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Comparative Geology and Geochemistry of Sedimentary-Rock-Hosted (Carlin-Type) Gold Deposits in the People's Republic of China and in Nevada, USA

by

Zhiping Li[1] and Stephen G. Peters[2]

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中华人民共和国与美利坚合众国
沉积岩(卡林)型金矿床的地质、地球化学对比研究

李治平　　史蒂芬 G. 皮特尔

内容提要

自从六十年代起，沉积岩(卡林)型金矿床已被认为是一种地质成因独特，经济意义巨大的矿床类型。除美国西部大盆地之外，类似的金矿床已经发现在中国，澳大利亚，多米尼加，西班牙，俄罗斯，马来西亚，菲律宾，南斯拉夫和希腊等国家。在中国的中部和西南地区发现大约有 112 个沉积岩型金矿床(点)，其中至少有19个金矿床具有潜在的工业储量。这使得中国成为继美国之后第二个在勘探和开发此类型金矿比较领先的国家。

中国沉积岩型金矿床主要分布在前寒武纪扬子准地台的边缘，并受区域深大断裂的控制。次一级区域 构造比如短轴背斜，高角度断层，层控角砾岩体和地层不整合面做为有利的容矿构造。这些金矿床产于古生代到中生代不纯的石灰岩，砂岩和泥岩之中。围岩蚀变类型包括硅化，去碳酸岩化， 泥化，碳化和局部钠长石化。除少量煌斑岩和长英岩脉外，大多数中国沉积岩金矿床中没有火成岩出露。

金以浸染状产于这些金矿中。主要的金属矿物有自然金，银金矿，黄铁矿，毒砂，辉锑矿，雌黄，雄黄和辰砂。脉石矿物包括石英，重晶石，有机碳，碳酸盐矿物和粘土矿物。钠长石出现在少数矿床中。

类似于美国内华达金矿床，Au，As，Sb和 Hg为这类金矿床的典型元素组合；一些中国沉积岩型金矿床与U矿床伴生，铂族元素在一些矿床中富集到工业利用水平。中国和美国沉积岩金矿床中的包体都具有低盐度的特点（3～9 wt%），同位素数据说明成矿热液具有多种来源，成矿温度变化在165^{o}～290^{o}之间，压力变化在52～560 巴，说明这些金矿床是在低温热液的环境下形成的。

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COMPARATIVE GEOLOGY AND GEOCHEMISTRY OF SEDIMENTARY ROCK-HOSTED (CARLIN-TYPE) GOLD DEPOSITS IN THE PEOPLE'S REPUBLIC OF CHINA AND IN NEVADA, USA

by

Zhiping Li *and* **Stephen G. Peters**

Abstract

Sedimentary rock-hosted (Carlin-type) gold deposits have been considered economically significant and geologically distinct since the early 1960's. Similar deposits have been discovered in P.R. China, Australia, Dominican Republic, Spain, Russia, Malaysia, Philippines, Yugoslavia, and Greece, *in* addition to the Great Basin, US. This report contains data on 113 sedimentary rock-hosted gold deposits (prospects) in southwest and central People's Republic of China. Of these, at least 19 deposits are of substantial tonnage, making P.R. China the second leading country to the United States in exploiting these deposits. A new Proterozoic age sedimentary rock-hosted gold deposit in northeastern P.R. China also is described.

Chinese sedimentary rock-hosted deposits are mainly located along the margins of the Precambrian Yangtz craton. Their distribution is controlled by regional rifts, whereas secondary structures, such as short-axial anticlines, high-angle faults, stratabound breccia bodies, and unconformity surfaces, also are favorable host structures. The deposits are found in sedimentary formations of Paleozoic to Cenozoic age, and local deposits in the northeastern part of China are hosted in Proterozoic age rocks. Impure limestone, siltstone, and argillite are the host rocks for ore. Alteration types are silicification, decalcification, argillization, carbonization, and locally albitization. Igneous intrusions usually are not present near most Chinese deposits, except for local lamprophyre and silicic dikes.

Gold is disseminated in sedimentary rock-hosted gold deposits. The main opaque minerals include gold, electrum, pyrite, arsenopyrite, stibnite, orpiment, realgar, and cinnabar; gangue minerals are quartz, barite, organic carbon, carbonate and clay minerals, and local albite. Elements associated with gold in Nevada deposits, As, Sb, and Hg, also are closely associated with the Chinese deposits, but U deposits also are associated with some gold deposits in China, and platinum group elements (PGEs) also locally are enriched to economic levels in some of these deposits. Low salinity fluid inclusions (3 to 9 wt. percent NaCl equivalent) and limited stable isotope data suggest possible multiple sources of metallogenic fluids in the Chinese deposits, similar to those in Nevada. Trapping temperatures vary from 165 to 290 °C, and pressures of formation range from 52 to 560 bars, indicating that Chinese Carlin-type gold deposits formed at or below the epithermal environment.

INTRODUCTION

The purpose of this paper is to describe a representative group of Chinese sedimentary rock-hosted gold deposits, and to compare them with similar (Carlin-type) deposits in Nevada. The main sources of information about the Chinese deposits are from 1980's and 1990's literature, both in English and in Chinese, and also data collected by the authors from a field trip to selected Chinese Carlin-type gold deposits in August, 1997. We hope this will be helpful for geologists who are interested in the study, exploration, and mining of Chinese Carlin-type gold deposits and in sedimentary rock-hosted gold deposits in general.

By the later part of the 1900's, sedimentary rock-hosted gold deposits became an important economic issue and an international academic research topic. Their origin is not well understood, and is a much-debated topic (see Vikre and others, 1997). Why are geologists motivated to study Carlin-type deposits? One reason is that the study of these deposits may help develop important innovations in metallogenic theory and in exploration methods for gold deposits. Secondly, many of these sedimentary rock-hosted gold deposits are large and have been part of a high discovery rate in Nevada over the past 25 years. Thirdly, similar gold deposits have been found in other countries besides the United States. In particular, more than one hundred similar deposits found in China make it possible to apply comparative research on Carlin-type gold deposits, and to develop a better understanding of the genesis of these deposits.

Recognition of Carlin-type gold deposits as a separate class of sedimentary rock-hosted gold deposits has been a significant event in the history of the science of economic geology, not only because of their large economic value, but also because this recognition has brought an important advancement to the field of economic geology in terms of exploration using a Carlin-type genetic ore deposit model. Traditional metallogenic theory has previously dealt with gold deposits contained in quartz veins that formed in igneous or metamorphic rocks (see Boyle, 1979, 1987; Bache, 1987). However, Carlin-type gold deposits are mainly hosted in sedimentary rocks, such as limestone, siltstone, argillite, and shale. Gold contained in them is micron-size, usually associated with arsenic-rich pyrite. One traditional exploration method for gold deposits is prospecting by tracing gold placers to their source. This has not worked in exploration for Carlin-type deposits (Tu, G.Z., 1994; Liu, K.Y., 1991), because the gold particles are so small that detectable gold in placers is not present downstream.

The discovery and exploitation of sedimentary rock-hosted gold deposits in Nevada has created significant wealth, jobs, and industry services, and has expanded cities. These deposits have made a large contribution to the economy of Nevada, as well as the USA. The large, rich, gold deposits along the Carlin trend, Nevada, a major elongate cluster of deposits, are a significant contributor to the United State's resource-based growth. Although their origin is incompletely understood, a number of features, including field relations at all scales, age relations, and geochemical and isotopic characteristics, bear on the origin of these deposits. Previous genetic models have been developed from mining the oxide or weathered parts of these systems in Nevada over the last two decades. Recent extensive exposures of unoxidized parts of the deposits provide new evidence that leads to consideration of additional hypothesis of their origin, particularly those that incorporate the role of small- and large-scale deformation of the ores and surrounding rocks.

Over 100 similar gold deposit occurrences have been found in southwest and central China since the first Carlin-type, the Shixia gold deposit, was identified there between 1964 and 1966 (see Liu, D.S. and Mao, 1994); of these, at least 19 are of substantial grade and tonnage. Since the 1980's, Chinese geologists have devoted a large-scale exploration and research effort to the Chinese Carlin-type gold deposits; these studies have been sponsored by the Bureau of National Gold Administration, Ministry of Metallurgical Industry, Ministry of Geology and Mineral Resources, Chinese Academy of Sciences, Chinese Non-ferrous Metal Industrial General Company, and other Chinese government agencies. As a result, there are more than 20 million ounces of proven gold reserves in sedimentary rock-hosted deposits in P.R. China and additional estimated and inferred resources also are present in numerous occurrences and prospects. This makes China second to Nevada in contained ounces of Au in Carlin-type deposits (see Liu, D.K, 1991).

Compared to Nevada deposits, Chinese sedimentary rock-hosted gold deposits are smaller in size, contain a shallower oxidation zone, and thus consist of dominantly refractory ores. However, this creates an opportunity for geologists to study the hypogene zones of the Chinese deposits to better understand those oxide deposits in Nevada. In addition, due to strict environmental regulation, and high labor costs, more and more western companies have started to move their mining interests to China, Mongolia and Asia where extraction costs are less expensive. Most Chinese sedimentary rock-hosted gold deposits are in an undeveloped state or are being exploited by small-scale mining by manual and mechanical methods (figs. 1, 2, 3, and 4). This is because of their refractory nature and because of the lack of financial capital. Therefore, *in* consideration of the needs from both economic geologic science and industry, it is necessary for geologists to do systematic comparative research on the Chinese deposits with respect to the relatively better-documented and studied deposits in Nevada. Such research is hampered by a lack of international cooperation, translation difficulties, and high travel costs and logistics in P.R. China. Early comparative studies of Carlin-type gold deposits between Nevada and P.R. China have been done during the past years (Cunningham and others, 1988; Dean and others, 1988; Ashley and others, 1991; Tu, G.Z., 1992; Mortensen and others, 1993; Wang, J. and Du, L.T., 1993; Liu, D.S. and others, 1994; and Li, Z.P. and Peters, 1996). These have demonstrated that there are comparative similarities between the deposits on the both continents and that the differences may be helpful in advancing our understanding of them.

In this report, *in*formation about Chinese Carlin-type gold deposits has been collected, translated and summarized into a database (appendix I), which is supported by Microsoft Access (97). This database currently consists of 114 records and 30 fields organized in six subsets. They are: (1) deposit name and reference; (2) geographical location (Province, County, latitude and longitude); (3) commodity information (size, ore and gangue mineral); (4) tectonic setting (regional trend, structural environment); (5) ore-control structures; and (6) host rock and alteration. Another 3 subsets are planned, they are: (7) geochemical data (analysis of rock and ore, trace elements, isotope, fluid inclusion, age data of rock and deposits); (8) graphic collection (regional, local, section, plan geological maps; photographs, sketch and chart of research result); and (9) production, reserves and resources (where possible). At the same time, part of these Chinese Carlin-type gold deposits have been input into MRDS (Mineral Resource Data System, see appendix-II), which is created by the U.S. Geological Survey. Translations of two Chinese language descriptions of the well studied and large Lannigou Carlin-type deposit in Guizhou Province (appendix 3-1) and the Proterozoic rock-hosted gold deposit in Hebei Province (Jidong area) (appendix 3-2) are contained in appendix III.

Chinese names and terms used in this paper are translated from Chinese symbols to pinyin, but do not contain the Chinese tones. References to Chinese authors also includes the author's initials to distinguish common last names. Chinese provinces have long and short names, so the two main areas of Chinese Carlin type deposits are referred to as a combination of the abbreviated short province names. The southwest area, Dian-Qian-Gui (Chen, Y.M., 1987), is located in the Yunnan (short name Dian), Guizhou (Qian), and Guangxi (Gui) Provinces. The central area, Qinling (or Chuan-Shan-Gan), is in the Sichuan (short name Chuan), Shannxi (Shan), Gansu (Gan) provinces. Eastern Hebei Province (shortened to Jidong), northeast China, respectively is a small and independent area that also contains several sedimentary rock-hosted gold deposits. The terms "Carlin-type" and "sedimentary rock-hosted" gold deposits are used interchangeably throughout this report and reflect the evolving nature of the classification of these deposits.

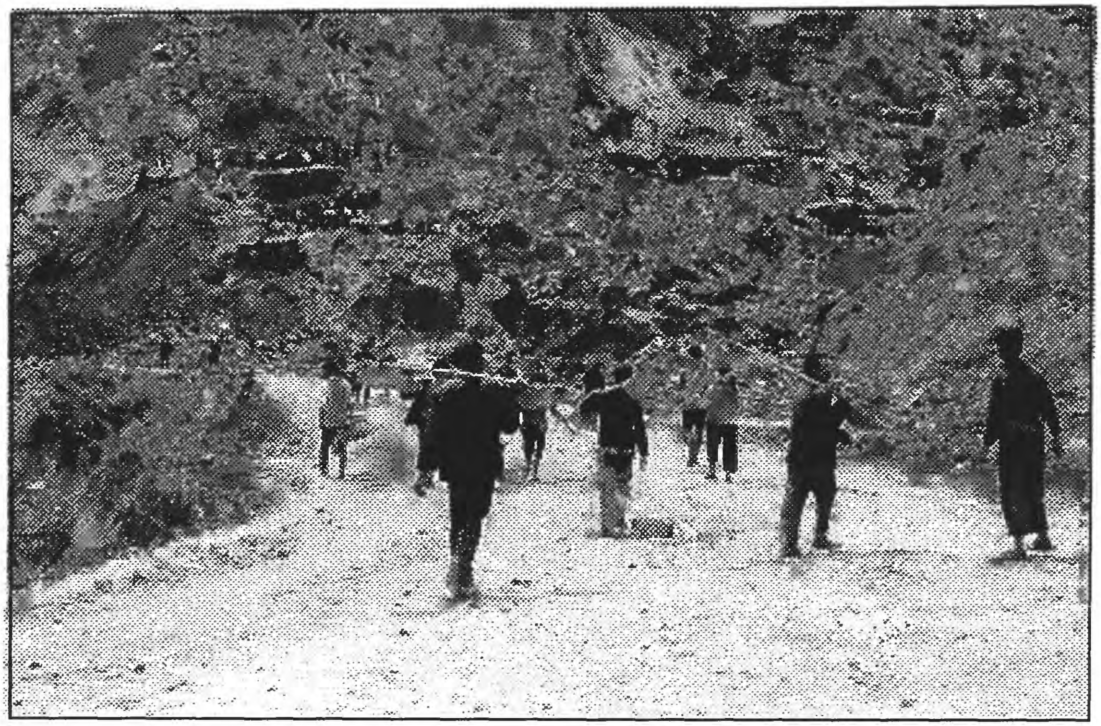


Figure 1. Photograph of manual mining in the Zimudang gold deposit, Guizhou province (Looking to southwest). Each miner trams about 25 kg of rock in double baskets. Total production is close to 300 tpd.

Figure 2. Photograph of manual mining in the Zimudang gold deposit, Guizhou province (Looking to southwest). Digging face in middle ground is the main shear zone.

Figure 3. Photograph of mechanized mining in the Hengxian gold deposit, Guangxi district (Looking to southwest). Blasting is commonly done at the toe of the bench, which collapses the brow. Mucking and tramming is by 20 tonne dump truck.

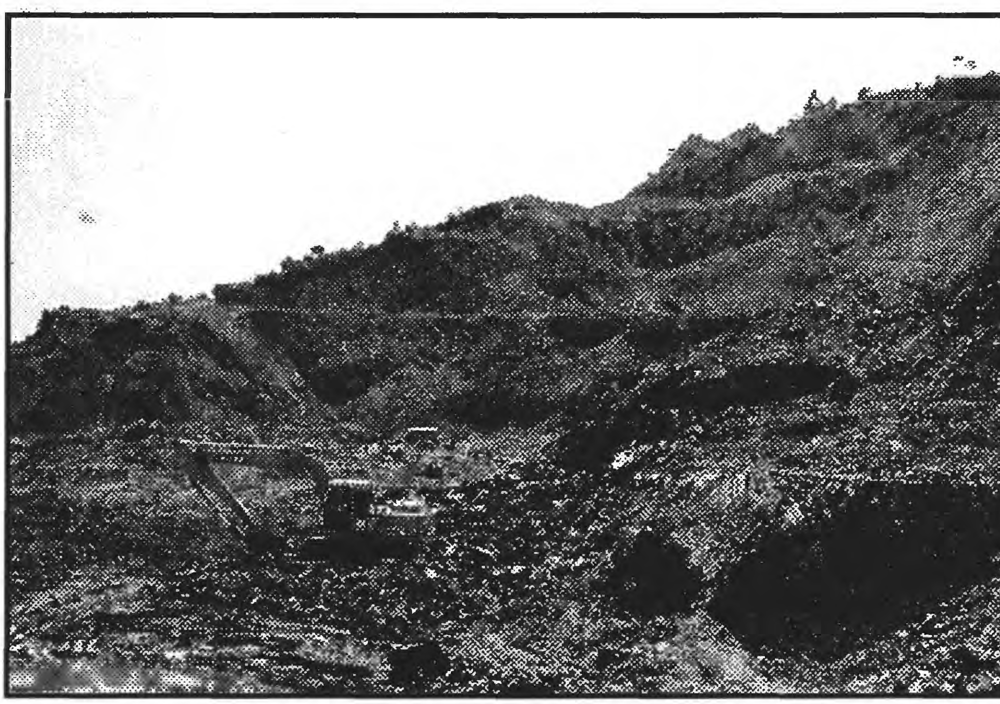


Figure 4. Photograph of mechanized mining in the Hengxian gold deposit, Guangxi District (Looking to southwest).

GENERAL CHARACTERISTICS OF SEDIMENTARY ROCK-HOSTED GOLD DEPOSITS

In order to describe Chinese Carlin-type gold deposits and to compare them with those in Nevada, a description of the known characteristics of these typical Carlin-type deposits is summarized below, on the basis of summaries of previous workers (see Hofstra, 1994; Peters and others, 1996; Arehart, 1996; Teal and Jackson, 1997).

Carlin-type gold deposits are deposits mainly hosted in sedimentary rocks. The ores typically have low gold concentrations but are present as large tonnage masses, so that large, low-cost open-pit mining methods are used to exploit them. These deposits commonly have 0.5 to 30 million ounces Au per deposit (Cox and Singer, 1992). Carlin-type deposits get their name from the first deposit discovered in 1960, the Carlin gold mine, near the town of Carlin, Nevada (Hausen and Kerr, 1968). Since then, gold reserves of over 80 million ounces Au have been discovered in north-central Nevada.

Carlin-type deposits also are known as sedimentary rock-hosted or carbonate-hosted, or disseminated gold deposits. The main ore minerals typically consist of disseminated sub-micron-sized gold and arsenic-rich pyrite, *in* variably silicified, argillized, and decalcified sedimentary rocks and other minor rock types (Tooker, 1985; Berger, 1986; Hofstra and others, 1990; Christensen, 1993, 1996; Peters, 1996; Arehart, 1996). Most common host rocks are thin-bedded, flaggy, mixed carbonate and silici-clastic rocks, although host rocks for many Nevada deposits also include skarn, mafic metavolcanic, and felsic intrusive rocks. Gold is hosted in all rock types; however, along the Carlin trend, 98 percent of all known gold occurrences are hosted within a 350-m-thick stratigraphic interval composed of para autochthonous Devonian and Silurian age carbonate rocks (see Armstrong and others, 1997).

Deposition of ore minerals was at moderate depths of at least 1 to 3 km and the deposits formed at pressures approaching 1 kbar, (Rytuba, 1985; Kuehn and Rose, 1985, 1995; Kuehn, 1989; Lamb and Cline, 1997). Mineralogy in the ore zones includes gold-bearing arsenopyrite, As-rich pyrite, pyrite, marcasite, stibnite, realgar, orpiment, cinnabar, thallium-sulfide minerals, rare silver-Sb-Hg and lead-Sb sulfosalt minerals, sphalerite, chalcopyrite, and galena. Barite, calcite and fine-grained quartz are common gangue minerals. Total sulfide mineral content in the ores ranges from less than 1 vol. percent to local massive accumulations of pyrite (Bagby and Berger, 1985; Percival and others, 1988; Berger and Bagby, 1991; Simon and others, 1997).

Physical characteristics of sedimentary rock-hosted gold deposits commonly depend on the nature of the host rock. In calcareous rocks, stratabound replacement and local brecciation is common. In non-reactive rocks, orebodies are made of millimeter-sized stockwork veinlets to meter-sized vitreous quartz veins and jasperoid. Stratabound jasperoid also is common at contacts between rock units and along other planar structures. Brecciated rocks of several different origins are very common in many of the deposits (see Peters and others, 1997). Ore-associated alteration types typically are decalcification and dolomitization of carbonate strata, as well as argillization and silicification. Silicified rocks are present as jasperoidal replacement, silica cementation, siliceous breccia bodies, or as open-cavity fillings of quartz veinlets. K-feldspar in the detrital sedimentary and igneous rocks alters to illite and kaolinite in the most intensely altered areas. Carbonaceous material typically is present and formed early, such that solid carbon arrived in a cryptocrystalline state before the gold, and consists of up to 0.1 to 3 vol. percent graphite plus some disordered carbon in many of the deposits.

Ore-controls may be considered at a number of different scales. Generally, regional-scale control in Nevada is defined by "trends" or linear zones (Roberts, 1960, 1966; Shawe and

Stewart, 1976; Bagby, 1989; Berger and Bagby, 1991; Shawe, 1991) that commonly are associated with tectonic windows, or associated structural highs, through regional-scale thrust faults in a region of tectonically over-thickened crust in the Great Basin. Local control of individual orebodies is associated with faults or folds or favorable stratigraphic horizons that are contained in and commonly parallel with the trends. An example of trend control is the northern Carlin trend, a 20-km-long by 8-km-wide zone of continuous gold mineralization, composed of at least 40 gold deposits that contain more than 70 million ounces of announced gold reserves. Gold mineralization there is concentrated along a series of NW- and NE-trending, medium- to low-angle, regional, Jurassic age shear zones, and NNW-trending, low-angle shear zones of post-Jurassic age. These structures represent part of a NW-SE strike-slip zone coincident with tectonic windows through the Roberts Mountains allochthon (Evans and Theodore, 1978; Peters, 1997 a, b and c).

Close spatial association exists between some sedimentary rock-hosted gold deposits and Mesozoic plutons (Silberman and others, 1974; Berger and Bonham, 1990; Margolis, 1997); closely related Tertiary intrusive rocks are relatively uncommon and are interpreted as post-ore in many of the large sedimentary rock-hosted gold-silver deposits. However, evidence from a regional perspective suggests that Carlin-type gold deposits may owe their origins to the initial Tertiary age extension of the Great Basin and its associated deeply circulating fluids (Seedorff, 1991; Ilchik and Barton, 1995; Gao, Z.B. and others, 1996; Hou, Z.L. and Guo, G.Y., 1996; Henry and Boden; 1997). Structures in Proterozoic basement rocks also may be important localizers of deposits and districts (Grauch, 1986; Grauch and Bankey, 1991; Grauch and others, 1995). Local control can be either typically structural (see Peters, 1996; Peters, 1997 a, b and c) or stratigraphic. Formations and even narrow stratigraphic intervals or zones in them are considered to be significant factors in localizing gold.

Generally, deep weathering of the deposits usually results in outcropping or sub-cropping mineralized rock, which involves some prominent outcrops of hematitic jasperoid. The geochemical signature is typically gold, silver with Au : Ag ratios generally greater than 1 (that is, silver is not of significant value), with arsenic, Sb, and Hg. Thallium is anomalously high in some deposits, but minor to absent in others. Tellurium and bismuth usually are absent to very low (Hill and others, 1986), but locally occur (see also Hitchborn and others, 1996). Base-metals usually are at background levels, but, locally in some deposits, such as Gold Quarry, base-metals attain concentrations in the thousands of parts per million in the upper parts of the deposits, although they do not contribute to the overall value of the deposit (Hausen and others, 1982; Rota, 1987).

Sedimentary rock-hosted gold deposits can be subdivided into a subclass of deposits, the distal-disseminated silver-gold deposits (Cox, 1992; Cox and Singer, 1992), which are directly attributable to fluids emanating from porphyry Cu systems (see Sillitoe, 1988; Sillitoe and Bonham, 1990). Ore-forming fluids responsible for most Carlin-type gold deposits do not show evidence for a relationship to porphyry-type systems (Seedorff, 1991), although some deposits (Twin Creeks, Getchell) may have been generated from fluids involving a significant magmatic component (Norman and others, 1996). Ilchik and Barton (1995) postulate the genesis of most of these deposits is associated with an amagmatic thermal process associated with middle Tertiary extension in the Basin and Range.

Distal disseminated silver-gold deposits contain silver and gold in stockworks of narrow quartz-sulfide veinlets and (or) iron oxide-stained fractures in sedimentary rock, and they contain lead, Zn, manganese, Cu, and bismuth, which suggests that they may be plutonic-related (Cox and Singer, 1992). In addition, stable-isotope studies indicate that the fluids involved in the generation of the silver-gold deposits in the northern part of the Battle

Mountain Mining District include a significant magmatic component (Howe and others, 1995; Norman and others, 1996). Several deposits of this type show significant potassium metasomatism (Bloomstein and others, 1993), which is comparatively rare in most Carlin-type deposits. Distal-disseminated silver-gold deposits are present in or near mining districts that contain major porphyry-related skarn, replacement, and vein base-metal ores, such as the Battle Mountain mining district (Doebrich and Theodore, 1995, 1996; Doebrich and others, 1995).

Examples of distal disseminated subclass of sedimentary rock-hosted gold-silver deposits are the Lone Tree deposit (Bloomstein and others, 1993; and Norman and others, 1996), the Marigold deposits (Graney and others, 1991). Gold, arsenic, Sb, barium (as barite), and Hg are enriched, but silver is generally low. The Marigold deposits, as well as the Lone Tree deposit, are considered by Howe and Theodore (1993), and Howe and others (1995) to be distal-disseminated silver-gold deposits, partly on the basis of the apparently abundant magmatic components of the fluids responsible for their genesis, and partly on the basis of the geologic setting in which they occur (see also Doebrich and Theodore, 1995, 1996).

LOCATION OF SEDIMENTARY ROCK-HOSTED DEPOSITS

Besides the Great Basin of the United States, sedimentary rock-hosted gold deposits have been identified in the China, Australia, Dominican Republic, Spain, Russia (Liu, D.S. and others, 1994), Malaysia (Sillitoe and Bonham, 1990), Philippines (Mercado, and others, 1987), Yugoslavia, and Greece (Radtke and Dickson, 1976a). This section summarizes the location of these deposits in Nevada, US and in P.R. China.

Location of deposits in Nevada, the United States of America

After the Carlin gold mine was developed in 1960, similar gold deposits were found along the Carlin-trend and elsewhere in north-central Nevada (Thorman and Christensen, 1991). There are several hundred million ounces of known and inferred gold in the northern Great Basin, of which over half is contained in the Carlin-type deposits, most along the Carlin trend. About 114 (table 1) sedimentary rock-hosted deposits have been found in Nevada, US. Most of them are distributed along three mineralization trends: Carlin, Battle Mountain-Eureka, and Getchell trends (see fig. 5). There are at least 40 small to large gold deposits present along the Carlin trend. Since 1965, 660 t (21 million ounces) of Au has been produced from mines along the Carlin trend. In 1995, three companies with 8 mines have produced more than 100 t (3 million ounces) of Au (Christensen, 1996). Additional significant amounts of Au have been produced from the Getchell and Battle Mountain-Eureaka trends and other areas in Nevada.

Location of deposits in Dian-Qian-Gui, Qinling and Jidong areas, P.R. China

Chinese sedimentary rock-hosted gold deposits are distributed in two main areas in southwest and central China respectively (fig. 6), each of these two main clusters of deposits lies in several government Provinces (fig. 7). Most of the 114 Carlin-type gold deposit occurrences are in the form of mines or prospects (Li, Z.P., and Peters, 1996) in the Dian-Qian-Gui and Qinling areas. The known size distribution of these occurrences includes eighteen large, fifteen medium, and twenty two small deposits (table 2; fig. 8; appendix 1-1). A few sedimentary rock-hosted gold deposits, such as the Greatwall deposit, were recently discovered in the Proterozoic Lengkou basin in the eastern Hebei Province, north China (fig. 6), although they are considered to be a new type gold deposit that differs from typical Carlin-type gold deposits (Qiu, Y.S. and Yang, W.S., 1997; appendix III). Other sedimentary rock-hosted gold deposits are scattered in the Guangdong, Hunan, Huabei, and Liaoning Provinces (Liao, J.L., 1987; Shi, X.Q., 1990; Cai,

Table 1. List of Carlin-type Gold Deposits in Nevada (MRDS, USGS)

Location	Large	Medium	Small	Unknown	Total
Carlin Trend	5	10	20	5	40
Battle Mountain	2	5	15	5	27
Getchell trend	3	4	5	5	17
Other	2	7	15	5	29
Total	**12**	**26**	**55**	**20**	**113**

Table 2. Size* and Location of Chinese Carlin-type Deposits

Location	Province	Large	Medium	Small	Unknown	Total
	Yunnan	1	1		3	5
Dian-Qian-Gui	Guizhou	3	2	8	16	29
	Guangxi	1	1	3	8	13
	Guangdong	1				1
	Shannxi	4	1	3	4	12
Qinling	Sichuan	4	3		6	13
	Gansu	1	5	4	12	22
	Hunan	1		1	4	6
	Huabei	1	2	3		6
Other	Laoning	1				1
	unknown				4	4
	Total	18	15	22	57	112

* Large: >20 tons Au (include extra large >50 tons Au)
Medium: 5 to 20 tons Au
Small: <5 tons Au
Unknown: not yet identified resource

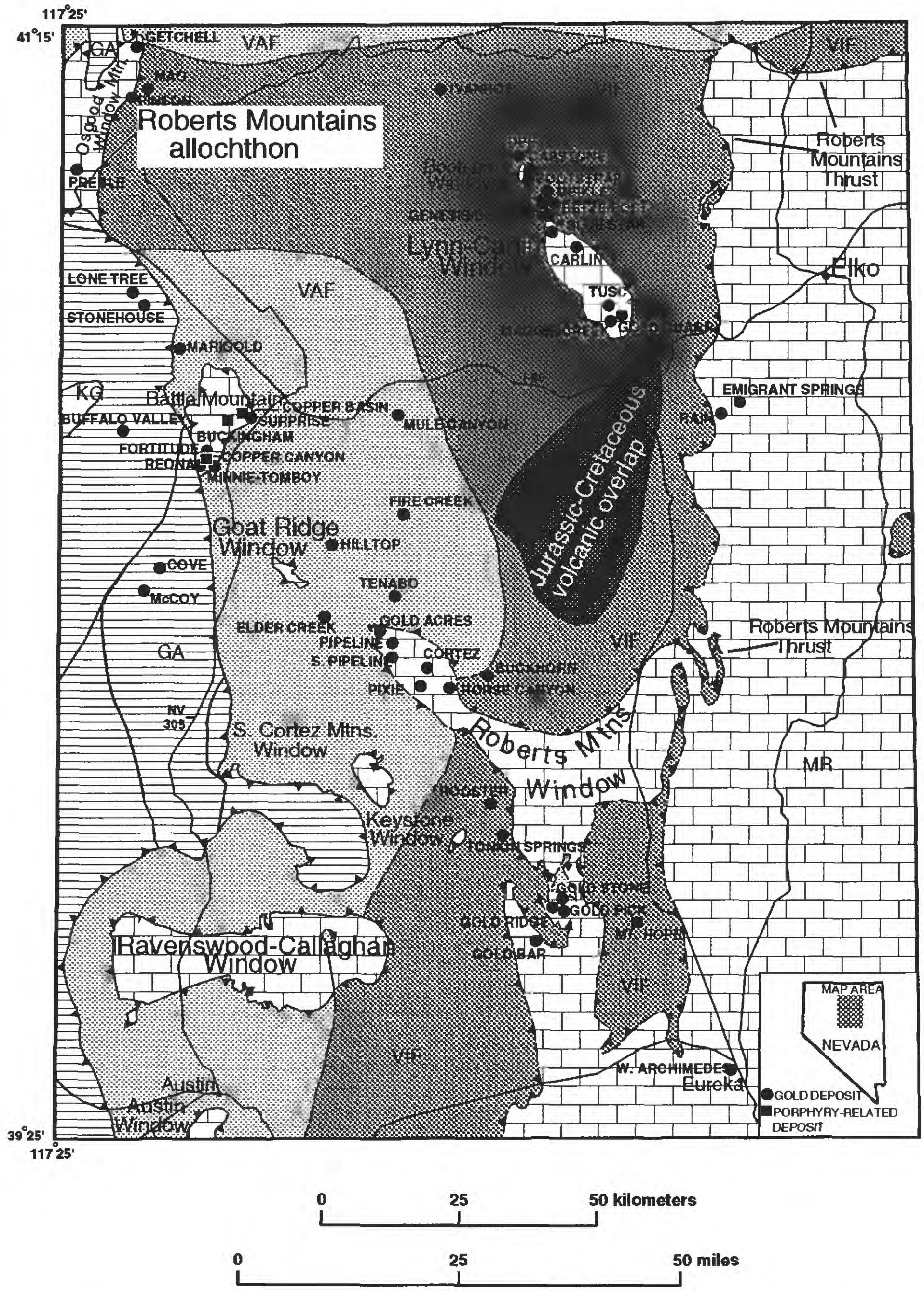


Figure 5. Gold deposits and tectonic units in north-central Nevada. The Carlin trend lies along the Carlin-Lynn window. Other windows through the Roberts Mountains allochthon also have associated gold deposits. Geologic units are designated by letters and shaded. VIF = Vinini Formation, VAF = Valmy Formation, GA = Golconda allochthon, MR = Miogeosynclinal (rocks of the lower-plate), KG = Koipato Group. Gold deposits are related to porphyry and gold-skarn deposits, and are also sedimentary rock-hosted (Carlin-type) gold deposits. Adapted from Prihar and others (1996) and Lahren and others (1995).

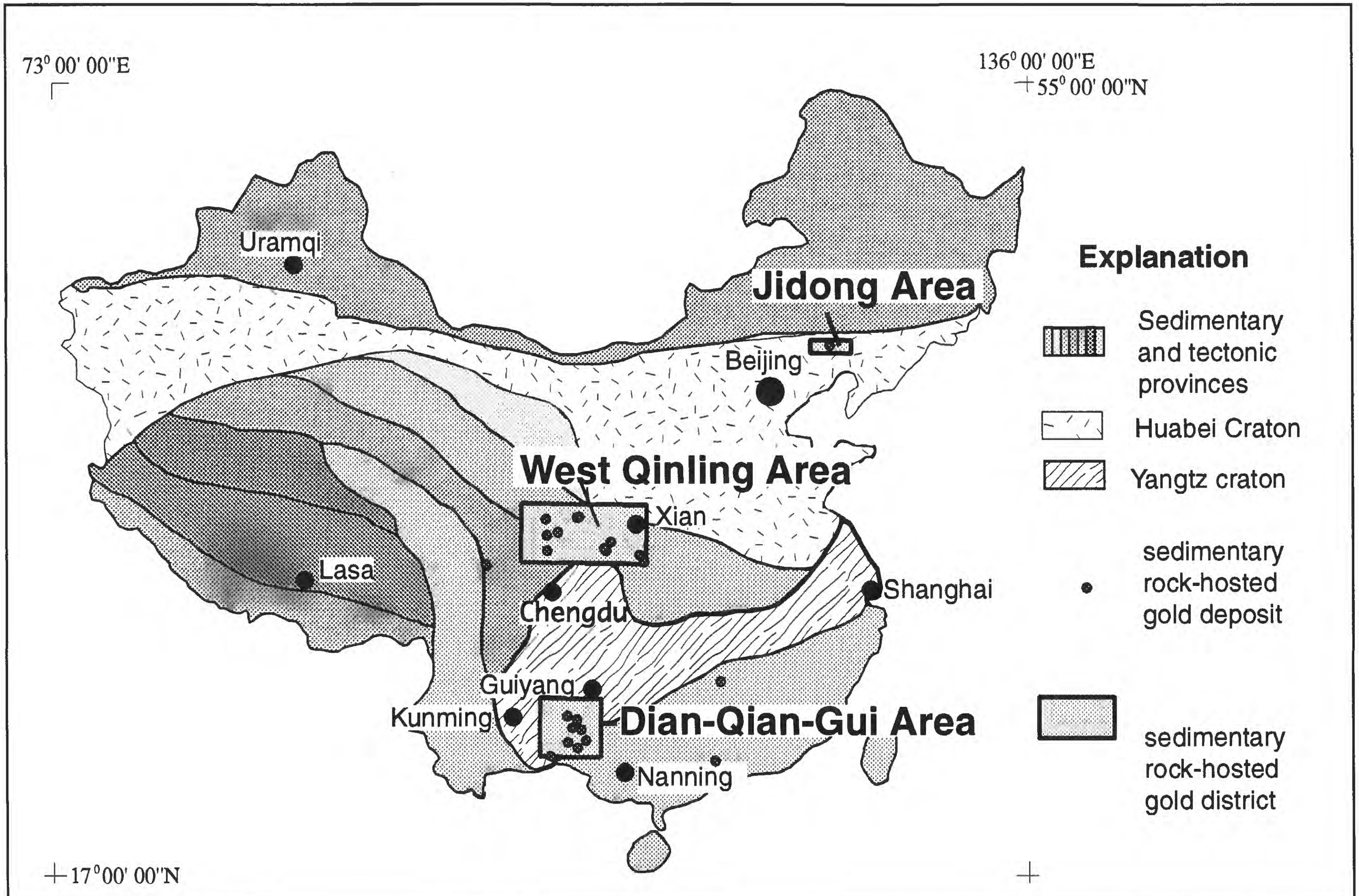


Figure 6. Location of Carlin-type gold deposits in China. The deposits are mainly in two areas: the Dian-Qian-Gui area in the south, at the southwestern margin of the Yangtz craton, and the Qinling area on the northern margin of the Yangtz craton. The Greatwall deposits, newly discovered, are in the Jidong area near Beijing. Major cities are noted with open circles, shaded areas represent Yangtz craton. Compiled from Li, D.S. (1994) and Wang, J. (1993).

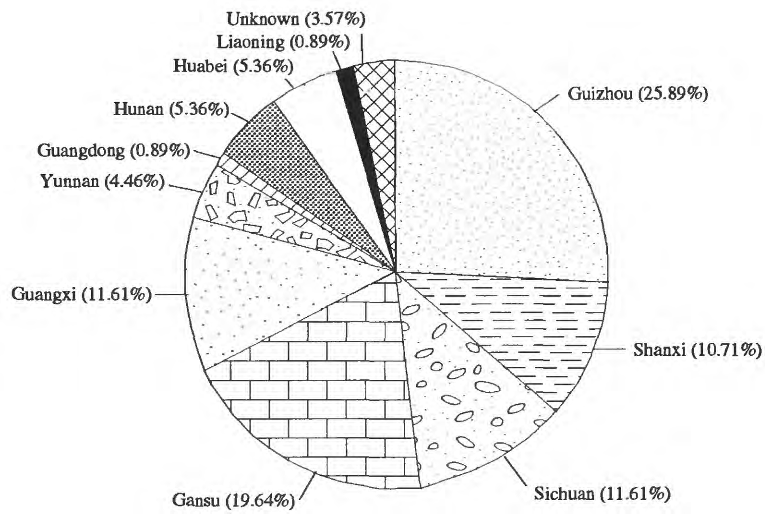


Figure 7. Distribution of Chinese Carlin-type gold deposits by Provinces

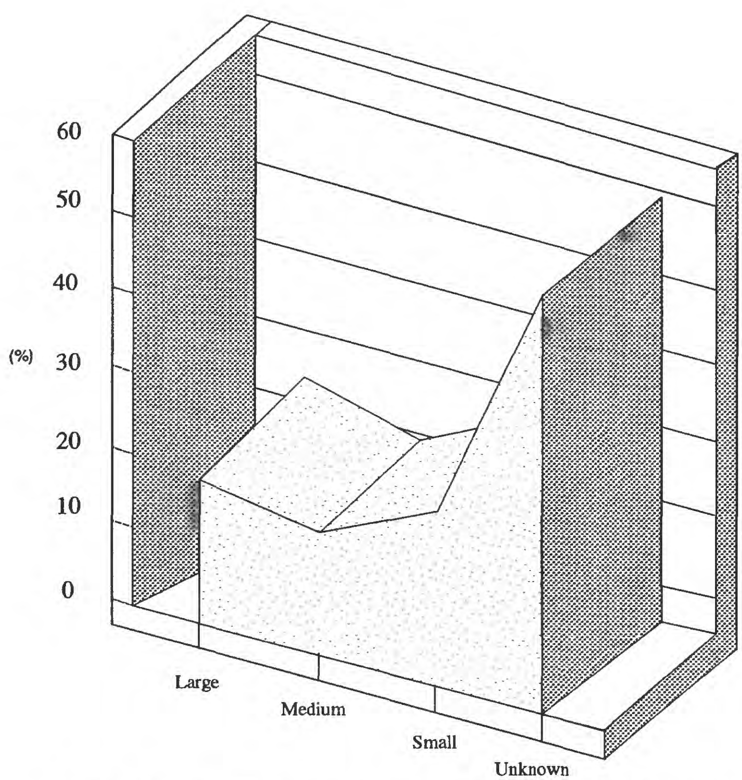


Figure 8. Diagram showing relative size of Chinese Carlin-type gold deposits. Small deposits contain less than 5 tons Au, medium deposit range between 5 and 20 tons; large deposits contain greater than 20 tons Au. (see appendix I).

G.X, 1991; Liu, B.G. and Yeap, E.B., 1992; and Cheng, Q.M., and others, 1994).

GEOLOGICAL SETTING OF SEDIMENTARY ROCK-HOSTED GOLD DEPOSITS

The geologic setting of the Carlin-type deposits is important to understand their genesis. Below, we briefly discuss the tectonic, sedimentary environment and the metallogenic epochs of both Nevada and Chinese Carlin-type gold deposits.

Tectonic and sedimentary environment

Sedimentary rock-hosted gold deposits lie in their own spatial geological environment. The description below summarizes these tectonic and sedimentary environments of these gold deposits in both Nevada and P.R. China.

Nevada, The United States of America

Sedimentary rock-hosted gold deposits in the western United States are located in the Great Basin and are spatially related to the western boundary of the North American Precambrian craton—this boundary can be determined by both stratigraphic sequences and by isotopic measurements (Cunningham, 1988). On the eastern part of this boundary, miogeosynclinal sediments—composed mainly of Silurian, Devonian and Ordovician carbonate rocks (eastern assemblage)—were formed across the Antler foredeep and continental shelf (fig. 9). To the west, eugeosynclinal sediments consisting of fine-grained, siliceous, clastic rocks, chert, and local basalt (western assemblage) were also deposited in the early Paleozoic (figs. 9 and 10). The Antler orogeny, a Mediterranean type orogeny, took place during the late Paleozoic to early Mesozoic, and resulted in the Robert Mountains thrust, a west-dipping thrust fault (Burchfield and Roydon, 1989). This thrusting resulted in western assemblage (or upper-plate, allochthon) rocks to be thrust over the eastern assemblage (or lower-plate) rocks. Several erosional or tectonic windows through the upper-plate exposed lower-plate rocks. Most of the Carlin-type gold deposits in Nevada are spatially related to these windows or their associated structural highs (Christensen, 1993, 1996; Peters, 1997 a, b, c). Several intermediate composition Mesozoic and Tertiary stocks and plutons, as well as lamprophyre dikes, are located near the sedimentary rock-hosted orebodies in north-central Nevada, but no direct relation has been documented between these igneous rocks and gold mineralization. Most of the Mesozoic intrusions were clearly emplaced earlier than the gold deposits.

Cunningham (1988) emphases the relation between Carlin-type gold deposits and the regional paleothermal anomaly, the eastern edge of which is coincident with the edge of both the Robert Mountains thrust and the Northern American Precambrian craton. Some of the largest sedimentary rock-hosted gold deposits, *in*cluding Jerritt Canyon, Betze, Gold Quarry, Carlin, Hose Canyon, Northumberland, and Round Mountain, are located near the boundary of the area containing dominantly supermature (>300°C) rocks. Most deposits lie in clusters or trends that are proximal to isotopic contours that indicate the western edge of the North American craton, such as the $^{87}Sr/^{86}Sr$ 0.708, $^{87}Sr/^{86}Sr$ 0.706, and $^{143}Nd/^{144}Nd$ -7 contour lines (Cunningham, 1988). These contours also lie parallel to and in the vicinity of the regional paleothermal anomaly that has been ascertained by conodont maturation indices (see Cunningham, 1988; Togashi, 1992). The various deposit models used in Nevada call upon connections to igneous activity at depth, complex evolution of tectonic windows, *in*herent host rock permeability, ore genesis resulting from evolved meteoric fluids, oil brines or organic fluids, and many other factors. The striking alignment of the gold deposits along trends suggests that these structural trends may possess features that have served as traps or conduits for the gold fluids.

Chinese Carlin-type gold deposits are present in two Paleozoic to Mesozoic

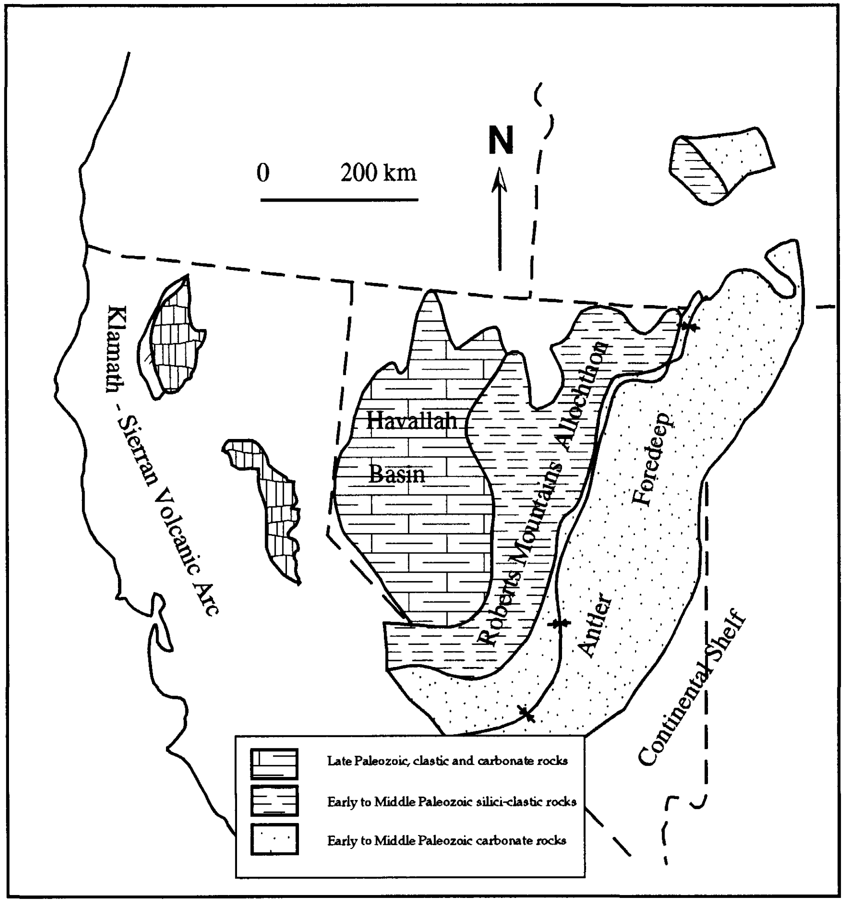


Figure 9. Generalized tectonic map of the Roberts Mountains allochthon, Antler orogeny and related tectonic units of the Great Basin, western United States. Tectonic units are shown in their present position except the Havallah Basin, which has been restored to a position west of the Antler belt (For discussion and details see Burchfiel and Royden (1991) from which this is modified).

