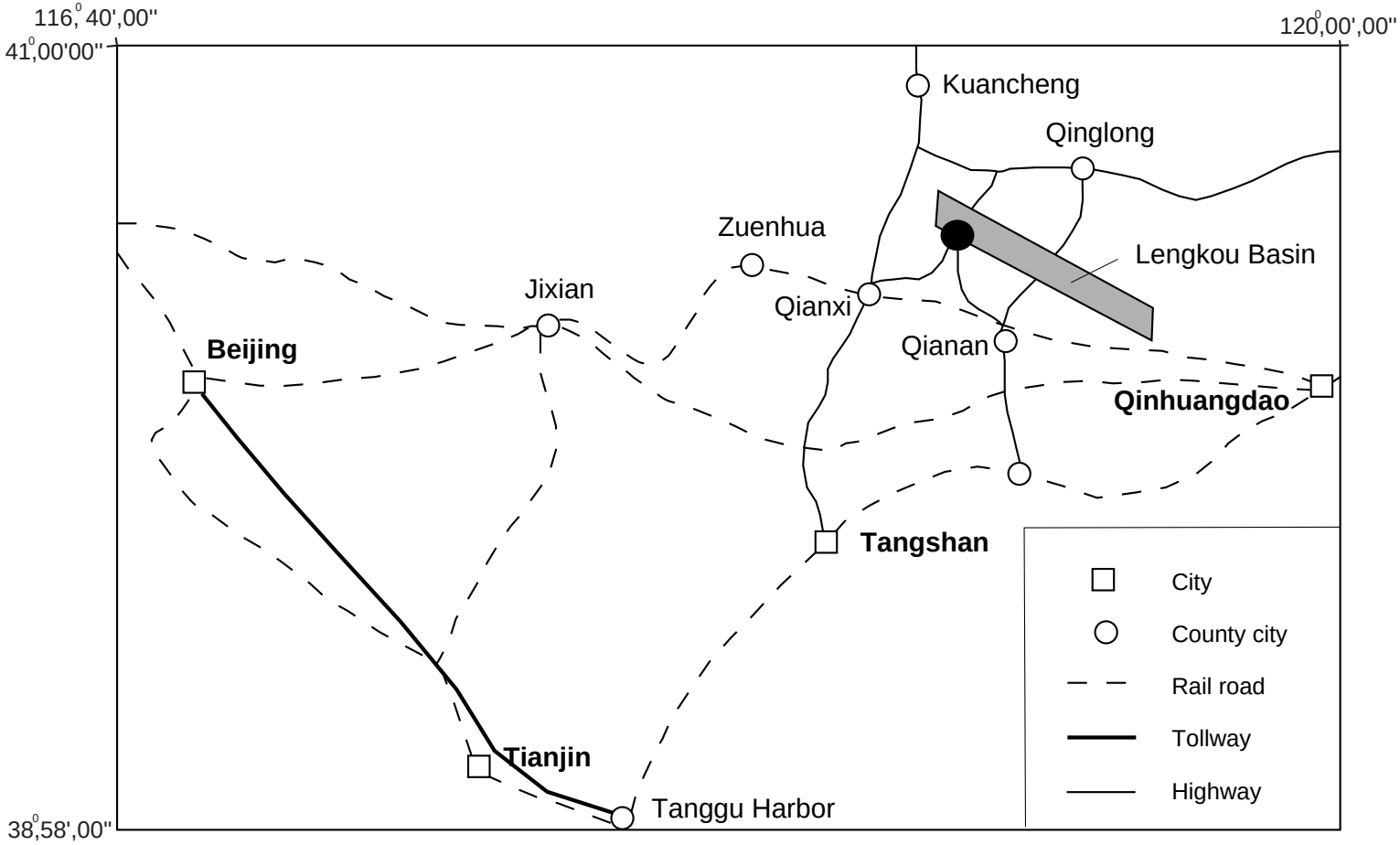

Figure 3-2-1. Location and Transportation map of the Greatwall gold deposits

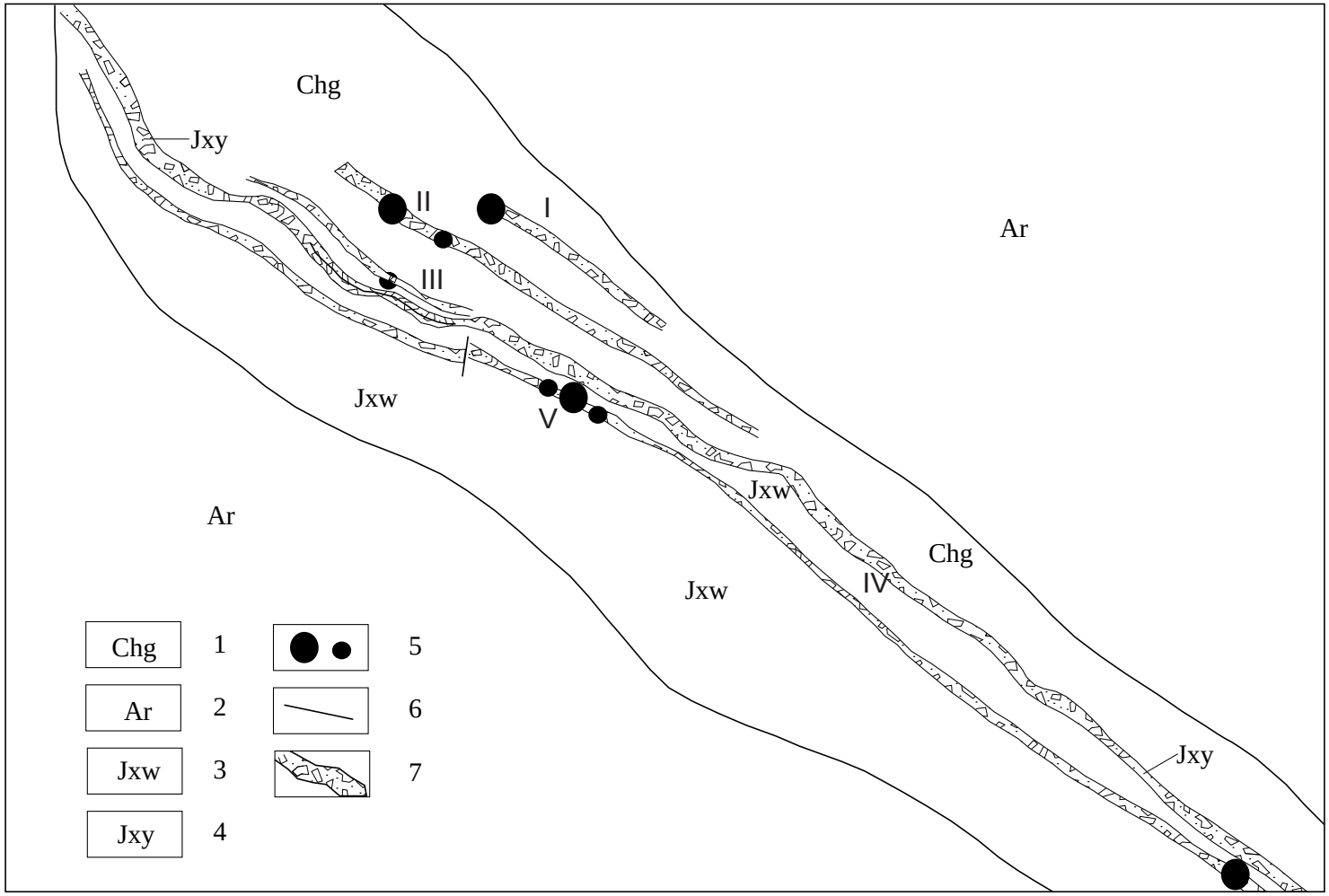

Figure 3-2-2. Geology and gold deposits in Lengkou basin, Jidong area, China. Showing the gold deposits are controlled by five breccia bodies northwestern-trending. 1-Gaoyuzhuang group of the Greatwall system (Chg); 2-Archaeozoic stratigraphy (Ar); 3-Wumishan group of the Jixian system (Jxw); 4-Yangzhuang group of the Jixian system (Jxy); 5-Gold deposits (prospects); 6-Boundary of the Lengkou basin; 7-Au-bearing breccia bodies with number. Adapted from Qiu, Y.S. and Yang, W.S. (1997, unpublished).

then compression by at least two structural events. However, the genetic mechanism of the breccia zone formation is still under study.