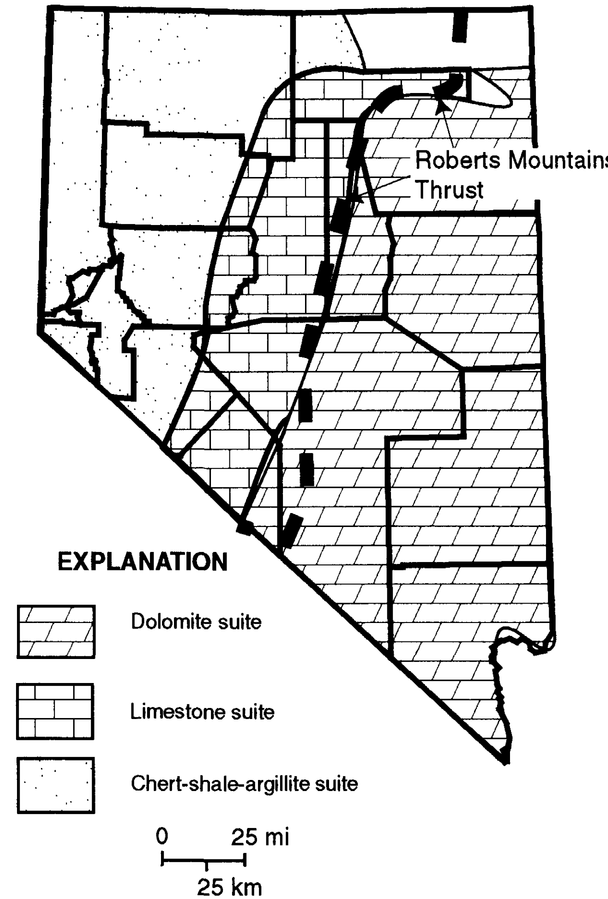


Figure 10. Distribution of late Silurian and early Devonian lithofacies and the approximate position of the Roberts Mountains thrust, Nevada. Compiled and adapted from Cunningham, (1988); Poole (1991), and Matti and McKee (1977).

sedimentary basins, which tectonically surround the Yangtz Precambrian craton (fig. 6). The Dian-Qian-Gui area is located on the southwest margin of the Yangtz craton and the Qinling area is located on the northwestern margin of the Yangtz craton (fig. 6, appendix I-5). The geological features and tectonic history of the two areas are similar. However, each of them has some local, unique geologic structures and lithofacies that influence the style of mineralization (Yao, Z.Y., 1990; Wang, Y.M. and others, 1996). Additionally, the Jidong area is geologically located in a late Proterozoic (Sinian) sedimentary Lengkou basin that is much order than Dian-Qian-Gui and Qinling areas.

Dian-Qian-Gui area, P.R. China

The tectonic and sedimentary environment in the Dian-Qian-Gui area surrounds a cluster of sedimentary rock-hosted gold deposits that are present in an area at the juncture between the Yangtz craton and Youjang orogenic belt (figs. 6 and 11). From late Paleozoic to early Mesozoic, this area consisted of shallow and deep water sedimentary environments along the northeast-trending southwest margin of the Yangtz Craton (fig. 12). Platform, shallow water (miogeosynclinal) assemblage carbonate sedimentary rocks were deposited on the northwest part of continental shelf of the carton during the late Paleozoic and early Mesozoic (fig. 13). Limestone and bioclastic limestone were deposited during the Carbonaceous and are overlain by Permian cherty limestone, limestone, bioclastic limestone, and tuffceous argillite. These rocks are in turn overlain by Triassic argillite, limestone, and dolomite. Coeval deep basin (euogeosynclinal) assemblage rocks consist of siliceous sediments, *in*cluding feldspathic graywacke, siltstone and argillite, formed during the same periods in the southeast part of the basin. Sedimentary rock-hosted gold deposits are present in both the deep and shallow water facies rocks, but are associated with distinct geological and geochemical features in these two parts of the basin.

Airborne magnetic data show that the upper crust in Dian-Qian-Gui area is made up of blocks which have been subjected to different types of stress. This typical tectonic pattern is clearer in the southwest Guizhou Province (fig. 14), where the Yangtz craton mainly consists of weakly strained of blocks, while the Youjang orogenic belt is composed of strongly strained blocks. The contact between these two tectonic units is a series of large-scale thrust structures (Wang, Y.G. and others, 1994). The structural pattern also is different in these two tectonic units at the margin of the Yangtz craton (fig. 15). On the northwest side, *in* the carbonate platform rocks, brittle faults and short-axial folds are more common, whereas tight folds and low-angle ductile-brittle thrust faults are more common in deep basin rocks in the southeast parts (Luo, X.H., 1994). The northwest-trending Indosinian-Yanshanian age Youjiang rift fault system (including all of the northwest-trending faults, such as the Xingyi and Ziyun faults) crosses the boundary of the Yangtz craton and has been interpreted as an extensional structure that post-dated compression tectonism in the region (fig. 14). The distribution of sedimentary rock-hosted gold deposits in the Dian-Qian-Gui area is spatially related to the Youjiang rift fault system (Tan, Y.J., 1994).

Qinling (Chuan-Shan-Gan) area, P.R. China

The tectonic and sedimentary setting of the Qinling area is between the Huabei and Yangtz Precambrian cratons (figs. 6, 16 and 17). Gold ore deposits are located in an area approximately 750 km long in an east-west direction and about 200 km wide in a north-south direction. Between these cratons is a Paleozoic sedimentary basin that contains greater than 10,000 m of sedimentary rocks deposited during the Devonian to Triassic periods. The east-trending Lixian-Baiyun-Shanyang deep-crustal rift, or subduction zone, trends east-west within this basin (fig. 17) and is generally considered as the boundary between the Yangtz and Huabei cratons (Liu, M., 1994). Most of the sedimentary rock-hosted gold

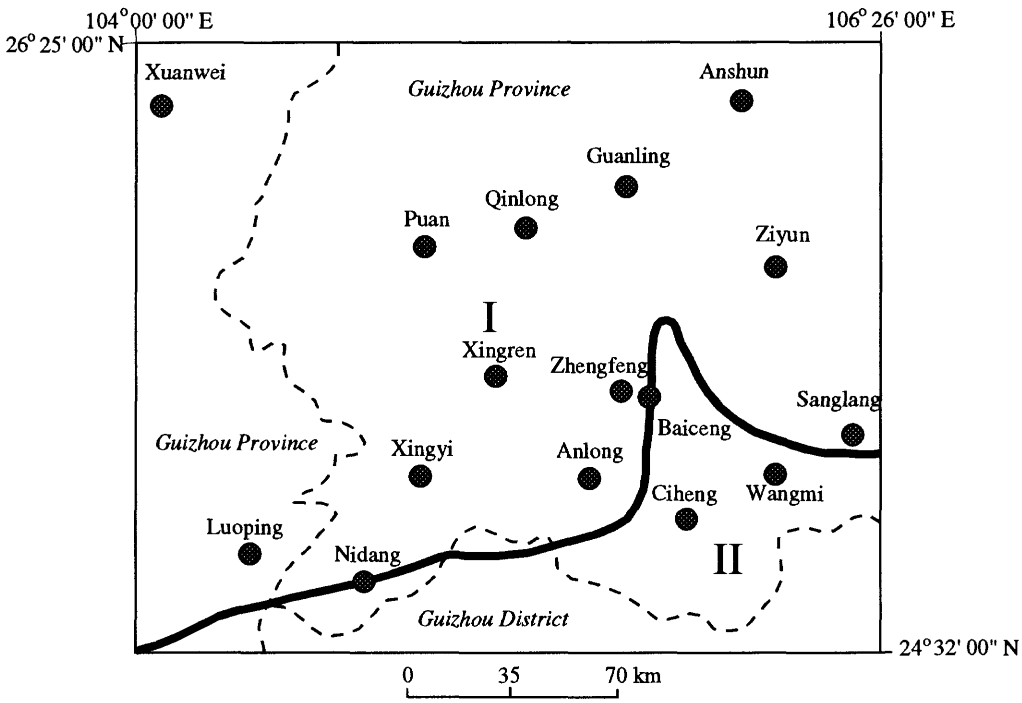


Figure 11. Generalized tectonic map of Dian-Qian-Gui area. I -Yangtz craton; II - Youjang orogenic belt. (boundary is heavy dark line). Adapted from Wang, Y.G. and others (1994). Circles represent main cities.

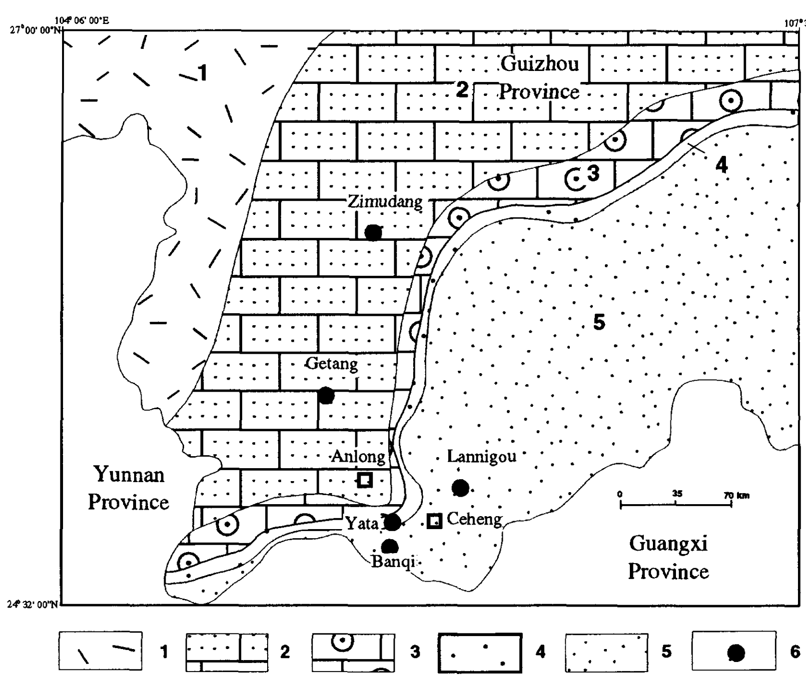


Figure 12. Sedimentary facies of Middle Triassic age rocks in the Dian-Qian-Gui area, Guizhou Province. Yangtz craton: 1-Lagoon tidal flat facies, 2- tidal flat facies, 3-biostromic reef facies; Youjang orogenic belt: 4-shelf facies, 5-abyssal facies. Main Carlin-type gold deposits are shown as dark circles (6): County cities are shown as open squares. Compiled and adapted from Yao, Z.Y. (1990).

Figure 13. Photograph of the karst topography in southwest Guizhou Province, P.R. China. This is the typical topographic expression of the carbonate shelf facies in the interior of domal-shaped short axial anticlines. Horizontal field of view approximately 750 m.

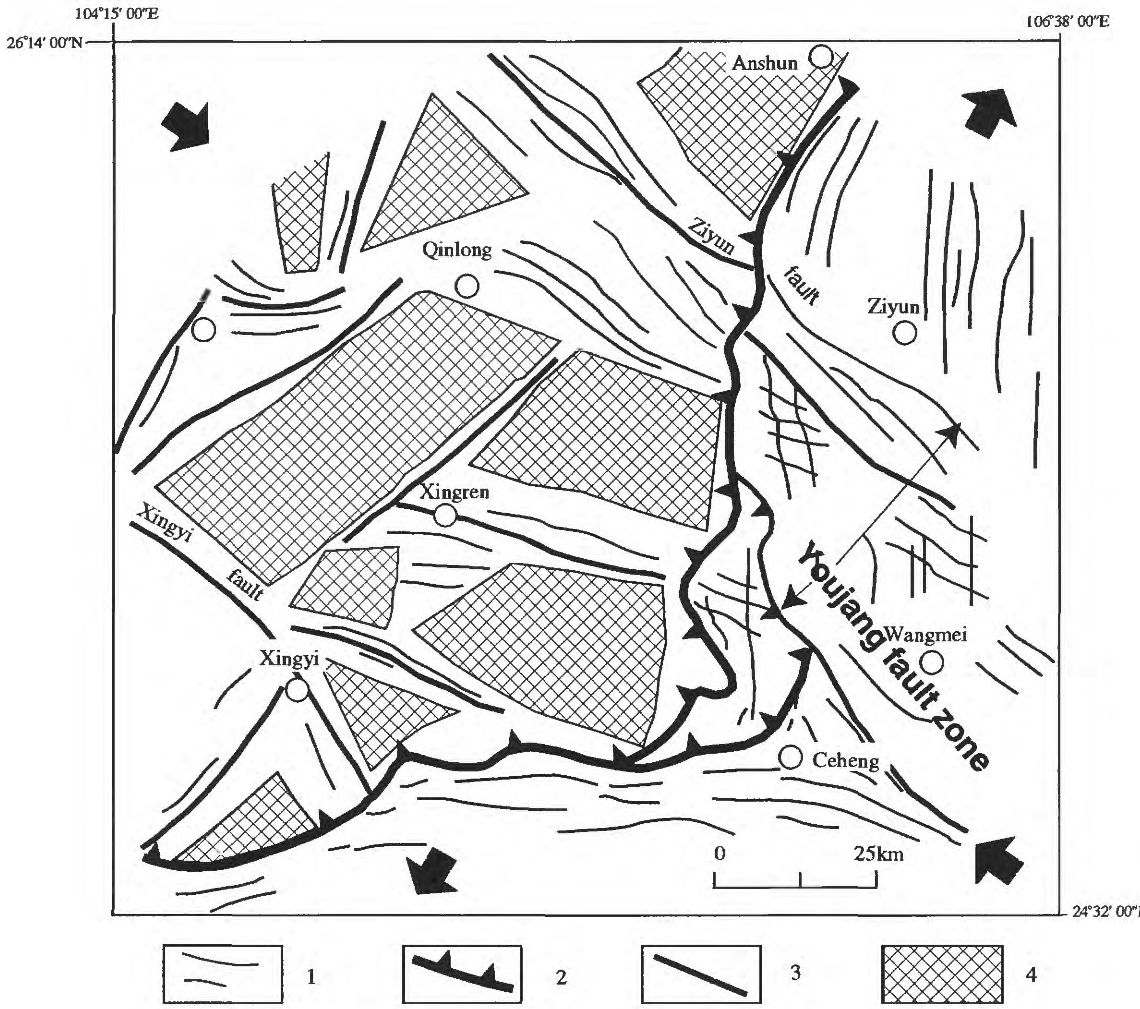


Figure 14. Structure map of upper crust in the southwest Guizhou province China, interpreted from areomagnetic data. 1-Axial plane of folds; 2-thrust fault zone; 3-Fault; 4-weakly strained block; arrows show the directions of compression and extension; county cities are shown open circles. Adapted from Wang, Y.G. and others (1994).

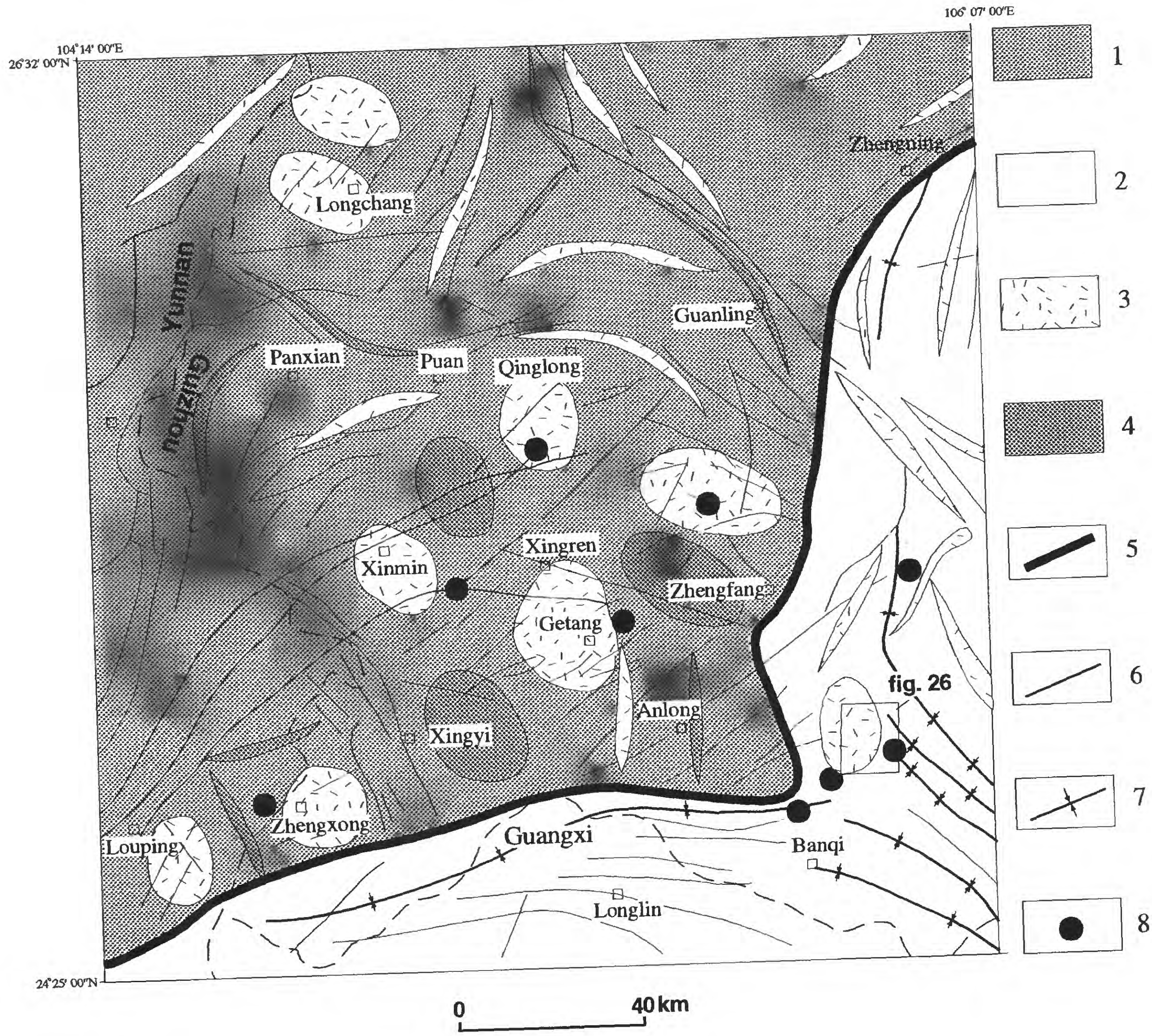


Figure 15. Regional structural framework of the Dian-Qian-Gui area showing the difference in structural pattern between platform area, which are short-axial anticline or dome in northwest Dian-Qian-Gui, and basin area in the southeast, which are with tight folds and thrust structure. 1-Yangtz craton; 2-Youjang orogenic belt; 3-short axial anticline; 4-short axial syncline; 5-tectonic boundary; 6-fault; 7-tight fold axial plane; 8-sedimentary rock-hosted gold deposit. County cities are shown by open squares. Adapted from Cheng, J.H. (1994).

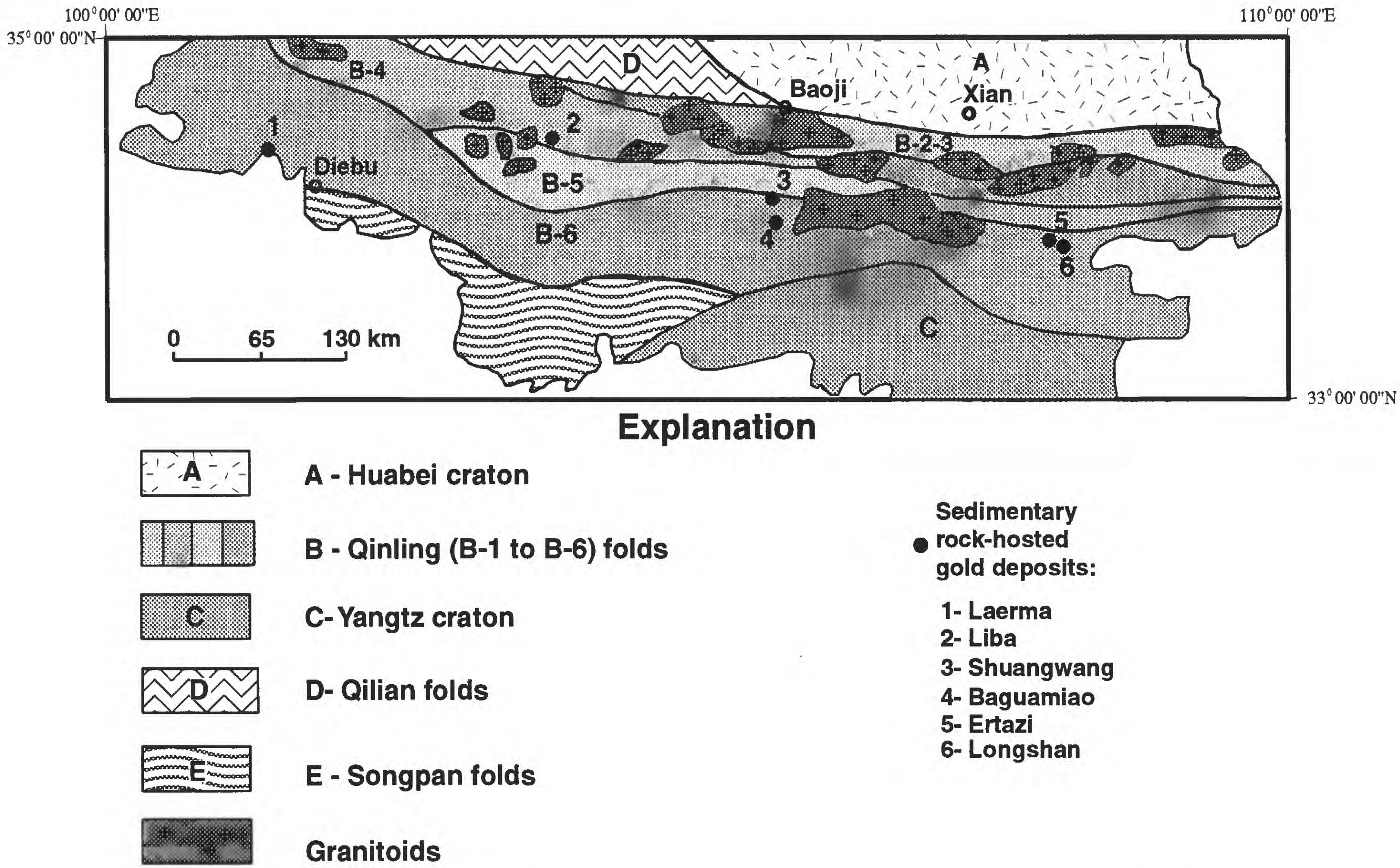


Figure 16. Structural geologic map of the Qinling area, showing litho-tectonic units and approximate location of the Lixian-Baiyun-Shanyang deep crustal lineament between the Yangtz and Huabei cratons: A - Huabei craton, B - Qinling fold belt (B1 to B6), C - Yangtz craton, D - Qilian fold belt, E - Songpan fold belt. Sedimentary rock-hosted gold deposits are noted as dark, round circles: 1 - Laerma, 2 - Liba, 3 - Shuangwang, 4 - Baguamio, 5 - Ertazi, 6 - Longshan. Adapted and compiled from Mio Liu (1994).

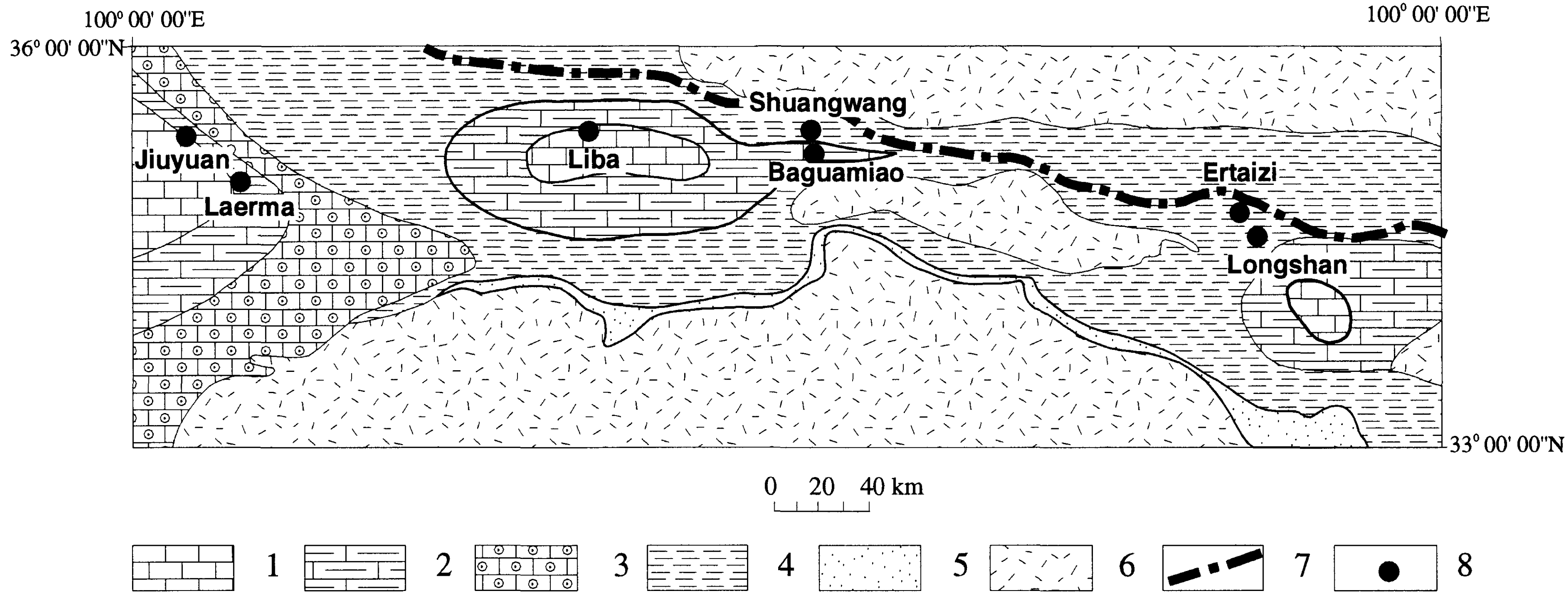


Figure 17. Relationship of lithofacies paleography to the distribution of gold deposits in the Qinling area. 1-carbonate area; 2-shale-carbonate area; 3-bio-reef facies at the margin of craton; 4-shallow sea platform facies; 5-transitional facies; (1through 5 are Devonian age). 6-craton; 7-deep crust rift; 8-gold deposit. Adapted from Yao, Z.Y. (1990).

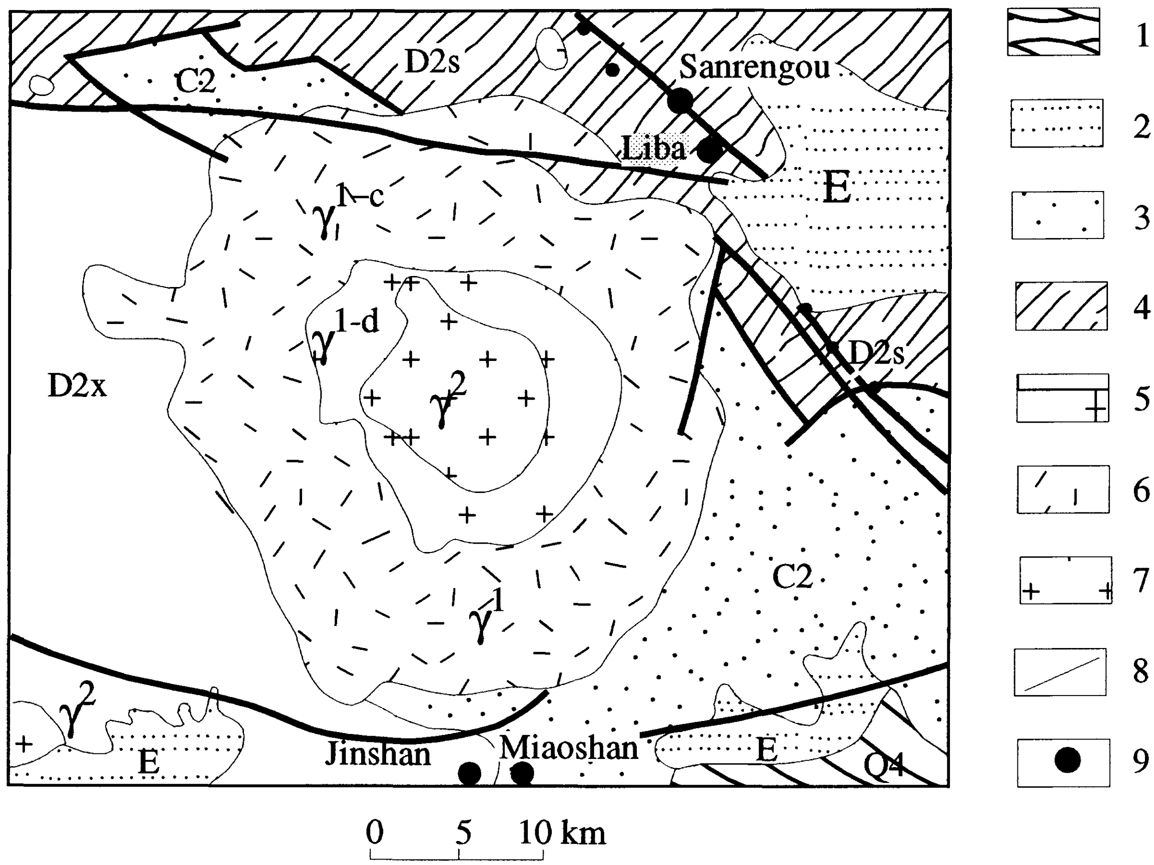


Figure 18. Regional geologic map of the Liba gold deposit area, showing a group of sedimentary rock-hosted gold deposits, which include the Liba, Sanrengou, and Jinshan deposits (appendix I). They are located near the Zhongchuan granite intrusion. 1-Quaternary; 2-lower Tertiary; 3-slate, meta-sandstone and conglomerate (C2); 4-phyllite, silty phyllite (Shujiaba group D2S); 5-meta-sandstone, marble, phyllite (Xihanshui group D2X); 6, 7-granite (Zhongchuan intrusion); 8-boundary of lithology; 9-sedimentary rock-hosted gold deposit. Compiled from Liu, M. (1994). Approximate location of figure is 104° 48' 00''E; 34° 36' 00''N.

deposits in this area are distributed along this deep-crustal rift zone. Several major deposits, such as the Longshan, Ertaizi, Shuangwang, Baguamiao, Pangjiahe, and Anjiacha deposits are present in this east-west zone (figs. 16, and 17; appendix I).

A complete upper Paleozoic stratigraphic section of rocks is present in the basin between the Huabei and Yangtz Precambrian from the Devonian to Permian. Permian sedimentary rocks mainly are carbonate rocks and include limestone, argillaceous limestone, interbedded silty shale, and siltstone. Littoral facies sedimentary rocks, such as quartz sandstone, carbonaceous shale, together with some limestone, were formed during the Carboniferous period. Devonian sedimentary rocks consist of upper limestone, interbedded calcareous sandstone, limestone, argillaceous limestone, and lower bioclastic limestone (fig. 17).

Magmatic activity was widespread in the Qinling area, compared to the Dian-Qian-Gui area (figs. 12 and 16). Igneous intrusions in the Qinling area mainly consist of intermediate composition stocks and plutons, such as biotite granite, and granodiorite, which were emplaced during the Mesozoic (149 to 230 Ma) (Liu, M., 1994); (198.3 to 212.8 Ma), (Fan, S.C. and Jin, 1994). A few small, late Paleozoic, mafic intrusive bodies and some andesite porphyrite bodies represent volcanic rocks present locally in the area. Igneous rocks are not generally exposed in or associated with the sedimentary rock-hosted gold deposits.

The Liba deposit (figs. 17 and 18) is an a exception to this general non-igneous association and it is located in a contact metamorphic zone about 2 km north of the Zhongchuan granite intrusion. Typical Carlin-type minerals are absent in the Liba deposit, such as stibnite, cinnabar, realgar, and orpiment. Instead the deposit contains a mesothermal mineral association of pyrite, arsenopyrite, pyrrhotite, chalcopyrite, sphalerite, galena, and sulfate minerals, which indicate that ore-forming temperatures were higher in the Liba deposit than in most sedimentary rock-hosted gold deposits. Igneous rocks in Liba gold deposit may have provided a heat source for the ore-forming system (Liu, M., 1994), and account for this different mineralogy.

Jidong area, P.R. China

The tectonic and sedimentary setting of the Jidong area is at the margin of Huabei craton, bounded on the north by the inter-Mongolia fold system (fig. 6). The Proterozoic sedimentary basin that contains sedimentary rock-hosted gold deposits is the northwest-trending Lengkou basin (fig. 19), which is about 5 to 15 km wide, more than 60 km long, and crosses the Qinglong, Kuancheng, Qianxi, Qianan and Lulong Counties of eastern Hebei Province, north P. R. China. The Lengkou basin consists of Ca- and Mg-carbonate rocks that belong to the late Proterozoic (Sinian system) Great Wall and Jixian stratigraphic systems (see appendix II-2). Sedimentary rock-hosted gold deposits mainly are present in the carbonate rocks of the upper Gaoyuzhuang group of the Great Wall system, and the lower Yangzhuang and Womishan groups of the Jixian system (figs. 20, appendix I-2). The gold deposits are hosted in stratabound breccia zones, which extend along the Lengkou basin (Qiu, Y.S. and Yang, W.S., 1997).

Both the Dian-Qian-Gui and Qinling areas in P.R. China have similar regional sedimentary and tectonic features to the sedimentary rock-hosted gold deposits in Nevada. The age of the Lengkou basin in Jidong area, however, is much older, and may have different metallogenic affinities. It is likely that many or all of the following features contributed to the localizing and formation of sedimentary rock-hosted gold deposits:

(1) Deposits cluster at the margins of one or more Precambrian cratons, or in areas where craton-scale tectonic units join.

(2) Deposits are hosted in or lie at the margins of Paleozoic and (or) Mesozoic sedimentary basins, which contain both shallow-water carbonate-rich rocks from the cratonic shelf and

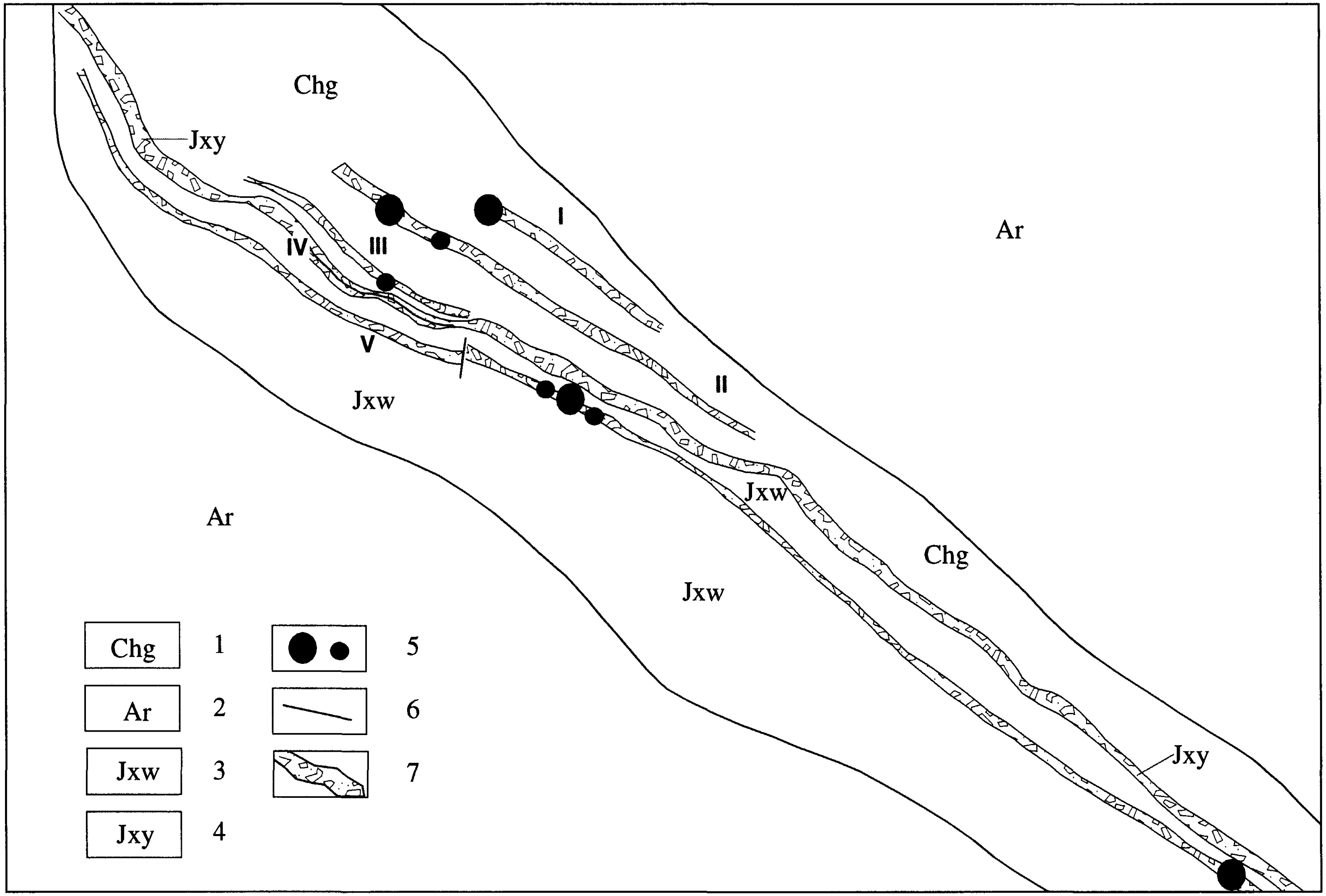


Figure 19. Geology and gold deposits in the Lengkou basin, Jidong area, China, showing the gold deposits are controlled by five northwestern-trending, stratabound breccia bodies . 1-Gaoyuzhuang group of the Greatwall system (Chg); 2-Archaeozoic stratigraphy (Ar); 3-Wumishan group of the Jixian system (Jxw); 4-Yangzhuang group of the Jixian system (Jxy); 5-Gold deposits (prospects); 6-Boundary of the Lengkou basin; 7-Au-bearing breccia bodies, labeled by number (I, II, III, IV, V). Adapted from Qiu, Y.S. and Yang, W.S. (1997, unpublished). Approximate location of figure is 118°18' 00''E; 40° 00' 00''N. See Figure 6 for approximate location.

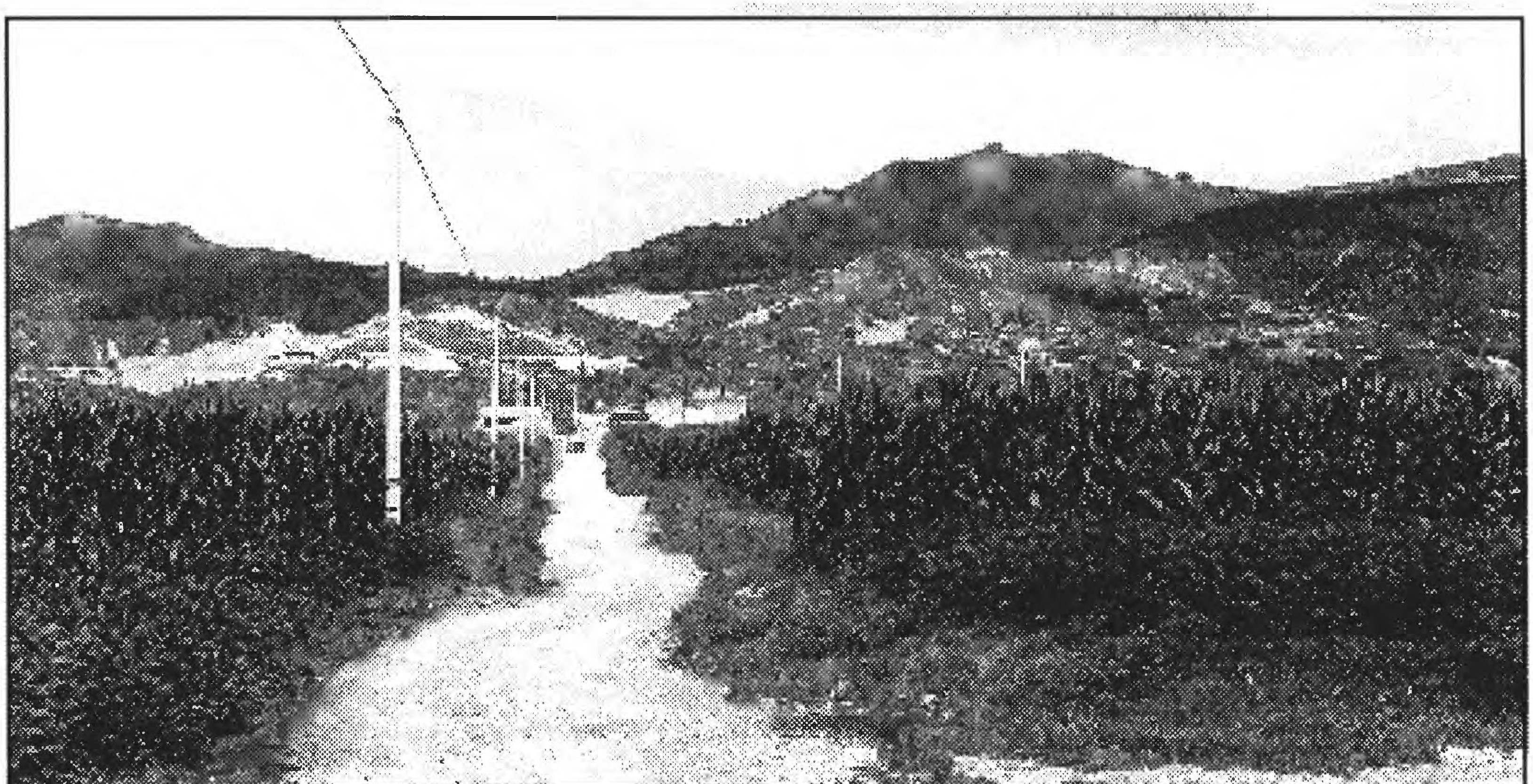


Figure 20. Photograph of several Greatwall gold deposits, Jidong area, China (Looking to the north). Skyline shows the Greatwall. Field of view of middle ground approximately 1 km.

fine-grained silici-clastic sedimentary rocks from the deeper basins.

(3) Tectonically, there is a history of both compressional and extensional deformation in the geologic histories, with both crustal thickening and thinning.

(4) There is evidence of alignment of geologic features of regional deep-crustal rifts or zones that were developed after or during major orogenies.

Metallogenic Epochs of Gold Mineralization

Sedimentary rock-hosted gold deposits are hard to date and contain many conflicting relations that contribute to controversies of their genesis and age. Stratigraphic chronology can only give a maximum age, because the orebodies are epigenetic and are commonly controlled by high-angle faults crossing several stratigraphic units that represent long periods of geological time. The radiometric methods require robust syn-ore alteration minerals, which are usually lacking in Carlin-type deposits. Illite and kaolinite are the most common alteration minerals, and these have not given reproducible ages in individual deposit or in ore districts (Folger and others, 1996; Arehart and others, 1993a). The following summary describes our understanding of the ages of these deposits in Nevada and in P.R. China.

Age of deposits in Nevada, the United States of America

The age of gold mineralization of sedimentary rock-hosted gold deposits in north-central Nevada is controversial, with published ages ranging from Jurassic to Late Mesozoic to early Tertiary (see Arehart and others, 1993c; Hofstra, 1995; Groff, 1996; Hitchborn and others, 1996; Hall and others, 1997; Parry and others, 1997). Most gold deposits along the Carlin trend in Nevada are present in the lower Paleozoic sedimentary rocks of eastern assemblage rocks, and their maximum age is between the Jurassic pre-ore Goldstrike stock at 158 Ma and the post-ore Tertiary Carlin Formation at 5 Ma.

Age of deposits in the Dian-Qian-Gui and Qinling area, P.R. China

Chinese Carlin-type deposits, with the same geologic characteristics as those in Nevada, also are as difficult to date, and a similar controversy also is present regarding their age. Chinese Carlin-type gold deposits have been found in sedimentary formations ranging from Paleozoic to Mesozoic in age (table 3, fig. 21). Of these, about 41 percent of the deposits are hosted in rocks of lower Triassic age. These rocks have proven to be ideal host rocks for the deposits, especially in Dian-Qian-Gui area (see also Zhang, F., and Yang, K.Y., 1993). Some deposits, such as Yata, Sanchahe, Ceyang, and Banqi deposits, are present near high-angle reverse or normal faults, which were formed in the Yanshanian orogeny, suggesting that the age of gold mineralization is less than 100 Ma (Ashley and others, 1991). However, radiometric dating of these deposits is not available.

About 21 percent of Carlin-type gold deposits in P.R. China are in Devonian age rocks (table 3, fig. 21), particularly in the Qinling area. Ages of gold mineralization derived from radiometric isotope methods (K/Ar, $^{40}Ar/^{39}Ar$ and U-Th-Pb) give many ages ranging from >300 Ma to <15 Ma (see table 4). The youngest age of gold mineralization (49.5 to 12.7 Ma) in the Laerma deposit is on the basis of analysis of both whole rock and ore minerals (Li, Y.D and Li, Y.T., 1994). The oldest ages reported are 337.5 to 234.3 Ma from the Pingding deposit by isotope analysis of realgar and orpiment associated with gold mineralization using the U-Th-Pb method (Lin, B.Z. and others, 1994). Other age dates are 168 Ma (pyrite, U-Th-Pb), 183.09 Ma (pyrite, $^{40}Ar/^{39}Ar$) in the Shuangwang deposit (Fan, S.C. and Jin, Q.H., 1994), and 210 Ma (whole rock and ore, U-Th-Pb) in Baguamiao deposit (Wei, L.M. and Cao, Y.G. 1994).

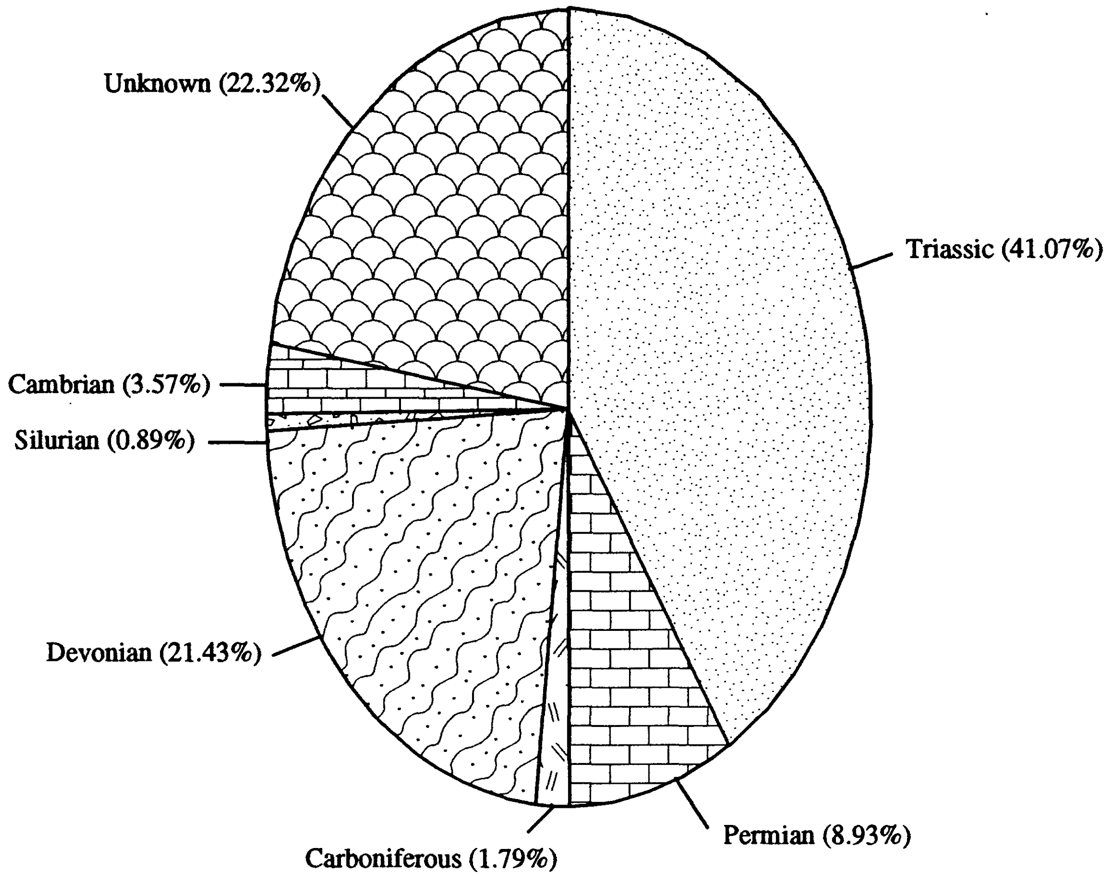


Figure 21. Chinese Carlin-type gold deposits according to host-rock age. Triassic and Devonian age rocks are the main host rocks of Chinese Carlin-type gold deposits.

Table 3. Distribution of Chinese Carlin-type Gold Deposits by Age of Host Rock

Host-rock age	Number of Deposits	Percent (%)
Triassic	46	41.07
Permian	10	8.93
Carboniferous	2	1.79
Devonian	24	21.43
Silurian	1	0.89
Ordovician	0	0.00
Cambrian	4	3.57
Unknown	25	22.32

Table 4. Age of Gold Mineralization in the Qinling Area, P.R. China

Deposit name	Age of gold mineralization (Ma)	sample	Result of Dating (Ma)	Method	Calculate method	Source
	49.5-12.7	Dacite(barren)	172	K-Ar		
		Dacite(gold-bearing)	12.77	K-Ar		
Laerma		ore	56.8-117.5	U-Th-Pb		Li, Y. 1994
		Quartz(gold-bearing)	47.3-49.5	$^{40}Ar/^{39}Ar$		
		U ore associated gold	46-10	U-Pb		
	Late Mesozoic	Dike	214.1	K-Ar		Lin, 1994
Pingding		Realgar orpiment	392-265	U-Th-Pb	Double stages	
			337.5-234.3		Single stages	
Jiu uan		Intermediate dike	200.7	K-Ar		
Shuangwang	168	II pyrite	183.08	$^{40}Ar/^{39}Ar$		Fan, 1994
		IV pyrite	168.0	$^{40}Ar/^{39}Ar$		
	210	strata	399.62	U-Th-Pb	Double stages	
Baguamiao		"	386.11	"	Single stages	Wei, 1994
		ore	289.89	"	Double stages	
			208.22	"	Single stages	

In general, the interpretive ages of sedimentary rock-hosted gold deposits in both Nevada and P.R. China span an interval between the age of the host rocks and the age of the post mineralization cover. Many of the dates are compatible with known metallogenic events and coincide with tectonic or magmatic activity in the region. The spread of ages is due to the limits of the analytical methods and to the unique features of the sedimentary rock-hosted gold deposits. It is likely, using some of the minimum age dates from the Chinese Carlin-type deposits, that they may have formed at a younger age than the Nevada deposits. As discussed below, possible evidence for syngenetic formation of the Chinese deposits is also present.

GEOLOGY OF SEDIMENTARY ROCK-HOSTED GOLD DEPOSITS

The deposit-scale geologic characteristics—such as host-structure, host-rock, alteration, and ore minerals for both Nevada and Chinese sedimentary rock-hosted gold deposits—are well documented in the geologic literature (see Christensen, 1993; Liu, D.S. and others, 1994; Wang, Y.G. and others, 1994; Bagby and Berger, 1985; Kuehn and Rose, 1995; Arehart, 1996). The following discussion outlines these characteristics, and compares the difference between deposits in P.R. China and Nevada. This discussion also helps us understand the difference in geologic characteristics between Carlin-type and other type of gold deposits that are directly related to igneous and metamorphic activity.

Host Structures and Feeder Systems

World-wide distribution of Carlin-type deposits is controlled by Paleozoic or Mesozoic sedimentary basins at the margins of Precambrian cratons. Location of Carlin-type deposits is closely related to compression and extensional regional structural tectonic events in these sedimentary basins. Tectonic structures and faults are related to these events, such as the Robert Mountains thrust and weakly defined trends in Nevada, the Youjiang deep-crustal rift system in the Dian-Qian-Gui area, and the Baiyun-Lixian-Shanyang rift in the Qinling (Jidong) area, P.R. China.

Regional-scale structures or lineaments usually serve as conduits or host-structures for most sedimentary rock-hosted gold deposits. In the Carlin trend area, these structures are high-angle faults, associated folds or tectonic windows (see Poole, 1991; Prihar and others; 1996), which are oriented parallel or perpendicular to the main trend or primary lineament. High-angle faults are generally considered to playing a key role in ore-control in these deposits (Togashi, 1992). Christensen (1993, 1996) summarized the styles of gold mineralization into three models, which form a spectrum between undeformed stratabound replacement bodies with little structure, more structurally controlled orebodies with either high-grade vein-like ores, and massive breccia- or stockwork-type (fig. 22). Peters (1996, 1997c) has suggested that shear folding of pre-existing regional folds was a major ore-control in the large Betze deposit in the Carlin trend and that some of the deformation was synchronous with ore deposition. Syn-deformational genesis has also been documented in the Lannigou deposit, Guizhou Province, by Luo, X.H. (1993, 1996).

Liu, D.S. and others (1994) identify four main types of host-structure in Chinese sedimentary rock-hosted gold deposits. These are: (1) short-axial anticlines; (2) stratabound breccia bodies; (3) unconformity surfaces; and (4) joints associated with faults and anticlines. Shear zones with ductile-brittle deformation textures of ore and rocks also are observed in some Chinese sedimentary rock-hosted gold deposits (figs. 23, and 24).

Short-axial anticlines—defined as folds with a length in the axial direction roughly equal to its limb widths—are common and important ore-controlling structures in the Dian-Qian-Gui area (fig. 15). Almost all Carlin-type gold deposits are related to folds or domes in this area (Luo, X.H., 1994). For example, the

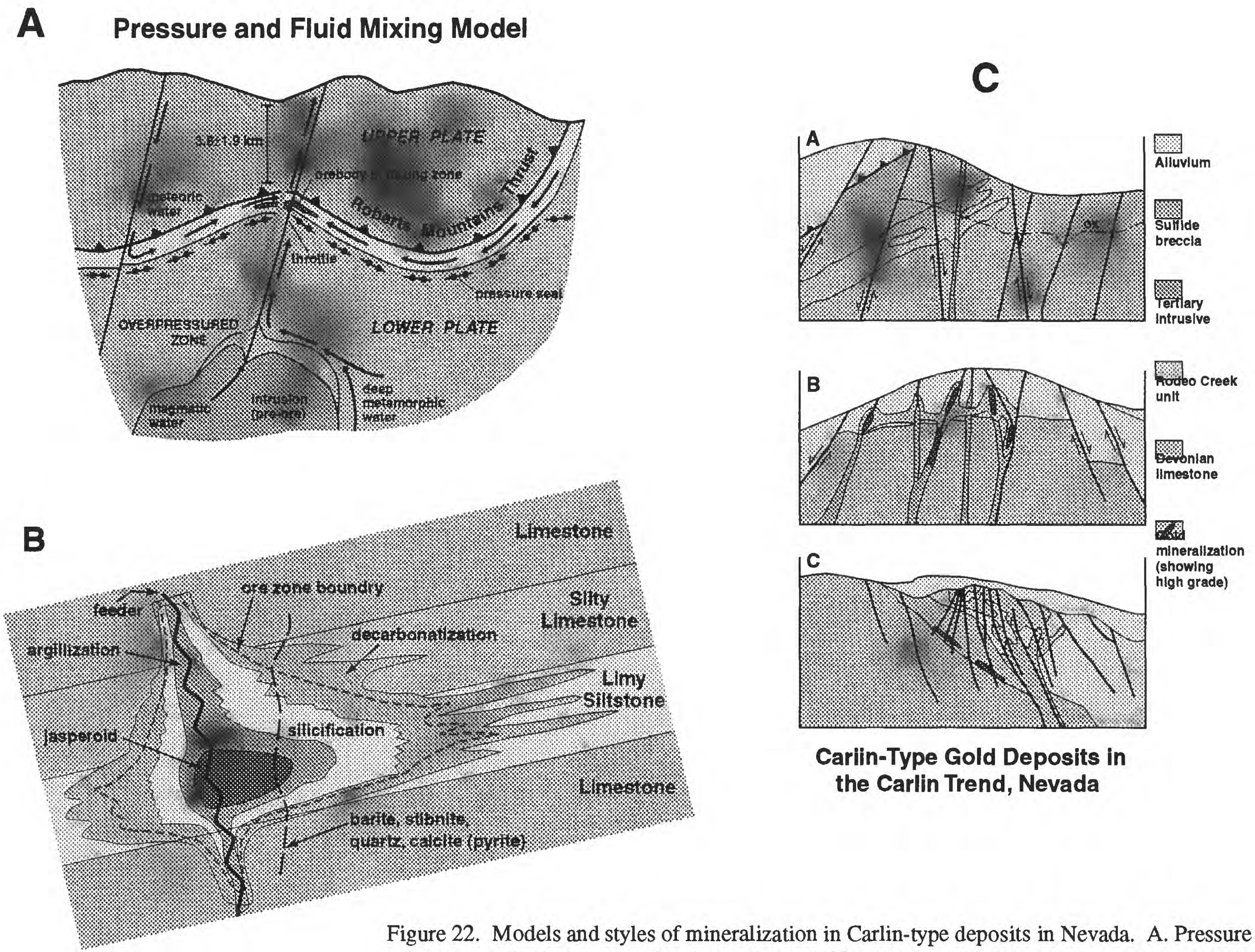


Figure 22. Models and styles of mineralization in Carlin-type deposits in Nevada. A. Pressure and fluid mixing model, adapted from Kuehn and Rose (1995). B. Model of typical sedimentary rock-hosted gold deposit, adapted from Arehart (1996). C. Three styles of Carlin deposit, stratabound, structure and complex (breccia), adapted from Christensen (1993, 1996).

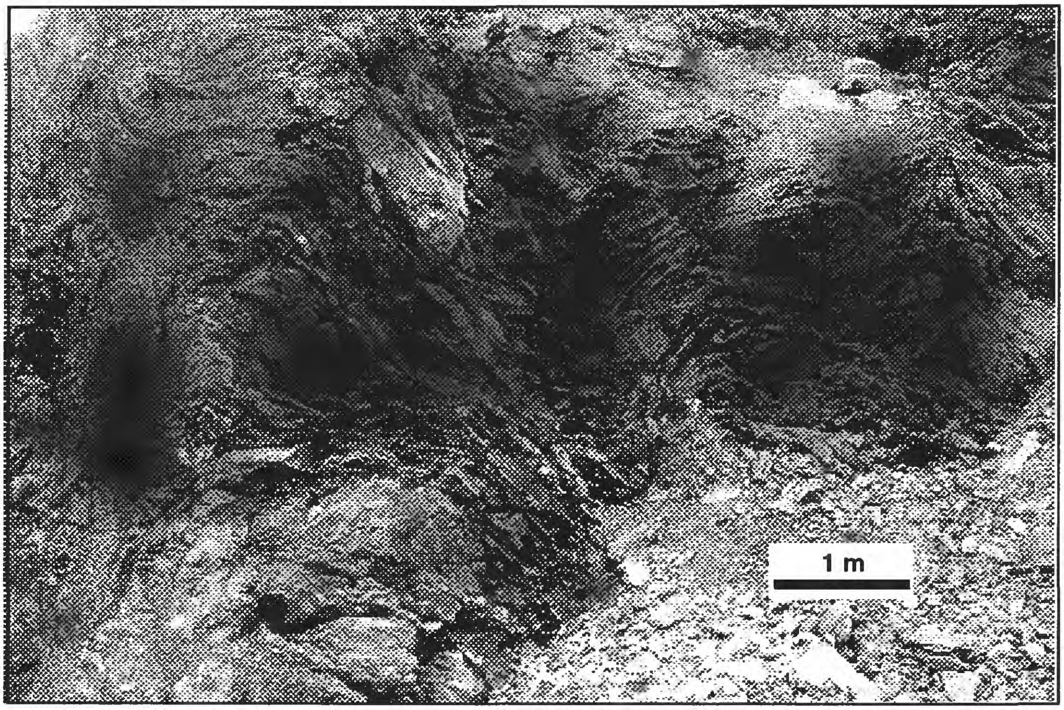


Figure 23. Photograph of deformation of carbonaceous laminated rocks in the Gaolong gold deposit (looking to northwest).

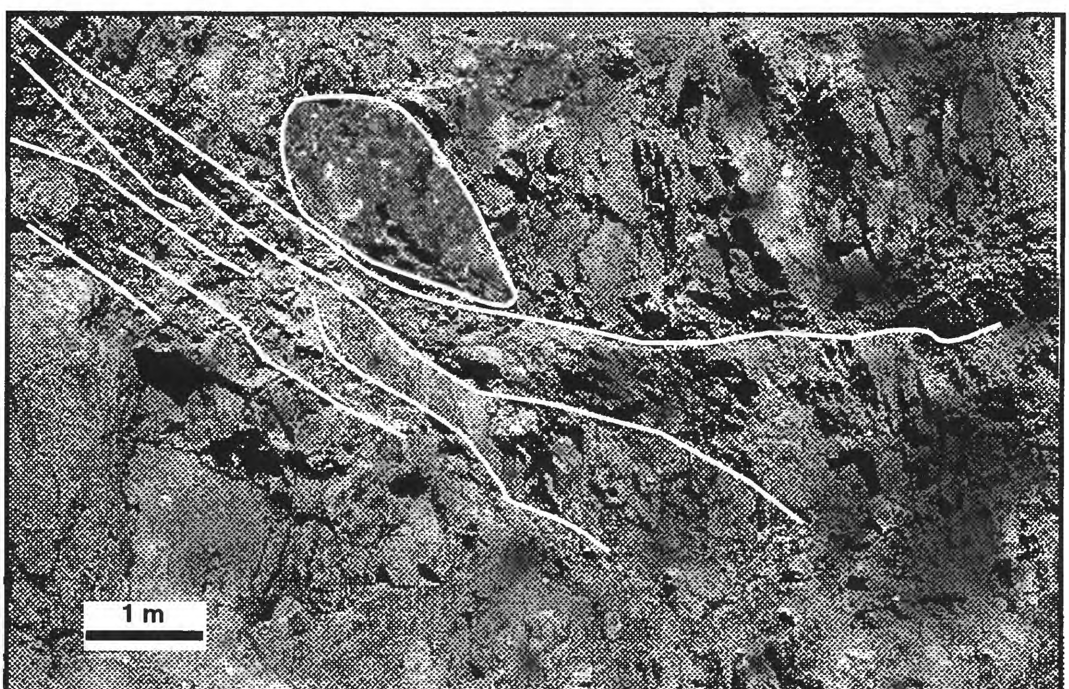


Figure 24. Photograph of flat, ductile-brittle deformation (shear zone) in the Gaolong gold deposits (looking to northwest). From a vertical mine bench.

Banqi deposit is controlled by the Naban fold (fig. 25); the Lannigou deposit is in the Laizishan dome (fig. 26). In addition, the Zimudang deposit is controlled by the west part of Huijiapu anticline and the Sanchahe, Puzilong, and Beiyinbe deposits (prospects) are located on the eastern Huijiapu anticline; the Getang deposit occurs in the Daba dome. The ore deposits typically cluster along structures on the outer most parts of the domes near the contact between carbonate and silici-clastic rocks.

Short-axial anticlines are generated by the interference of two fold systems crossing each other, similar to refolding or partial doming. High-angle breccia zones and detachment faults host gold orebodies on the axial margin of these domes. The Laizishan dome is 25 km long and 12 km wide and is typical of short-axial anticlines (fig. 26). The central domal area is comprised of approximately 1,300 m of Carbonaceous to Permian limestone, bioclastic limestone, and reef limestone, with interlayered argillite and tuffaceous argillite (Dachang unit) exposed at its core. Triassic sediments (1,000 m thick) are distributed on the west and east limbs of this dome. The western limb consists of carbonate rocks of the platform facies that dip 5° to 20° to the west, whereas the eastern limb is composed of clastic rock of the abyssal sedimentary facies with dips of 20° to 40° to the east. The faults surrounding this short-axial anticline are well-developed, and are spatially associated with Au, As, Hg, and Sb mineralization. The Lannigou deposit, the largest sedimentary rock-hosted gold orebody (shown on figs. 27, and 28) in this district, is located on the eastern limb of the Laizishan short-axial anticline (fig. 26). Other sedimentary rock-hosted gold deposits surrounding this fold are the Bannian, Yangyuo, Begao, and Luodong deposits, and the Qingping, Tangxinzhai prospects (appendix I) (Luo, X.H., 1994).

Stratabound breccia bodies also are a type of ore-controlling structure or host of sedimentary rock-hosted gold deposits in P.R. China. These breccia bodies are conformable with stratigraphic units in the host rock. An example of this is the Shuangwang gold deposit (Fan, S.C. and Jin, Q.H., 1994), which is a large Carlin-type gold deposit in the Qinling area, hosted by stratabound breccia bodies (fig. 29), and located in Devonian age Xinhongpu Formation rocks, which consist of silty slate, interbedded argillaceous silty limestone, mirolitic limestone, argillaceous limestone, and interbedded slate. Eight gold-bearing breccia bodies are present in a composite extensional breccia zone that is 11.5 km long and 700 to 500 m wide, trending N290° to 310° W. The breccia occurrences are conformable or cross cut stratigraphy at low-angles. The breccia clasts (size ranges from 10 cm to several meters) are composed of altered slate, siltstone, marble, and micritic limestone. The breccia matrix is made up of albite, ankerite, and calcite, as well as local quartz and pyrite formed at multiple stages of hydrothermal activity. About fourteen orebodies have been defined at Shuangwang inside a 1 ppm Au cut-off. The No. 8 orebody, the largest one, is approximate 680 m long, 28.3 m wide, and 348 m deep.

Another example of stratabound breccia bodies is the Greatwall gold deposit, Jidong area, where gold mineralization is hosted by five stratabound breccia bodies. These breccia bodies are 5 to 15 km wide, up to 25 to 30 km long, and are present in Ca- and Mg-rich carbonate rocks containing chert layers and nodules (figs. 19, 30, 31) in the Gaoyuzhuang (Great Wall system) and Wumishan groups (Jixian system). Most orebodies are hosted in conformable breccia zones (figs. 32, 33), and have a layered or stratified appearance and tabular shape. The breccias usually strike between NW 290° to 310°, and dip SW between 50° to 80°, and vary locally with host strata. Clear boundaries between the orebodies and host-rock (brecciated-dolomitic limestone) are sometimes lacking. Out of 34 rock chip samples randomly taken from 4 mining sites, from northwest to southeast along the breccia zone, gold assays were 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) (Qiu, Y.S. and Yang, W.S., 1997).

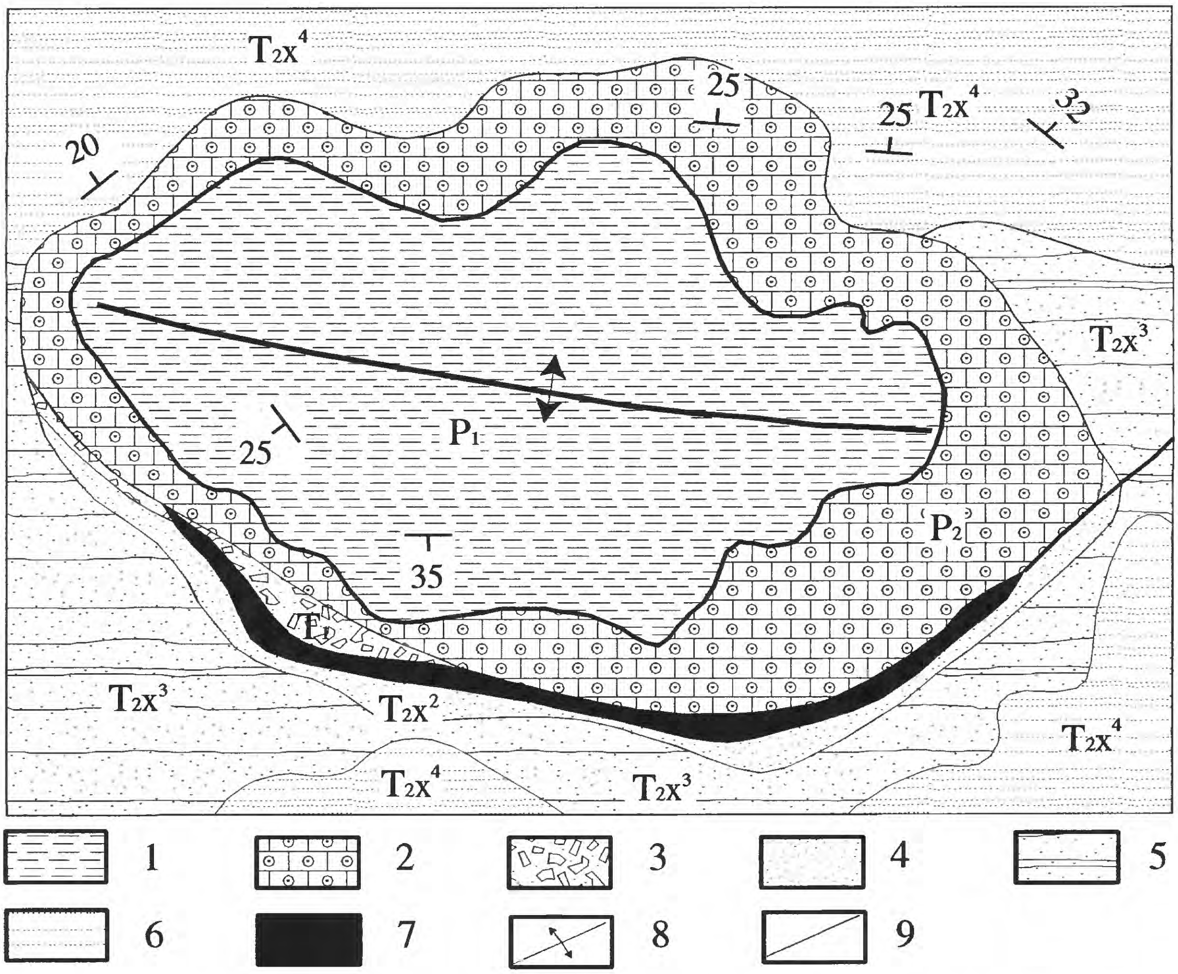


Figure 25. Geologic map of the Banqi gold deposit, showing the domal short-axial anticline structure that controls ore called the Naban fold. 1,2-the Permian rocks (P1, P2); 3-the Triassic Ziyun group rocks (T1Z); 4, 5, 6-the Triassic Xinyun group rocks (T2X2, T2X3 and T2X4); 7-the gold orebody; 8-Axis of short-axial anticline; 9-fault. Modified from Pu, Hanke (1987); and Liu, D.S. (1994). Approximate location of figure is 105^0 39' 00''E; 24^0 48' 00''N.

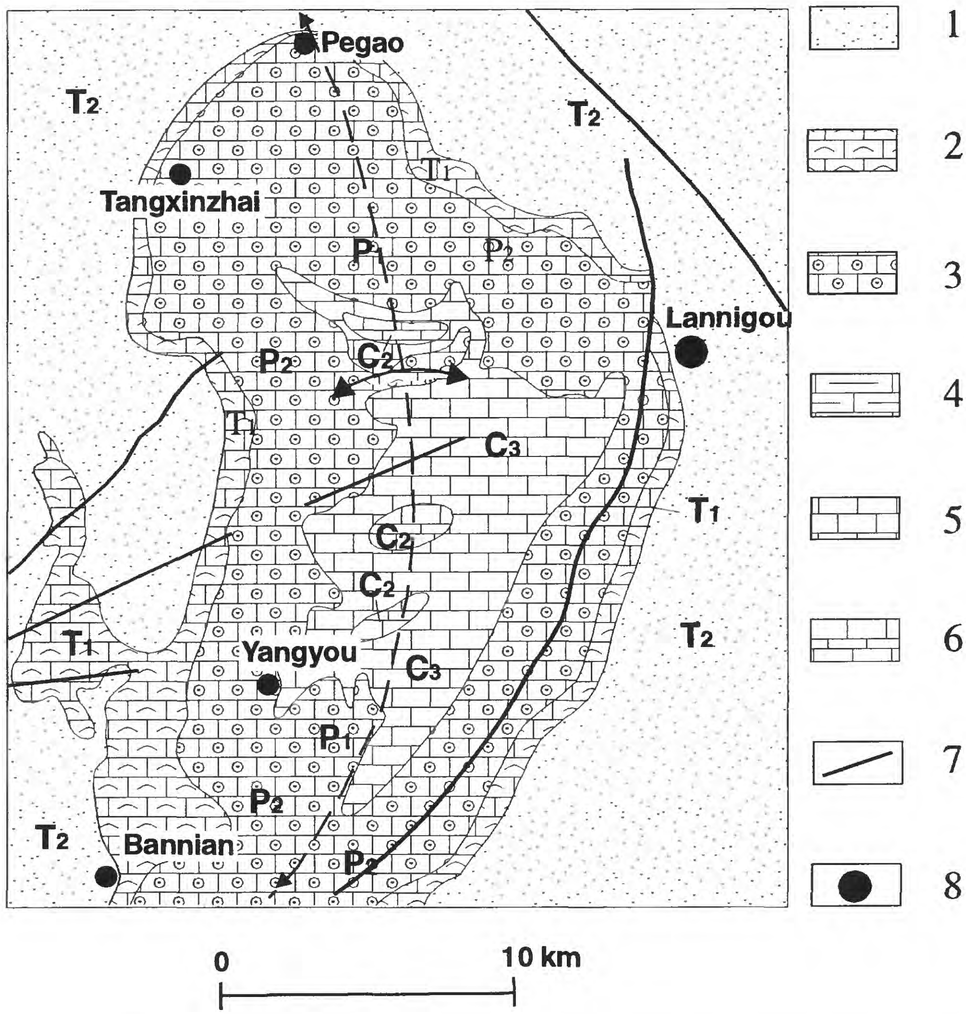


Figure 26. Laizishan dome (short-axial anticline structure). 1, 2 Triassic stratigraphy (T2b, T1l), which is located on the east and west flanks; 3, 4, 5, 6-Carbonaceous to Permian limestone, and bioclastic limestone, located in the anticlinal core; 7-Faults surrounding the fold are related to Carlin-type gold mineralization such as the Lannigou deposit; 8-Gold deposit. Adapted from Luo, X.H. (1994). Approximate location of figure is 105° 41' 24''E; 25°21' 00''N.

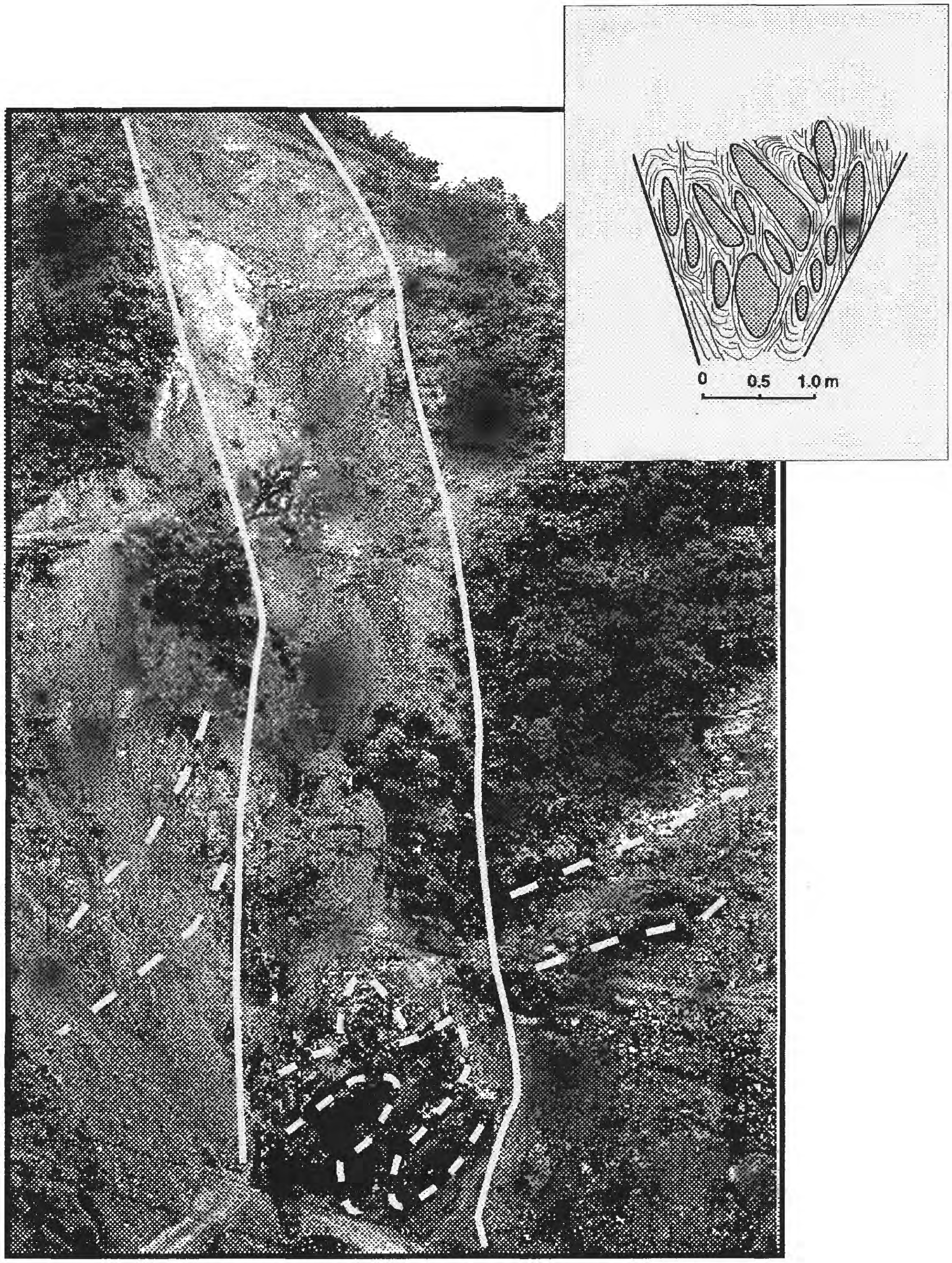
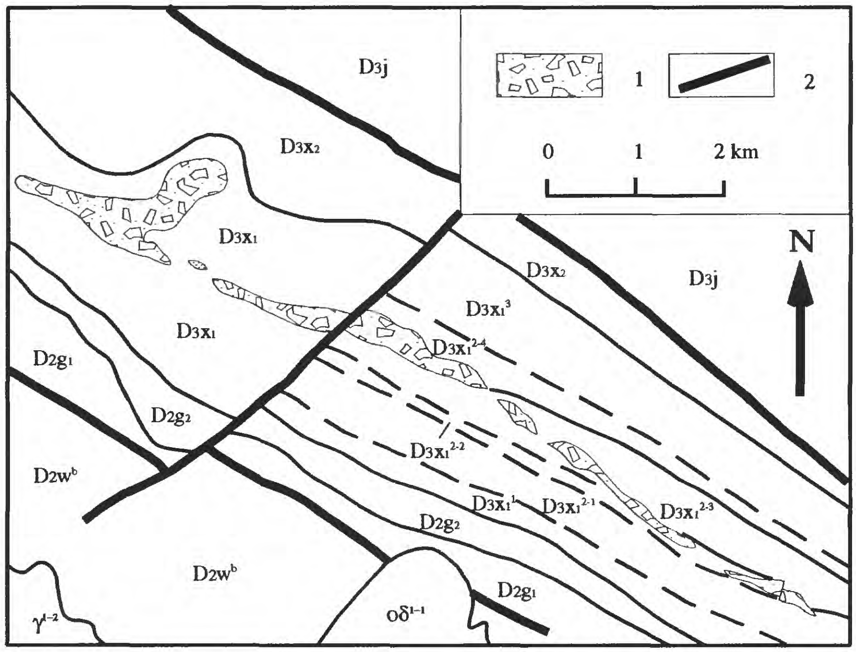


Figure 27. Photograph of No. 1 orebody of the Lannigou gold deposit, Guizhou province (looking to north). Center scarred area is the host shear zone (bounded by white lines) Bedding is shown in dashed lines. Inset: phacoidal deformation style typical in host shear zone of the Lannigou deposits, suggesting multiple periods of syn-deformational mineralization (from Lou, X., 1993, 1996).

Figure 28. Photograph of bedding slip in No. 1 orebody of the Lannigou gold deposit, Guizhou province (looking to north). The darker, sheared pelitic, carbonaceous bands contain the pyrite-gold mineralization.



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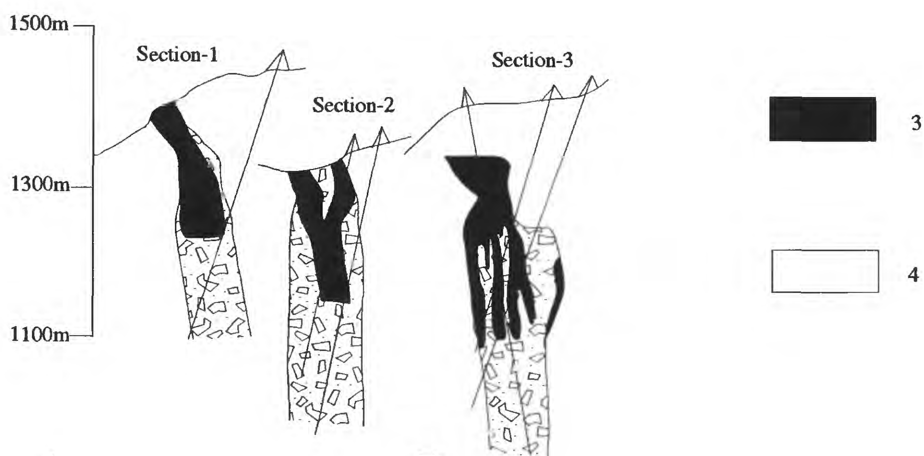

B

Figure 29. Stratabound breccia ore control in the Shuangwang gold deposit, Qinling area. A. Plan geologic map of the Shuangwang gold deposit showing localization of the orebody in the D3 x1 unit. B. Sections 1, 2, and 3 showing gold orebody in the upper parts of the stratabound breccia zone. 1-breccia body; 2-fault; 3-orebody; 4-host rocks; D2wa-b- meta sandstone interbedded limestone, carbonaceous shale (Wangjialeng group); D2G1-2-limestone, sandstone (Gudaoling group); D3x1-2- siltstone, limestone, phyllite (Xinghongpu group); D3j-siltstone, slate (Jiuliping group). Adapted from Fan, S.C. (1994). Approximate location of figure is 107 18' 00''E; 34 00' 00''N.

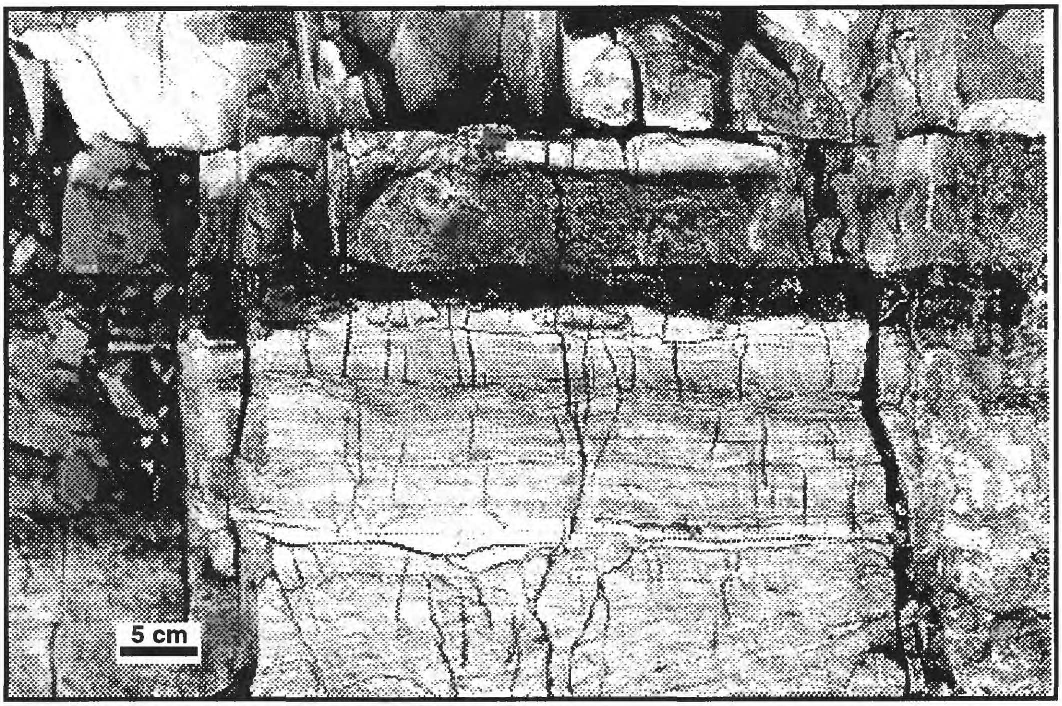

Figure 30. Photograph of dolomite interbedded with black chert lenses in wall rock of the Greatwall gold deposit, Hebei Province (looking to east). Black chert locally has a back ground of 2 ppb Au.

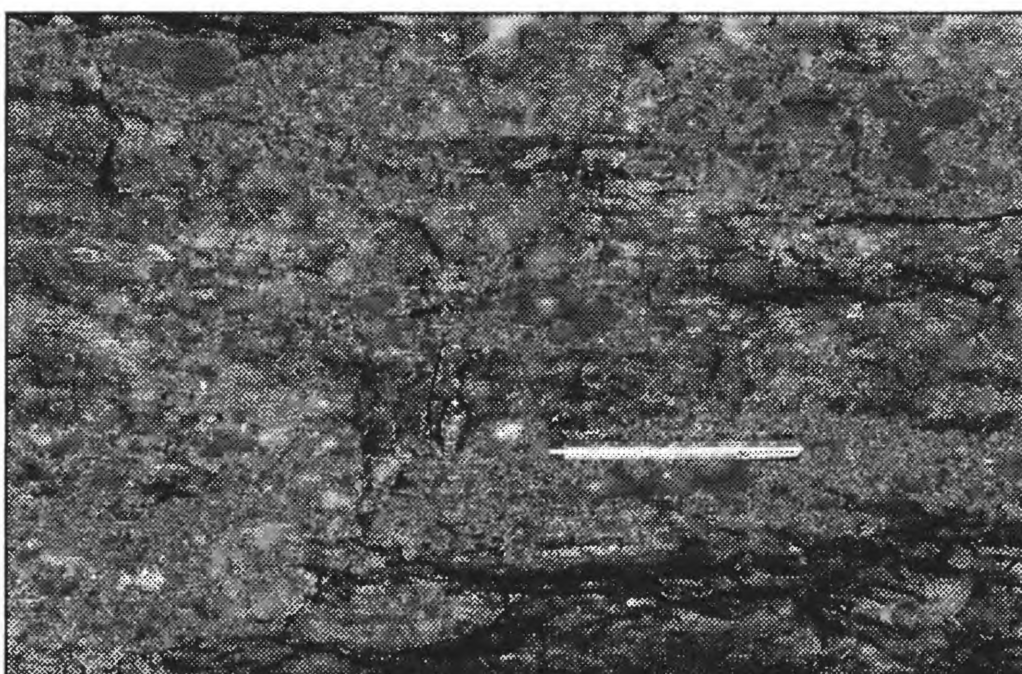

Figure 31. Photograph of layered black chert in the wall of open pit in the Greatwall gold deposit, Hebei Province (looking to north). Breccia zone no. 3.

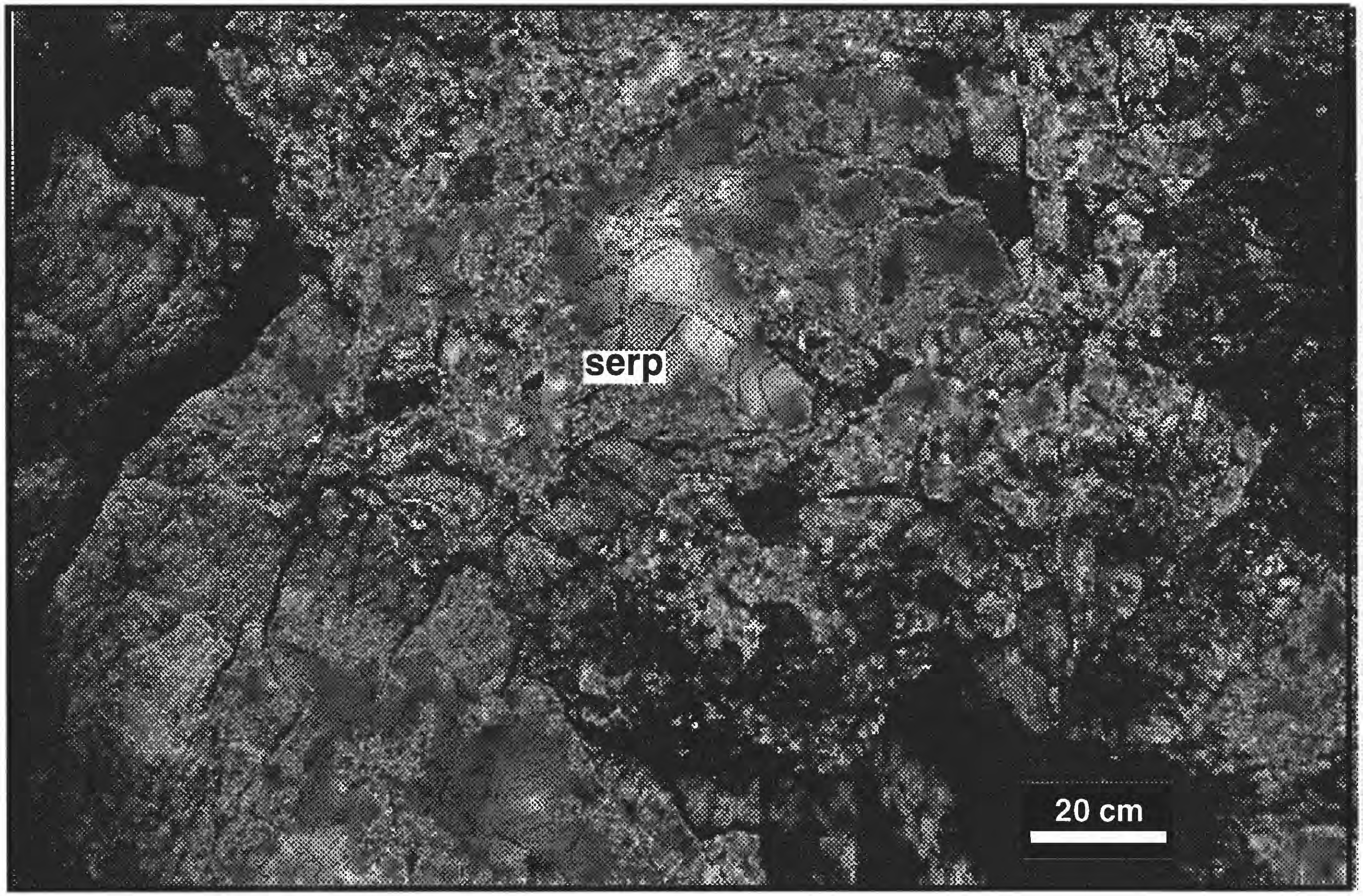

Figure 32. Photograph of dolomite breccia with serpentine clasts (serp) in the Greatwall gold deposit, Hebei Province. This is typical of the main host rock for many of the ore deposits.