Low levels of toxic elements and high metallurgical recovery rates

An important characteristic of the ore includes no visible sulfides small clay mineral content, low carbon and low As, Sb, Hg, and Tl. Some very fine-grained pyrite has been observed under high power microscope. The polished sections and pan concentrate analysis shows that the ore-minerals in these deposits are pyrite, geothite, native gold, with trace sphalerite and chalcopyrite. The geometry of these deposits is amenable to large scale mining and the metallurgy allows high recovery heap leaching because the ore bears low As and S. High gold recoveries of up to 91.67% could be achieved from all sliming cyanidation and column cyanidation experiments.

Native gold hosted by cement

In polished thin section, native gold occurs in cement composed of geothite (limonite)-bearing ankerite. Native gold coexists with geothite, and is enclosed by geothite. Some geothite pseudomorphs pyrite, *in*dicating that geothite formed from oxidized pyrite. Separate assays of breccia and cement show 0.29 to 0.87 ppm Au in breccia and 9 to 46.8 ppm Au in cement.

Au grades increase with depth

Assays are relatively low in Au on the surface—generally less than 0.5 ppm and usually uneconomic. This also makes surface prospecting difficult. Research shows that gold assays increase gradually with depth, up to 8 to 10 times greater than the surface at depths of between 25 to 30 m. This indicates that a secondary enrichment process is likely in many of these deposits. The exact depth of secondary enrichment needs further research.

EXPLORATION POTENTIAL

The Greatwall gold deposits are clearly different from Carlin-type gold deposits, and have their type example in eastern Hebei Province, P.R. China. There is a the possibility for discovery of large gold deposits there. Recognition of this new type of gold deposit broadens the field of gold exploration. Most known Greatwall deposits contain widespread, uniform gold mineralization, close to the surface, with wide widths, and low toxic elements.

These gold deposits are stratabound and controlled by a set of uniform stratigraphic horizons in the Greatwall and Jixian systems, such as Gaoyuzhuang, Yangzhuang, and Wumishang groups. Mineralized northwest-trending breccia zones are further controlled by Lengkou regional fault. To the north of this area, the regional-scale Xifengkou-Qinglong fault, trends east to west and also controls the distribution of Greatwall and Jixian system rocks in Kuancheng County, and is associated with northeast-striking secondary and east-west faults. Gold-bearing geologic bodies also have been discovered in Qianxi County, south of the main area, and in Lulong County east of the area. These goldfields also are favorable for Greatwall gold deposit exploration.

Regional-scale pan concentrate gold anomalies show that the Qingheyan deposit, a Greatwall gold deposit in Qinglong County, also is associated with a Pb anomaly. Similarly, all the peripheral areas mentioned above, which are all associated with the Greatwall and Jixian stratigraphic systems have found Au-Pb anomalies, and indicate a good potential for exploration deposit type. Geochemical anomalies are also present in the northwest and southeast parts of the area in the 60–km-long Lengkou gold mineralization zone. Some anomalies are higher than those from known orebodies

and are untested, suggesting a larger potential for the area.

SUMMARY

Genetic theories of the Greatwall gold deposits still need further research. Some problems, such as the genesis of the breccia zones are still under consideration and deal with two theories, one syngenetic breccia, another epigenetic breccia. Other problems, such as the mechanism of gold enrichment, the function of surface leaching, and enrichment of surface gold need to be examined in more detail.