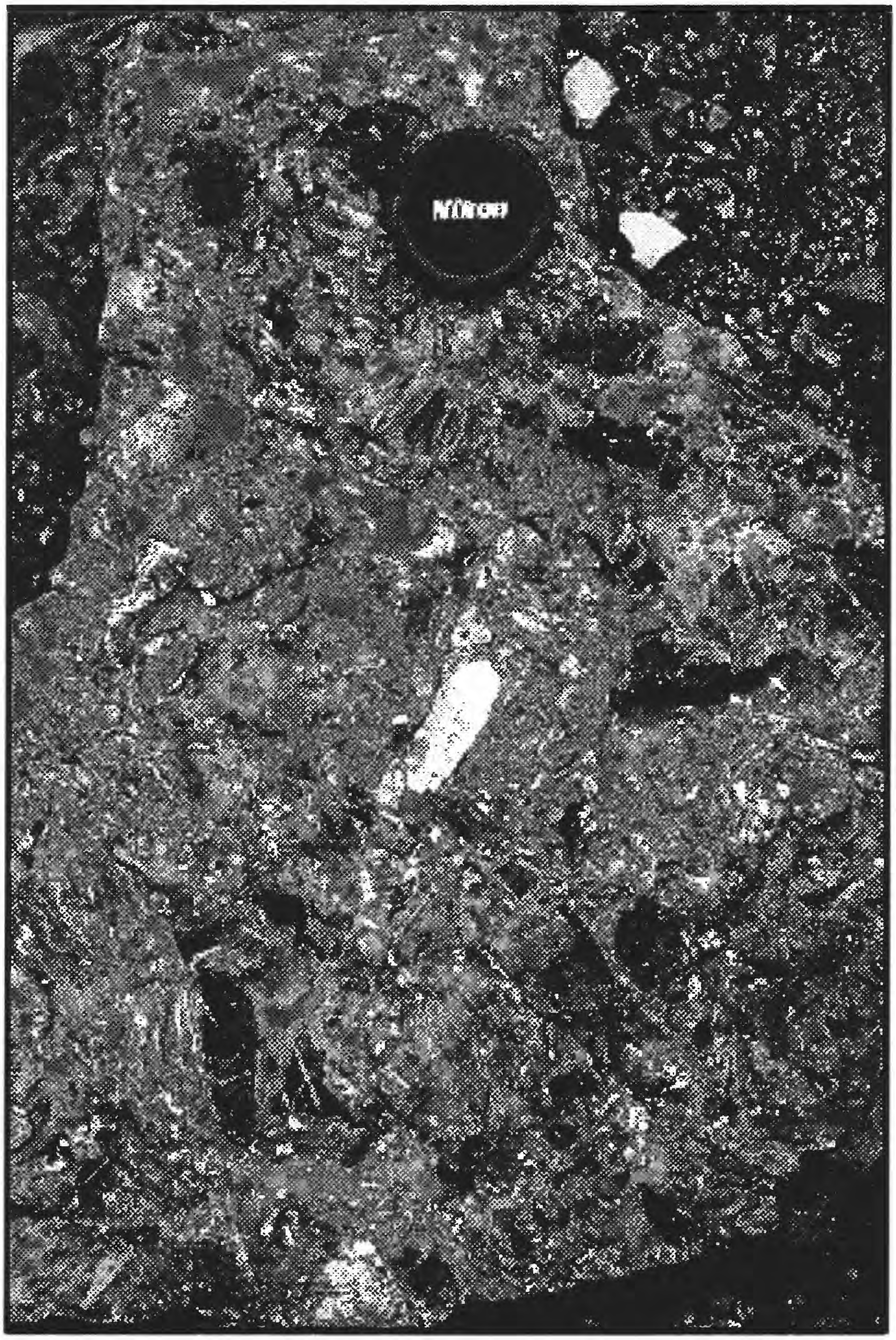

Figure 33. Photograph of mineralized dolomite breccia with black chert in the Greatwall gold deposit, Hebei Province. This breccia is typical of many heterolithic breccias that contains abundant red to black matrix fill (cement). This breccia is from the No. 3 Breccia ore zone.

Unconformity surfaces or bedding planes, and bedding plane faults often serve as ore-control structures in Dian-Qian-Gui area. Karst caves and paleo-erosional surfaces are common near unconformities, and some gold orebodies take the shape of karst pots. These features also are more easily subjected to weathering and laterite development and are the sites of local oxidized ("red earth") orebodies. The orebodies in the Changkeng deposit (fig. 34), for example, are strictly controlled by the unconformity surface between the upper Triassic rocks (T_3X) and lower Carbonaceous rocks ($C_1Z^{a\text{-}b}$). Some karst caves exist in the bioclastic limestone at the footwall of the orebodies (Du, J.E and Ma, C.H., 1994). The Getang deposit (fig. 35) is present in siliceous, brecciated argillite, and siliceous limestone breccia. This group of breccia bodies is located at the unconformity surface between the Longtan unit (P_2l) and Maocou unit (P_1m) (Tao, C.G., 1990). Similarly, the Jinyia deposit (fig. 36) in Triassic rocks is controlled by a bedding-plane faults. Other gold ore bodies with this style of mineralization are the Lubuge, Beyian, Maxiong, Kagou, Dachang and Shaziling deposits or prospects (Deng, X.N., 1993).

Joints associated with folds and faults are important local ore-control structures in the Chinese sedimentary rock-hosted gold deposits. Folds usually control the overall distribution of the deposit, whereas, structural breccia zones control the local shape of the orebodies. The Zimudang (figs. 37, 38, and 39) and Yata gold deposits (fig. 40) serve as typical examples, where joints associated with folds and faults exert a strong control on the breccia-hosted gold mineralization.

In general, anticlines and faults (including high-angle and bedding faults) have been documented as the important host structures in both Nevada and Chinese Carlin-type gold deposits. There is a similarity of scale between these two regions where anticlines play a role in controlling the gold deposits regionally, while local high-angle faults, bedding faults, breccia bodies, unconformity surfaces, and other weak zones locally host or control the shape of the orebodies. The anticlines in Carlin trend, Nevada are well aligned along northwest, and some important high-angle faults such as Post and Gen faults that parallel the trend, are documented as important for orebody location and shape (Teal and Jackson, 1997). In contrast, the short-axial anticlines—important in the sedimentary rock-hosted deposits in P.R. China—contain high-angle faults which arc around the domal structures, rather than cross cut them.

Regional deep-crustal rifts are major influences on the host structures in sedimentary rock-hosted gold deposits. This is because these deep, through-going structures play a significant role in localizing the deposits by providing regional-scale permeable conduits and by providing foci for tectonic and hydrothermal activity. District- and local-scale high-angle faults proximal to these deep-crustal rifts provide local conduits for hydrothermal fluids. Other structures provide conduits for deposition or replacement of hydrothermal fluids rich in gold, silica, and other constituents found in the deposits. Most structures in sedimentary rocks have potential to serve as host-structures for Carlin-type gold deposits, which implies that these deposits have the potential to occur at any particular structural weakness in sedimentary rocks.

Host-rocks

The host rocks of sedimentary rock-hosted gold deposits in the area of the Carlin trend, Nevada are shown in table 5. Two main kinds of sedimentary assemblages, carbonate and siliciclastic rocks, are the most common host rocks of sedimentary rock-hosted gold deposits in north-central Nevada. Their lithology includes silty limestone and dolomite, siltstone, sandstone, conglomerate, and argillite with interbedded clay and shale. Silty carbonate, calcareous siltstone, and specifically local debris flows or sedimentary breccias—that represent transitional lithofacies between massive limestone units—are the most favorable host

Table 5. Host rocks of Carlin-type Gold Deposits in Carlin Trend, Nevada

Deposit Name	Host Rocks	Formation	age
Gold Quarry	Rhythmically thin-bedded gray siltstone, mudstone, chert and argillite	Rodeo Creek unit	Devonian
Post, Blue Star, Bootstrap, Deep Star, Genesis, Betze	Medium to thick-bedded gray limestone, with variably micritic, sparry, and grainy texture and locally fossiliferous	Devonian Limestone (Popovich limestone or Devils Gate limestone)	Devonian-Silurian
Carlin, Betze	Thin-bedded platy gray silty limestone, dolomitic calcareous siltstone, debris flow and fossil debris beds	Robert Mountains Formation	Ordovician

Compiled from Christensen (1994)

Figure 34

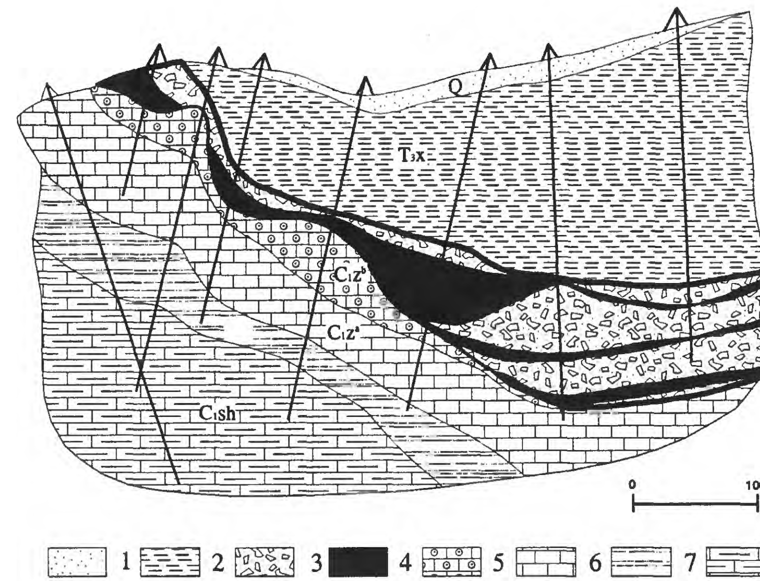

Figure 34. Geologic section of the Changkeng gold deposit, showing ore control on and between unconformity surfaces T3x and C1b. 1-Quaternary rocks; 2-shale, carbonaceous shale, siltstone; 3-breccia alteration zone; 4-orebody; 5- bioclastic limestone; 6- argillaceous limestone; 7-siltstone, calcareous siltstone, thin-bedded limestone, coal; 8-thick limestone. Compiled from Du, J.E and Ma (1994).

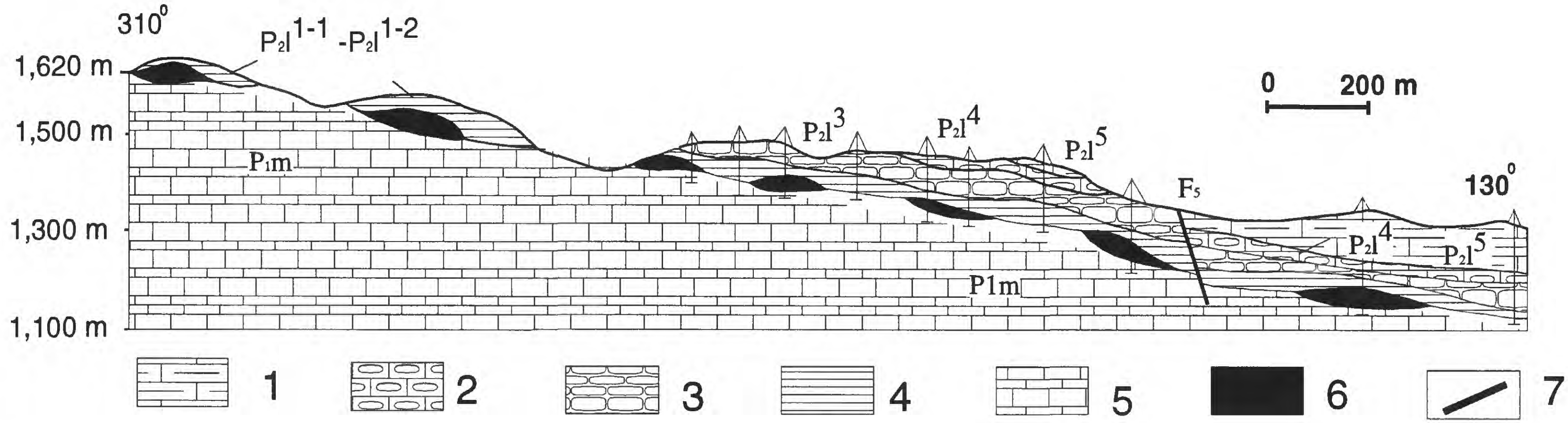

Figure 35. Geological section of Getang gold deposit. Orebodies are located on the unconformity between unit P2l3 and P1m and have the shape of topographic surface. The orebodies were formed on the old erosion surface. 1-limestone (Maokou group); 2, 3, 4, 5-mudstone, siltstone, limestone and coal (Longtan group); 6-orebody; 7-fault. Adapted from Tao, C.G. (1990).

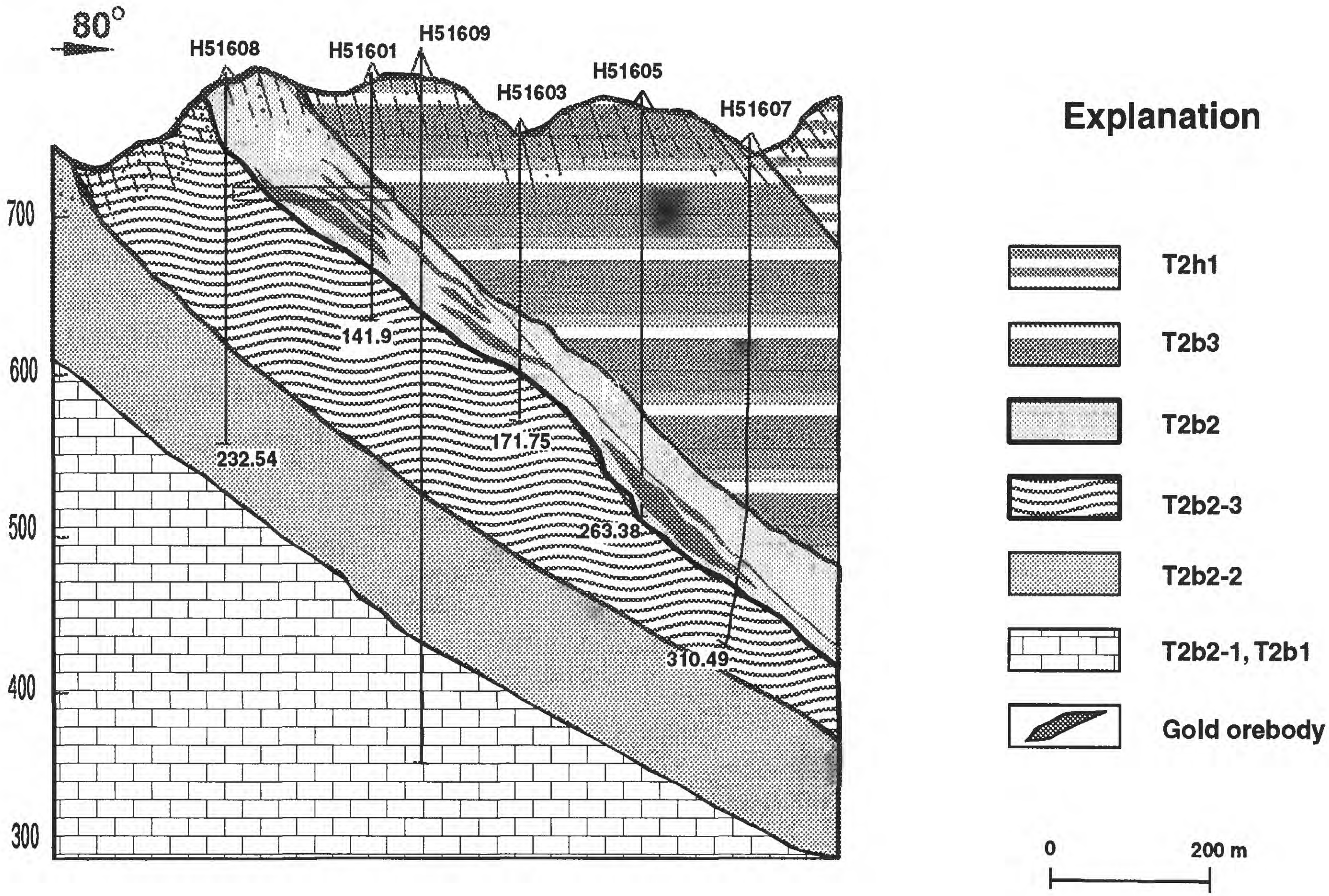

Figure 36. Geologic section from the Jinyia gold deposit, showing ore-control along lithofacies contact between units T2b2 and T2b3. Adapted from Li, Z.H. and others (1994).

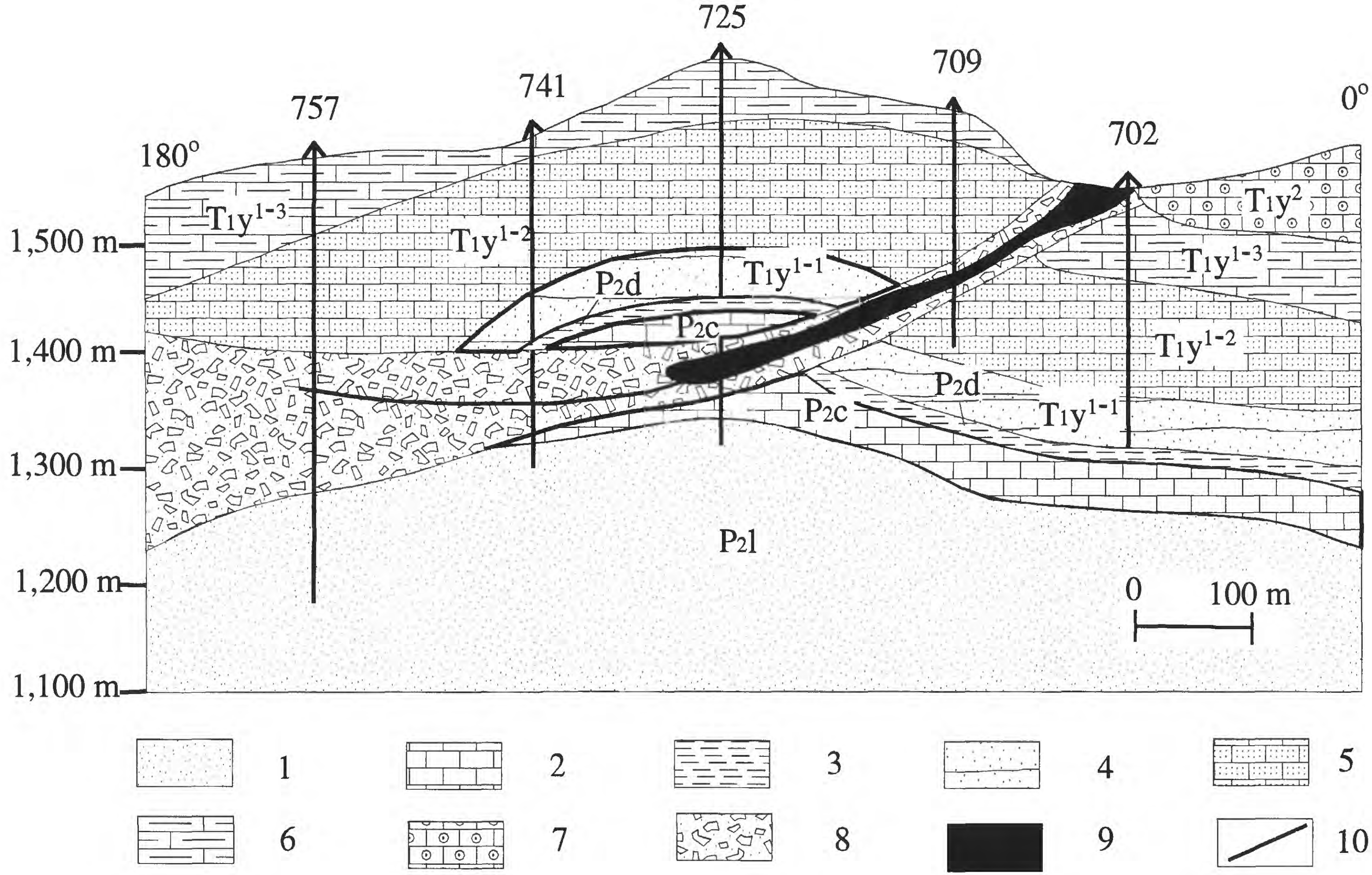

Figure 37. Geologic section of the Zimudang gold deposit. Joints associated with fault and anticlines provide the localizing host structure for the ore. 1-siltstone, silty argillite, bioclastic limestone, coal; 2-bioclastic limestone interbedded argillite; 3-thick argillite; 4-siltstone, argillite; 5-strip marl interbedded silty argillite; 6-thick bioclastic limestone; 7-bioclastic limestone, dolomitic limestone interbedded silty argillite; 8- breccia alteration zone; 9-orebody; 10-fault. Adapted from Guo, Z.C. (1994).

Figure 38. Photograph of ore with breccia texture in the Zimudang gold deposit, Guizhou Province.

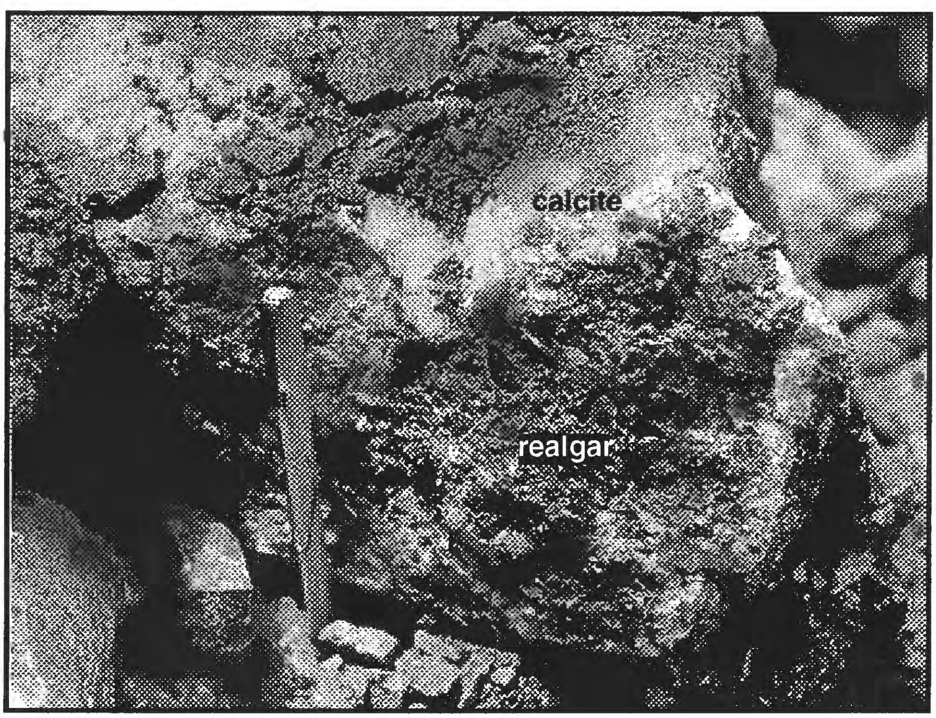

Figure 39. Photograph of ore with realgar and calcite in the Zimudang gold deposit, Guizhou Province.

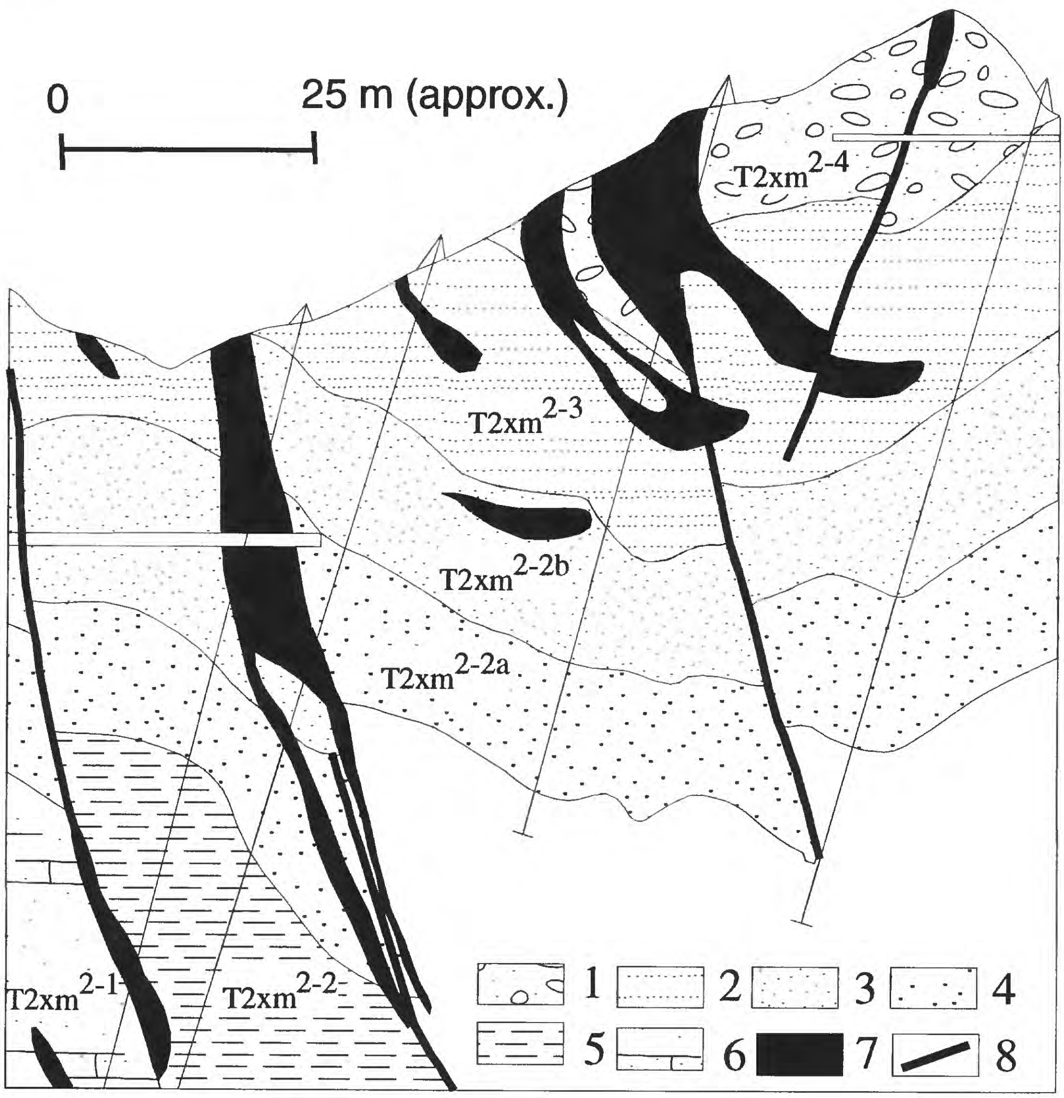

Figure 40. Geological section of the Yata gold deposit, showing the joints associated with faults and anticlines that control the orebodies. 1-sandstone, argillite; 2-sandstone interbedded limestone; 3, 4, 5-argillite, siltstone; 6-calcareous sandstone, siltstone interbedded lenses of limestone; 7-orebody; 8-fault. Adapted from Tao, C.G. (1990).). Approximate location of figure is 105°39' 00''E; 24°56' 00''N.

rocks Carlin-type gold deposits (Christensen, 1996; Arehart, 1996).

Most Chinese sedimentary rock-hosted gold deposits are hosted in marine carbonate- and clastic-rich sedimentary rocks, and locally interbedded volcanic flow rocks or tuff. The host-rocks of the main Chinese Carlin-type gold deposits are listed in table 6. These rocks typically were formed in abyssal or bathyal and turbidite environments, such as limestone, argillite, siltstone, sandstone, and shale. Low-grade metamorphic rocks such as spotted phyllite, slate, and crystalline limestone, which had original carbonate and clastic sedimentary protolith, host some deposits.

In the Dian-Qian-Gui area (fig. 6), siltstone, argillite and impure limestone are the main host rocks. A very important feature, similar to Nevada Carlin-type gold deposits, is the presence of impure carbonate and calcareous clastic rocks that represent a transitional zone of sedimentary facies. These are the best host rocks, and gold mineralization is more common in the clastic rocks of the transitional zone. For example, *in* the Zimudang gold deposit, the main host rocks are argillite, silty argillite, basaltic tuffaceous siltstone and silty dolomite. All of these rocks near the orebody have been broken by faults and are strongly silicified. Gold orebodies occur along these faults with the largest tonnages and grades located where argillite and clastic rocks intersect the fault. There is little ore or no gold mineralization in thick dolomite and limestone, which also intersect the faults (Peng, Y.Q., 1994).

Sedimentary rock-hosted deposits in the Dian-Qian-Gui area usually are stratabound, and this has lead several workers to suggest that specific sedimentary or volcanic horizons should be considered as source-beds for the gold in the deposits, even suggesting that the gold deposits could be syngenetic (Tan, Y.J., 1994). Three kinds of sedimentary formations, which were formed in different environments and are related to different types of gold mineralization, are considered as the main host stratigraphic units or source-beds for Carlin-type gold deposits in this area by Tan, Y.J. (1994):

(1) terrigenous clastic or volcanic-terrigenous siliceous clastic rocks formed in a littoral environment, *in*cluding the Bejiao (Yujiang) units (lower Devonian) and the Longtan unit (including Dachang group, upper Permian);

(2) carbonate-bearing fine-grained clastic rocks deposited in a platform shallow sea environment, *in*cluding the upper Permian Changxing unit and lower Triassic Yielang assemblages; and

(3) turbidites deposited at the continental slope and in a deep sea environment, *in*cluding Xinyuan (local name: Xuman, Baifeng and Banna group, upper Triassic).

The characteristics of these host stratigraphic units (Tan, Y.J., 1994) are as follows:

(1) **Terrigenous clastic or volcanic-terrigenous clastic rocks**, the lower Devonian Yujiang assemblage, consisting of greenish gray to dark gray, silty argillite, and interbedded siltstone, has an average Au content of 4.6 ppb. The upper Permian Longtan assemblage is argillite (1.92 ppb Au, locally averaging 8 ppb Au, with some horizons up to 19 ppb Au), siltstone (2.67 ppb Au), coal layers (1.63 ppb Au), basalt (44.7 ppb Au), and pyroclastic rock (54.33 ppb Au). These rocks host Au-Sb-pyrite mineralization (Tan, Y.J., 1994) in the northwest part of the Dian-Qian-Gui area, *in*cluding the Gedang, Maxiong, Getang and Dachang deposits (appendices I and II).

(2) **Carbonate-fine clastic rocks**, the upper Permian Changxing unit and lower Triassic Yielang assemblages, consisting of argillite, siltstone, and impure limestone averaging 8 ppb Au. Of these, the silty argillite contains gold values up to 15 ppb. They host Au-Hg-Tl mineralization in the northwest Dian-Qian-Gui area including the Zimudang gold deposits (Tan, Y.J., 1994).

(3) **Turbidites,** the middle Triassic Xinyuan assemblage rocks, *in*cluding 70 vol. percent

Table 6. Host rocks of Carlin-type Gold Deposits in P.R. China

Deposit	Overlying strata	Host-rock	Underlying strata
Jinya	dolomitic, argillic siltstone, silty mudstone, dolomite	medium to thick silty mudstone inter-layers argillic siltstone	thin, bioclastic limestone; medium limestone inter-layers carbonaceous mudstone, tuffaceous mudstone and tuff
Shuangwang	calcareous sandstone, siltstone, crystalline limestone, bioclastic limestone	breccia, silty slate inter-layers argillic limestone, crystalline limestone	siltstone, slate, argillic limestone
Getang	chert limestone, siliceous shale	siliceous limestone breccia	limestone, clay rocks
Liba	phyllite, spotted phyllite, siltstone	silty phyllite, meta-siltstone	phyllite, spotted phyllite, siltstone
Pingding	tuffaceous slate, limestone, silty slate	tuffaceous slate, carbonaceous, calcareous slate, bioclastic limestone argillic dolomite	argillic slate, silty slate, limestone
Baguamiao	siltstone, silty slate	spotted silty phyllite inter-layers crystalline limestone	medium limestone, dolomitic phyllite,
Lannigou		thick sandstone, siltstone inter-layers clay rocks	clay rocks, limestone, inter-layers clay rocks, micritic limestone, bioclastic limestone

siltstone and argillite, 10 vol. percent graywacke, and 20 vol. percent carbonate (micritic limestone, bioclastic limestone). Their gold content ranges from 2 to 12 ppb, averaging 6.73 ppb. These rock contain Bouma sequences (fig. 41), which consist of rhythmic bedding of calcareous fine sandstone, siltstone, calcareous argillite; there also are inter-beds and lenses of argillaceous limestone and limestone. Au-As-(Sb) mineralized occurrences are typically related to these turbidites in the southeast part of the Dian-Qian-Gui area (Tan, Y.J., 1994).

In the Qinling area, sedimentary formations of Devonian age are the main host rocks (figs. 6 and 17). Lithology and local names vary from one place to another so that correlation of different rock units is not well understood. Generally, the sedimentary lithofacies in the Qinling area can be divided into three zones, which are exposed as stripes with an east-west orientation: The north and south stripes are the Tangzang-Shanyang sub-basin and the Hueixian-Xunyang sub-basin. The central stripe is the Fengxian-Zhengan sub-basin in which the well-known Shuangwang gold deposit resides. The main characteristics of the Devonian stratigraphic sequence in the middle of the Fengxian-Zhengan sub-basin stratigraphic zone, according to Fan, S.C. and Jin, Q.H. (1994) are: the middle Devonian Gudaoling assemblage of calcareous sandstone, siltstone, interbedded micritic limestone is present at the top, and a medium-thick micritic limestone and bioclastic limestone, interbedded with carbonaceous calcareous slate is present at the bottom. The upper Devonian Xinghongpu assemblage includes micritic limestone and argillaceous limestone interbedded with slate at the top and silty slate interbedded with thin layers of argillaceous limestone at bottom. The upper Devonian Jiuliping assemblage consists of a sequence of siltstone, slate, and argillaceous limestone, which were deposited in a flysch sedimentary environment at the top, and calcareous siltstone interbedded with silty slate at the bottom.

The Qinling area, along the northwest margin of Yangtz Craton, also contains sedimentary rock-hosted gold deposits with high organic carbon content. Many large or extra-large gold deposits occur in or are associated with these carbon-rich, black sedimentary units. The Laerma deposit is a typical example, and others include the Dongbeizhai, Pingding, Jiuyuan, and Heidousi gold deposits (appendices I and II), all of which are hosted by fine-grained, black clastic rocks (Zeng, Y.F. and Yin, H.S., 1994). The organic carbon content ranges from 0.66 to 14.63 wt. percent (average 3.42 wt. percent) at the Laerma deposit (Li, Y.D. and Li., Y.T., 1994), and 0.2 to 0.7 wt. percent (average 0.45 percent) in the host rocks of the Dongbeizhai deposit (Mao, Y.N. and Li, X.Z., 1994). The high gold content in these carbon-rich, black-colored sedimentary rocks is a common geochemical feature. For example, the gold content of the host rock at Laerma (21.06 to 30.70 ppb) is 10 to 15 times higher than the regional background gold content (1.95 to 2.1 ppb).

Some geologists consider that these black formations are the source-beds for both petroleum and gold deposits (Li, Y.D. and Li, Y.T., 1994; Zeng, Y.F. and Yin, H.S., 1994). Their theories suggest that organic carbon was involved in the process of gold mineralization and was an important factor in the enrichment of gold; however, other geologists think there is no direct relation between gold enrichment and organic carbon (see also Huang, Y., 1993; and Mao, Y.N., and Li, X.Z., 1994).

The Liba and Dongbeizhai gold deposits in the Qinling area are hosted in low-grade metamorphic Devonian and Triassic meta-siltstone, phyllite, and slate. Igneous rocks are more plentiful in the Qinling area relative to the Dian-Qian-Gui area (figs. 15, 18). Six large late Mesozoic granitic intrusions, several small Middle Paleozoic basic rock intrusions, and local andesitic porphyritic-dacite bodies, as well as Cenozoic alkalic to ultramafic volcanic rocks are exposed near the Liba gold deposits. Spessartite, diorite, oligoclase aplite, and granodiorite dikes also are present in the Liba gold deposit (Liu, M., 1994). Some dikes are mineralized by gold. The geochemical signature of the granitic intrusions, Sn, W, Mo,

Figure 41. Photograph of turbidite stratigraphy in the Guangxi Province. Horizontal field of view approximately 15 m.

Bi, is different from intrusions found near most sedimentary rock-hosted gold deposits in Nevada.

In summary, the host rocks of sedimentary rock-hosted gold deposits in P.R. China are carbonate-bearing sedimentary units that are interbedded with siliciclastic and volcanic rocks, similar host rocks in Nevada. In the Dian-Qian-Gui area, impure limestone, silty argillite and siltstone (carbonate-clastic formation) are related to Au-Hg-Tl type gold deposits; Au-Sb-pyrite deposits are present in silty argillite, siltstone interbedded with basaltic lava, breccia, and tuff, (terrigenous or volcanoclastic formations). Turbidites, including siltstone, argillite, graywacke, and carbonate-bearing rocks (micritic and bioclastic limestone) also host Au-As-(Sb) type gold deposits. In the Qinling area, argillaceous limestone, bioclastic limestone, argillite, siltstone, carbonaceous calcareous slate and shale host most of the sedimentary rock-hosted gold deposits. However, some carbon-rich black clastic sedimentary rocks (black shale) host both large and extra-large sedimentary rock-hosted gold deposits and also U deposits. Low-grade metamorphic rocks and some igneous dikes also serve as host rock to some of gold deposits, but a direct connection of gold mineralization to igneous activity is usually lacking in most deposits.

In general, Chinese sedimentary rock-hosted gold deposits are more common near the transitional zone between carbonate and siliceous clastic rocks, particularly on the siliceous clastic rock side (for example, Lannigou deposit). Many of the deposits are hosted in sandstone or calcareous sandstone. The diagnostic characteristics of these host-rocks are: (1) carbonate and siliceous clastic rocks; (2) turbidite layering; (3) interbedded tuff or other volcanic rocks; and (4) organic carbon content in host rocks up to 0.5 wt. percent (Liu, D.S. and others, 1994).

Hydrothermal Alteration

Common hydrothermal alteration types—such as silicification, and argillization—have been observed in most sedimentary rock-hosted gold deposits both in Nevada and in P.R. China (Radtke, 1985; Kuehn and Rose, 1985, 1992; Bakken, 1990a, b; Ferdock and others, 1996). Decalcification (decarbonatization), sericitization, alunitization, baritization, and carbonization vary from one deposit to another. Carbonization, decarbonatization and albitization are specific and common alteration types found only in some Chinese sedimentary rock-hosted gold deposits (Wang, J. and Du, L.T., 1993; Fan, S.C. and Jin, Q.H., 1994; Liu, D.S. and others, 1994).

Silicification is the most important hydrothermal alteration type related to gold mineralization in most sedimentary rock-hosted gold deposits, and also is widespread in other types of gold deposits. Most gold deposits (including Carlin-type, hot-spring, porphyry-related, volcanic-hosted, and low-sulfide gold quartz-veins) are related to silicification and to quartz veining (Li, Z.P., 1989, 1992; Li, Z.P. and Yang, W.S., 1989; Yang, M.Z. and Li, Z.P., 1989). Silicification in Carlin-type deposits may take one of several forms. Commonly, silicification is present as cryptocrystalline, hard replacements and as microcrystalline jasperoid, as well as quartz stockwork veinlets and veins in fractures of altered host rocks. Silicification in Carlin-type gold deposits is more common as replacement silica in host rocks relative to veining.

Silicification has been reported in most sedimentary rock-hosted gold deposits in Nevada, P.R. China and elsewhere (Arehart, 1996; Liu, D.S. and others, 1994). Multiple episodes of silicification are often observed. For example, at least seven different episodes of silicification related to gold mineralization have been recognized in the Gold Quarry Mine, southern Carlin trend (Dean and others, 1990); multiple silcification episodes are recorded by Leonardson and Rahn (1996) in the Betze deposit; two to five of episodes silicification are described in the Pingding deposit (Lin, B,Z. and others, 1994); three episodes of silicification are known in the Lannigou (Luo, X.H., 1994) and the Jinlongshan gold deposits (Hu, J.M. and Zhang, H.S., 1994). In general, silicification in Carlin-type gold deposits can be divided into three stages, with different characteristics and relation to gold mineralization:

(1) Cryptocrystalline silica with chalcedony and microcrystalline jasperoid are formed by replacement of host rock at an early stage. These silicified rocks contain silica-replaced bedding layers and breccias, and may be distributed as cap rock above the deposits. This often constitutes good landmarks for exploration such as at the Gaolong gold deposit (figs. 42, 43, 44, 45).

(2) Stockwork veining is a type of silicification that is commonly formed during the middle stages of ore formation. It is often present on the flanks of orebodies along ore-controlling faults and is closely related to gold deposition.

(3) Late-stage ore formation is accompanied by silicification that consists of quartz-calcite-(stibnite-barite) veinlets, which occur in fractures and cavities in brecciated host rock (see Peters and others, 1997).

This three-stage silicification pattern has been observed in the Gaolong, Lannigou and the Jinlongshan Chinese Carlin-type gold deposits (Luo, X.H.; 1994, Hu, J.M. and Zhang, H.S., 1994) and is similar to silicification stages in the Betze deposit in the Carlin trend (Leonardson and Rahn, 1996).

Decalcification (also referred to as decarbonatization, Arehardt, 1996) is widespread in those Carlin-type deposits in Nevada that are hosted by limestone, for example in the Carlin, Gold Quarry and Betze deposits (Dean and others, 1990; Christensen, 1996; Leonardson and Rahn, 1996). Decalcification is not as common in deposits in P.R. China, because carbonate host rocks are not as common there. However, decalcification has been reported in a few Chinese sedimentary rock-hosted gold deposits such as the Pingding, Jinlongshan, and Gaolong gold deposits where decalcification has a direct spatial relation to gold mineralization. This is also discussed below in the section on geochemistry of ores. Decalcification is a typical alteration type in most sedimentary rock-hosted gold deposits and has a direct spatial relation to gold mineralization in these deposits. This alteration type reflects dissolution and leaching of carbonate components in the host rock, especially limestone and dolomitic limestone, and increases host rock permeability. Silicification and gold mineralization may have occurred simultaneously when ore-forming fluid enriched in silica and gold moved through the porous, decalcified host rock.

Decalcification at the Carlin Mine accounts for a volume loss of 40 percent in the host Roberts Mountain Formation due to dissolution of carbonate minerals (Bakken, 1990a, b). Similarly, only 20.80 to 22.47 wt. percent CaO remains in the siliceous carbonate ore at the Changkeng deposit, which means that more than half of the carbonate in the limestone has been leached by decalcification (Du J.E. and Ma, C.H., 1994). Decalcification typically precedes early stage silicification during hydrothermal alteration and mineralization, whereas carbonization, which forms quartz-calcite veins in the host rock, is part of the late stage of the silicification process. In this way, decalcification, silicification and carbonatization may be thought of as three stages. Carbonate components in the host rock are remobilized, transported and re-precipitated, *in* the hydrothermal process. Carbonate rocks in the Pingding deposit are altered to jasperoid, which is composed of fine-grained gray quartz (or chalcedony) and hosts the orebodies. Similarly, gold orebodies are present in jasperoid along ore-controlling structures in the Jinlongshan and Gaolong gold deposits (fig. 42). Decalcification, silicification and carbonization in these Chinese deposits are thought of by Lin, B.Z. and others (1994), Hu, J.M. and Zhang, H.S. (1994) as three stages in the hydrothermal process of gold ore formation.

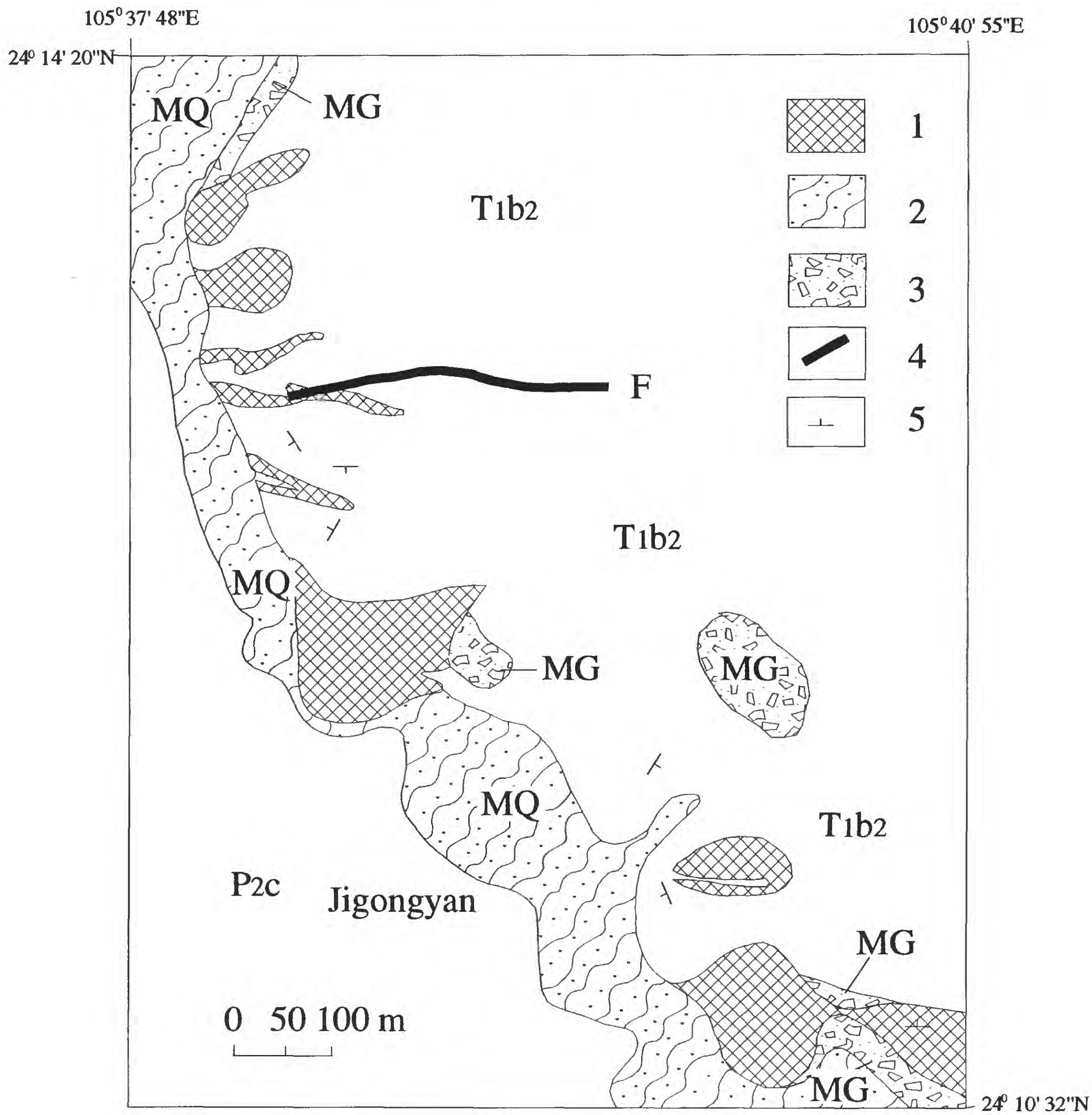

Figure 42. Silicification cap in Gaolong gold deposits area, composed of silicification breccia rock (MG) and quartz veins (MQ) that are closely associated with gold orebodies. 1-orebody; 2-quartz vein; 3 -silicification breccia; 4 -fault; 5-stike-dip. Adapted from the Second Team of Geology, Guangxi Province (Liu, D.S. and others, 1994).

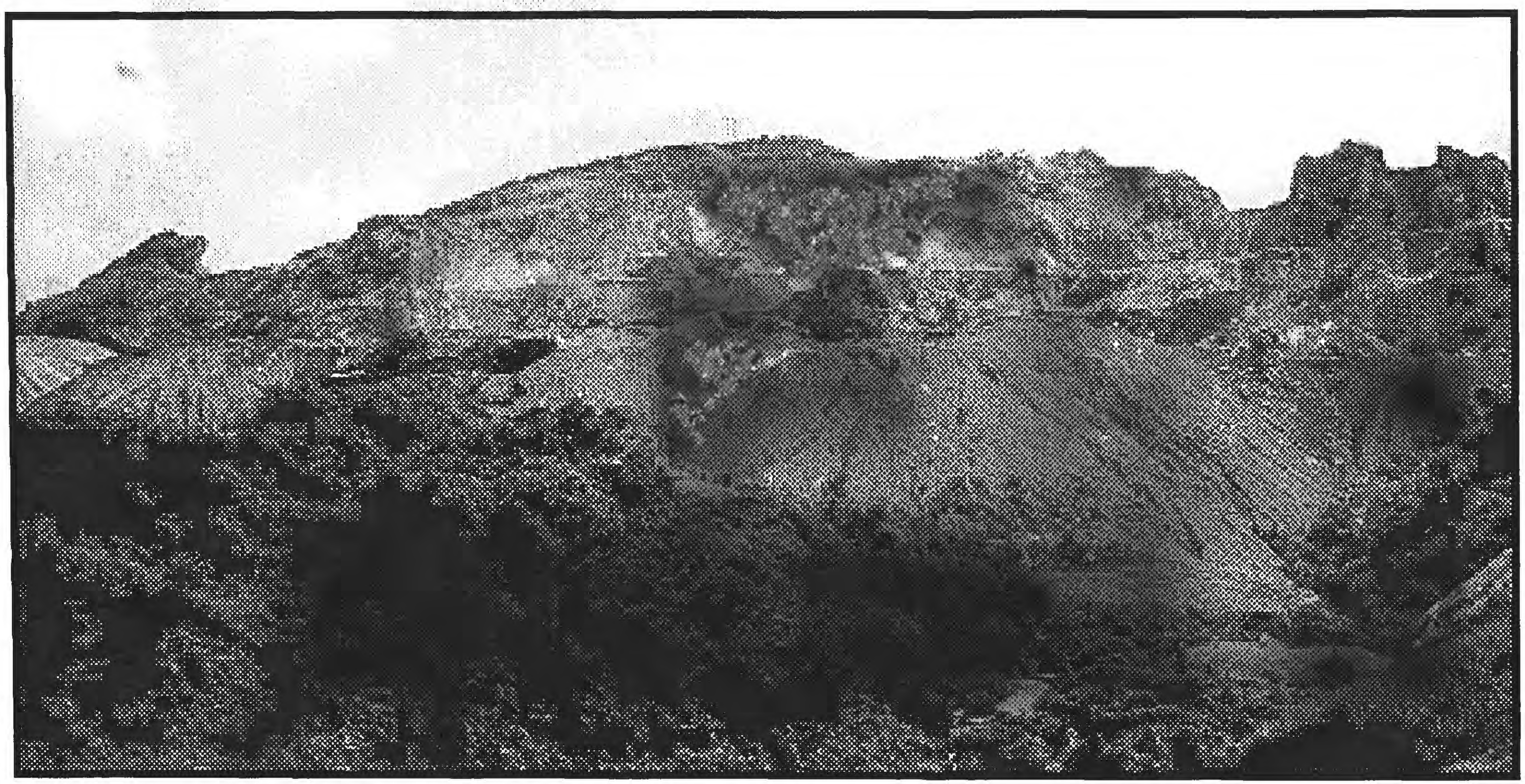

Figure 43. Photograph of overview of the Gaolong gold deposit, Guangxi Province (looking north). Field of view approximately 0.75 km.

Figure 44. Photograph of mineralized jasperiod breccia in the Gaolong gold deposit, Guangxi District.

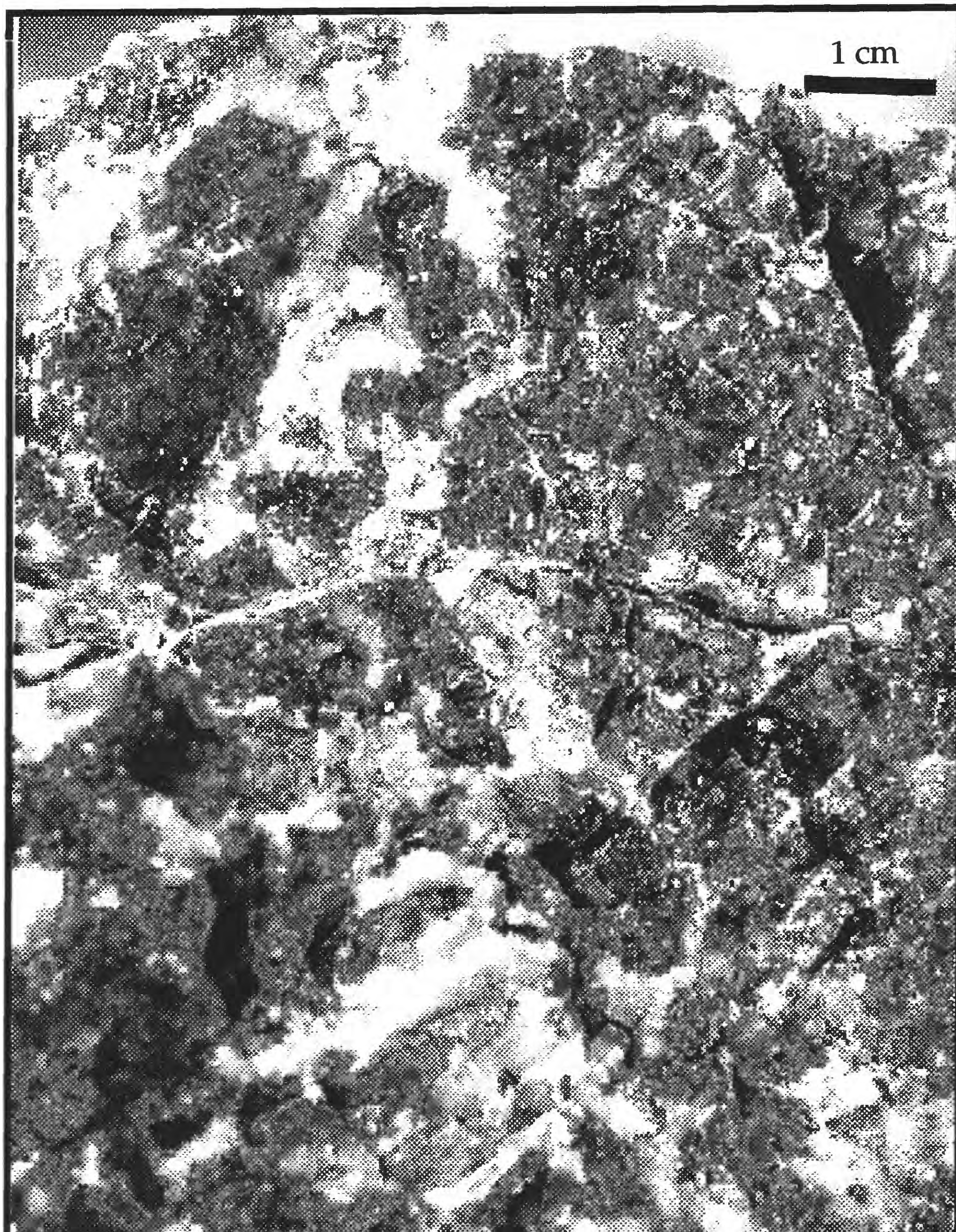

Figure 45. Photograph of mineralized jasperiod breccia in the Gaolong gold deposit, Guangxi District. White areas are hydrothermal quartz; darker areas are silicified bedrock.

Argillization is a general term that includes the processes of sericitization, kaolinitization, illitization and alunitization. This type of alteration is common in sedimentary rock-hosted gold deposits, specifically those hosted by felsic volcanic rock or by clastic sedimentary rocks such as sandstone, siltstone and mudstone (Parry and others, 1997). Illite-kaolinite assemblages also are common in the decalcified limestone in the Betze deposit (Ferdock and others, 1996, 1997). Sericitization is known in deposits proximal to igneous intrusions, but commonly is interpreted to be pre-gold alteration (see Phinisey and others, 1996). Argillization typically is present when host rocks, rich in feldspar and argillaceous components, are altered by epithermal or shallow surface acidic fluids, but formation of clay minerals also has been documented in the deeper zones of Carlin-type deposits (Bakken and Einaudi, 1986; Kuehn and Rose, 1985).

Argillization often converts the host rock to a pale color, and therefore may be a marker for gold deposit exploration. Argillization has been reported as a common alteration type in most sedimentary rock-hosted gold deposits both in Nevada and P.R. China. For example, sericitization is closely associated with gold mineralization in the Liba deposits, where the alteration pattern is observed as zones grading from pyrite-sericitization, sericitization, to chloritization (from inner to the outer zones of ore-bodies). Ore-bodies are present in the sericitization zone, and the grade and thickness of orebodies directly correlate with the intensity of sericitization (Liu, M., 1994).

Carbonization is defined as alteration that enriches the host rock in carbon content and is widely present in most Carlin-type deposits (Ballantyne, 1988; Berger and Bagby, 1991; Arehart, 1996; Zeng, Y.F. and Yin, H.S., 1994). This is a part of the metallogenic process, *in* which organic materials—together with gold—are remobilized, transported and re-precipitated in the hydrothermal, ore-forming system. Graphite and pitchblende usually are the products of carbonization in Chinese deposits. Carbonization alteration has been reported in the Dongbeizhai, Laerma, and Jinyia gold deposits (Liu, D.S. and others, 1994).

Decarbonatization results from oxidation and this process could decrease the carbon content of the host rock, and promote leaching of gold from its source bed. It is considered to be favorable for gold mineralization (Wang, J. and Du, L.T., 1993). Carbon is mobilized and driven outward by hydrothermal fluids, or in the case of the Betze deposit, Nevada, by contact metamorphism (Leonardson and Rahn, 1996).

Albitization has been observed in the Shuangwang, Ertaizi, Baguamiao and other sedimentary rock-hosted gold deposits in Qinling area, but is not common in Dian-Qian-Gui area and in the Nevada deposits. Albite- and rutile-rich layers in Devonian strata in these deposits are considered to be favorable host rocks. Rutile- and other Ti-rich ores also are present in parts of the Betze deposit in the Carlin trend and are thought to be derived from detrital components in the host sedimentary rocks (Peters, and others 1997). In the Shuangwang gold deposit, a light-colored alteration zone consists of early albite, sericite, and late ankerite that extends beyond the gold-bearing breccia bodies, and is a chief prospecting marker for gold deposits in this area. Fan, S.C. and Jin, Q.H. (1994) studied the relation between gold mineralization and alteration in the Shuangwang deposit, and divided the intensity of alteration into strong, medium and weak classes (table 7). Although Au is inversely related to areas of intense albitization in most deposits, albitization is associated directly with gold in two occurrences in the Shuangwang gold deposit; one is as a gangue mineral with the gold ore; another is as matrix in the host breccia of the ore body. Albite is generally considered to be formed at an early stage of hydrothermal activity, perhaps pre-ore (Fan S.C. and Jin, Q.H., 1994).

Table 7. Intensity of Albitization and gold mineralization in the Shuangwang gold deposits. (Modified from Fan, S.C. and Jin, Q.H., 1994)

albitization		**Gold mineralization**	
Intensity	Feature of rock	Gold content	Mineralization type
Strong	Brownish red, hard, albite is as main mineral	0-1 ppm	Au-bearing breccia
Medium	—	>1-3 ppm	Poor gold orebodies
	Gray yellow, medium hardness, carbonate & albite	>3-5 ppm	Rich gold orebodies
weak	Dark gray, soft, sericite & albite	>5 ppm	High grade orebodies

Ore Mineralogy

Hydrothermal mineral species in Chinese sedimentary rock-hosted gold deposits are numerous (Shao, J.L. and others, 1982; Xu, G.F. and others, 1982; Geng, W.H., 1985; Liu, D.S. and Geng, W.H., 1985; Shao, J.L., 1989; Wang, K.R. and Zhou, Y.Q., 1992; Wang, X.C., 1993). At least fifty minerals have been identified from these gold deposits. However, what is the typical ore mineral association of the Carlin-type gold deposit? How numerous are the ore minerals in the ore? And, where is the gold?

Mineral association: In general, the hydrothermal minerals in Chinese sedimentary rock-hosted gold deposits are similar to those present in Nevada. Typical ore minerals associated with Carlin-type gold deposits are pyrite, As-rich pyrite, stibnite, realgar, and orpiment. Gangue and alteration minerals are typically quartz, calcite, barite, clay minerals, and sericite(illite)-clay. A list of minerals and their frequency of occurrence in Chinese sedimentary rock-hosted gold deposits is contained in table 8. Pyrite is present in 96.4 percent of the Chinese deposits, and 73.2 percent of these deposits contain arsenopyrite (and/or As-rich pyrite). Other common ore minerals are stibnite, realgar, orpiment, cinnabar and some base-metal sulfide minerals, such as chalcopyrite, sphalerite, and galena. Sub micron-size gold is identified in 51.7% of the Chinese deposits. Common gangue minerals in Chinese sedimentary rock-hosted gold deposits are quartz, calcite, barite, clay minerals, sericite, and fluorite. The mineral association is different in different subtypes of deposits.

Wang, J. and Du, L.T. (1993) considered Chinese Carlin-type gold deposits as CSA type deposits (carbonaceous-siliceous-argillaceous) and classified them into three types according to host rock, and further into five subtypes differentiated by geochemical elemental and mineral association (table 9). The five mineral associations in these subtypes of Chinese Carlin-type gold deposit are: (1) gold, stibnite, aurostibnite, tungstite, pyrite, and arsenopyrite as Au-Sb-W mineralization in argillite and siltstone; (2) gold, arsenopyrite, and pyrite as Au-As mineralization in argillite and siltstone; (3) gold, stibnite, barite, and pitchblende as Au-U mineralization in cryptocrystalline silica rock; (4) gold, galena, and sphalerite as Au-Pb-Zn mineralization in silica rocks; and (5) gold, cinnabar, realgar, orpiment, chalcopyrite, pyrite, arsenopyrite, flourite as Au-As mineralization hosted by carbonate rock, considered by Wang, J. and Du, L.T. (1993) to be similar to those gold deposits in Nevada. Wang, J. and Du, L.T. (1993) think that the first four subtypes of gold mineralization are different because they are in a different host rock from sedimentary rock-hosted gold deposits in Nevada.

Similar classifications have been described by Wang, Y.G. (1994), who recognized two main subtypes of Chinese sedimentary rock-hosted gold deposits in the Dian-Qian-Gui area. One subtype is the gold deposit at Lannigou, which is hosted in silici-clastic rocks such as siltstone, and fine-grained sandstone that contain pyrite, gold, arsenopyrite, orpiment, and cinnabar with quartz, and clay mineral alteration. Another subtype is typified by the Getang and Zimudang deposits, which are hosted by limestone and interbedded shale, and contain pyrite, marcasite, gold and stibnite, with carbonate and kaolinite alteration. The differences between these two subtype implies that arsenopyrite, orpiment and cinnabar are more related to clastic sedimentary host rocks, whereas gold marcasite, and stibnite are more commonly related to limestone host rocks.

Chinese sedimentary rock-hosted gold deposits contain some unique minerals not commonly found in the Nevada deposits (Liu, D.S. and others, 1994); for example, pyrrhotite is present in the Baguamiao gold deposit as one of the main gold host minerals. Albite is present in the Shuangwang and Ertaizi gold deposits and is closely associated with gold mineralization. Carbon and U minerals,

Table 8. Frequency of Minerals Present in Chinese Carlin-type gold Deposits

Ore minerals[1]			Non-ore minerals[2]		
mineral	**present**	**%**	**Mineral**	**present**	**%**
Native gold	29	51.7	Quartz	41	83.7
Pyrite	54	96.4	Chalcedony	3	5.4
Marcasite	15	26.8	Barite	30	61.2
Arsenopyrite	41	73.2	Calcite	32	65.3
Stibnite	32	57.1	Clay mineral	24	54.7
Realgar	22	39.3	Fluorite	11	22.4
Orpiment	18	32.1	Sericite	15	30.6
Cinnabar	15	26.7	Dolomite	9	18.4
Chalcopyrite	21	37.5	Carbon	8	16.3
Sphalerite	19	33.9	Ankerite	6	12.2
Galena	10	17.8	Rutile	4	8.1
Tennantite	4	7.1	Serpentine	1	2.0
Tungstite	4	7.1	Gypsum	1	2.0
Argentite	3	5.4	Chlorite	1	2.0
Chalcocite	3	5.4	Jarosite	2	4.1
Limonite	13	23.2	alunite	1	2.0
Hematite	3	5.4	Albite	1	2.0
Pyrrhotite	3	5.4	Sulfur	1	2.0
Electrum	2	3.6	Native mercury	1	2.0
Silver	2	3.6	Muscovite	2	4.1
Magnetite	3	5.4			
Molybdenite	3	5.4			
Bornite	5.4	3			
Cerussite	1	1.7			
Siegenite	1	1.7			
Bismite	1	1.7			
Pearceite	1	1.7			
Scheelite	1	1.7			

1- the statistic result of ore mineral is based on 56 deposits; 2- the statistic result of non-ore mineral is based on 49 deposits

Table 9. Mineral Associations in Chinese Carlin-type Gold Deposits (Modified from Wang, J. and Du, L.T., 1993)

Type	subtype	Host rock	Age	Mineralogy	Deposit example
Deposits in argillite and siltstone	Au-Sb-W	Argillite, slate, siltstone	Proterozoic, Sinian	Gold-stibnite-aurostibnite-tungstite-pyrite-arsenopyrite	Woxi, Longshan, Mobing, Gutaishan
	Au-As	Siltstone, carbonaceous argillite, argillaceous limestone, carbonaceous slate	Proterozoic, Triassic, Cambrian, Ordovician,	Gold-arsenopyrite-pyrite-realgar	Banqi, Yata, Dongbeizhai
Deposit in jasperoid	Au-U	Carbonaceous silicalite, carbonaceous slate	Cambrian	Gold-stibnite-barite-pitchblende	Laerma
	Au-Pb-Zn	Siliceous-argillaceous limestone, silicified breccia	Permian	Gold-galena-sphalerite	Kangjiawan
Deposit in carbonate	Au-Hg	Limestone, dolomitic limestone, silty dolomite	Silurian, Devonian	Gold-cinnabar-realgar-orpiment-chalcopyrite-pyrite-arsenopyrite-picrofluite-christite	Ertaizi, Shixia, Jinyia, Langquan

Table 10. Mineral Percent and Au Content of Minerals in Ore of the Banqi Gold Deposit (After Tao, C.G., 1990)

Items	Pyrite (including Marcasite)	Arsenopyrite	carbon	Clay mineral	
Mineral (%)	3.55	0.13	0.05	40.11	
Gold (%)	5.03	0.30	0.99	92.99	
Grade (ppm)	45.89	75	53.60	75	
Items	Quartz	Carbonate minerals	Illuminate(diopside, siderite, barite)	Magnetite	total
Mineral (%)	55.85		0.20	0.11	100
Gold (%)	1.55		0.02	0.02	100
Grade (ppm)	1.76	0.03	2.94	6.50	

Table 11. Mineral Percent and Au Content of Minerals in Ores of the Yata Gold Deposit (After Tao, C.G., 1990)

Items	Pyrite	Stibnite	Clay mineral	carbon
Mineral (%)	4.72	0.05	42.51	0.11
Gold (%)	62.425	0.01	35.01	0.48
Grade (ppm)	83.2	1.32	5.2	27.32
Items	Quartz	Carbonate minerals	Pyrrhotite & Magnetite	total
Mineral (%)	47.96	4.6	0.05	100
Gold (%)	1.82	0.55	0.005	100
Grade (ppm)	0.24	0.75	0.61	

including pitchblende and graphite, are more common in some Chinese sedimentary rock-hosted gold deposits such as the Laerma, Banqi, Yata, Jinyia and Dongbeizhai deposits. In addition, several native elements are present in Chinese sedimentary rock-hosted gold deposits, such as native sulfur (Qinlong deposit), native Cu, Zn, iron, aluminum (Getang deposit), and arsenic (Yata and Jinyia deposits). Native arsenic has also been reported in the north-central Carlin trend (Barrick Goldstrike unpublished data).

In summary, mineral associations of pyrite, arsenopyrite, stibnite, realgar, orpiment, quartz, barite, calcite, and illite-clay minerals are characteristic of most Carlin-type gold deposits in both P.R. China and Nevada. Specific mineral associations depend on rock type, such that in P.R. China, arsenopyrite, realgar and orpiment are more common in silici-clastic rock hosts, whereas stibnite is more prominent in carbonate rocks. In general, the type and combination of ore, gangue and alteration minerals in Chinese sedimentary rock-hosted gold deposits are more complicated than those in Nevada. The reason for this may be due to different classification schemes or may be due to different crustal conditions or metallogenic epochs. The Chinese Carlin-type gold deposits are more widely spaced and distributed, and contain host rocks that represent more diverse geological settings. The presence of pyrrhotite, tungstite, and albite, as well as native metals, chalcopyrite, sphalerite and galena, are prominent features in a few Chinese sedimentary rock-hosted gold deposits.

Content of gold in ore: A characteristic feature of Carlin-type gold deposits is a very low ore mineral content, with typically fine-grained and disseminated ore minerals. For example, the average pyrite content varies from 0.5 to 3 vol. percent in the ores of the Carlin Mine, Nevada (Togashi, 1992). Similarly, about 4 vol. percent of ore minerals are contained in ores of the Banqi gold deposit (table 10), and 4.8 vol. percent ore minerals are present in the Yata gold deposits (table 11) (Tao, C.G., 1990).

State of gold and its host minerals: Gold mainly is present as sub-microscopic particles in Carlin-type gold deposits and is one of the distinct characteristics of these deposits; however, where is the gold? Satisfying answers to the total distribution of gold have not been found in current studies of Carlin-type gold deposits, even through several modern techniques such as Mossbauer spectroscopy have been applied on this research (Xu, G.F. and others, 1982; Wagner and others, 1986; Bakken and others, 1989; Wu, X. and others, 1989; Li, J.L and others, 1993, unpublished; Aerhardt and others, 1993b; Wang, K.R. and Zhou, Y.Q., 1994).

Sub-micron inclusions of native gold in the crystal lattice of pyrite or chemically bound gold in pyrite—particularly in As-rich pyrite rims on earlier pyrite—are considered as the most common probable occurrences of gold in Carlin-type deposits. Most geologists consider that gold is present as native gold, as tiny inclusions in the host minerals. For example, Mossbauer spectroscopy of pyrite in the Ertaizi deposit, P.R. China, indicates that there is no difference between gold-bearing and barren pyrite; and therefore, it is difficult to understand how the gold entered into the crystal lattice of gold-bearing pyrite (Xu, G.F., and others, 1981). According to microscopy and electron microprobe research, gold particles in the Ertaizi deposit are from 0.5- to 20-mm-size with granular or irregular and sheeted shapes, hosted mainly in pyrite and also in oxide minerals. In other research on the Shixia gold deposits, P.R. China, by transmitted electron microscopy, spherical 0.05- to 0.2-mm-size gold particles are attached to the surface of halloysite and hematite (Zhang, Z.R., 1984).

Studies using Mossbauer spectroscopy by Wagner and others (1986) revealed that some invisible gold was present in an undetermined non-metallic chemical state in pyrite and arsenopyrite. Laboratory experiments on gold-bearing arsenopyrite indicated that gold content increased with increasing As and decreasing Fe content in the pyrite grains (Wu, X. and others, 1989). Because gold is present in a metal state, it is possible that Au may substitute for Fe in the lattice of arsenopyrite, such as 2Au ´ Fe. The same result comes from dissolution experiments on arsenopyrite and pyrite (Li, Z.H. and others, 1994). Li, J.L and others (1993, unpublished data) also have suggested that gold in Carlin-type gold deposits may occur in a non-metallic chemical state, and possibly as negatively charged ions in pyrite and arsenopyrite. Research also suggests that the proportions of three forms of gold in the Jinyia deposit, P.R. China, are 90.6 to 96.9 vol. percent of sub-micron-size native gold; 9.4 to 3.1 vol. percent of chemically bound gold in pyrite, and arsenopyrite; and small amounts of gold attracted by the surface of clay minerals (Li, Z.H. and others, 1994). In summary, the most likely occurrence of gold is as sub-micron native gold inclusions in and as chemically bound gold.

Several hydrothermal minerals in sedimentary rock-hosted gold deposits also may be potential host minerals for gold, depending on mineral association, host rock, and metallogenic conditions of the individual deposits (Mao, S.H., 1991), although As-rich pyrite is considered to be the most common gold host. Arsenopyrite, stibnite, cinnabar, realgar, orpiment, barite, quartz, organic carbon, clay, and carbonate minerals may also be gold-bearing in individual Carlin-type gold deposits. The host mineral and proportion of gold in some of the Chinese Carlin-type gold deposits are shown in table 12 and figure 46. It is clear that pyrite, arsenopyrite and clay minerals play an important role for hosting sub-micron gold in the Chinese Carlin-type gold deposits, and to a lessor extent, quartz, stibnite, and barite also are important.

Pyrite, especially As-rich pyrite, is considered to be the most favorable host mineral of Au both in Nevada and Chinese sedimentary rock-hosted gold deposits. At least two main kinds of gold-bearing pyrite are reported in the Carlin, Cortez and Getchell Mines in Nevada. One is fine-grained pyrite (<0.005 mm) with a gold content of up to 4,200 ppm; another is euhedral, coarse-grained, zoned pyrite that contains 700 to 900 ppm Au in its cores and 1,500 ppm Au in its rim. A common feature of these two gold-bearing pyrites is a high As content of about 2.25 wt. percent (7.4 wt. percent As in fine-grained pyrite and 0.29 wt. percent As in coarse-grained pyrite). Barren and As-poor pyrite is present as well in unaltered, unmineralized rocks that contain about 0.05 wt. percent As (Wells and others 1969; Wells and Mullens, 1973). In the Laerma gold deposit, P.R. China, two types of pyrite with the same features as those in Nevada deposits are present in quartz-veinlets and in the host rock as disseminations. Most of these pyrites contain very low As and a corresponding low Au content, suggesting that the ability of pyrite to host sub-micron gold depends on its As content. This positive correlation between As and Au in pyrites often is observed in sedimentary rock-hosted gold deposits (Wells and Mumin, 1973; Bakken and others, 1989; Arehart and others, 1993b; Fleet and Hamid, 1997). Corona textures of pyrites, which are formed by alteration of arsenopyrite, also are common both in Nevada and Chinese Carlin-type gold deposits. It is interesting that these pyrites usually have gold and arsenic enriched margins and depleted cores (table 13).

Quartz is a common non-metallic mineral and also an important gold-bearing host mineral in some of the sedimentary rock-hosted gold deposits. Quartz, as the main host mineral of gold in the Laerma deposit (Zhang, Z.A., 1993), and contains 1 to 28 ppm Au, 13 ppm Hg, and elevated values of As and Sb. Gold-bearing quartz can be distinguished from barren quartz by: (1) high Al_2O_3 contents (>0.20 wt. percent)—generally, the Al_2O_3 concentration of quartz ranges from 0.001 to 0.01 wt. percent; (2) high Hg content; and (3) the high correlation of Au to high thermoluminescence values of quartz, a property of thermal analysis when quartz is heated.

Stibnite is reported as a host for gold in some Chinese sedimentary-rock hosted gold deposits (Zhang, Z.A., 1993; Liu D.S. and Geng, W.H., 1987). The highest gold content of stibnite in the Laerma deposit is 233.40 ppm Au, and this stibnite also contains 135 ppm Hg.

Table 12

Gold Content of Host Minerals in Chinese Carlin-type Gold Deposits.

(Compiled from Liu, D.S., 1994)

Mineral	Changkeng		Yata	Getang	Jinyia	Banqi
Pyrite	14.05	8	62.13	52.61	12.42	5.03
Arsenopyrite	4.34	-	-	-	76.92	0.3
quartz	17.00	38	1.82	5.6	3.65	1.55
clay minerals	56.80	31	35.01	38.6	4.93	92.99
carbonate minerals	-	-	0.55	-	1.83	-
carbon	-	-	0.48	4.65	0.23	0.99
others	7.81	19	0.015	-	-	0.04

- No data available

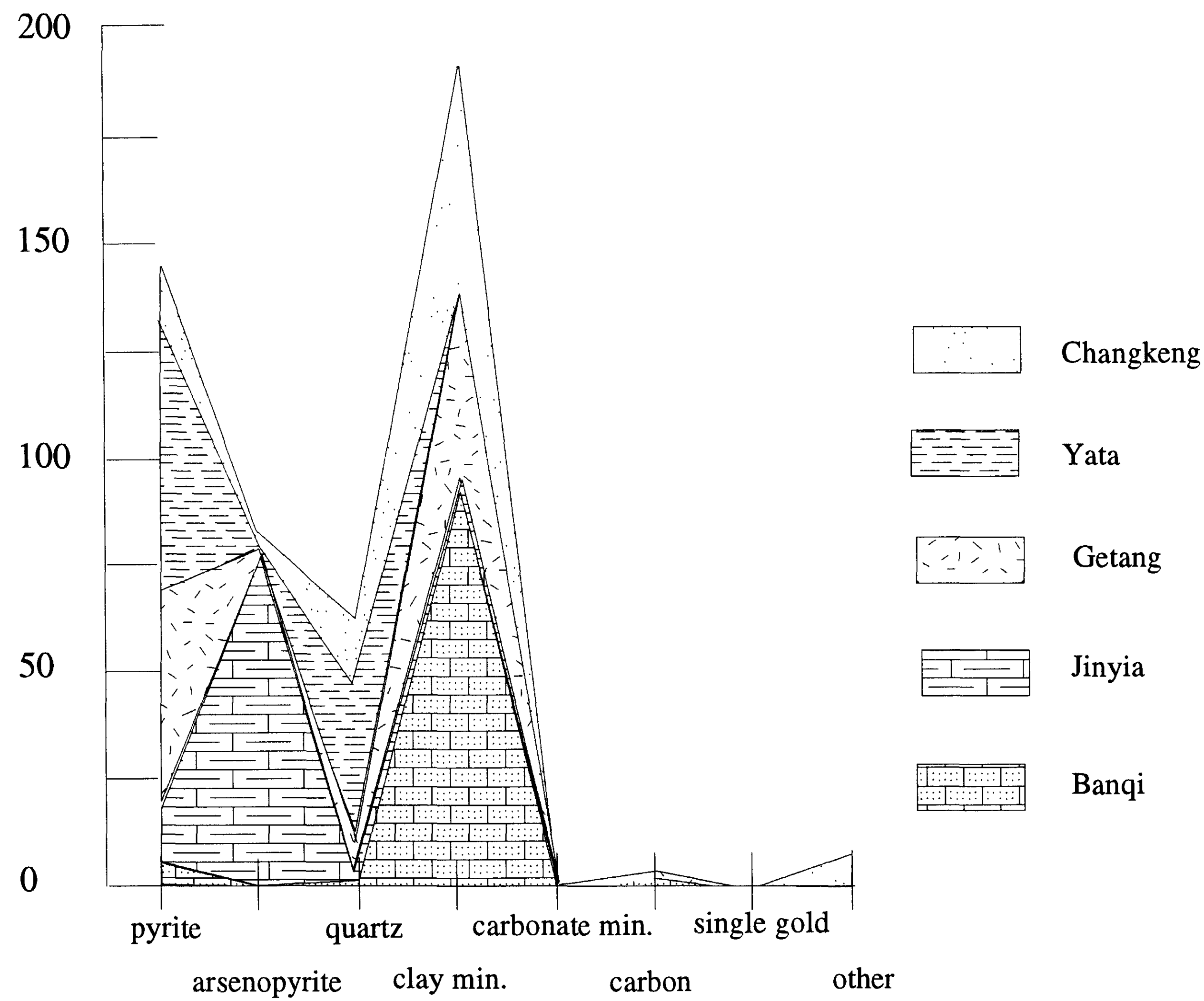

Figure 46. Percentage of gold in host minerals of Chinese Carlin-type gold deposits, showing pyrite and clay minerals are the most important host minerals for gold in some Chinese Carlin-type gold deposits.

Table 13. Analysis by Electron Probe of Corona Pyrite in Gedang Gold Deposit, P.R. China (in wt. percent) (After Tianjin Geological Academy, 1992)

Sample	location	Fe	S	Au	Cu	Ni	Co	As	Zn	Sb
LL32-G	core	45.47	52.75	0	0.04	0	0.03	0	0	0
	margin	45.33	52.20	0.09	0	0.01	0.02	0.51	0.2	0
	core	45.59	53.83	0	0	0	0.01	0	0.04	0.01
LL32-G	middle	44.06	52.99	0.01	0.04	0	0.01	1.81	0.03	0
	margin	46.02	50.48	0.06	0.01	0.06	0.03	3.75	0	0.02
	core	46.82	52.96	0	0.04	0	0.02	0	0	0
LL32-G	middle	44.50	52.80	0.01	0.03	0.01	0.03	1.33	0	0
	margin	45.92	51.14	0.07	0.04	0	0.02	2.56	0.01	0
	core	45.96	53.18	0	0.037	0	0.020	0	0	0.003
Total	middle	44.28	52.90	0.010	0.035	0.005	0.020	1.570	0.015	0
	margin	45.76	51.27	0.073	0.017	0.023	0.023	2.273	0.010	0.007

Lower gold values also are found in stibnite of the Miaolong deposit 2.87 ppm, and in the Banqi deposit stibnite contains up to 10 ppm Au. A new sedimentary rock-hosted gold deposits, *in* which stibnite is present as the main gold host mineral, also are present in Huabei Province, P.R. China (Liu, D.S. and Geng, W.H., 1987).

Barite is widespread in most Carlin-type gold deposits, and sometimes can serve as a host mineral for sub-micron gold. For example, barite in the Laerma deposit, P.R. China, contains between 1 to 98.56 ppm Au, and also has elevated values of Ag, Sb, Se, and Hg (Zhang, Z.A., 1993).

Clay minerals also are important gold host minerals in the Banqi, Yata, Getang, Shixia, and Changkeng Chinese sedimentary rock-hosted gold deposits. X-ray diffraction analysis indicates that clay minerals contain very fine-grained metallic minerals, such as pyrite and arsenopyrite. A dissolution experiment (Geological Institute, Chinese Academy of Science, 1992) showed that 90 wt. percent of gold in clay minerals is enclosed in fine-grained pyrite (arsenopyrite), whereas, only 5 to 10 wt. percent of the gold is on the surface of clay minerals (Liu, D.S. and others, 1994).

In general, As-rich pyrite and arsenopyrite are the most important host mineral for gold in sedimentary rock-hosted gold deposits. Clay minerals serve either as host for gold-enriched fine-grained pyrite and arsenopyrite or host sub micron-size gold adsorbed on its surfaces. Stibnite, quartz, and barite also are host minerals for gold in individual deposits. Other minerals such as cinnabar, realgar, orpiment, and tetrahedrite, generally have low gold contents in most sedimentary rock-hosted gold deposits.

GEOCHEMISTRY OF THE SEDIMENTARY ROCK-HOSTED GOLD DEPOSITS

Basic geochemical characteristics of sedimentary rock-hosted gold deposits, such as composition of host rock, and of ore, trace elemental assemblages, and fluid inclusion and isotope studies will be discussed in this section. The composition of the host rock and ore reflects the geological and geochemical environments of formation (see Dean and others, 1988). Certain elemental assemblages are characteristic of gold-bearing hydrothermal solutions. Fluid inclusion and isotope data give important parameters about the fluids that formed the deposits.

Composition of Host Rock and Ore

The host rock lithology of Chinese sedimentary rock-hosted gold deposits vary from one deposit to another, and their geochemical compositions also vary. Tan, Y.J. (1994) summarized the geochemical characteristics of host rock in the Dian-Qian-Gui area, partially mudstone, siltstone and argillaceous limestone (tables 14, 15 and 16, and figs. 47, 48 and 49). Generally, host rocks in the deposits are shelf facies sedimentary rocks in the northwest part of the area, with lower SiO_2, higher TiO_2 compositions, and Fe_2O_3+FeO, MgO/CaO ratios than those in abyssal facies in the southeast part.

The most simplified description for the characteristics of ore in Carlin-type gold deposit is "look like rock" or in Chinese "Xiang shi tou", because orebodies of this type of deposit were formed by replacement of the host rock by hydrothermal fluids and therefore there is no clear boundary between the orebody and the unmineralized host rock. Gold assays commonly are the only means to distinguish between rock and ore; therefore, a very important geochemical feature to identify mineralized area is the inheritance of minerals and geochemical components from the unmineralized host-rocks, because in most cases, the ores have similar petrologic oxides as the original protolith. Another common geochemical feature of ore in sedimentary rock-hosted gold deposits, both in Nevada and P.R.

Table 14. Analysis of argillaceous limestone (host-rock) in the Carlin-type gold deposits, Dian-Qian-Gui area, P.R. China (in wt. percent) (After Tan, Y.J., 1994)

SiO_2	TiO_2	Al_2O_3	T Fe	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	Au*
30.43	0.16	3.07	2.24	0.10	1.39	15.01	0.02	0.68	0.28	2.13
30.58	0.57	10.11	7.39	0.12	5.37	32.18	0.08	1.78		2.44

* Au ppm

Table 15. Chemical Composition of Argillite (host-rock) in Carlin-type Gold Deposits, Dian-Qian-Gui area, P. R. China (in wt. percent) (From Tan, Y.J., 1994)

Oxide	Gedang	Maxong	Getang	Dachang	Zimudang	Yata	Gaolong	Banqi	Jinyia
SiO_2	59.08	43.2	48.87	57.52	43.13	62.74	62.62	52.5	58.12
TiO_2	0.95	0.78	2.46	4.13	2.34	0.68	0.56	-	0.59
Al_2O_3	15.67	21.28	16.76	16.38	15.14	16.58	17.86	16.52	15.23
T Fe	7.37	9.46	12.63	8.72	12.94	5.57	4.86	5.68	6.5
MnO	0.12	0.09	0.06	-	0.11	0.05	0.02	-	0.1
CaO	0.06	2.84	0.47	0.42	1.89	2.89	0.61	5.05	3.72
MgO	2.08	3.28	0.21	0.56	2.76	1.33	0.53	1.78	1.92
Na_2O	0.22	0.09	0.76	0.05	0.1	0.26	0.38	0.78	0.46
K_2O	4.6	6.7	1.45	4.55	3.28	3.55	3.89	4.24	2.56
P_2O_5	0.14	0.16	0.18	0.35	0.23	0.21	0.08	-	0.46
LOI	2.68	10.9	15.7	6.59	13.45	6.64	7.49	11.83	8.89
Au*	0.02	0.93	0.077	-	3.29	7.155	2.369	6.8	5.85

* Au ppm, - no data available

Table 16. Chemical Composition of Siltstone (host rock) in Carlin-type Gold Deposits, Dian-Qian-Gui Area, China (in wt. percent) (From Tan, Y.J., 1994)

Oxide	Gedang	Maxong	Zheyi	Longchang	Getang	Zimodang	Banqi	Yata	Lannigou	Jinyia
SiO_2	67.11	67.45	69.44	67.95	66.03	53.20	73.47	65.94	68.80	59.63
TiO_2	0.78	0.33	1.64	3.12	1.87	1.09	0.54	0.46	0.24	0.46
Al_2O_3	12.07	8.72	12.51	8.54	6.87	6.79	10.89	10.90	6.40	11.12
Fe_2O_3	8.87	7.84	6.51	9.42	15.24	5.17	6.15	5.40	2.46	4.28
FeO	0.73	0.43	1.13	0.65	0.92	1.15	0.97	1.45	5.24	2.66
MnO	0.04	0.35	0.11	0.041	0.044	0.10	0.05	0.14	0.195	0.11
CaO	0.27	1.92	0.13	0.17	0.23	14.54	0.44	2.08	2.78	6.0
MgO	0.74	1.52	0.68	0.21	0.19	0.86	0.32	1.25	1.46	1.70
Na_2O	0.14	0.052	0.10	0.058	0.32	0.012	0.05	0.19	0.38	0.75
K_2O	3.57	2.74	3.30	0.94	0.40	1.66	1.39	2.26	1.70	1.42
P_2O_5	0.31	0.28	0.10	0.274	0.134	0.38	1.03	0.090	0.15	0.43
LOI	-	8.74	3.93	6.70	6.78	14.13	4.40	8.50	9.01	3.025
Au*	4.71	1.68	0.021	1.080	1.94	5.18	4.42	3.486	7.47	0.174

* ppm

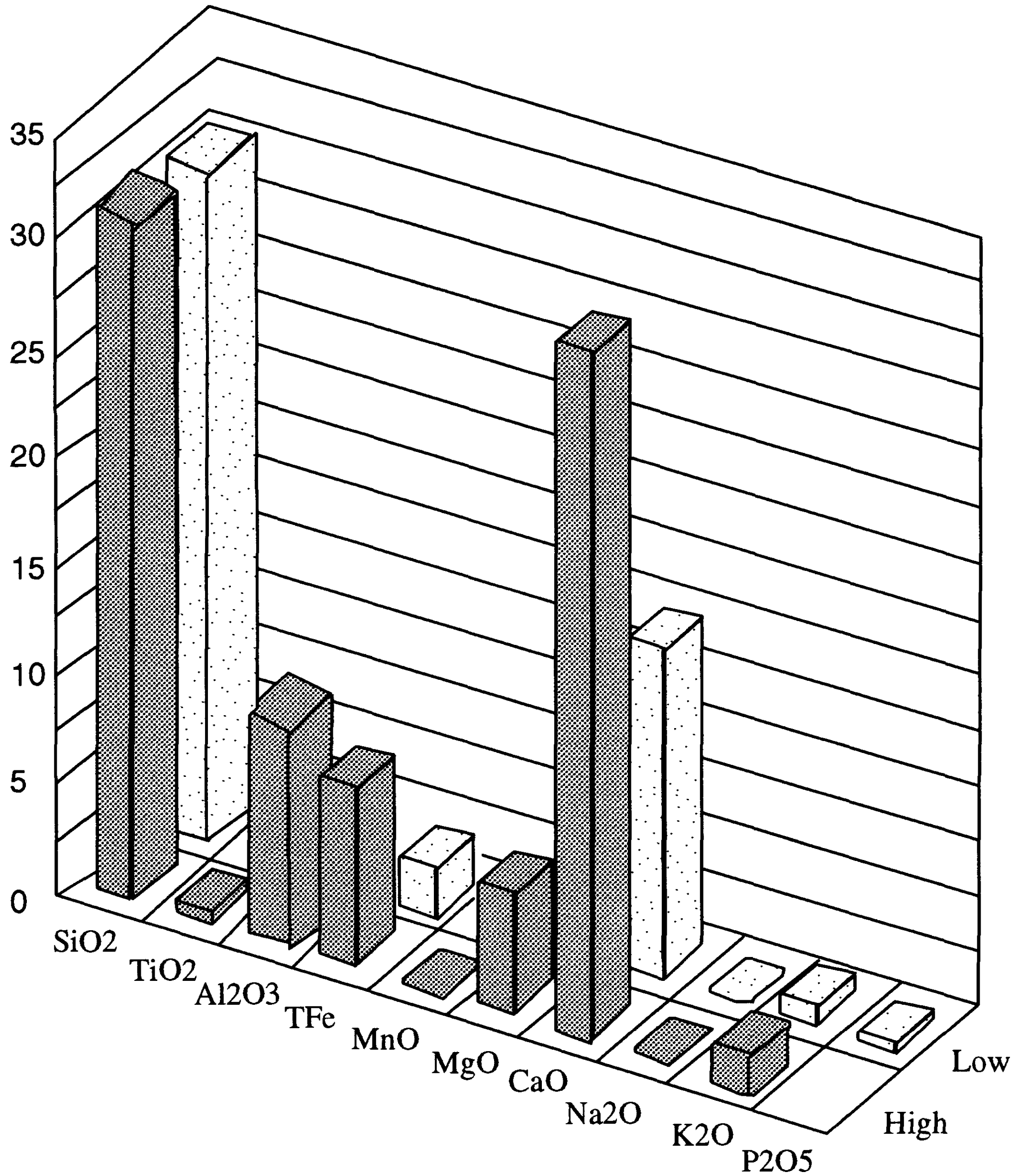

Figure 47. Analysis of argillaceous limestone in host rock of Chinese gold deposits, which are present in Dian-Qian-Gui area, Low and High means the arrangement of oxides contents.

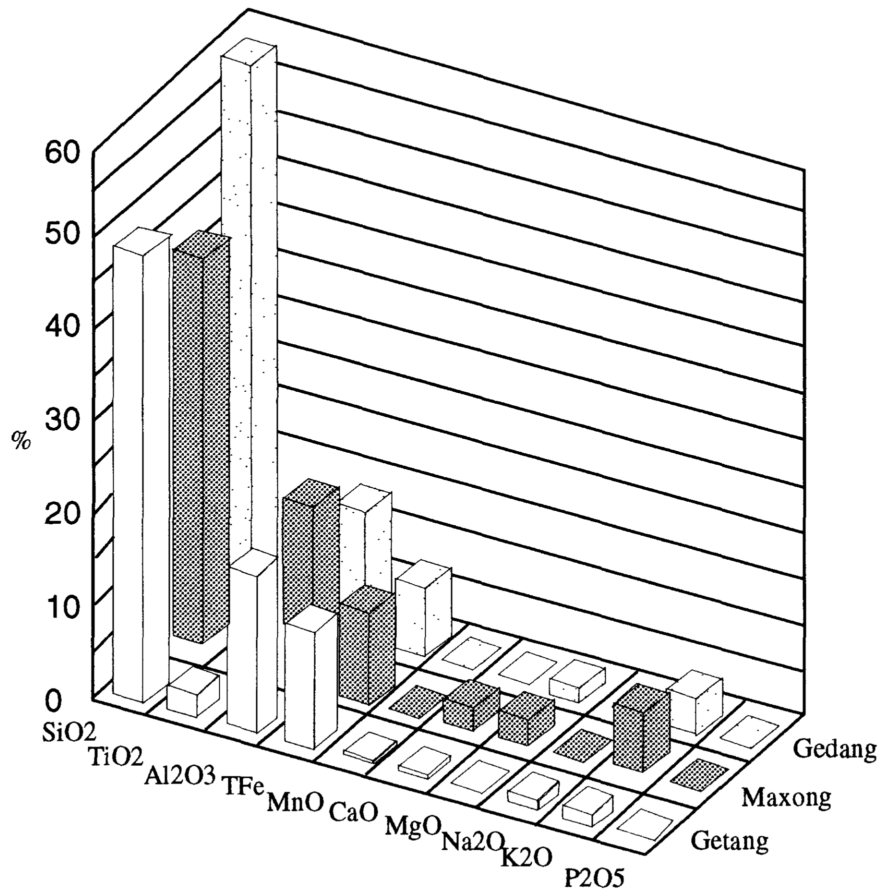

Figure 48. Analysis of argillite in host rock of Chinese gold deposits, which are presented in Dian-Qian-Gui area, showing oxide content of argillite in the Gedang, Maxong and Getang gold deposits.