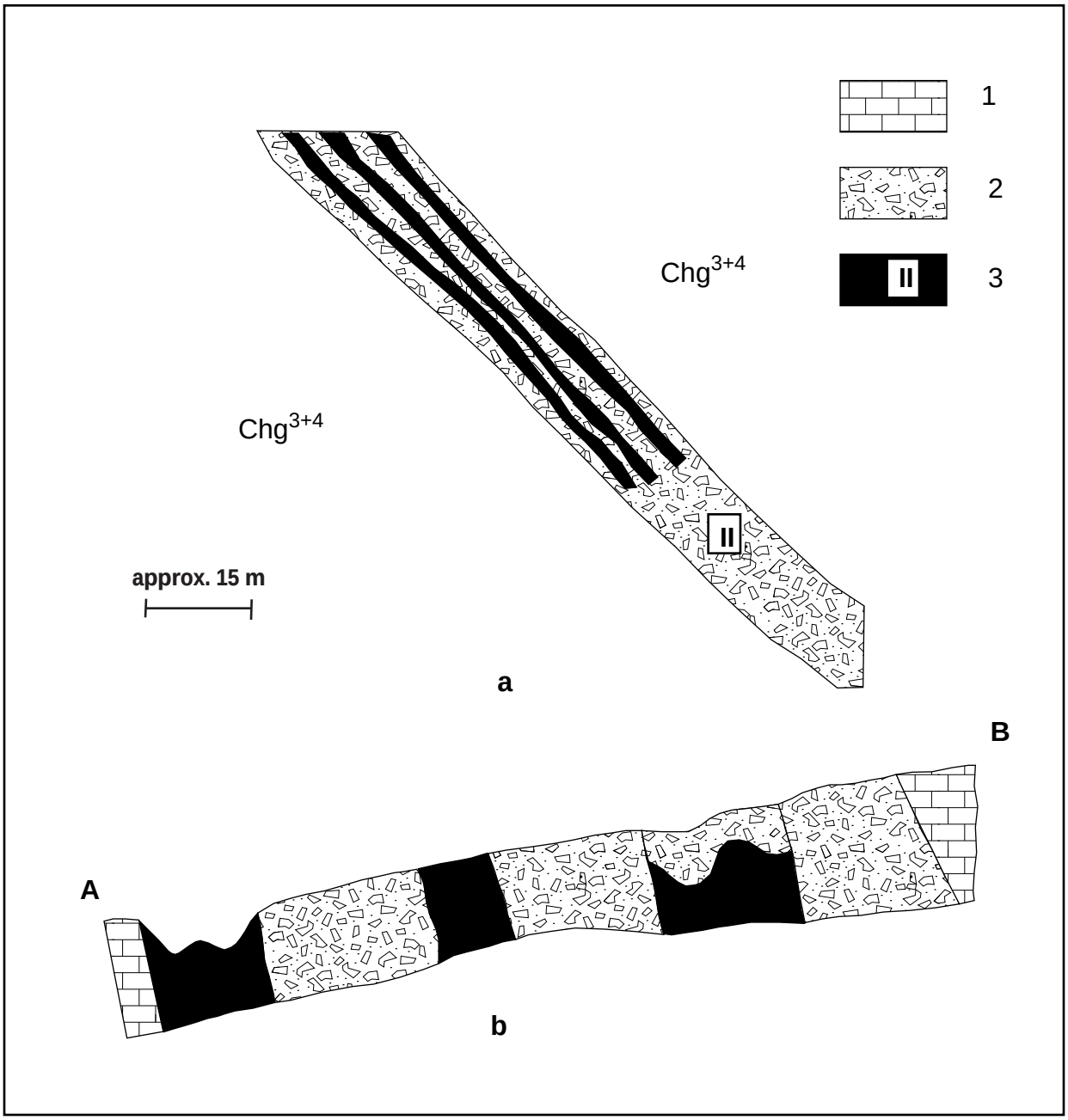

Figure 3-2-3. Stratabound breccia bodies control the No. II orebody in the Qingheyian gold deposit, a Greatwall type deposit. a - plane map; b - section; 1 - dolomitic limestone, 2 - breccia, 3 - orebodies; Chg^{3+4} - Gaoyuzhuang group of the Greatwall system.