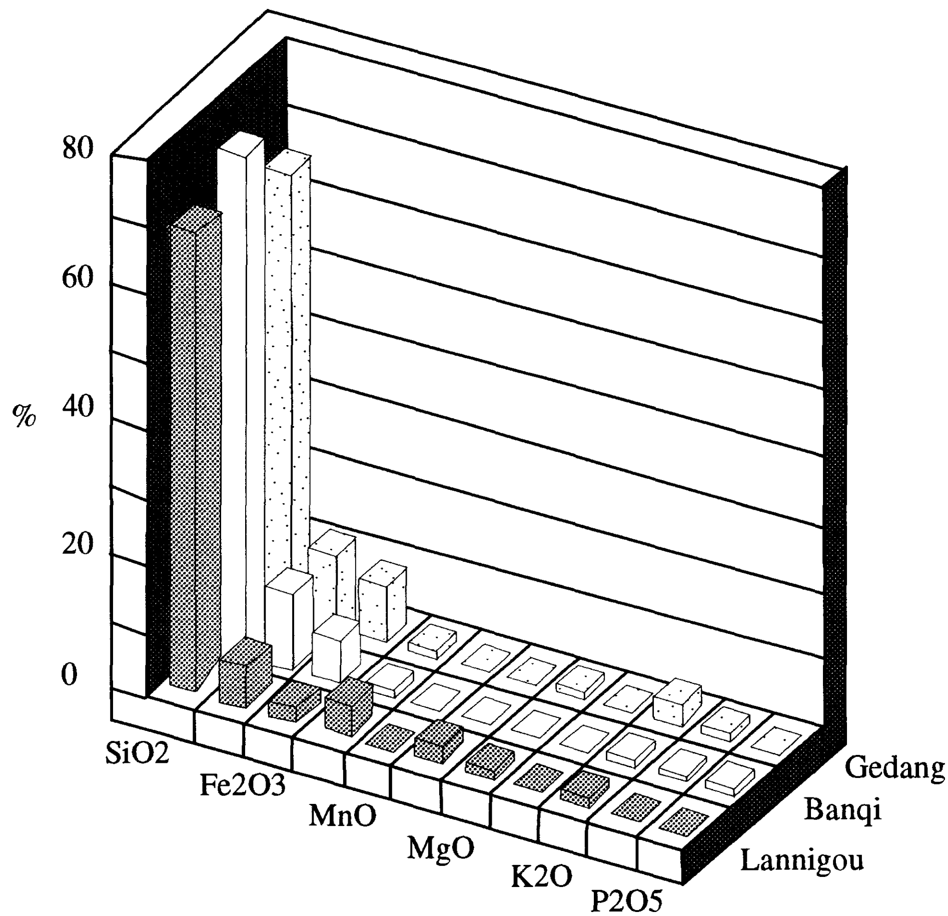

Figure 49. Analysis of siltstone in host rock of Chinese gold deposits, which are presented in Dian-Qian-Gui, showing oxide content of siltstone on figure in the Gedang, Banqi and Lannigou gold deposits.

China, is the introduction of large amounts of SiO_2 from ore-forming fluids that accompany gold mineralization. In addition, CaO and MgO in the host rocks are dissolved and removed by hydrothermal fluids. At the Carlin mine, about 40 vol. percent loss may have occurred in the Roberts Mountain Formation due to dissolution of carbonate (Bakken, 1990a, b). Vol. percent of CO_3 drops from 30 percent to less than 1 percent (Leonardson and Rahn, 1996). Some of the high SiO_2 contents may be due to residual quartz rather than new SiO_2 introduction (Madeisky, 1996). Similarly, the siliceous carbonate ore in the Changkeng deposit only contains between 20.80 and 22.47 wt. percent CaO, and more than half of the carbonate minerals in the altered limestone have been leached out during decalcification (Du, J.E. and Ma, C.K., 1994).

Similar geochemical classification of ore types is used both in Nevada and in P.R. China (see Radtke, 1985; Tan, Y.J., 1994). The common ore types are siliceous, pyritic, arsenic, and oxidized ore. Normal ores are composed of dolomite, illite, quartz, and carbonaceous materials (with organic carbon content ranging from 1 to 6 wt. percent) as documented in the Carlin mine, Nevada by Radtke (1985) and in the Betze deposit, Nevada, by Peters (1996). These ores also are present in the Chinese deposits, and in addition, argillaceous and carbonate ore also are recognized in the Dian-Qian-Gui area, P.R. China. The geochemical chemical compositions of five types of ore from Carlin-type deposits in Dian-Qian-Gui area are shown in table 17. And also, 18 ores (rocks) sample assays, which were taken from five Chinese sedimentary rock-hosted gold deposits by the authors in August of 1997, are shown in table 18.

Elemental Assemblages in Ore

Sedimentary rock-hosted gold deposits have characteristic elemental assemblages that reflect the mineral association found in the ores. These element assemblages vary from one deposit to another, but usually contain several common elements. For instance, there is a general association of certain trace elements in most Carlin-type gold deposits. As shown in table 18, Au, Ag, As, Sb, Hg in the ores (rocks) of the Chinese deposits are much higher than their average value in the regional rocks and the Clark value of the crust; while Cu, Pb, Zn and other base-metals are lower in the deposits than their Clark value in regional and the crust. A typical geochemical characteristic of sedimentary rock-hosted gold deposits is a low Au : Ag ratio. A ratio of between 9.2 to 66.9 in the Lannigou deposit may reflect common local variations in the amount of Ag there and is not uncommon in these deposits. The following paragraphs discuss several typical geochemical characteristics of these deposits.

High Au : Ag. ratios are an important geochemical feature of Carlin-type gold deposits (table 19). Ag and base-metals such as Cu, Pb, and Zn are rare; however, exceptions have been observed both in Nevada and P.R. China (Rota and Ekburg, 1988; Du, J.E. and Ma, C.K., 1994). The distal-disseminated class of Ag-Au deposits, discussed earlier as related to porphyry systems, have higher amounts of Ag and base-metals. The average Ag content is usually less than 1 ppm in most Carlin-type gold deposits of Nevada, but the Gold Quarry deposit has ore that contains Ag values up to 80 ppm (Rota and Ekburg, 1988). High Ag values and Ag minerals also are noted in late-stage isolated polymetallic breccia bodies in the Betze orebody, Nevada (Peters and others, 1997; Ferdock and others, 1997). In the Changkeng gold deposit, P.R. China, there are two gold orebodies and three silver orebodies that occur separately along the same brecciated NE-trending fault zone (Du, J.E. and Ma, C.K. 1994). These orebodies do not overlap or enclose each other. In vertical section, the gold orebodies are located at the top and the silver orebodies are present at the bottom of a fault zone. The gold orebodies in the Changkeng deposit contain high As, Sb, Bi, Hg, Ba, and S contents; in particular, the values of As, Bi, and Hg are one to two times higher than in those in the silver orebodies. The silver orebodies contain one to two times more Zn, Pb, and Cu relative to gold orebodies. The Au : Ag. ratio is

1/0.8 in gold orebodies, and 1/644 in silver orebodies.

As is the most common trace element associated with gold mineralization in most sedimentary rock-hosted gold deposits. It is usually present in pyrite as isomorphism, as growth rims, and also occurs in independent minerals such as arsenopyrite, realgar, orpiment, or as native As. The content of As in the Carlin Mine ores ranges from 400 to 500 ppm, with a maximum value of 2.5 wt. percent (Togashi, 1992). In some Chinese sedimentary rock-hosted gold deposits, As has been enriched up to an economic level, such as at the Jinyia deposit (As: 0.44 to 1.89 wt. percent), and the Pingding deposit (As: 3.99 to 15 wt. percent) (Liu, D.S. and others, 1994).

Sb is a principle associated trace element in most Carlin-type gold deposits, both in Nevada and P.R. China. Sb is concentrated both in unoxidized and oxidized ores at levels of 100 ppm in the Carlin mine (Radtke, 1985; Kuehn, 1989). A distinct zoning of minerals and geochemistry (fig. 50) was observed in the Betze orebodies of Goldstrike Mine, Nevada (Peters, 1997c), where Sb is present in siliceous breccia as stibnite in fracture coatings and vug fillings with late quartz veinlets along with calcite, sphalerite, and barite. This siliceous stibnite-bearing breccia ore is located at the core of the orebody and is one of the late stage events. In P.R. China, Sb prospects have played an important role in the history of exploration of Carlin-type gold deposits. For example, the Banqi gold deposit was found in 1978 by investigation of an Sb prospect. Afterward, a group of gold prospects associated with Sb, As, and Hg were discovered surrounding the Banqi deposit. Then, the Getang, Zimudang, Xongwu, and Ceyang sedimentary rock-hosted gold deposits also were found in the Dian-Qian-Gui area (appendix I) (Mai, C.R., 1989).

Hg also has a positive correlation with Au and in most Carlin-type gold deposits. Unoxidized ores in the Carlin Mine contain an average of 20 ppm Hg, with Hg values up to 280 ppm in As-rich ores (Togashi, 1992). Ore minerals containing Hg, Zn, Cu, Ag, and other base-metals have been identified as late-stage components of the Betze orebody, Nevada (Ferdock and others, 1997; Peters and others, 1997). Similarly, most Hg-rich Chinese Carlin-type gold deposits are present in or near zones of economic Hg mineralization (Liu, D.S. and Geng, W.H., 1987). For example, the Sando-Danzhai Hg mineralized zone (Huang, G.S. and Du, Y.Y., 1993), located in the southern Guizhou Province, is 50 km long, elongated NS, and 7 km wide in an EW direction, and occurs in Cambrian silty and argillaceous limestone. There are 3 large, 1 medium and 11 small Hg deposits in this zone. Recently, this Hg zone was confirmed to be a Carlin-type gold mineralization zone, in which 1 medium and 6 small Chinese sedimentary rock-hosted gold deposits (prospects) were discovered since 1978. Some of them, such as the Sixiangchang and Miaolong deposits (appendix I), were old Hg mines. Another typical example, the Sixiangchang deposit—a new Carlin-type gold deposit composed of 13 gold orebodies (not all shown on fig. 51) with 7.19 ppm average Au was discovered in the Sixiangchang (fig. 51)—was a large old Hg deposit, and has been developed by mining to a depth of 500 m (Huang, G.S. and Du, Y.Y., 1993. Another Au (As)-Hg-(Sb) mineralized zone (Li, Y.D. and Li, Y.T., 1994), which extends from Nima (Maqu County, Gansu Province) to Manaoke (Nanping County, Sichuan Province) in the Qinling area, occurs in Permian and Triassic carbonate and clastic rocks. The host rocks are silty slate, interbedded dolomitic limestone, and diorite dikes. Some Hg-bearing sedimentary rock-hosted gold deposits occur in this zone, such as Manaoke (Nanping county), Shijiba (Wenxian county), and Geerzhongqu (Maqu county). Gold prospects associated with Hg also are found at Baxi, Tuanjie, Qilicun and Jiawuchi (Sichuan province), as well as the Nima Hg (As) prospect. The Laerma to Pingding sedimentary rock-hosted gold trend in the Qinling area overlaps an extensive Hg-Sb-U province, and Hg is enriched up to economic levels (0.01 wt. percent) in the Laerma gold deposit (table 20).

Tl is a common trace element in many Carlin-type gold deposits in Nevada; at the

Table 17. Chemical Composition of Five Types of Ore in Carlin-type Gold Deposits, Dian-Qian-Gui area, P.R. China (From Tan, Y.J., 1994)

Oxide (%)	**siliceous**	**clay**	**pyrite**	**arsenic**	**carbonate**
SiO_2	83.49	57.92	63.5	61.95	33.28
TiO_2	0.35	1.1157.92	0.84	0.59	0.32
Al_2O_3	5.77	14.38	9.67	13.3	8.45
T Fe	3.62	6.97	14.17	7.14	6.76
MnO	0.07	0.07	0.06	0.09	0.11
MgO	0.47	1.81	0.74	1.19	3.28
CaO	0.75	1.59	0.98	3.23	18.11
Na_2O	0.13	0.36	0.22	0.21	0.05
K_2O	1.39	3.9	1.83	2.94	1.77
P_2O_5	0.47	0.39	0.22	0.37	0.28
H_2O	1.65	3.63	-	-	1.32
S	1.42	2.04	-	-	-
Au (ppm)	8.84	8.81	6.86	6.1	2.29
As (ppm)	1525.2	1415.4	1262	4914.9	-
Sb (ppm)	-	31.9	-	-	-
Hg (ppm)	-	4.8	-	-	-
LOI (%)	-	-	-	-	26.16

- No data available

Table 18. Assay of ore and rocks in Chinese sedimentary rock-hosted gold deposits (in ppm)

DEPOSIT	LAB	USML	USML	USML	USML	USML	USML	USML	USML	USML	ACME	USML	USML	USML
	Sample No.	**Au**	**Ag**	**As**	**Sb**	**Hg**	**Cu**	**Pb**	**Zn**	**Mo**	**Ba**	**Se**	**Te**	**Tl**
Qinglong	SP97901	0	0.042	95.9	101	0.023	1.4	7.28	10.4	0.332	10	0.169	0.259	0.596
	SP97902	0.0004	0.116	145	156	0.014	2	10.7	12.1	0.973	9	0.257	0.268	0.402
	SP97903	0.0002	0.07	248	2.46	2.83	31.1	2.48	40.2	0.355	19	0.107	0.223	0.424
Zimudang	SP97904	0	0.066	281	3.83	4.82	14.5	2.2	42.3	0.541	36	0.017	0.249	0.577
	SP97905	1.16	0.082	170	4.76	0.693	5.89	0.861	7.21	2.43	10	0.04	0.204	0.612
	SP97906	2.49	0.272	2883	29.8	48.4	15.1	17	56.1	4.38	147	0.59	0.318	0.933
Lannigou	SP97907	3.92	0.253	2224	7.32	8.63	26.2	10.2	39.5	4.52	117	0.609	0.333	0.954
	SP97908	30.5	0.456	5819	23.3	19.4	48.5	11.1	94.6	4.47	146	1.73	0.53	1.31
	SP97909	16.9	0.267	4749	9.3	18	53.5	6.98	45.9	5.52	104	2	0.586	0.812
	SP97910	0.001	0.1	1898	11.7	0.43	28.1	8.78	30.4	2.37	391	0.897	0.173	1.23
	SP97911	0.052	0.49	85.1	80.3	1.01	16.2	2.33	47.6	8.94	91	0.25	0.253	2.72
Gaolong	SP97912	0.064	0.228	37.3	32.8	1.31	5.51	1.51	15.3	6.86	99	0.193	0.22	0.758
	SP97913	0	0.091	340	14.7	0.271	21.1	7.5	79.9	1.95	321	0.178	0.312	0.673
	SP97914	0.0004	0.137	408	28.6	0.285	22.6	7.97	89.6	1.32	343	0.266	0.213	0.909
	SP97915	1.92	5.14	1259	9634	15.5	17.3	928	6.75	4.55	379	57.4	0	17
Hengxian	SP97916	4.8	44.6	468	9690	28.1	136	14.2	9.15	12.1	1144	39.5	0.419	5.52
	SP97917	0.308	21.2	79.7	9823	13.5	13.4	43.4	1.06	1.45	4	54.9	22.6	27.7
	SP97918	0.718	6.73	70.1	9690	8.91	59.3	45.8	0.739	1.74	5	63.2	20	26.5
Ave. value in Rocks[1]		0.0025	0.11*	12*	-	0.15	112	32*	117	0.75	-	-	-	-
Clarke value of the Crust[2]		0.0043	0.070	1.7	0.50	0.083	47.0	32.0	83.0	-	650	-	-	-

1-The average value of elements in rocks in the southwest or whole of the Guizhou province (*) according to He, L.X. and others (1993).

2-Clarke value of elements in the Crust according to Vinogradov (1962).

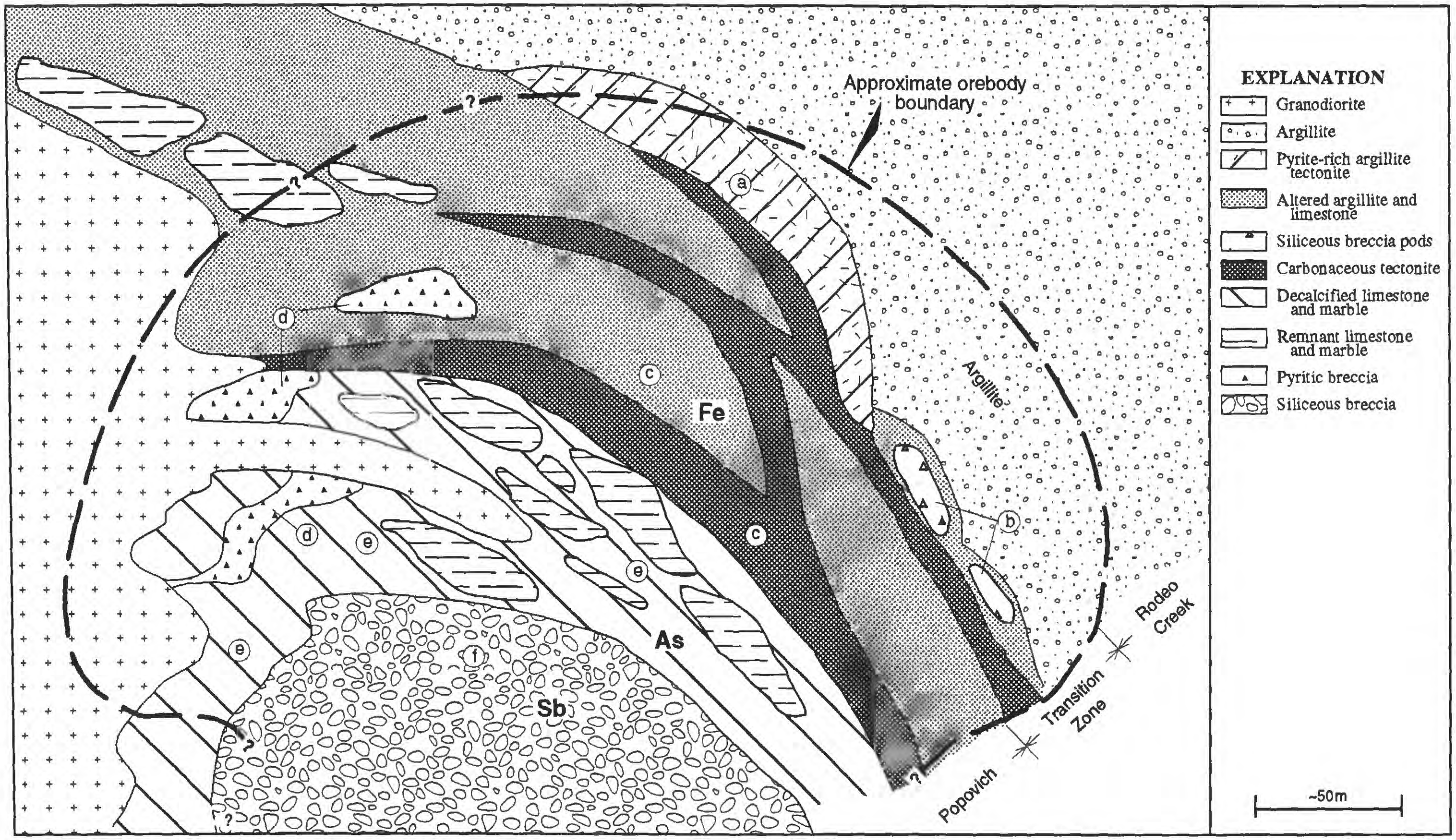

Figure 50. Idealized sketch of a cross section through the central Betze orebody, looking WNW. General zoning in the orebody is Illite-clay pyrite, Fe-rich ores on the top, realgar- and orpiment-rich As-rich ores in the central parts, and Sb- and Ba-rich siliceous ores at the bottom. The oreshoots are characterized by higher metal content than the adjacent parts of the host conduit. The mass of most oreshoots ranges between 2 x 104 and 1 x 106 tonnes and grades are generally 0.1 oz/t Au. There is a tendency for oreshoots to have a heterogeneous grade distribution, such that they are thicker and richer in the center or in a lobe along one side. Oreshoots in the Betze orebody may terminate abruptly, usually at geologic features, or may taper in thickness or grade to assay cut-offs. A characteristic feature of many oreshoots is their unique internal geologic complexity and mineralogy that reflect episodes of formation. Six distinct ore types are recognized by Peters (1996, 1997c) and by Leonardson and Rahn (1996) designated by letter as: (a) cataclastic and sulfidic breccia ore; (b) siliceous, sulfidic breccia pods in argillite; (c) disseminated, carbonaceous ore; (d) sulfidic breccia pods; (e) seam ore; and (f) siliceous stibnite-bearing breccia.

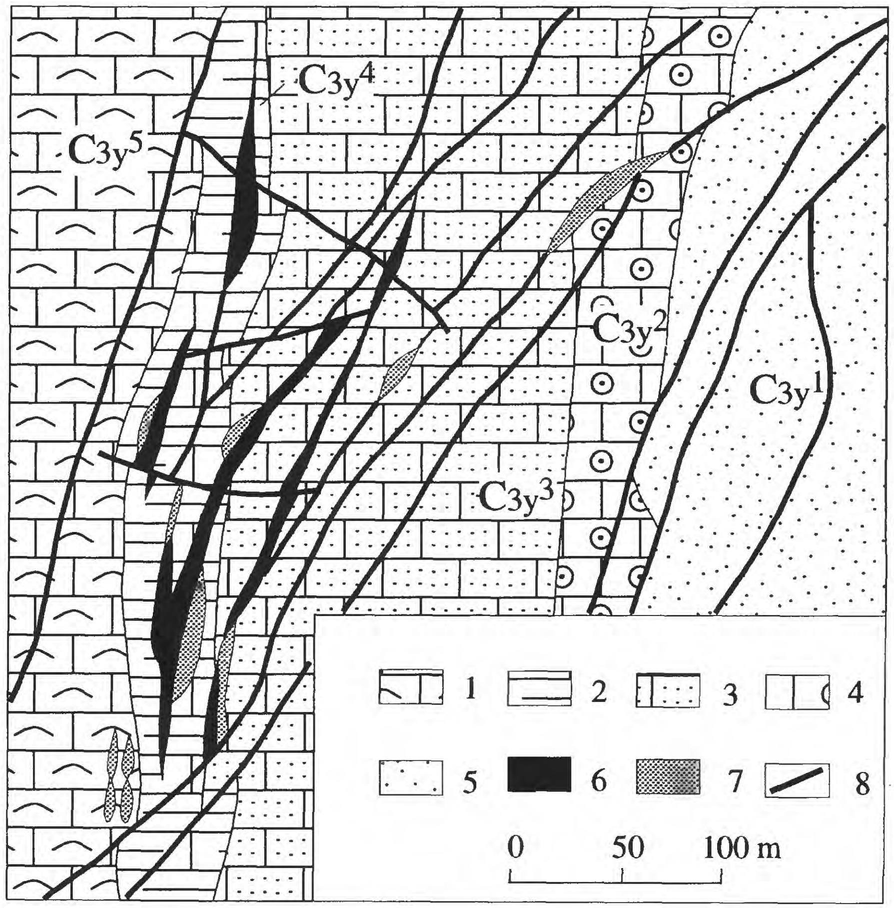

Figure 51. Geological plan of 405 m level of the Sixiangchang Hg-Au deposit. Gold and mercury orebodies are controlled by the same faults in this deposit. 1-micritic limestone, argillaceous siltstone; 2-thick limestone; 3- micritic limestone, argillaceous siltstone; 4-thick limestone, strip micritic limestone and argillaceous siltstone; 5- micritic limestone, argillaceous siltstone; 6-Au orebody; 7-Hg orebody; 8-fault. Adapted from Huang, G.S. (1993). Approximate location of figure is 107°51 00 E; 26°00 00 N.

Table 19. Au, Ag Content and Au/Ag ratio of Chinese Carlin-type Gold Deposits (After Liu, D.S., 1994)

Deposit Name	Au			Ag (average)	Au/Ag	Number. Of samples
	low	high	average			
Dongbeizhai	-	5.2	3.78	0.15	25.2	-
Qiulou	2.78	16.21	-	1.00	3-17	-
Laerma	2.87	14.62	3.92	2.34	1.68	-
Jiuyuan	-	40.0	8.81	3.03	2.91	-
Liba	-	22.0	4.2	2.19	1.92	31
Baguamiao	-	14.59	5.85	1.00	5.85	7
Shuangwang	-	17.10	3.30	0.18	18.33	-
Zimodang	1.05	5.18	2.72	<0.09	>30	7
Lannigou	-	13.82	5.80	0.68	8.53	-
Banqi	1.25	18.0	8.92	<0.5	>18	8
Yata	1.27	15.83	4.52	<0.66	>6.85	9
Gedang	2.15	7.14	3.96	0.22	18.0	9
Jinyia	1.55	7.20	4.38	0.46	9.52	2
Gaolong	1.68	16.78	5.82	1.71	3.4	15
Maxqn	1.15	4.30	2.05	<0.28	>7	5
Changkeng	-	-	8.32	6.49	1.28	-

1 Not available

Table 20. Elemental Assemblage of Chinese Carlin-type Gold Deposits

Deposit Name	Element assemblage	Product	By product
Jinyia	Au-Ag-Cu-Pb-Zn-Sb-S-As	Au	As
Lannigou	Au-As-Tl-Cr-Cu	Au	
Laerma	Au-Hg-Sb-Mo-Y-U(Cu-Zn-Ni)(Pt-Os-Pd)	Au	Hg (0.01%)
Shuangwang	Mn-S-Te-Au-Se-Ag (Pt-Pd)	Au	
Banqi	Au-As-Sb-Ag-Hg	Au	
Getang	Au-As-Sb-Hg-F-Mo	Au	As 3.99-15% S>4%
Changkeng	As-Bi-Hg (in gold orebodies) Zn-Pb-Cu (in silver orebodies)	Au Ag	
Baguamiao	Au-Ag-As-Sb-Bi-Pb	Au	

Carlin Mine, the ore contains between 40 to 50 ppm Tl in most unoxidized ores, about 150 ppm in arsenic ores, and 3 ppm in unaltered rock (Togashi, 1992). The Zimudang deposit, P.R. China is reported as a Au-Hg-Tl Carlin-type gold deposit, and an unidentified red thallium mineral was found in the Lanmuchang deposit near the Zimudang deposit. The Lannigou mineralization contains a Au-As-Tl-Cr-Cu element assemblage, and the Shuangwang deposit also contains elevated concentrations of Tl, Li, Ti, Ba, Sn, V, and Cr.

Ba is usually present as barite, a very common mineral in alteration or late stage barite-calcite veins. It is associated with many sedimentary rock-hosted gold deposits both in Nevada and in P.R. China. However, it does not positively correlate with gold. In the Rain Mine barite ore with a barite content in excess of 40 vol. percent is common (Thoreson, 1990). In the Laerma gold deposit barite together with quartz is found in veinlets and veins, which lie in alteration zones on the flanks of orebodies (Li, Y.D and Li, Y.T., 1994). Gray to gray-white quartz-barite veins contain 0.39 to 2.46 ppm gold. Generally, baritization in Chinese deposits is less than that found in Nevada deposits.

U is an associated element in some Chinese Carlin-type gold deposits in the Qinling area. Uranium and REE minerals are reported by Peters (1996), and Peters and others (1997) in the Betze deposit, Nevada as detrital grains in localized layers of the host rock and also associated with the contacted zone of the Goldstrike diorite stock. These are not considered part of the ore sequence. The Laerma deposit is the typical gold deposit with enriched U. In this deposit, the host rock consists of carbonaceous siliceous slate, silici-clastic rock and carbonaceous silty slate and contains between 5.19 and 15.50 ppm U. The U content of altered rocks ranges from 16.86 to 53.33 ppm, and the average U content in ore is 28.41 ppm U (Li, Y.D. and Li, Y.T., 1994). Some independent economic grade U deposits were formed near the sedimentary rock-hosted gold deposits in this area.

Pt group elements, *in*cluding *Os* and *Pd* are enriched in several Chinese sedimentary rock-hosted gold deposits, *in*cluding the Laerma and Shuangwang deposits. In the Laerma gold deposit, analysis of 20 samples of carbonaceous siltstone, contained 0.02 to 0.022 ppm Pt, 0.001 to 0.005 ppm (highest 10 ppm) Os, and 0.001 to 0.024 ppm Pd. A few small orebodies rich in Pt group elements also have been found. In the Shuangwang gold deposit, electron microprobe analysis of pyrite and ankerite grains show a Pt value of 2.66 wt. percent and a Pd value of 0.34 wt. percent.

In general, Au, As, Sb, and Hg make up the typical elemental assemblage in both Nevada and Chinese sedimentary rock-hosted gold deposits (Radtke, 1985; Hill and others, 1986; Togashi, 1992; Tu, G.Z., 1992; Liu, D.S. and others, 1994). Among seven gold deposits along the Carlin-trend, high As is associated with six, Sb and Hg with four, Zn and Ba with three, and Ag, Tl, Pb with two (Jones, 1989). Trace element assemblages of Chinese Carlin-type gold deposits are shown in table 20, and clearly As, Sb and Hg are closely associated with Au in most deposits. Tl and Ba also are present in many sedimentary rock-hosted gold deposits. Ag, Cu, Pb, Zn, Bi, and Mo are generally present but in low concentrations, however they are associated elements in some Carlin-type deposits. U is enriched in the Laerma, Pingding and nearby deposits in the Qinling area, P.R. China. Pt group elements also may be enriched up to ore levels in some Chinese Carlin-type gold deposits.

Fluid and Isotope Characteristics

Fluid inclusions and stable isotopes from sedimentary rock-hosted gold deposits have been studied in Nevada and P.R. China (Lu, H.Z., 1988; Li, W.K. and others, 1989; Hofstra and others, 1991a, b; Bagby and Cline, 1991; Zheng, M.H. and others, 1991; Lu, G.Q. and others, 1992; He, L.X. and others, 1993; Liu, D.S. and others, 1994; Cline and others, 1996; He, M.Y., 1996; Hofstra, 1997). Although fluid inclusion and isotope data vary from one deposit to another, an epithermal to mesothermal hydrothermal model is suggested for most Carlin-type gold deposits.

The fluid inclusion data on Carlin-type gold deposits in Nevada indicates that main-stage ore-formation occurred between 200 and 250 °C, at pressures between 400 and 800 bars. Boiling in genetically associated fluids is not documented by many fluid-inclusion studies (Hofstra and others, 1991a, b; Lamb and Cline, 1997). In P.R. China, the formation temperature for these deposits varies from between 165 and 290 °C, and from 52 to 560 bars. Depths of formation calculations are between 300 and 1,500 m, indicating upper-epithermal to mesothermal conditions for these deposits (Liu, D.S. and others, 1994). Similarly, He, L.X. and others (1993) suggested a medium formation temperature of 170 °C with a range from 160 to 200 °C for Carlin-type gold deposits in southwest Guizhou Province on the basis of the homogeneous temperature data of fluid inclusions from late-stage Hg-Sb mineralization. In the same study they considered the deposits in Guizhou Province to have formed at least 1,000 m below surface, because there are not any boiling fluid inclusions found in these deposits. Fluid inclusion analysis has proven to be only a partially successful tool in Carlin-type gold deposits because of the fine-grained nature or scarcity of the inclusions.

Stable isotope data from sedimentary rock-hosted gold deposits show a wide range, and vary from one deposit to another. In Nevada, there is a wide range of $d^{34}S$, from –5 to +20 per mil, *in* gold-associated minerals see Radtke, 1985). Hydrothermal fluids are considered to be dilute (between approximately 0.5 to 10 wt. percent NaCl equivalent) and are dominantly from fluids with isotopic signatures similar to evolved meteoric water (Hofstra and others, 1991a, b; Hofstra, 1997), except at Getchell and Twin Creeks (Cline and others, 1996) where either magmatic or metamorphic water also is suggested by D and O isotope signatures. Fluid characteristics in Carlin-type deposits suggest an environment below the epithermal zone but the fluid source and the source of the gold is still equivocal.

In P.R. China, Zheng, M.H. and others (1991) conducted systematic isotopic research on the Dongbeizhai gold deposit, Qinling area, using S, H, O, C, Pb, and Rb-Sr stable isotopes, and concluded that the ore-formation fluids were mainly derived from meteoric water; the sulfur was derived from the host rock; carbonate-bearing sedimentary units are the main source of many metallic elements (see Wang, X.C. 1996). Isotope data from some Carlin-type gold deposits in Dian-Qian-Gui area are shown in table 21, and parts of the H and O isotopic data of these gold deposits are summarized in figure 52. The plotted isotope data form complex fields, and suggests that there may have been several possible fluid sources, including hydrothermal fluids arising from the deep crust or from distal magmatic bodies. The field of D and O isotopes in the Chinese deposits has some similarities with those in the Getchell trend, Nevada (see fig. 52, table 21, and Cline and others, 1996). As a supplementary isotopic research method, Li, Z.H. and others (1994) analyzed the Co, Ni, and As content of pyrite from the Jinyia deposit, Dian-Qian-Gui area, and considered that the nature of fluid is similar to those in hot-spring type gold deposits (fig. 53).

An analysis geochemical and fluid parameters in Chinese sedimentary rock-hosted gold deposits compared to those in Nevada suggests that common features are: (1) ore-forming fluids containing complex stable isotopic signatures; (2) indications that some ore fluids may have been derived from meteoric water, but magmatic, basinal brine, and metamorphic sources also are possible; (3) low to medium temperatures of formation; (4) formation pressures indicating a medium to shallow geological crustal environment of formation; and (5) low salinity combined with high Au : Ag. ratios and low base-metal contents typify most Carlin-type gold deposits.

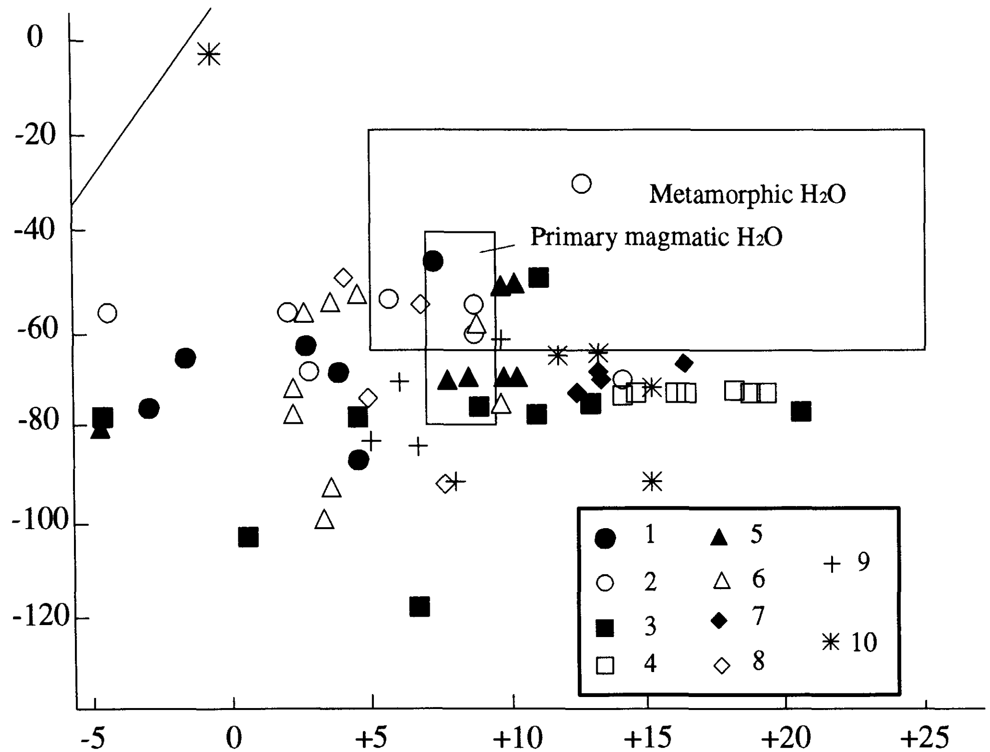

Figure 52. dD vs. d18O diagram showing that H and O data of Chinese Carlin-type gold deposit are scatted over a large area. This implies that metallogenic fluids may derive from different sources. Adapted from Liu, D.S. and others (1994).

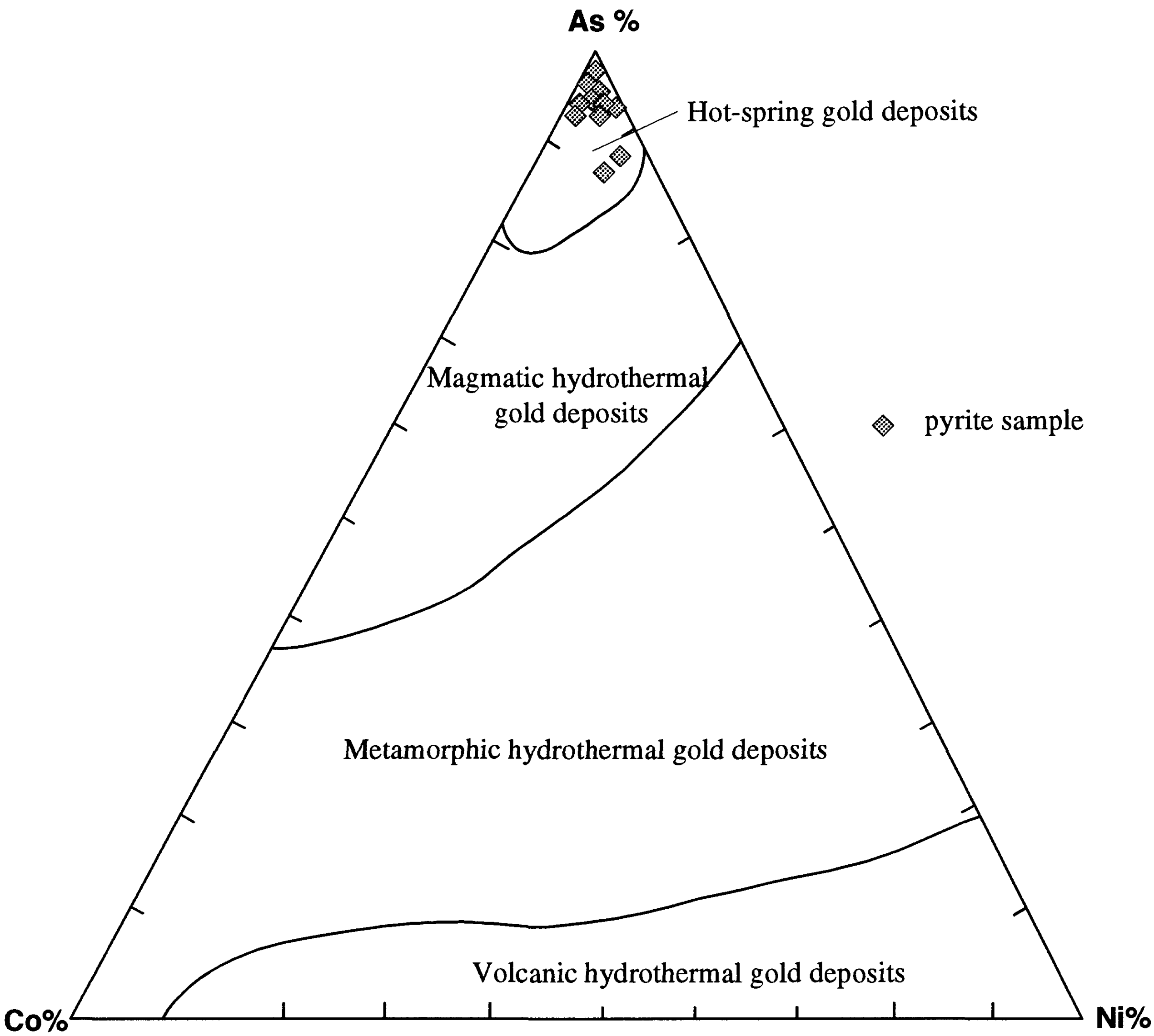

Figure 53. Co, Ni, As in pyrite from Jinyia gold deposit. Pyrites of Jinyia gold deposits fall in the area of Hot-spring gold deposits. This indicates that some Chinese Carlin-type gold deposit may be formed by hot-spring hydrothermal fluids. Adapted from Li, Z.H. and others (1994).

CONCLUSIONS

The purpose of this paper has been to describe the general geological and geochemical characteristics of Chinese Carlin-type gold deposits and compare them to those in Nevada so that common aspects of the mineralizing system can be recognized. As the economic value and scientific significance of sedimentary rock-hosted gold deposits becomes more important to science, industry and human society, increased research, prospecting, and mining of these deposits is receiving more attention in areas outside of Nevada. To successfully discover and exploit these deposits in new regions, it is important to recognize their known characteristics and to build on the existing knowledge of their origin in order to apply this data correctly to exploration models. Previous ore deposit models, developed from the mining of the oxide parts of Carlin-type deposits in Nevada, have influenced the worldwide exploration for this type of gold deposit. New studies on the hypogene parts of these systems are developing updated genetic models and exploration techniques. The definition of sedimentary rock-hosted and Carlin-type gold deposits is expanding, and may include some skarn and metamorphic rock-related gold deposits, as well as those related to porphyry systems. The US and P.R. China contain the two largest groups of sedimentary rock-hosted gold deposits in the world, and therefore recognition of the similarities and differences of the deposits in these two regions will help identify new models. Similarities between these two large regional groups suggest that a similar mineralizing type of hydrothermal system most likely operated in both areas. The following are some geological similarities and differences of the gold deposits (table 22) in these two regions.

(1) Chinese sedimentary rock-hosted gold deposits have some similar regional sedimentary and tectonic features to many Carlin-type gold deposits in Nevada. For example: (a) all deposits occur near the margin of one or more Precambrian cratons, or in areas where craton-scale tectonic units join; (b) the deposits are hosted in Paleozoic or Mesozoic sedimentary basins, which contain both shallow water cratonic shelf and sedimentary rocks from the adjacent deeper basins; (c) tectonically, there is a history of both compressional and extensional deformation; and (d) there is evidence of alignment of geologic features that reflect regional deep-crustal rifts or zones that were developed by major orogeny. It is likely that many or all of these features contribute to the localizing and formation of clusters of sedimentary rock-hosted gold deposits.

(2) Both Chinese and U.S. deposits are hosted by carbonate and silici-clastic sedimentary rocks, especially rocks formed in shelf transitional zones of sedimentary facies, such as argillaceous limestone, calcareous siltstone, and silty argillite. Chinese sedimentary rock-hosted gold deposits are more commonly hosted in silici-clastic sedimentary facies, whereas Nevada deposits generally formed in carbonate-bearing rocks. Some carbonaceous, black clastic rocks host U deposits in China. Phyllite, slate, and low-grade metamorphic rocks are only known at some Chinese sedimentary rock-hosted gold deposits. Host rocks of Carlin-type deposits in Nevada are Paleozoic in age, whereas host rocks of Chinese deposits are Mesozoic (Triassic) and Paleozoic (Devonian) in age.

(3) A high content of organic material is common in or near most sedimentary rock-hosted gold deposits in both Nevada and P.R. China, although the role of carbon in gold mineralization is not yet clear. Organic matter may have preceded gold-bearing fluids or may have been introduced or remobilized by the hydrothermal event. Mineralization of carbonaceous matter is evident in many deposits, and the worldwide correlation with these gold deposits suggests there may be a genetic link. Some of the Chinese carbonaceous ores have syngenetic characteristics. Chinese gold deposits in Proterozoic rocks in northeast China may also have volcanogenic or exhalative-sedimentary characteristics.

Table 22. Comparison of Carlin-type gold deposits between Nevada and China (After Liu, D.S., 1994)

Geological Feature	Nevada Carlin-type Gold Deposits	Chinese Carlin-type Gold Deposit
tectonic setting	transform zone of miogeoclinal	rift area of cratonic margin
host strata	carbonate rocks of Paleozoic, and S, D are important	carbonate and clastic rocks of mostly Devonian and Triassic age
host rock types	impure carbonates, fine-grained clastic rock, breccia; high carbon content in some rocks	fine-grained clastic rock, Carbon + Silica argillite, breccia; high carbon content in some rocks
metamorphic grade	slate - phyllite, dynamo-metamorphic	slate - phyllite
igneous intrusions rocks	igneous intrusion of Cretaceous - Jurassic; Tertiary volcanic rarely present	dikes of Tertiary age present in some deposits
metallogenic epoch	late Cretaceous - Tertiary	Tertiary
paragenetic deposits	Hg, Sb, barite, and skarn-related porphyry Cu	Hg, Sb, As, barite; granitic and C-Si argillite U; stratabound Pb-Zn
ore control structure	structural window in low-angle faults, high- angle normal faults, breccia zone in strata	regional base faults, faults parallel to axis of anticlines, breccia zone in strata, density squeezed fracture zones, and unconformable plane
deposits morphology	stratiform, lensoidal, vein, irregular	stratiform lensoidal, vein
alteration	decalcification, jasperoids, solidification, argillization, pyritization, dolomitization	silicification, argillization, pyritization, dolomitization, albitization
structure of ore	disseminated, stockworks, breccia	disseminated, stockworks, breccia
size of gold grains	microscopic - submicroscopic grains native gold	microscopic - submicroscopic grains native gold, rare visible
mineral assemblage	native gold, pyrite, realgar, orpiment, cinnabar, stibnite, arsenopyrite, Tl minerals, quartz, clay minerals, carbonate barite, organic carbon	native gold, pyrite, realgar, orpiment, cinnabar, stibnite, arsenopyrite, (pyrrhotite), quartz, clay minerals, carbonate, barite, organic carbon
pathfinder elements	Au, As, Hg, Sb, Tl, W, Mo	Au, As, Hg, Sb (Ag)
Au / Ag	3 to 17	> 1 to 25
zone of oxidation	common	insignificant

(4) Lack of evidence for distinct temporal links between gold mineralization and igneous rocks is another common feature for most Carlin-type gold deposits. There is no obvious relation between most Carlin-type gold deposits and igneous intrusions both in Nevada and China, but many of the Carlin-type deposits in Nevada occur near Mesozoic stocks and locally Tertiary plutons and volcanic rocks. A few sedimentary rock-hosted deposits in Nevada, particularly the distal-disseminated deposits in the Battle Mountain Mining District and the Getchell deposit may have formed in association with igneous activity. Contact metamorphic rocks have been shown as prolific hosts for ore in the Betze deposit, Nevada. A few Chinese Carlin-type deposits, such as at the Liba, Pangjiahe, and Qiuluo, occur near igneous intrusions. Both Nevada and Chinese Carlin-type gold deposits may coexist with some volcanic-hosted gold deposits.

(5) Common hydrothermal alteration types, such as silicification, argillization, and decalcification have been observed in most sedimentary rock-hosted gold deposits in both Nevada and P.R. China. Decalcification is more often observed in Nevada Carlin-type gold deposits; whereas, carbonization, decarbonatization and local albitization are specific and unique to some Chinese sedimentary rock-hosted gold deposits.

(6) Pyrite, arsenopyrite, stibnite, realgar, orpiment, quartz, barite, calcite, and illite-clay minerals are the common minerals associated with sedimentary rock-hosted gold deposits in both P.R. China and Nevada. The combination of minerals is different in each deposit depending on the host rocks. For instance, arsenopyrite, realgar and orpiment are more common in silici-clastic host rocks; whereas stibnite is more common in carbonate host rocks. Chalcopyrite, sphalerite, and galena are present in trace amounts in the Nevada deposits, but may be more abundant in some Chinese deposits. Different mineral assemblages may also be the result of zoning in individual deposits. Pyrrhotite, tungstite, albite and several native metals are special features in some Chinese sedimentary rock-hosted gold deposits.

(7) The Au-As-Sb-Hg-Ba elemental assemblage is common in sedimentary rock-hosted gold deposits in both Nevada and P.R. China, but Tl seems to be more common in the Nevada deposits and is only found in a few Chinese deposits, such as Zimudang. U and PGEs are uniquely related to some Chinese deposits not known in the Nevada Carlin-type deposits.

(8) Gold is present in hypogene ores mainly as invisible sub-microscopic particles in As-bearing pyrite in sedimentary rock-hosted gold deposits. Illite-clay minerals, quartz, barite, and pyrrhotite also act as host minerals in some Chinese Carlin-type gold deposits.

(9) The high Au : Ag. ratios, low fluid salinity, and moderate ore-forming temperatures, as well as stable isotope data of Carlin-type gold deposits in Nevada and P.R. China, can only partially explain the genesis gold deposits. A contribution of igneous activity is possible and in China the volcanic rocks also may play a part in some systems. Deep-seated igneous intrusions may have provided heat to the ore-forming system rather than be directly involved in the process of metallogeny.

(10) Oxidation zones in Nevada sedimentary rock-hosted deposits are more developed than in Chinese deposits. This has had a negative economic impact on the development of such deposits in China.

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Appendix I: DATABASE OF CHINESE CARLIN-TYPE GOLD DEPOSITS

I-1. List and cross-references

I-2. Geographical location

I-3. Commodity information

I-4. Host rocks

I-5. Tectonic setting

I-6. Ore-control structure and alteration

Appendix I-1. List and Cross References of Chinese Carlin-type* gold deposits

No.	Record Number	Site for sort	State Name	County name	Size **	Reference
1.	RE00759	Lannigou	Guizhou	Zhengfeng	l	p. 00***; Wang, Y.G., 1994; Zhang, F., 1993; Liu, K.Y., 1991
2.	RE00760	Dongbeizhai	Sichuan	Songpan	l	p. 17; Zheng, M.H., 1991
3.	RE00761	Baguamiao	Shaanxi	Fengxian	l	p. 86
4.	RE00762	Jinyia	Guangxi	Fangshan	l	p. 9; Wang, J., 1993; Wang, K.R., 1992; Deng, X.N., 1993;
5.	RE00763	Liba	Gansu	Lixian	l	p. 60;
6.	RE00764	Shuangwang	Shaanxi	Taibai	l	p. 54; Wang, J., 1993;
7.	RE00765	Laerma	Gansu	Luqu	m	p. 26; Wang, J., 1993; p. 74; Zhang, Z.A., 1993
8.	RE00766	Pingding	Gansu	Zhouqu ?	m	p. 03; Wang, J., 1993;
9.	RE00767	Jinlongshan	Shaanxi	Zhenan ?	l	p. 06
10.	RE00768	Changkeng	Guangdong	Gaoming	l	p. 43
11.	RE00769	Dachang	Guizhou	?	m ?	Mai, C.R., 1989; Deng, X.N., 1993;
12.	RE00770	Zimudang	Guizhou	Qinglong	l	p. 9; Wang, Y.G., 1994; Mai, C.R., 1989; Wang, J., 1993; Deng, X.N., 1993; Liu, K.Y., 1991
13.	W700366	Yata	Guizhou	Ceheng ?	m	Togashi, Y., 1992; Wang, J., 1993; Deng, X.N., 1993; Liu, K.Y., 1991
14.	W700367	Getang	Guizhou	Xingren ?	L	p. 16; Wang, Y.G., 1994; Mai, C.R., 1989; Wang, J., 1993; Deng, X.N., 1993; Liu, K.Y., 1991
15.	W700368	Sanchahe	Guizhou	Zhengfeng ?	?	Wang, J., 1993; Deng, X.N., 1993; Liu, K.Y., 1991
16.	W700369	Ceyang	Guizhou	Ceheng	?	Mai, C.R., 1989; Deng, X.N., 1993;
17.	W700370	Banqi	Guizhou	Ceheng ?	?	Mao, S.H., 1991; Liu, D.S., 1987; Wang, J., 1993; Deng, X.N., 1993; Liu, K.Y., 1991
18.	RE00771.	Badun	Gansu	?	p	p. 19
19.	RE00772.					
20.	RE00773.	Chabu	Gansu	Minxian	p	p. 29
21.	RE00774.	Dashui	Gansu	Maqu	s	p. 19
22.	RE00775.	Gejiebisu	Gansu	?	p	p. 19
23.	RE00776.	Heduosi	Gansu	Minxian	p	p. 29
24.	RE00777.	Jinshan	Gansu	Lixian	m	p. ; p. , 161, p. 76
25.	RE00778.	Jiuyuan	Gansu	Zhouqu	p	p. 18; p. 29; Wang, J., 1993; p. ; p. 4; p. 6;
26.	RE00779.	Kama	Gansu	Zhouqu	p	p. 29
27.	RE00780.	Lazikuo	Gansu	Minxian	P	p. 18
28.	RE00781.	Lianhecun	Gansu	?	p	p. 19
29.	RE00782.	Maquan	Gansu	Lixian	m	p. ; p. ; p. 4, p. 76
30.	RE00783.	Qingkeyan	Gansu	Zhouqu	p	p. 29
31.	RE00784.	Quongme	Gansu	Luqu	m	p. 18; p. 29
32.	RE00785.	Sanrengou	Gansu	Lixian	s	p. ; p.
33.	RE00786.	Shijiba	Gansu	Winxian	s	p. 29
34.	RE00787.	Yaerma	Gansu	Luqu	p	p. 29; p. 27
35.	RE00788.	Yiaxiang	Gansu	Luqu	p	p. 29; p. 18
36.	RE00789.	Zhuongqu	Gansu	Maqu	s	p. 19, p. 29
37.	RE00790.	Damingshan	Guangxi	Lingyun	s	Liu, K.Y., 1991; p. 50, p.
38.	RE00791.	Gaolong	Guangxi	Tianlin	M	Wang, J., 1993; Deng, X.N., 1993; p. ; p. 0; p. 3-14; p. 6-27;
39.	RE00792.	Longhue	Guangxi	Longlin	p	p. ; p. 49
40.	RE00793.	Longna	Guangxi	Xilin	p	p. 35; Liu, K.Y., 1991
41.	RE00794.	Maxuong	Guangxi	Longlin	s	Wang, J., 1993; Deng, X.N., 1993; Liu, K.Y., 1991; p. ; p. 3; p. 5-27; p. 48
42.	RE00795.	Peyian	Guangxi	Longlin	p	Deng, X.N., 1993; p. 49
43.	RE00796.	Puzilong	Guangxi	?	p	p. 35; p. 0
44.	RE00797.	Zheyi	Guangxi	Longlin	s	p. 49
45.	RE00798.	Baidi	Guizhou	Ceheng	p	Tao, C.G., 1990; Zhang, F., 1993
46.	RE00799.	Bannian	Guizhou	Ceheng	s	p. 02
47.	RE00800.	Beiyinpe	Guizhou	Zhengfeng	p	p. 35, p. 0
48.	RE00801.	Daguan	Guizhou	Wangme	s	Tao, C.G., 1990; Liu, K.Y., 1991
49.	RE00802.	Dayakou	Guizhou	Xingren	p	p. 35; Liu, K.Y., 1991
50.	RE00803.	Loudong	Guizhou	Zhengfeng	p	p. 02
51.	RE00804.	Lubuge	Guizhou	Xingyi	p	Deng, X.N., 1993; p. 43
52.	RE00805.	Miaolong	Guizhou	?	s	Huang, G.S., 1993; Liu, D.S., 1987; Geng, W., 1985
53.	RE00806.	Nipu	Guizhou	Xingren	p	p. 35
54.	RE00807.	Pegao	Guizhou	Zhengfeng	p	p. 02
55.	RE00808.	Qingping	Guizhou	Ceheng	a	p. 02; p.
56.	RE00809.	Shaziling	Guizhou	Qinglong	s	Tao, C.G., 1990; Deng, X.N., 1993; p. ;
57.	RE00810.	Sixiangchang	Guizhou	Puan	s	Huang, G.S., 1993
58.	RE00811.	Tangxinzhai	Guizhou	Zhengfeng	a	p. 02
59.	RE00812.	Wangme	Guizhou	Wangme	?	Tao, C.G., 1990; p. 49
60.	RE00813.	Weihuai	Guizhou	Ceheng	s	Tao, C.G., 1990; Deng, X.N., 1993;
61.	RE00814.	Xuongwu	Guizhou	Xingyi	s	Mai, C.R., 1989; Liu, K.Y., 1991
62.	RE00815.	Yangyou	Guizhou	Ceheng	s	p. 02; Tao, C.G., 1990; p.
63.	RE00816.	Huameinao	Huabei	Daye	s	Cai, G.X., 1991
64.	RE00817.	Jiguanzui	Huabei	Daye	m	Huang, Y.N., 1993;
65.	RE00818.	Jilongshan	Huabei	Daye	l	Huang, Y.N., 1993
66.	RE00819.	Tuongkangling	Huabei	Daye	s	Cai, G.X., 1991
67.	RE00820.	Yangjishan	Huabei	Ruichang	m	Deng, X.N., 1993;
68.	RE00821.	Zhanghai	Huabei	Daye	s	Cai, G.X., 1991
69.	RE00822.	Gaojiaao	Hunan	Xingshao	l	p. 56

70.	RE00823.	Gutaishan	Hunan	?	?	Wang, J., 1993
71.	RE00824.	Longshan	Hunan	?	?	Wang, J., 1993
72.	RE00825.	Mobing	Hunan	?	?	Wang, J., 1993
73.	RE00826.	Shixia	Hunan	Hengdong	s	Wang, J., 1993; Liu, D.S., 1987; Geng, W.H., 1985; p. 6
74.	RE00827.	Woxi	Hunan	?	?	Wang, J., 1993
75.	RE00828.	Maoling	Liaoning	Gaixian	l	Cheng, Q.M., 1994;
76.	RE00829.	Ertaizi	Shaanxi	Zhengan	l	p. 54; Liu, D.S., 1987; Geng, W.H., 1985; Wang, J., 1993; Yiao, Z.Y., 1990; p. 2; p. 6; Xu, G.F., 1982; Shao, J.L., 1982
77.	RE00830.	Lijiagou	Shaanxi	Shangyang	?	Wang, J., 1993
78.	RE00831.	Qilixia	Shaanxi	Shanyang	s	p. ; p. 09
79.	RE00832.	Qiuling	Shaaxi	Zhengan	s	p. ; p. 09
80.	RE00833.	Yaojian	Shaaxi	Zhengan	s	p. ; p. 09
81.	RE00834.	Baxi	Sichuan	Nanping	p	p. 19
82.	RE00835.	Gala	Sichuan	Ganzi	l	p. 19, Wang, X. C., 1993
83.	RE00836.	Huayuangou	Sichuan	?	s& m	p. 19
84.	RE00837.	Jiawuchi	Sichuan	Songpan	p	p. 19, p. 29
85.	RE00838.	Mahuanggou	Sichuan	Beichuan	p	p. 19
86.	RE00839.	Manaoke	Sichuan	Nanping	l	p. 19, p. 29
87.	RE00840.	Qiaoqiaoshang	Sichuan	Songpan	m	p. 5-27
88.	RE00841.	Qilicun	Sichuan	Nanping	p	p. 19
89.	RE00842.	Quluopunongba	Sichuan	Ganzi	l	p. ; p. 2; p. 4; p. 5-27, Wang, X. C., 1993
90.	RE00843.	Shuishengou	Sichuan	?	p	p. 19
91.	RE00844.	Tuanjie	Sichuan	Nanping	p	p. 19
92.	RE00845.	Zhepeshan	Sichuan	Songpan	s& m	p. 19
93.	RE00846.	Beiya	Yuennan	Mojiang	?	Liu, B.G, 1992
94.	RE00847.	Gedang	Yuennan	?	l	p. ; p. 1; p. 3; p. 5; p. 18
95.	RE00848.	Jinchang	Yuennan	Mojiang	?	Liu, B.G, 1992
96.	RE00849.	Tangshang	Yuennan	Guangnan	?	p. ; p. 43
97.	RE00850.	Zacuen	Yuennan	?	m	p.
98.		Zaorendao	Gansu	?		p. , p.
99.		Jiaoguan	Guangxi	?		p. 35
100.		Jiaoman	Guangxi	?		Liu, K.Y., 1991; Yao, Z.Y., 1990
101.		Longchang	Guangxi	?	?	p. 35; p. 48
102.		Zhutong	Guangxi	?	?	p. 35
103.		Danzhai	Guizhou	?	?	Lu, G.Q., 1992
104.		Gulu	Guizhou	Qinglong	?	Tao, C.G., 1990;
105.		Kagu	Guizhou	?	?	Deng, X.N., 1993;
106.		Guji	Shaanxi	?	?	p. 19
107.		Laotiechang	Shaanxi	?	?	p. 19
108.		Panghe	Shaanxi	?	?	p. 19
109.		Pangjiahe	Shaanxi	?	M	p. ; p. 4
110.		Bancanggou	?	?	?	p.
111.		Daqiao	?	?	?	p.
112.		Jiucaigou	?	?	?	p.
113.		Linxiang	Qinling	?	?	p.

* Carlin-type gold deposits (or sedimentary rock-hosted, or veinlet-disseminated in sedimentary rocks)
** Size:
l -- large: ä 30 tons Au (?)
m -- medium: 10 to 30 tons Au (?)
s -- small: â 10 tons Au (?)
p -- prospect: not yet identified resource
a -- geochemical anomaly
*** p.100 -- *in* Liu, D.S., ed., 1994, Chinese Carlin-type Gold Deposits, University of Nanjing, p. 100.

Appendix I-2. Geographical Location of Chinese Carlin-type Gold Deposits

No.	Record Number	Site for sort	State Name	County name	Latitude	Longitude	Position
1.	RE00759	Lannigou	Guizhou	Zhengfeng	25-21-00N	105-41-24E	Northwest Zhengfeng county town
2.	RE00760	Dongbeizhai	Sichuan	Songpan	32-18-00N	102-45-36E	?
3.	RE00761	Baguamiao	Shaanxi	Fengxian	34-55-12N	106-54-00E	40 km east of Fengxian county town
4.	RE00762	Jinyia	Guangxi	Fangshan	24-31-12N	107-00-30E	14 km northwest Fengshan county town
5.	RE00763	Liba	Gansu	Lixian	34-06-00N	104-35-24E	Northwest Lixian county town
6.	RE00764	Shuangwang	Shaanxi	Taibai	34-00-03N	107-18-00E	south Taibai county town
7.	RE00765	Laerma	Gansu	Luqu	34-00-24N	102-19-12E	?
8.	RE00766	Pingding	Gansu	Zhouqu ?	34-00-06N	102-48-00E	?
9.	RE00767	Jinlongshan	Shaanxi	Zhenan ?	33-12-00N	109-04-38E	southeast of Zhenan county town
10.	RE00768	Changkeng	Guangdong	Gaoming	22-30-00N	112-24-00E	?
11.	RE00769	Dachang	Guizhou	Qinglong	25-36-00N	105-12-00E	15 km southwest Qinglong county
12.	RE00770	Zimudang	Guizhou	Xingren	25-25-12N	105-11-24E	west of Sanchahe gold deposit
13.	W700366	Yata	Guizhou	Ceheng	24-56-00N	105-39-00E	access to mine is by trail from viilage of Yata
14.	W700367	Getang	Guizhou	Xingren ?	25-15-00N	105-16-00E	27 km northwest of Anlong
15.	W700368	Sanchahe	Guizhou	Zhengfeng	25-31-00N	105-37-00E	45 km northwest of Anlong
16.	W700369	Ceyang	Guizhou	Ceheng	24-59-00N	105-45-00E	7 km west of Ceheng
17.	W700370	Banqi	Guizhou	Ceheng ?	24-48-00N	105-39-00E	10 km south of Yata deposit
18.	RE00771.	Badun	Gansu	?	33-30N	104-30E	Nanping-Maqu gold belt
19.	RE00772.	Chabu	Gansu	Minxian	34-06-36N	103-45-00E	5 km northwest Lazikou
20.	RE00773.	Dashui	Gansu	Ma u	34-05-00N	101-59-00E	18 km northeast Ma u ctyun
21.	RE00774.	Gejiebisu	Gansu	?	33-30N	104-30E	Nanping-Maqu gold belt
22.	RE00775.	Heduosi	Gansu	Minxian	34-06-00N	104-45-30E	2 km northwest Lazikou
23.	RE00776.	Jinshan	Gansu	Lixian	34-12-00N	104-47-00E	18 km west Lixian
24.	RE00777.	Jiuyuan	Gansu	Zhouqu	34-00-50N	102-47-30E	2 km northwest Pingding gold deposit
25.	RE00778.	Kama	Gansu	Zhouqu	33-51N	104-00-00E	10 km northwest Zhouqu
26.	RE00779.	Lazikuo	Gansu	Minxian	34-12-00N	104-00-00E	30 km south Minxian county
27.	RE00780.	Lianhecun	Gansu	?	33-30N	104-30E	Nanping-Maqu gold belt
28.	RE00781.	Maquan	Gansu	Lixian	34-12-00N	104-48-00E	16 km west Lixian
29.	RE00782.	Qingkeyan	Gansu	Zhouqu	33-51N	104-00-10E	6 km northwest Zhouqu
30.	RE00783.	Quongme	Gansu	Luqu	34-24-30N	102-29-00E	5 km east Laerma gold deposit
31.	RE00784.	Sanrengou	Gansu	Lixian	34-06-50N	104-34-30E	5 km northwest Liba gold deposit
32.	RE00785.	Shijiba	Gansu	Winxian	33-00-00N	104-35-00E	Nanping-Maqu gold belt
33.	RE00786.	Yaerma	Gansu	Luqu	34-10-48N	102-15-36E	55 km northeast Maqu
34.	RE00787.	Yiaxiang	Gansu	Luqu	34-24-00N	102-30-00E	10 km east Laerma gold deposit
35.	RE00788.	Zhuongqu	Gansu	Maqu	34-10-00N	101-58-50E	13 km northeast Maqu county
36.	RE00789.	Damingshan	Guangxi	Lingyun	24-18-00N	106-27-00E	7.5 km southeast Loulou town
37.	RE00790.	Gaolong	Guangxi	Tianlin	24-13-12N	105-42-00E	60 km west Tianlin county
38.	RE00791.	Longhue	Guangxi	Longlin	24-36-00N	105-	50 km east Xilin county
39.	RE00792.	Longna	Guangxi	Xilin	24-35-00N	105-00-00E	?
40.	RE00793.	Maxuong	Guangxi	Longlin	24-39-00N	105-25-24E	19 km southeast Longlin county
41.	RE00794.	Peyian	Guangxi	Longlin	24-38-00N	105-25-58E	20 km southeast Longlin county
42.	RE00795.	Puzilong	Guangxi	?	25-37-00N	105-36-00E	9.5 km southeast Zimudong gold deposit
43.	RE00796.	Zheyi	Guangxi	Longlin	24-40-00N	105-25-12E	11 km southeast Longlin county
44.	RE00797.	Baidi	Guizhou	Ceheng	25-00-00N	105-45E	in Ceheng county
45.	RE00798.	Bannian	Guizhou	Ceheng	25-10-00N	105-29-00E	southwest Lannigou deposit
46.	RE00799.	Beiyinpe	Guizhou	Zhengfeng	25-37-12N	105-36-10E	11 km southeast Zimudong gold deposit
47.	RE00800.	Daguan	Guizhou	Wangme	25-01-00N	106-05-00E	southeast Wangme
48.	RE00801.	Dayakou	Guizhou	Xingren	25-18-00N	105-06-00E	7 km southeast Xingren county
49.	RE00802.	Loudong	Guizhou	Zhengfeng	25-21-00N	105-33-00E	northwest of Lannigou gold deposit
50.	RE00803.	Lubuge	Guizhou	Xingyi	25-10-00N	104-40-00E	west Xingyi county
51.	RE00804.	Miaolong	Guizhou	?	25-50-00N	105-00-00E	6 km southeast Puan county
52.	RE00805.	Nipu	Guizhou	Xingren	25-25-12N	104-54-00E	18 km west Xingren county
53.	RE00806.	Pegao	Guizhou	Zhengfeng	25-20-10N	105-33-02E	northwest Lannigou gold deposit
54.	RE00807.	Qingping	Guizhou	Ceheng	25-18-00N	105-32-00E	west Lannigou gold deposit
55.	RE00808.	Shaziling	Guizhou	Qinglong	25-46-48N	104-57-00E	7 km southwest Qinglong
56.	RE00809.	Sixiangchang	Guizhou	Puan	25-55-00N	105-00-00E	8 km northeast Puan county
57.	RE00810.	Tangxinzhai	Guizhou	Zhengfeng	25-20-00N	105-32-00E	northwest Lannnigou gold deposit
58.	RE00811.	Wangme	Guizhou	Wangme	25-06-00N	106-06-00E	near southeast Wangme county
59.	RE00812.	Weihuai	Guizhou	Ceheng	25-24-00N	105-31-00E	south Lannigou gold Deposit
60.	RE00813.	Xuongwu	Guizhou	Xingyi	24-55-12N	104-48-00E	21 km southwest Xingyi county
61.	RE00814.	Yangyou	Guizhou	Ceheng	25-15-00N	105-30-00E	southwest Lannigou gold deposit
62.	RE00815.	Huameinao	Huabei	Daye	29-50-00N	114-50-00E	southwest Daye
63.	RE00816.	Jiguanzui	Huabei	Daye	30-06-00N	114-58-48E	20 km south Huangshi city
64.	RE00817.	Jilongshan	Huabei	Daye	29-50-24N	115-12-00E	45 km south Huangshi city
65.	RE00818.	Tuongkangling	Huabei	Daye	29-59-50N	114-50-00E	25 km southwest Daye
66.	RE00819.	Yangjishan	Huabei	Ruichang	29-41-24N	115-38-24E	30 km west Jiujiang city
67.	RE00820.	Zhanghai	Huabei	Daye	29-59-00N	114-50-00E	24 km southwest Daye county
68.	RE00821.	Gaojiaao	Hunan	Xinshao	27-20-24N	111-25-12E	30 km north Shaoyang city
69.	RE00822.	Gutaishan	Hunan	?	26 ~ 28 N	110 ~ 111 E	West Hunan ?
70.	RE00823.	Longshan	Hunan	?	26 ~ 28 N	110 ~ 111 E	West Hunan ?
71.	RE00824.	Mobing	Hunan	?	26 ~ 28 N	110 ~ 111 E	West Hunan ?
72.	RE00825.	Shixia	Hunan	Hengdong	26-28-00N	112-35-00E	near Hengyang city
73.	RE00826.	Woxi	Hunan	?	26 ~ 28N	110 ~ 111	west Hunan
74.	RE00827.	Maoling	Liaoning	Gaixian	40-00-00N	122-24-00E	60 km south Gaixian
75.	RE00828.	Ertaizi	Shaanxi	Zhengan	33-36-00N	109-06--00E	18 km south Zhashui county
76.	RE00829.	Lijiagou	Shaanxi	Shangyang	33-30N	109-58E	Lingtan-Shanyang area
77.	RE00830.	Qilixia	Shaanxi	Shanyang	33-12-00N	109-04-50E	east Jinglongshan gold deposit
78.	RE00831.	Qiuling	Shaaxi	Zhengan	33-12-30N	109-02-00E	west Jinlongshan gold deposit
79.	RE00832.	Yaojian	Shaaxi	Zhengan	33-12-00N	109-03-00E	west Jinlongshan gold deposit
80.	RE00833.	Baxi	Sichuan	Nanping	33-02-00N	104-01-29E	Nanping-Maqu ore belt
81.	RE00834.	Gala	Sichuan	Ganzi	30-48-00N	100-11-20E	between Ganzi and Luhou county
82.	RE00835.	Huayuangou	Sichuan	?	33-30N	104-30E	Nanping-Maqu gold belt
83.	RE00836.	Jiawuchi	Sichuan	Songpan	33-00-00N	103-48-00E	50 km northeast of Songpan county
84.	RE00837.	Mahuanggou	Sichuan	Beichuan	31-58-00N	104-24 -00E	Longmenshan gold belt

85.	RE00838.	Manaoke	Sichuan	Nanping	33-36-00N	103-24-00E	50 km east Nouergai county
86.	RE00839.	Qiaoqiaoshang	Sichuan	Songpan	32-42-00N	103-30-00E	10 km northeast Songpan county
87.	RE00840.	Qilicun	Sichuan	Nanping ?	33-01-00N	104-01-00E	Nanping-Maqu ore belt
88.	RE00841.	Quluopunongba	Sichuan	Ganzi	30-47-30N	100-12-00E	between Ganzi and Luhou county
89.	RE00842.	Shuishengou	Sichuan	?	33-30N	104-30E	Nanping-Maqu gold belt
90.	RE00843.	Tuanjie	Sichuan	Nanping ?	33-00-00N	104-00-00E	Nanping-Maqu gold belt
91.	RE00844.	Zhepeshan	Sichuan	Songpan	32-36-00N	103-06-00E	38 km northwest Songpan county
92.	RE00845.	Beiya	Yuennan	Mojiang	?	?	?
93.	RE00846.	Gedang	Yuennan	?	?	?	?
94.	RE00847.	Jinchang	Yuennan	Mojiang	?	?	?
95.	RE00848.	Tangshang	Yuennan	Guangnan	?	?	?
96.	RE00849.	Zacuen	Yuennan	?	?	?	?
97.		Zaorendao	Gansu	?	?	?	?
98.		Jiaoguan	Guangxi	?	?	?	?
99.		Jiaoman	Guangxi	?	?	?	?
100.		Longchang	Guangxi	?	?	?	?
101.		Zhutong	Guangxi	?	?	?	?
102.		Danzhai	Guizhou	?	?	?	?
103.		Gulu	Guizhou	Qinglong	?	?	?
104.		Kagu	Guizhou	?	?	?	?
105.		Guji	Shaanxi	?	?	?	?
106.		Laotiechang	Shaanxi	?	?	?	?
107.		Panghe	Shaanxi	?	?	?	?
108.		Pangjiahe	Shaanxi	?	?	?	?
109.		Bancanggou	?	?	?	?	?
110.		Daqiao	?	?	?	?	?
111.		Jiucaigou	?	?	?	?	?
112.		Linxiang	?	?	?	?	?

Appendix I-3. Commodity Information of Chinese Carlin-type Gold Deposits

No.	Record Number	Site for sort	Commodity	Ore-minerals	Non-ore minerals
1.	RE00759	Lannigou	Au As Hg	pyrite arsenopyrite orpiment realgar	quartz clay minerals carbonate minerals
2.	RE00760	Dongbeizhai	Au Ag As Hg	native gold pyrite orpiment arsenopyrite stibnite	quartz calcite
3.	RE00761	Baguamiao	Au	pyrite pyrrhotite chalcopyrite limonite molybdenite rutile native gold native silver	sericite quartz
4.	RE00762	Jinyia	Au As Ag Cu Pb Zn Sb	pyrite arsenopyrite stibnite galena sphalerite chalcopyrite tetrahedrite marcasite orpiment realgar native arsenic	quartz calcite ankerite clay minerals
5.	RE00763	Liba	Au	pyrite limonite chalcopyrite arsenopyrite sphalerite galena pyrrhotite native gold	muscovite sericite quartz
6.	RE00764	Shuangwang	Au	native gold calaverite pyrite marcasite	albite dolomite calcite quartz rutile apatite
7.	RE00765	Laerma	Au U Hg Sb Mo Y Pt (Os Pd)	native gold pyrite stibnite cinnabar tennantite	quartz barite dickite sericite pitch
8.	RE00766	Pingding	Au As Hg	pyrite orpiment realgar arsenopyrite marcasite native arsenic native sulfur limonite	quartz calcite
9.	RE00767	Jinlongshan	Au Hg Sb	pyrite arsenopyrite stibnite sphalerite chalcopyrite	quartz calcite sericite barite clay minerals
10.	RE00768	Changkeng	Au Ag As Bi Hg	native gold pyrite realgar orpiment stibnite argentite	quartz illite dickite muscovite
11.	RE00769	Dachang	Au Sb As Hg	pyrite arsenopyrite magnetite	quartz carbonate minerals clay minerals
12.	RE00770	Zimudang	Au Hg Tl	pyrite marcasite arsenopyrite realgar jarosite chalcopyrite bornite tennantite galena sphalerite	sericite calcite dolomite
13.	W700366	Yata	Au	native gold pyrite realgar arsenopyrite chalcopyrite marcasite stibnite sphalerite	ankerite quartz clay minerals
14.	W700367	Getang	Au	gold pyrite stibnite marcasite arsenopyrite realgar cinnabar	chalcedony quartz illite calcite dolomite fluorite barite limonite
15.	W700368	Sanchahe	Au	gold pyrite arsenopyrite realgar cinnabar marcasite barite fluorite stibnite	quartz calcite
16.	W700369	Ceyang	Au	gold pyrite arsenopyrite chalcopyrite	clay minerals
17.	W700370	Banqi	Au Hg Sb	native gold pyrite stibnite bismite arsenopyrite realgar orpiment marcasite sphalerite	quartz kaolinite montmorillonite carbon ankerite barite
18.	RE00771.	Badun	Au Hg (As Sb)		
19.	RE00772.	Chabu	Au (As Sb)		
20.	RE00773.	Dashui	Au		
21.	RE00774.	Gejiebisu	Au Hg (As Sb)		
22.	RE00775.	Heduosi	Au (As Sb)		
23.	RE00776.	Jinshan	Au As Sb		
24.	RE00777.	Jiuyuan	Au (As Sb)	pyrite arsenopyrite native gold limonite realgar	quartz clay minerals calcite
25.	RE00778.	Kama	Au (As Sb)		
26.	RE00779.	Lazikuo	Au		
27.	RE00780.	Lianhecun	Au Hg (As Sb)		
28.	RE00781.	Maquan	Au		
29.	RE00782.	Qingkeyan	Au (As Sb)		
30.	RE00783.	Quongme	Au (U)		
31.	RE00784.	Sanrengou	Au		
32.	RE00785.	Shijiba	Au Hg (As Sb)		
33.	RE00786.	Yaerma	Au (As Sb)		
34.	RE00787.	Yiaxiang	Au		
35.	RE00788.	Zhuongqu	Au Hg (As Sb)		
36.	RE00789.	Damingshan			
37.	RE00790.	Gaolong	Au As Sb	arsenopyrite pyrite realgar native arsenic	quartz barite clay minerals
38.	RE00791.	Longhue			
39.	RE00792.	Longna			
40.	RE00793.	Maxuong	Au As	pyrite arsenopyrite stibnite realgar orpiment cinnabar	quartz calcite fluorite
41.	RE00794.	Peyian	Au As	pyrite arsenopyrite stibnite realgar orpiment cinnabar	quartz calcite fluorite
42.	RE00795.	Puzilong	Au Hg	pyrite marcasite arsenopyrite realgar native gold chalcopyrite	sericite calcite dolomite

43.	RE00796.	Zheyi	Au Sb	pyrite arsenopyrite stibnite realgar orpiment cinnabar	quartz calcite fluorite
44.	RE00797.	Baidi	Au	pyrite arsenopyrite	illite quartz
45.	RE00798.	Bannian			
46.	RE00799.	Beiyinpe	Au Hg	pyrite marcasite arsenopyrite realgar native gold chalcopyrite	sericite calcite dolomite
47.	RE00800.	Daguan	Au AS Sb	pyrite limonite arsenopyrite stibnite orpiment	carbon quartz clay minerals calcite
48.	RE00801.	Dayakou	Au (Sb)	pyrite limonite arsenopyrite stibnite orpiment	carbon quartz clay minerals calcite
49.	RE00802.	Loudong	Au		
50.	RE00803.	Lubuge	Au As	pyrite arsenopyrite stibnite realgar orpiment cinnabar	Quartz calcite fluorite
51.	RE00804.	Miaolong	Au As Sb	native gold stibnite cinnabar arsenopyrite orpiment realgar pyrite sphalerite galena chalcopyrite	ankerite calcite quartz illite barite fluorite rutile chalcedony carbon
52.	RE00805.	Nipu	Au	pyrite limonite arsenopyrite stibnite orpiment	carbon quartz clay minerals calcite
53.	RE00806.	Pegao	Au		
54.	RE00807.	Qingping	AU		
55.	RE00808.	Shaziling	Au As	pyrite arsenopyrite stibnite realgar orpiment cinnabar	Quartz calcite fluorite
56.	RE00809.	Sixiangchang	Hg Au	native gold electrum arsenopyrite pyrite marcasite cinnabar native mercury stibnite sphalerite	sericite carbon clay minerals chalcedony quartz calcite ankerite dolomite barite gypsum
57.	RE00810.	Tangxinzhai	Au		
58.	RE00811.	Wangme	Au		
59.	RE00812.	Weihuai	Au As	pyrite arsenopyrite stibnite realgar orpiment cinnabar	Quartz calcite fluorite
60.	RE00813.	Xuongwu	Au Sb AS Hg		
61.	RE00814.	Yangyou	Au		
62.	RE00815.	Huameinao	Au Ag	pyrite chalcopyrite galena sphalerite limonite hematite	quartz sericite calcite barite
63.	RE00816.	Jiguanzui	Au Cu	pyrite chalcopyrite bornite chalcocite molybdenite siderite magnetite native gold	
64.	RE00817.	Jilongshan	Au Cu	pyrite chalcopyrite bornite molybdenite magnetite native gold	
65.	RE00818.	Tuongkanglin g	Au		
66.	RE00819.	Yangjishan	Au Ag Pb Zn	pyrite galena sphalerite tennantite chalcopyrite native gold	
67.	RE00820.	Zhanghai	Au	pyrite	quartz sericite carbon clastics
68.	RE00821.	Gaojiaao	Au	pyrite native gold marcasite arsenopyrite stibnite sphalerite galena scheelite argentite limonite	jarosite sericite alunite quartz clay minerals barite tourmaline
69.	RE00822.	Gutaishan	Au Sb W	native gold stibnite tungstite pyrite arsenopyrite	
70.	RE00823.	Longshan	Au Sb W	native gold stibnite tungstite pyrite arsenopyrite aurotite (?)	
71.	RE00824.	Mobing	Au Sb W	native gold stibnite tungstite pyrite arsenopyrite aurotite	
72.	RE00825.	Shixia	Au Hg As	native gold pyrite cinnabar stibnite orpiment realgar sphalerite chalcopyrite marcasite	quartz barite calcite dolomite
73.	RE00826.	Woxi	Au Sb W	native gold stibnite tungstite pyrite arsenopyrite aurotite	
74.	RE00827.	Maoling	Au	native gold arsenopyrite pyrrhotite galena pyrite marcasite chalcopyrite sphalerite	
75.	RE00828.	Ertaizi	Au Ag AS Hg Ba	native gold native silver tennantite cinnabar siegenite pyrite marcasite chalcocite chalcopyrite	ankerite calcite quartz sericite barite rutile carbon
76.	RE00829.	Lijiagou			
77.	RE00830.	Qilixia	Au Hg Sb	pyrite arsenopyrite stibnite sphalerite chalcopyrite limonite	quartz calcite sericite barite clay minerals
78.	RE00831.	Qiuling	Au Hg Sb	pyrite arsenopyrite stibnite sphalerite chalcopyrite limonite	quartz calcite sericite barite clay minerals
79.	RE00832.	Yaojian	Au Hg Sb	pyrite arsenopyrite stibnite sphalerite chalcopyrite limonite	quartz calcite sericite barite clay minerals
80.	RE00833.	Baxi	Au Hg (As Sb)		
81.	RE00834.	Gala			
82.	RE00835.	Huayuangou			
83.	RE00836.	Jiawuchi	Au Hg (As Sb)		
84.	RE00837.	Mahuanggou			
85.	RE00838.	Manaoke	Au Hg (As Sb)		
86.	RE00839.	Qiaoqiaoshang			
87.	RE00840.	Qilicun	Au Hg (As Sb)		
88.	RE00841.	Quluopunong ba	Au As Sb Hg Tl Ba	native gold pyrite arsenopyrite stibnite cinnabar realgar sphalerite chalcopyrite	quartz calcite dolomite chlorite
89.	RE00842.	Shuishengou	Au Hg (As Sb)		
90.	RE00843.	Tuan'ie	Au Hg (As Sb)		
91.	RE00844.	Zhepeshan			
92.	RE00845.	Beiya	Au	pyrite galena sphalerite chalcocite hematite clectrum cerussite	
93.	RE00846.	Gedang	Au Sb	pyrite arsenopyrite stibnite	fluorite quartz calcite
94.	RE00847.	Jinchang	Au	electrum argentite pearceite pyrite hematite galena sphalerite	quartz dolomite calcite serpentine
95.	RE00848.	Tangshang			
96.	RE00849.	Zacuen			
97.		Zaorendao			
98.		Jiaoguan			
99.		Jiaoman			
100.		Longchang			
101.		Zhutong			
102.		Danzhai			
103.		Gulu			
104.		Kagu	Au As	pyrite arsenopyrite stibnite realgar orpiment cinnabar	Quartz calcite fluorite
105.		Gu'i g g			
106.		Laotiechang			
107.		Panghe			
108.		Pangjiahe			
109.		Bancanggou			
110.		Daqiao			
111.		Jiucaigou			
112.		Linxiang			

Appendix I-4. Host rocks of Chinese Carlin-type gold deposits

No.	Record Number	Site for sort	Host rock type	Unit name	Unit age
1.	RE00759	Lannigou	thin to medium sandstone, siltstone and interlayered clay rocks	Bianyang	M. Triassic
2.	RE00760	Dongbeizhai	carbonaceous silty slate, carbonaceous slate interlayered sandstone	Duxinqiao	L. Triassic
3.	RE00761	Baguamiao	carbonate rocks silty sericite phyllite	Gudaoling Xinghuongpu	 M. Devonian
4.	RE00762	Jinyia	medium to thick silty mudstone interlayered argillaceous siltstone	Baifang	M. Triassic
5.	RE00763	Liba	silty phyllite, siltstone and phyllite	Shujiaba	M. Devonian
6.	RE00764	Shuangwang	calcareous sandstone siltstone interlayered limestone, medium to thick limestone interlayered calcareous slate siltstone interlayered argillic limestone, limestone. argillic limestone interlayered slate siltstone slate argillic limestone interlayered slate	Gudaoling Xinghuongpu Jiuliping	M. Devonian L. Devonian L. Devonian
7.	RE00765	Laerma	Carbonaceous argillic slate carbonaceous siliceous rocks carbonaceous silty slate chert carbonaceous argillic slate. medium to thin black carbonaceous siliceous slate carbonaceous silicalite interlayered thin hematite layer silty slate with pyrite and sericite, chert	Edu Yaxiang	 E. Cambrian
8.	RE00766	Pingding	tuffaceous slate, carbonaceous slate, biostromic limestone, argillic dolomite	Xiawuna	M. Devonian
9.	RE00767	Jinlongshan	medium to thick ferruginous and calcareous quartz sandstone. sandstone, siltstone, shale, biolimestone and biogenetic clastic rocks. calcareous shale, calcareous siltstone. thin limestone interlayered calcareous shale ,chert and siltstone	Dafanggou Yanglinggou Nanyangshan Yuanjiagou	M. Devonian L. Devonian E. Cambrian
10.	RE00768	Changkeng	thick limestone siltstone interlayered shale, calcareous siltstone and thin limestone argillaceous limestone, breccia limestone with bioclastic carbonaceous shale, shale, siltstone	Shichengzi Ceshui Xinmengiao Xiaoping	E. Cambrian M. Cambrian L. Triassic
11.	RE00769	Dachang	conglomerate (Basalt, limestone), silicalite, breccia silicalite, breccia clay rocks, tuffaceous clay rocks	Dachang	L. Permian
12.	RE00770	Zimudang	siltstone, argillic limestone, bioclastic limestone, oolitic limestone	Yelang	E. Triassic
13.	W700366	Yata	argillaceous limestone and interlayered shale, arkose, turbidite sandstone	Xinyuan	M. Triassic
14.	W700367	Getang	basal karst carbonate breccia	Longtan	L. Permian
15.	W700368	Sanchahe	sandy shales containing thin coal beds, argillaceous carbonates, arkosic shales	Longtan & Changxing	L. Permian
16.	W700369	Ceyang	arkosic shales	Xinyuan	M. Triassic
17.	W700370	Banqi	limestone reef limestone fine clastic rock clay rock		E. Permian & E. Triassic
18.	RE00771.	Badun	silty slate interlayered dolomitic limestone		Triassic
19.	RE00772.	Chabu	argillic limestone interlayered silty slate, carbonaceous slate	Xiawuna & Gudaoling	M. Devonian
20.	RE00773.	Dashui	silty slate interlayered dolomitic limestone		Triassic
21.	RE00774.	Gejiebisu	silty slate interlayered dolomitic limestone		Triassic
22.	RE00775.	Heduosi	argillic limestone interlayered silty slate, carbonaceous slate	Xiawuna & Gudaoling	M. Devonian
23.	RE00776.	Jinshan	phyllite silty slate	Xihanshui	M. Devonian
24.	RE00777.	Jiuyuan	argillic limestone interlayered silty slate, carbonaceous slate	Xiawuna & Gudaoling	M. Devonian
25.	RE00778.	Kama	argillic limestone interlayered silty slate, carbonaceous slate	Xiawuna & Gudaoling	M. Devonian
26.	RE00779.	Lazikuo	carbonate rocks interlayered clastic rocks	Xiawuna & Gudaoling	M. Devonian
27.	RE00780.	Lianhecun	silty slate interlayered dolomitic limestone		Triassic
28.	RE00781.	Maquan	spotted slate		
29.	RE00782.	Qingkeyan	argillic limestone interlayered silty slate, carbonaceous slate	Xiawuna &Gudaoling	M. Devonian
30.	RE00783.	Quongme	carbonaceous-siliceous mudstone interlayered siltstone	Taiyangding	Cambrian
31.	RE00784.	Sanrengou	silty phyllite spotted phyllite metamorphic-sandstone		Carboniferous
32.	RE00785.	Shijiba	silty slate interlayered dolomitic limestone		Triassic
33.	RE00786.	Yaerma	argillic limestone interlayered silty slate, carbonaceous slate	Xiawuna &Gudaoling	M. Devonian
34.	RE00787.	Yiaxiang	argillic limestone interlayered silty slate, carbonaceous slate	Xiawuna &Gudaoling	M. Devonian
35.	RE00788.	Zhuongqu	silty slate interlayered dolomitic limestone		Triassic
36.	RE00789.	Damingshan	thin argillite, argillaceous siltstone tuff	Baifeng	M. Triassic
37.	RE00790.	Gaolong	siltstone & clay rocks (70%) sandstone (10%) carbonate rock(20%)		
38.	RE00791.	Longhue			
39.	RE00792.	Longna	clay rocks siltstone argillic limestone	Bianyang	M. Devonian
40.	RE00793.	Maxuong	clay rocks limestone sandstone	Yilan	E. Devonian
41.	RE00794.	Peyian	clay rocks limestone sandstone	Yilan	E. Devonian
42.	RE00795.	Puzilong	siltstone clay rocks bioclastic limestone	Yelang	E. Triassic
43.	RE00796.	Zheyi	clay rocks limestone sandstone	Yilan	E. Devonian

44.	RE00797.	Baidi			
45.	RE00798.	Bannian	limestone clay rocks tuff	Louluo	E. Triassic
46.	RE00799.	Beiyinpe	clay rocks argillic limestone siltstone	Peduan	M. Triassic
47.	RE00800.	Daguan	clastic & carbonate rocks	Louluo & Ziyun	E. Triassic
48.	RE00801.	Dayakou	clastic & carbonate rocks	Longtan	L. Permian
49.	RE00802.	Loudong	clay rocks argillic limestone siltstone	Xinyuan	M. Triassic
50.	RE00803.	Lubuge	clay rocks conglomerate siltstone	Xinyuan	M. Triassic
51.	RE00804.	Miaolong	streaked limestone argillic limestone	Sandu	
52.	RE00805.	Nipu	clastic & carbonate rocks	Longtan	L. Permian
53.	RE00806.	Pegao	clay rocks argillic limestone siltstone	Xinyuan	M. Triassic
54.	RE00807.	Qingping	limestone clay rocks tuff	Louluo	E. Triassic
55.	RE00808.	Shaziling	siliceous clay rocks basaltic siltstone silty dolomitite	Dachang	E. Triassic
56.	RE00809.	Sixiangchang	thin bedding argillic limestone argillic sandstone mudstone streaked limestone		L. Cambrian
57.	RE00810.	Tangxinzhai	limestone clay rocks tuff	Louluo	E. Triassic
58.	RE00811.	Wangme	siltstone clay rocks	Ziyun	M. Triassic
59.	RE00812.	Weihuai	sandstone siltstone clay rocks argillic limestone	Bianyang	M. Triassic
60.	RE00813.	Xuongwu	tuffaceous clay rocks breccia jasperoid	Dachang	L. Permian
61.	RE00814.	Yangyou	clastic & carbonate rocks	Qixia	E. Permian
62.	RE00815.	Huameinao	sandstone shale (Puqi group), marble (Daye group)		Triassic
63.	RE00816.	Jiguanzui	medium to thick dolomitic limestone, limestone, dolostone; Fengshandong granodiorite	Daye formation	E. Triassic
64.	RE00817.	Jilongshan	medium to thick dolomitic limestone, limestone, dolostone; Fengshandong granodiorite	Daye formation	E. Triassic
65.	RE00818.	Tuongkangling	sandstone shale (Puqi group), marble (Daye group)		Triassic
66.	RE00819.	Yangjishan	breccia body formed by hydrothermal explosion in Daye formation		
67.	RE00820.	Zhanghai	bioclastic shales, silty-fine sandstone streaked shales, silty argillite	Gaojiabian & Fentou	E~M. Silurian
68.	RE00821.	Gaojiaao	quartz sandstone siltstone silty argillite	Banshan	M. Devonian
69.	RE00822.	Gutaishan	siltstone argillite siliceous rocks dolomitite		
70.	RE00823.	Lon shan	siltstone ar illite siliceous rocks dolomitite		
71.	RE00824.	Mobing	argillite slate siltstone		
72.	RE00825.	Shixia	limestone argillaceous limestone		L. Devonian
73.	RE00826.	Woxi	argillite slate siltstone		
74.	RE00827.	Maoling	sericitic phyllite, sericite-chlorite-phyllite, banded silicalite	Gaixian & Yushulazi	Proterozoic
75.	RE00828.	Ertaizi	dolomitic limestone marble slate		M. Devonian
76.	RE00829.	Lijiagou	siltstone argillite siliceous rocks dolomitite		
77.	RE00830.	Qilixia	thin limestone calcareous shales thick limestone, chert limestone siltstone	Yuanjiagou	E. carboniferous
78.	RE00831.	Qiuling	ferriferous-calcareous quartz sandstone, thick limestone, siltstone shales	Dafenggou & Yangling	L. Triassic
79.	RE00832.	Yaojian	medium to thick ferruginous and calcareous quartz sandstone.	Dafanggou Yanglinggou	M. Devonian
			sandstone, siltstone, shale, biolimestone and biogenetic clastic rocks.	Nanyangshan	L. Devonian
			calcareous shale, calcareous siltstone.	Yuanjiagou	E. Cambrian
			thin limestone interlayered calcareous shale ,chert and siltstone		
80.	RE00833.	Baxi	silty slate interlayered dolomitic limestone		Triassic
81.	RE00834.	Gala	siliceous slate, silicalite sandstone diabase dikes	Niange	L. Triassic
82.	RE00835.	Huayuangou	silty slate interlayered dolomitic limestone		Triassic
83.	RE00836.	Jiawuchi	silty slate interlayered dolomitic limestone		Triassic
84.	RE00837.	Mahuanggou	Carbonate rocks (L. Cambrian) & clastic rocks (Triassic)		
85.	RE00838.	Manaoke	silty slate interlayered dolomitic limestone		Triassic
86.	RE00839.	Qiaoqiaoshang	calcareous siltstone		L. Triassic
87.	RE00840.	Qilicun	silty slate interlayered dolomitic limestone		Triassic
88.	RE00841.	Quluopunongba	siliceous slate, silicalite sandstone diabase dikes	Niange	L. Triassic
89.	RE00842.	Shuishengou	silty slate interlayered dolomitic limestone		Triassic
90.	RE00843.	Tuanjie	silty slate interlayered dolomitic limestone		Triassic
91.	RE00844.	Zhepeshan	volcanic clastic rocks & land-derived clastic rocks		Triassic
92.	RE00845.	Beiya	carbonate & syenitic rocks		Triassic
93.	RE00846.	Gedang	clay rocks limestone sandstone	Yilan	E. Devonian
94.	RE00847.	Jinchang	quartzite meta-arenite slate	Jinchang	
95.	RE00848.	Tangshang	siltstone clay rocks limestone	Xinyuan	Triassic
96.	RE00849.	Zacuen			
97.		Zaorendao	contact zone of Triassic formation & granodiorite porphyry		Triassic & Permian
98.		Jiaoguan	clastic & carbonate rocks	Maokou	E. Permian
99.		Jiaoman			
100.		Longchang	clastic & carbonate rocks	Longtan	L. Permian
101.		Zhutong			
102.		Danzhai			
103.		Gulu			
104.		Kagu	clay rocks limestone sandstone	Yilan	E. Devonian
105.		Gu'i	y		
106.		Laotiechang			
107.		Panghe			
108.		Pangjiahe			
109.		Bancanggou			
110.		Daqiao			
111.		Jiucaigou			
112.		Linxiang			

Appendix I-5. Tectonic setting of Chinese Carlin-type gold deposits

No.	Record Number	Site for sort	Tectonic setting	Regional trends
1.	RE00759	Lannigou	southwest margin of Precambrian Yangtze craton	east wing of Laizi mountain short-axial anticline, southwest of the Banchang thrust trending northwest
2.	RE00760	Dongbeizhai	west margin of Yangtze craton	near the intersection of west Qinling thrust folds belts trending west-east and Minjiang thrust folds belts
3.	RE00761	Baguamiao	south of Qinling transform zone	Sujiagou-Kuonggua multiple syncline, with tight folds and faults trending northwest
4.	RE00762	Jinyia	southwest margin of Yangtze craton	slope zone of Lingyun dome uplift, northeast of fault valley; A series of folds go along with faults trending north-south
5.	RE00763	Liba	west Qinling transform zone	intersection of rifts, which were produced ether by moving of ground blocks or igneous intrusions
6.	RE00764	Shuangwang	west Qinling transform zone	Fengxian-Zhenan suborder fold in late Mesozoic age include Yuanbazi multiple syncline, Xiba multiple anticline and Xinghuongpu-Sangba multiple syncline. The breccia zone, which hosted deposit, is located at north wing of Xiba multiple syncline
7.	RE00765	Laerma	west Qinling transform zone	faults zone trending east to west are main ore control structure in Maqu-Diebu thrust
8.	RE00766	Pingding	west Qinling transform zone	north wing of Bailongjiang multiple anticline, which belongs to a sub-zone of western Qinling fold system. Deposit occurs in Jiuyuan-Pingding syncline
9.	RE00767	Jinlongshan	west Qinling transform zone	a series of folds and faults which trend east-west
10.	RE00768	Changkeng	southwest margin of Yangtze craton & Hunan fold system	Sanzhou basin is located at intersection of Enping-Cong faults zone, trending northeast, and Gaoyiao-Huilai faults zone, trending east-west
11.	RE00769	Dachang	southwest margin of Yangtze craton	two graben faults in this area trend northeast and northwest
12.	RE00770	Zimudang	southwest margin of Yangtze craton & Huanan fold system	by influence and control from late Mesozoic tectonic activity, Faults and folds in this area trend as northeast, northwest and east-west. They overlapped or intersected each other so that more short-axial anticlines were developed on craton area, while more strong compression zone in basin area.
13.	W700366	Yata	near buried southwestern margin of Precambrian Yangtze craton	gentile to locally moderately tight folds, sometime with high-angle faults, trend generally east-west
14.	W700367	Getang	near buried southwestern margin of Precambrian Yangtze craton	deposit located on eastern limb of Getang dome, a northwest-trending anticline about 50 km long; Permian rocks exposed at center of dome
15.	W700368	Sanchahe	near buried southwestern margin of Precambrian Yangtze craton	deposit located along crest of 40 km long NW-trending anticline that exposes Permian strata in center
16.	W700369	Ceyang	near buried southwestern margin of Precambrian Yangtze craton	at southern end of 30 km-long Lugong anticline, which exposed Permian rocks along crest; Axis of anticline trends north-south, parallel to margin of Yangtze craton and to strike of faces changes
17.	W700370	Banqi	near buried southwestern margin of Precambrian Yangtze craton	along southern edge of small (15-km-long) east-west trending dome that has Permian Houziguan limestone exposed in center
18.	RE00771.	Badun	western Qinling transform zone	Nanping-Maqu gold belt, trending northwest and 200 km long, consists of three suborder thrust zones. Its major body is Baxi multiple-syncline which is made up of Triassic clastic and carbonate rocks.
19.	RE00772.	Chabu	western Qinling transform zone	Bailongjiang gold belt is about 160 ~ 200 km long and trends east to west. It is distributed along with Bailongjiang thrust zone. Gold mineralization occurs in a black formations of Cambrian and Devonian
20.	RE00773.	Dashui	western Qinling transform zone	Nanping-Maqu gold belt, trending northwest and 200 km long, consists of three suborder thrust zones. Its major body is Baxi multiple-syncline which is made up of Triassic clastic and carbonate rocks.
21.	RE00774.	Gejiebisu	western Qinling transform zone	Nanping-Maqu gold belt, trending northwest and 200 km long, consists of three suborder thrust zones. Its major body is Baxi multiple-syncline which is made up of Triassic clastic and carbonate rocks.
22.	RE00775.	Heduosi	western Qinling transform zone	Bailongjiang gold belt is about 160 ~ 200 km long and trends east to west. It is distributed along with Bailongjiang thrust zone. Gold mineralization occurs in a black formations of Cambrian and Devonian
23.	RE00776.	Jinshan	west Qinling transform zone	located at south of Zhongchuan granite, *in* Wujiazhuang outfold
24.	RE00777.	Jiuyuan	western Qinling transform zone	Bailongjiang gold belt is about 160 ~ 200 km long and trends east to west. It is distributed along with Bailongjiang thrust zone. Gold mineralization occurs in a black formations of Cambrian and Devonian
25.	RE00778.	Kama	western Qinling transform zone	Bailongjiang gold belt is about 160 ~ 200 km long and trends east to west. It is distributed along with Bailongjiang thrust zone. Gold mineralization occurs in a black formations of Cambrian and Devonian
26.	RE00779.	Lazikuo	western Qinling transform zone	Bailongjiang gold belt is about 160 ~ 200 km long and trends east to west. It is distributed along with Bailongjiang thrust zone. Gold mineralization occurs in a black formations of Cambrian and Devonian.

27.	RE00780.	Lianhecun	western Qinling transform zone	Nanping-Maqu gold belt, trending northwest and 200 km long, consists of three suborder thrust zones. Its major body is Baxi multiple-syncline which is made up of Triassic clastic and carbonate rocks.
28.	RE00781.	Maquan	west Qinling transform zone	located at south of Zhongchuan granite, *in* Wujiazhuang outfold
29.	RE00782.	Qingkeyan	western Qinling transform zone	Bailongjiang gold belt is about 160 ~ 200 km long and trends east to west. It is distributed along with Bailongjiang thrust zone. Gold mineralization occurs in a black formations of Cambrian and Devonian
30.	RE00783.	Quongme	western Qinling transform zone	Bailongjiang gold belt is about 160 ~ 200 km long and trends east to west. It is distributed along with Bailongjiang thrust zone. Gold mineralization occurs in a black formations of Cambrian and Devonian
31.	RE00784.	Sanrengou	western Qinling transform zone	near Liba gold deposit
32.	RE00785.	Shijiba	western Qinling transform zone	Nanping-Maqu gold belt, trending northwest and 200 km long, consists of three suborder thrust zones. Its major body is Baxi multiple-syncline which is made up of Triassic clastic and carbonate rocks.
33.	RE00786.	Yaerma	western Qinling transform zone	Bailongjiang gold belt is about 160 ~ 200 km long and trends east to west. It is distributed along with Bailongjiang thrust zone. Gold mineralization occurs in a black formations of Cambrian and Devonian
34.	RE00787.	Yiaxiang	western Qinling transform zone	Bailongjiang gold belt is about 160 ~ 200 km long and trends east to west. It is distributed along with Bailongjiang thrust zone. Gold mineralization occurs in black formations of Cambrian and Devonian
35.	RE00788.	Zhuongqu	western Qinling transform zone	Nanping-Maqu gold belt, trending northwest and 200 km long, consists of three suborder thrust zones. Its major body is Baxi multiple-syncline which is made up of Triassic clastic and carbonate rocks.
36.	RE00789.	Damingshan	Dian-Qian-Gui district is located near buried southwestern margin of Precambrian Yangtze craton, among Kangdian, Yuebei and Jiangnan old lands	Youjiang rift valley, which trends northwest, is a regional ore-control structure in Dian-Qian-Gui area. With the development of Youjiang rift valley, ore-bearing formations, which are made up of alternative phases of shallow sea and land such as clastic, carbonate and tholeitic volcanic rocks, was formed on northwestern of the area at early; while clastic and clay rocks, which was formed in deep sea at later stage, are distributed on southeastern this area. Different geochemical features are recognized in Carlin-type gold deposits which occur both in northwest and southeast Dian-Qian-Gui area.
37.	RE00790.	Gaolong	Same as RE00789	Same as RE00789
38.	RE00791.	Longhue	Same as RE00789	Same as RE00789
39.	RE00792.	Longna	Same as RE00789	Same as RE00789
40.	RE00793.	Maxuong	Same as RE00789	Same as RE00789
41.	RE00794.	Peyian	Same as RE00789	Same as RE00789
42.	RE00795.	Puzilong	Same as RE00789	controlled by Huijiapu anticline which trend east to west
43.	RE00796.	Zheyi	Same as RE00789	Same as RE00789
44.	RE00797.	Baidi	Same as RE00789	Same as RE00789
45.	RE00798.	Bannian	Same as RE00789	at south of Laizishan short axial anticline
46.	RE00799.	Beiyinpe	Same as RE00789	controlled by Huijiapu anticline which trend east to west
47.	RE00800.	Daguan	Same as RE00789	Same as RE00789
48.	RE00801.	Dayakou	Same as RE00789	Same as RE00789
49.	RE00802.	Loudong	Same as RE00789	at north of Laizishan short axial anticline
50.	RE00803.	Lubu e g	Same as RE00789	Same as RE00789
51.	RE00804.	Miaolong	southwest margin of Yangtze craton	Sandu-Danzhai gold belt trending north to south
52.	RE00805.	Nipu	Same as RE00789	Same as RE00789
53.	RE00806.	Pegao	Same as RE00789	on Laizishan short axial anticline
54.	RE00807.	Qingping	Same as RE00789	on north of Laizishan short axial anticline
55.	RE00808.	Shazilin g	Same as RE00789	Same as RE00789
56.	RE00809.	Sixiangchang	southwest margin of Yangtze craton	Sandu-Danzhai gold belt trending north to south
57.	RE00810.	Tangxinzhai	Same as RE00789	on north of Laizishan short axial anticline
58.	RE00811.	Wangme	Same as RE00789	Same as RE00789
59.	RE00812.	Weihuai	Same as RE00789	at southeast of Laizishan short axial anticline
60.	RE00813.	Xuongwu	Same as RE00789	Same as RE00789
61.	RE00814.	Yangyou	Same as RE00789	on Laizishan short axial anticline
62.	RE00815.	Huameinao	intersection of Tanlu rift and Huaiyang folds, Yangtze craton	tight close folds trending east-west were cut by igneous intrusion
63.	RE00816.	Jiguanzui	intersection of Tanlu rift and Huaiyang folds, Yangtze craton	tight close folds trending east-west were cut by igneous intrusion
64.	RE00817.	Jilongshan	intersection of Tanlu rift and Huaiyang folds, Yangtze craton	tight close folds trending east-west were cut by igneous intrusion
65.	RE00818.	Tuongkangling	intersection of Tanlu rift and Huaiyang folds, Yangtze craton	tight close folds trending east-west were cut by igneous intrusion
66.	RE00819.	Yangjishan	intersection of Tanlu rift and Huaiyang folds, Yangtze craton	tight close folds trending east-west were cut by igneous intrusion
67.	RE00820.	Zhanghai	intersection of Tanlu rift and Huaiyang folds, Yangtze craton	tight close folds trending east-west were cut by igneous intrusion
68.	RE00821.	Gaojiaao	intersection of Baimashan-Longshan magma-structural zone and Taojiang-Chengbu rift in Yangtze craton	Lianhuazhai-Baiyunchuong dome formed by fault is major structure in the orefield, which trends northwest. Two sets of fault trending northeast and northwest are relative to gold deposit

69.	RE00822.	Gutaishan	margin of Yangtze craton	located in Proterozoic and Sinian silty argillite, sericite slate and siltstone
70.	RE00823.	Longshan	margin of Yangtze craton	located in Proterozoic and Sinian silty argillite, sericite slate and siltstone
71.	RE00824.	Mobing	margin of Yangtze craton	located in Proterozoic and Sinian silty argillite, sericite slate and siltstone
72.	RE00825.	Shixia		
73.	RE00826.	Woxi	margin of Yangtze craton	located in Proterozoic and Sinian silty argillite, sericite slate and siltstone
74.	RE00827.	Maoling	Huabei craton (or north China platform)	Yinkao-Kuandian subprovince near boundary with Fuzhao Subprovince of north China platform. the area is mostly underlain by Proterozoic sedimentary rocks and Mesozoic granites
75.	RE00828.	Ertaizi	west Qinling transform zone	deposit is on south of a multiple anticline, controlled by intersection of two sets of fault trending east-West and northeast
76.	RE00829.	Lijiagou	middle of Qinling transform zone	intersection of Qinling fold system and Lingtan-Shanyang fault. Devonian formation that is composed of slate, metamorphic siltstone and carbonate rocks is predominant in the area
77.	RE00830.	Qilixia	west Qinling transform zone	a series of folds and faults which trend east-west
78.	RE00831.	Qiuling	west Qinling transform zone	a series of folds and faults which trend east-west
79.	RE00832.	Yaojian	west Qinling transform zone	a series of folds and faults which trend east-west
80.	RE00833.	Baxi	western Qinling transform zone	Nanping-Maqu gold belt, trending northwest and 200 km long, consists of three suborder thrust zones. Its major body is Baxi multiple-syncline which is made up of Triassic clastic and carbonate rocks.
81.	RE00834.	Gala	west margin of Yangtze craton	Ganzi-Xianshuihe gold belt trending northwest
82.	RE00835.	Huayuangou	western Qinling transform zone	Nanping-Maqu gold belt, trending northwest and 200 km long, consists of three suborder thrust zones. Its major body is Baxi multiple-syncline which is made up of Triassic clastic and carbonate rocks.
83.	RE00836.	Jiawuchi	western Qinling transform zone	Nanping-Maqu gold belt, trending northwest and 200 km long, consists of three suborder thrust zones. Its major body is Baxi multiple-syncline which is made up of Triassic clastic and carbonate rocks.
84.	RE00837.	Mahuanggou	north margin of Yangtze craton	Houlongmenshan gold belt goes along the thrust and trends northeast. carbonate formation of Paleozoic exposed at southeast side and clastic formation of Triassic at northwest.
85.	RE00838.	Manaoke	western Qinling transform zone	Nanping-Maqu gold belt, trending northwest and 200 km long, consists of three suborder thrust zones. Its major body is Baxi multiple-syncline which is made up of Triassic clastic and carbonate rocks.
86.	RE00839.	Qiaoqiaoshang	west margin of Yangtze craton	Xueshan gold belt is composed of carbonate formation
87.	RE00840.	Qilicun	western Qinling transform zone	Nanping-Maqu gold belt, trending northwest and 200 km long, consists of three suborder thrust zones. Its major body is Baxi multiple-syncline which is made up of Triassic clastic and carbonate rocks.
88.	RE00841.	Quluopunongba	west margin of Yangtze craton	Ganzi-Xianshuihe gold belt trending northwest
89.	RE00842.	Shuishengou	western Qinling transform zone	Nanping-Maqu gold belt, trending northwest and 200 km long, consists of three suborder thrust zones. Its major body is Baxi multiple-syncline which is made up of Triassic clastic and carbonate rocks.
90.	RE00843.	Tuanjie	western Qinling transform zone	Nanping-Maqu gold belt, trending northwest and 200 km long, consists of three suborder thrust zones. Its major body is Baxi multiple-syncline which is made up of Triassic clastic and carbonate rocks.
91.	RE00844.	Zhepeshan	north margin of Yangtze craton	Minjiang gold belt, 120 to 140 km long and trending north to south, is composed of a series of thrusts
92.	RE00845.	Beiya	Ailao mountain low pressure metamorphic belt	Jinchang gold lode zone trending north-south is found at west of the ultrbasic intrusions
93.	RE00846.	Gedang		
94.	RE00847.	Jinchang	Ailao mountain low pressure metamorphic belt	Jinchang gold lode zone trending north-south is found at west of the ultrbasic intrusions
95.	RE00848.	Tangshang	Same as RE00789	Same as RE00789
96.	RE00849.	Zacuen		
97.		Zaorendao		
98.		Jiaoguan		
99.		Jiaoman		
100.		Longchang		
101.		Zhutong		
102.		Danzhai		
103.		Gulu		
104.		Kagu		
105.		Guji		
106.		Laotiechang		
107.		Panghe		
108.		Pangjiahe		
109.		Bancanggou		
110.		Daqiao		
111.		Jiucaigou		
112.		Linxiang		

Appendix I-6. Ore control and Alteration of Chinese Carlin-type gold deposits

No.	Record Number	Site for sort	Ore control	Alteration
1.	RE00759	Lannigou	breccia alteration zone of fault at Laizi short-axial anticline	silicification carbonatization
2.	RE00760	Dongbeizhai	orebodies occur in breccia zone of F1 thrust footwall trending north-south	silicification carbonatization pyritization
3.	RE00761	Baguamiao	breccia zones parallel to the axis of folds	silicification sericitization
4.	RE00762	Jinyia	breccia zones in Baifeng formation	carbonatization chloritization argillization s
5.	RE00763	Liba	Twenty fault breccia zones are ore-control structures. Of these, a branch fault of Lixian-Luoba-Soulongkou rift trending northwest is main ore-control fault in this area.	silicification carbonatization pyritization arg
6.	RE00764	Shuangwang	Shuangwang gold breccia zone is made up of 8 breccia bodies, overall strike is N70W to N50W and 11.5 km long. The breccia bodies occur as lenticular dip 50 ~ 80 degree to northeast. Some of them dip 81 ~ 87 degree to southwest. Breccias are composed of mixed rocks, which are cemented by albite, ankerite and calcite as well as small amounts of quartz veins.	albitization dolomitization silicification
7.	RE00765	Laerma	Edu syncline and anticline are host structure. Rifts in regional are main channel of hydrothermal fluid.	silicification
8.	RE00766	Pingding	Suborder faults trending east-west intersected with main fault as " Y" pattern, which control the orebodies.	silicification carbonatization
9.	RE00767	Jinlongshan	strong compression plastic deformed zones were distributed on the core as well as wings of anticlines.	silicification carbonatization
10.	RE00768	Changkeng	A gentle dipped detachment normal fault between carboniferous formation and Triassic formation. The fault breccia zone is > 10 meter wide and about 10 km long, and dips southeast.	silicification argillization
11.	RE00769	Dachang		
12.	RE00770	Zimudang	F1 is main ore-control structure, which is more than 2000 meters long, extention in dip is more than 600 meters, dips 25 ~ 30 degree to south above 1380 m elevation, while dips 0 ~ 15 degree below 1380m	silicification carbonatization
13.	W700366	Yata	orebodies located by steeply dipping east-trending faults; gold is disseminated into wallrocks	intense silicification, minerals predominantl kaolinite
14.	W700367	Getang	gold concentrated as dissemination in basal breccia horizon, also occurs with limonite in oxidized rocks	silicification; gold content of ore increase w of silicification
15.	W700368	Sanchahe	mineralization and wall rock alteration is principally in vicinity of faults	wall rock alteration
16.	W700369	Ceyang	orebodies in silicified and pyritized zone at intersection of arkosic shales and northeast-trending faults	silicification pyritization
17.	W700370	Banqi	unconformable surface	silicification argillization stibnitization carbc
18.	RE00771.	Badun		
19.	RE00772.	Chabu		
20.	RE00773.	Dashui		
21.	RE00774.	Gejiebisu		
22.	RE00775.	Heduosi		
23.	RE00776.	Jinshan		
24.	RE00777.	Jiuyuan		
25.	RE00778.	Kama		
26.	RE00779.	Lazikuo		
27.	RE00780.	Lianhecun		
28.	RE00781.	Maquan		
29.	RE00782.	Qingkeyan		
30.	RE00783.	Quongme		
31.	RE00784.	Sanrengou		
32.	RE00785.	Shijiba		
33.	RE00786.	Yaerma		
34.	RE00787.	Yiaxiang		
35.	RE00788.	Zhuongm		
36.	RE00789.	Damingshan		
37.	RE00790.	Gaolong		

38.	RE00791.	Longhue		
39.	RE00792.	Longna	Nanpanjiang dome	
40.	RE00793.	Maxuong		
41.	RE00794.	Peyian		
42.	RE00795.	Puzilong	faults trending east-west is at near axial of Huijiapu anticline	silicification pyritization argillization carbon
43.	RE00796.	Zheyi		
44.	RE00797.	Baidi		
45.	RE00798.	Bannian		
46.	RE00799.	Beiyinpe	faults trending east-west is at near axial of Huijiapu anticline	silicification pyritization argillization carbon
47.	RE00800.	Daguan	Nanpanjiang dome	
48.	RE00801.	Dayakou		
49.	RE00802.	Loudong		
50.	RE00803.	Lubu e g		
51.	RE00804.	Miaolong	four sets of fault compressive zone trending NS, EW, NW and NE, occur in a multiple-fold which consists of Paixiang, Miaolong and Wazhai synclines and trend north to south	silicification pyritization carbonatization bai stibnitization
52.	RE00805.	Nipu		
53.	RE00806.	Pegao		
54.	RE00807.	Qingping		
55.	RE00808.	Shaziling	Qinglong dome	
56.	RE00809.	Sixiangchang	high angle faults trending NNE, at east wing of Zhushachang-Duimenzhai syncline	silicification pyritization carbonatization dolomitization
57.	RE00810.	Tangxinzhai		
58.	RE00811.	Wangme		
59.	RE00812.	Weihuai		
60.	RE00813.	Xuon gi		
61.	RE00814.	Yangyou		
62.	RE00815.	Huameinao	on north wing of Xiaojiapu anticline	silicification pyritization
63.	RE00816.	Jiguanzui	margin of Yangxin intrusion with carbonate rocks	skarn
64.	RE00817.	Jilongshan	contact zone of carbonate and intrusion & breccia structures	skarn & mesothermal alteration
65.	RE00818.	Tuongkangling	west part of Yinzu outfold	silicification pyritization
66.	RE00819.	Yangjishan	hydrothermal brecciation structure	mesothermal brecciation
67.	RE00820.	Zhanghai	south wing of Yinzu outfold	silicification pyritization
68.	RE00821.	Gaojiaao	faults trending N70W ~N30W, 800 m long and n ~ 30 m wide	silicification pyritization baritization
69.	RE00822.	Gutaishan		
70.	RE00823.	Longshan		
71.	RE00824.	Mobing		
72.	RE00825.	Shixia	breccia zone in beds	silicification pyritization carbonatization or realgar mineralization
73.	RE00826.	Woxi		
74.	RE00827.	Maoling	two high angle faults & ductile shear zone trending NNW	silicification sericitization pyrrhotitization b chloritization carbnatization
75.	RE00828.	Ertaizi	breccia zone at west Dingjiashan-Majiagou Au-Hg-Sb belt	silicification pyritization albitization carbon
76.	RE00829.	Lijiagou		
77.	RE00830.	Qilixia	strong compressive deformation zone(Qiuling anticline)	jasperoid carbonatization
78.	RE00831.	Qiuling	strong compressive deformation zone(Qiuling anticline)	jasperoid carbonatization
79.	RE00832.	Yaojian	strong compressive deformation zone(Qiuling anticline)	jasperoid carbonatization
80.	RE00833.	Baxi		
81.	RE00834.	Gala	Qiulou fault zone trending NW or NNW	silicification chloritization carbonatization a
82.	RE00835.	Huayuangou		
83.	RE00836.	Jiawuchi		
84.	RE00837.	Mahuanggou		
85.	RE00838.	Manaoke		
86.	RE00839.	Qiaoqiaoshang		
87.	RE00840.	Qilicun		
88.	RE00841.	Quluopunongba	Qiulou fault zone trending NW or NNW	silicification chloritization carbonatization a
89.	RE00842.	Shuishengou		
90.	RE00843.	Tuanjie		
91.	RE00844.	Zhepeshan		
92.	RE00845.	Beiya	contact zone of carbonate rocks and syenitic intrusion	

93.	RE00846.	Gedang		
94.	RE00847.	Jinchang	contact zone between ultrbasic rock and sedimentary rocks	silicification pyritization
95.	RE00848.	Tangshang		
96.	RE00849.	Zacuen		
97.		Zaorendao		
98.		Jiaoguan		
99.		Jiaoman		
100.		Longchang		
101.		Zhutong		
102.		Danzhai		
103.		Gulu		
104.		Kagu		
105.		Guji		
106.		Laotiechang		
107.		Panghe		
108.		Pangjiahe		
109.		Bancanggou		
110.		Daqiao		
111.		Jiucaigou		
112.		Linxian		

Appendix II

MRDS RECORDS OF SELECTED CHINESE CARLIN-TYPE GOLD DEPOSITS

Mineral Resources Data System (MRDS)

Report Title	CHINA - Carbonated Hosted AU-AG		
Issue Date	00/00/00	*Number*	In Set of 1
Current Date	Thursday, April 10, 1997 — *Current Time* 14:30:48	*Printed*	1 of 1

Record Number	RE00759	*User Field*	
Record Type	Site	*File Link ID*	
Reporter	ZHIPING LI, S. G. PETERS		
Reporter Affiliation	USGS	*Report Date*	96 01
Site Name	LANNIGOU		

-- Location Information --

District Name	DIAN-QIAN-GUI		
Country	CHINA	*Country Code*	CH
State	GUIZHOU	*State Code*	GZ
County	ZHENFENG		
Physiographic Prov	04INTERIOR HIGHLANDS		
Latitude	25-21-00N	*Decimal Lat*	25.35
Longitude	105-41-24E	*Decimal Long*	105.99
Accuracy	EST		
Position	NORTHEAST OF ZHENFENG COUNTY TOWN		

-- Commodity Information --

Commodity Type	Metallic
Commodities	AU AS HG SB C S
Major	AU
Minor	AS HG SB C S
Ore Materials	PYRITE, ARSENOPYRITE, ORPIMENT, REALGAR
Non-Ore Materials	QUARTZ, CLAY MINERALS, CARBONATE MINERALS
Analytical Data	AU, 4.01 - 11.01 PPM; AVERAGE 7.01PPM

-- Geology --

Tectonic Setting	SOUTHWEST MARGIN OF PRECAMBRIAN YANGTZ CRATON
Regional Trends	EAST WING OF LAIZI MOUNTAIN SHORT-AXIS ANTICLINE, SOUTHWEST OF THE BANCHANG THRUST TRENDING NORTHWEST
Local Structure	NORTH-SOUTH TRENDING STRUCTURE IS DEVELOPED IN WEST OF THE ORE FIELD, WHILE NORTHWEST TRENDING STRUCTURE IN EAST
Alteration	SILICIFICATION, CARBONATIZATION
Ore Control	BRECCIA ALTERATION ZONE OF FAULTS
Age Mineralization	L CRET MES (82.9 MA)
Host Rock Type	SANDSTONE
Host Rock Age	M TRI MES

Host Rock Type Name	Age	Host Rock Unit Name	Age
THIN TO MEDIUM THICKNESS SANDSTONE, SILTSTONE AND INTERLAYERED CLAY ROCKS	MIDDLE TRIASSIC	BIANYANG FORMATION	

Geology Comm CLASTIC SEDIMENTAY ROCKS OF MIDDLE TRIASSIC ARE HOST ROCKS FOR THE DEPOSIT. NO IGNEOUS INTRUSIONS WERE FOUND IN THE OREFIELD. HIGHANGLE BREECIA ZONES FORMED AT THE INTERSECTION OF TWO SETS FAULTS AND CONTROL THE GOLD MINERALIZATION; THE DEPOSIT IS MARKED BY AU ANOMALY. THE DEPOSIT WAS LOCATED AT SOUTHWEST MARGIN OF YANGTZ CRATON, SEDIMENTARY ROCKS FROM LATE PALAEOZOIC TO EARLY MESOZOIC WERE DEVELOPED IN THE AREA. IT WAS A TRANGLE AREA AMONG THREE SETS OF STRUCTURES NNE, NW AND EW. GRID STRUCTURE WAS FORMED BY INTERSECTION OF NNE, NW, EW FAULTS. LAIZI SHORT-AXIS ANTICLINE AND BANCHANG THRUST DIRECTLY CONTROL THE EVOLUTION AND DISTRIBUTION OF GOLD DEPOSITS IN THIS AREA. LAIZI SHORT-AXIS ANTICLINE TRENDS NNE, 25 KM IN LENGTH AND 12 KM IN WIDTH. LIMESTONE, BIOCLASTIC LIMESTONE AND REEF LIMESTONE FROM CARBONIFEROUS TO PERMIAN AS WELL AS CLAY ROCKS, TUFFACEOUS CLAY ROCKS BETWEEN EARLY AND LATE PERMIAN WERE MADE UP OF THE CORE OF LAIZI SHORT-AXIS ANTICLINE. WHILE SANDSTONE, SILTSTONE INTERLAYED CLAY ROCKS IN TRIASSIC WERE DISTRIBUTED ON BOTH WINGS OF THE ANTICLINE. THE DIP ANGLE ON ITS EASTERN WING IS 20-40 AND ON WESTERN WING 5-20. FAULTS AROUND LAIZI SHORT-AXIS WERE DEVELOPED AND ASSOCIATED AU, AS HG, SB MINERALIZATION. BANCHANG THRUST IS AT 3 KM NORTHEAST OF LANNIGOU DEPOSIT, OVERALL STRIKE NORTHWEST, DIP TO NE, LOW TO MIDDLE DIP ANGLE. FAULTS ZONE IS 1-13 KM IN WIDTH, 60 KM LONG. OF THIS, THE BRECCIA ZONE IS 30-100M, SLIPPING DISTANCE IN HORIZONTAL AROUND 1.5 KM AND FAULT THROW (VERTICAL) AROUND 800M. THERE WAS NOT STRONG IGNEOUS ACTIVITY FOUND IN THIS AREA. ONLY SOME SMALL ULTRABASIC ROCK BODIES OCCUR AT 27 KM OF NORTHEASTERN BAICENG, ZHENGFENG COUNTY. DISSEMINATED SEDIMENTARY ROCK-HOSTED GOLD DEPOSITS IS THE MAIN TYPE DISCOVERED IN THIS AREA RECENTLY. BANQI, YATA GOLD DEPOSITS ON THE SOUTH OF THIS AREA. THERE ARE ALSO BANNIAN, YANGYOU GOLD DEPOSITS AND BEGAO, LEDONG PROSPECT AS WELL AS QINGPING, TANGXINZHAI GOLD MINERALIZATION POINTS IN THIS AREA. MIDDLE TRIASSIC CLASTIC FORMATION WAS A POSSIBLE SOURCE FOR GOLD. THE ANALYSIS RESULT FOR GOLD VALUE IN THIS FORMATIONS IS 20.37 PPB (AVE.) AU IN SILTSTONE, AND 17.40 PPB AU IN CLAY ROCKS. ORE-FORMING TEMPERATURE WAS ABOUT 172-265C. POSSIBLE MECHANISM IS: THE ENERGY FROM STRONG STRUCTURE ACTIVITY HEATED THE GROUND WATER, WHICH TOOK AU ETC. FROM SEDIMENTARY ROCKS AND CIRCULATED ALONG FAULTS. GOLD PRECIPITED WHEN HRDROTHERMAL ENTER A LOW PRESSURE FAULT ZONE.

-- Deposit Description --

Deposit Size Medium

--Individual Ore Bodies--

Ore Body Number	1	*Ore Body Name*	
USGS Model Name	CARBONATE-HOSTED AU-AG	*Model Number*	26A
Deposit Type	HYDROTHERMAL BRECCIA-FILLING		
Deposit Form	TABULAR		
Length	680	*Units*	M
Width	570	*Units*	M
Thickness	5.77 -19.77, AVERAGE 10.70	*Units*	M
Strike	290	*Dip*	NNE

Deposit Desc Comm #1 OREBODY IS THE LARGEST, WHICH IS CONTROLED BY F3 BRECCIA ALTERATION ZONE; THERE ARE THREE GOLD-ENRICHED ZONES IN THE #1 OREBODY, THEIR RESERVE IS ABOUT 40% OF THE OREBODY.

Record Number RE00759 *(....Continued)*

THERE ARE 0.12-1.10% (AVE. 0.35%) AS, 10-1000 PPM (AVE. 108 PPM) HG, AND 1-2% (AVE. 1.58%) C IN #1 OREBODY. A ENRICHMENT CENTER OF AS, HG EXIST IN THE OREBODY WHERE THE AS, HG VALUE IS 3 TIMES MORE THAN THEIR AVERAGE. C IS HIGHER ON BOTH THE TOP AND BOTTOM, AND IS LOW IN THE CENTER OF OREBODY. GOLD OCCUR AS INVISIBLE MICROGRAINS, THE LARGEST MASUREMENT OF GOLD GRAIN IS 0.06 X 0.06 X 0.03 MM. PYRITE AND ARSENOPYRITE ARE MAIN HOST MINERALS OF GOLD.

-- Exploration and Development --

Production Size Medium
Year of Discovery 1986 *Nature of Disc*
Owner BUREAU OF NATIONAL GOLD ADMINISTRATION ?
Expl/Devl Comments THE DEPOSIT WAS DISCOVERD AS A REALGAR PROSPECT IN 1986. DETAIL GEOLOGY, GEOCHEMISTRY AND METALLURGY STUDIES WERE DONE DURING 1987 TO 1992.
Economic Comments THE ORE TYPE IS A REFRACTORY, HIGH AS AND SULFIDE-POOR ORE; GOLD OCCURS MAINLY AS NATIVE GOLD. ONLY GOLD CAN BE UTILIZED BY NOW. HOPEFULLY, AS, HG, SB, C, S WILL BE RECOVERED BY IMPROVING THE PROCESSED METHOD.

-- Description of Workings --

Desc Workings Surface and Underground
Workings Comments SECONDARY GEOCHEMICAL HALO (SOIL WORK) WAS DONE, IN WHICH 34 ELEMENTS WERE ANALYSED. GOLD CONTENT IN SOIL VARIES FROM 1->3000 PPB, AVE. 1.26 PPB (IN SOUTHWESTERN OF GUIZHOU AREA, 311128 SQURE KM). ANORTH BACKGROUND GOLD VALUE PROVIDED BY ANALYSIS OF SEDIMENTS IN RIVER SHOW 2.1 PPB AU. TOTALLY, 17 GOLD ANOMALIES WERE FOUND. OF THESES AU5 ANOMALY WAS THE BIGGEST, IN WHICH THE SIZE WAS ABOUT 2.124 SQURE KM, AVERAGE GOLD VALUE WAS 104.6962 PPB, THE HIGHEST IS 3000 PPB AU. MOST OF GOLD ANOMALIES OCCUR CONSITENT WITH FAULT ZONES. AU5, AU6, AU10, AU12, AU14 AND AU15 HAVE BEEN PROVED TO BE PRODUCED BY GOLD MINERALIZATION. 12 ELEMENTS (INCLUDE AU, AS, SB, HG, BA, AG, U, TL, CU, PB, ZN, CR) WERE ANALYSED IN PRIMARY GEOCHEMICAL HALO. AS, SB, HG WAS LOW ON BOTH THE TOP AND BOTTOM OF THE ORE OREBODIES AS SAME AS GOLD, THAT SHOW THE CHARACTERISTIC OF FRONT HALO OF GEOCHEMICAL ANOMALY. BUT, BA AND U IS REVERSE. RELATIVE ANALYSIS OF ELEMENTS SHOW THAT AS, TL, CR ARE POSITIVE RELATIVE TO AU, WHILE BA, U ARE NEGTIVE RELATIVE TO AU. THE ASSEMBLAGE OF ELEMENTS AU-AS-TL-CR-CU IS SIMILAR TO JINYA DEPOSIT, GUANGXI. BUT, IT IS DIFFERENT FROM BANQI, YATA DEPOSITS(AU-AS-SB-AG-HG).

-- Reference --

Reference LUE, XIAOHUAN, 1994, GEOLOGIAL CHARACTERISTICS, FORMING MECHANISM AND PROSPECT ON LANNIGOU GOLD DEPOSIT IN ZHENFENG COUNTY, GUIZHOU PROVINCE: IN LIU, DONGSHENG (ED.), CHINESE CARLIN-TYPE GOLD DEPOSITS, UNIVERSITY OF NANJING PRESS, P. 100-115.

Mineral Resources Data System (MRDS)

Report Title CHINA - Carbonated Hosted AU-AG
Issue Date 00/00/00 *Number* In Set of 1
Current Date Thursday, April 10, 1997 *Current Time* 14:30:48 *Printed* 1 of 1

Record Number RE00760 *User Field*
Record Type Site *File Link ID*
Reporter ZHIPING LI, S. G. PETERS
Reporter Affiliation USGS *Report Date* 96 01
Site Name DONGBEIZHAI

-- Location Information --

District Name CHUAN-SHAN-GAN
Country CHINA *Country Code* CH
State SICHUAN *State Code* SC
County SONGPAN
Physiographic Prov 04INTERIOR HIGHLANDS
Latitude 32-18-00N *Decimal Lat* 32.3
Longitude 102-45-36E *Decimal Long* 102.76
Accuracy EST

-- Commodity Information --

Commodity Type Metallic
Commodities AU AG AS HG
Major AU AG
Minor AS HG
Ore Materials NATIVE GOLD PYRITE ORPIMENT ARSENOPYRITE STIBNITE
Non-Ore Materials QUARTZ CALCITE
Analytical Data AU 5.12 PPM (AVERAGE)
Commod Comments MORE THAN 30 MINERALS WERE FOUND IN THE ORE. BUT PYRITE, REALGAR, ARSENOPYRITE AND STIBNITE ARE ASSOCIATED WITH GOLD EXCEPT NATIVE GOLD. THE DISTRIBUTION COEFFICIENT OF GOLD IN MINERALS IS 78.86% IN PYRITE, 0.19% IN REALGAR AND 21.95% IN CLAY MINERALS AS WELL AS OTHERS. TWO TYPES OF ORE ARE PYRITE-BRECCIA ROCK ORE, AND REALGAR-PYRITE BRECCIA ROCK ORE. THEIR CHEMICAL COMPONENT IS AS FOLLOWS: PYRITE-BRECCIA ROCK ORE IS 46.06% SIO_2, 13.34% AL_2O_3, 3.65% FE_2O_3, 3.33% FEO, 2.97% MGO, 9.15% CAO, 0.10% MNO, 0.22% NA_2O, 3.02% K_2O, 0.65% TIO_2, 0.13% P_2O_5, 0.33% H_2O-, 4.37% H_2O+, 11.13% CO_2, 5.54PPM AU, 2.25PPM AG, 1.29% AS, 0.01% HG, 1.83% S, 0.05% ZN, 0.02% CU, 0.23% PB. REALGAR-PYRITE BRECCIA ROCK ORE IS 51.97% SIO_2, 12.76% AL_2O_3, 3.71% FE_2O_3, 2.62% FEO, 2.29% MGO, 8.03% CAO, 0.08% MNO, 0.14% NA_2O, 2.88% K_2O, 0.69% TIO_2, 0.14% P_2O_5, 0.73% H_2O-, 4.59% H_2O+, 8.20% CO_2, 5.69PPM AU, 1.57PPM AU, 1.61% AS, 0.01% HG, 1.85% S, 0.11% ZN, 0.01% CU, 0.03% PB.

-- Geology --

Tectonic Setting WEST MARGIN OF YANGTZ CRATON
Regional Trends NEAR THE INTERSECTINON OF WEST QINLING THRUST FOLDS BELTS TRENDING WEST-EAST AND MINJIANG THRUST FOLDS BELT
Local Structure MINJIANG THRUST ZONE, 130KM IN NORTH-SOUTH AND 60KM IN EAST-WEST, INCLUDES

XIANGLATAI-KUASHIYA FAULT(F1), YANGDONG HE-ZHADOUSHAN FAULT (F2), MINJIANG VALLY FAULT (F3)

Alteration SILICIFICATON, CARBONATIZATION, PYRITIZATION

Conc/Enrichment THE FIRST CONCENTRATION OF GOLD IN SEDIMENTARY ROCKS WAS BY ABSORPTION OF CLAY MINERALS AND ORGANIC MUD. STRONG STRUCTURE AND HYDROTHERMAL ACTIVITY IN MESOZOIC PLAY A IMPORTANT ROLE IN CONCENTRATION OF GLOD.

Ore Control OREBODIES OCCUR IN BREECIA ZONE OF F1 THRUST FOOTWALL TRENDING NORTH-SOUTH

Age Mineralization TERTIARY ?

Host Rock Type SLATE

Host Rock Age L TRI MES

Host Rock Type Name	Age	Host Rock Unit Name	Age
CARBONACEOUS SILTY SLATE, CARBONNACEOUS SLATE INTERLAYED SANDSTONE		DUXINQIAO FORMATION	L TRI MES

Geology Comm THE COMBINED AREA OF SICHUAN, GANSU AND SHANXI PROVINCE IS USUALLY CALLED AS " GOLD TRANGLE" IT IS BOUNDED ON NORTH BY QINLING THRUST ZONE, ON THE SOUTHEAST BY METIANLING AND LONGMEN MOUNTAIN THRUST ZONES AND ON THE SOUTHWEST GANZI-XIANSHUIHE THRUST ZONES. IT WAS LOCATED AT A TECTONIC TRANSFORM ZONE WITH ACTIVE SEDIMENTATION, STRUCTURE, AND MAGAMATISM. THE DEPOSITS AND GEOCHEMICAL ANOMALY WERE DISTRIBUTED AS SWARM OR STRIPES ALONG REGIONAL THRUST. SPATIALLY, THERE ARE SIX GOLD MINERALIZATION BELTS IN THIS AREA: 1. BAILONGJIANG GOLD BELT - 160 KM TO 200 KM LONG IN EAST-WEST. STARTS AT LUQU, GANSU PROVINCE, THROUGH RUOERGAI AND DIEBU, AND ENDS AT ZHOUQU, GANSU PROVINCE. GOLD MINERALIZTION WERE HOSTED BY CAMBRIAN AND DEVONIAN BLACK SEDIMENTARY FORMATIONS. THE GOLD DEPOSITS WHICH HAVE BEEN PROVED INCLUDE LAERMA(SEE #RE00765), PINGDING(SEE #RE00765) AND YAXIANG, JIUYUAN, LAZIKOU, ETC. GOLD PROSPECTS. THE PROVED RESERVES IS MORE THAN TENS TONS GOLD. 2. NANPING-MAQU GOLD BELT - ADJOIN CLOSELY AT SOUTH OF BAILONGJING GOLD BELT. STARTING AT NANPING IN SOUTHEASTERN, SICHUAN PROVINCE, AND ENDS AT MAQU IN NORTHWESTERN, GANSU PROVINCE. >200 KM IN LENGTH. GOLD MINERALIZTION OCCURS IN LAND DERIVED CLASTIC AND CARBONATE ROCKS OF TRIASSIC IN AGE. MANAOKE, HUAYUANGOU, ZHONGQU AND DASHUI GOLD DEPOSITS HAVE BEEN PROVED. BESIDE, BAXI, TUANJIE, BADUN, SHUISHENGOU, GEJIEBISU, LIANHECUN AND JIAWUCHI GOLD PROSPECTS NEED FURTHER MORE WORK. 3. HOULONGMEN MOUNTAIN GOLD BELT - TRENDS IN NORTHEAST AND DISTRIBUTED IN BEICHUAN, PINGWU, SICHUAN PROVINCE. GEOCHEMICAL EXPLORATON HAS BEEN DONE IN PART OF THIS BELT AND MAHUANGGOU ETC. GOLD PROSPECT WAS DISCOVERD. 4. MINJIANG GOLD BELT - IS THE FIRST ONE WHICH WAS DISCOVERED IN THIS AREA. DONGBEIZHAI GOLD DEPOSIT OCCURS IN THIS BELT. MOST OF THIS BELT WAS DISTRIBUTED IN SONGPAN COUNTY, SICHUAN PROVINCE. 120 TO 140 KM IN LENGTH. THE BELT CONSISTES OF A SERIES OF THRUST FAULTS. GOLD MINERALIZATION WERE HOSTED BY CLASTIC ROCKS OF TRIASSIC AS WELL AS EARLY PALAEOZOIC CARBONATE ROCKS. DONGBEIZHAI AND ZHEBESHAN ARE PROVED GOLD DEPOSITS. PROVED RESERVES IS ABOUT ONE HUNDREND TONS. 5. XUESHAN GOLD BELT - DISTRIBUTES IN SONGPAN COUNTY, SICHUAN PROVINCE. > 50 KM IN EAST-WEST TRENDING. EARLY PALAEOZOIC CARBONATE ROCK APPEARS ON NORTH OF THE BELT, WHILE TRIASSIC CLASTIC ROCKS ON SOUTH. QIAOQIAOSHANG IS A LARGE PROVEN GOLD DEPOSIT. ADDITIONALY, MORE HG-AU, SB-AU MINERALIZTION WAS FOUND IN THIS BELT. 6. GANZI-XIANSHUIHE GOLD BELT - TRENDS NORTHWEST ALONG XIANSHUIHE THRUST ZONE. ALL OF THE GOLD DEPOSITS AND GOLD PROSPECTS OCCUR IN TRIASSIC FORMATIONS. KALA AND QULUO (?) ARE TWO PROVED GOLD DEPOSITS. F1 FAULT

ZONE, THE MAJOR HOST FAULT FOR DONGBEIZHAI GOLD DEPOSIT IN MINJIANG GOLD BELT, CONSISTES OF 6 SECONDARY FAULTS, 120 KM LONG IN STRIK AND 5 TO 15KM WIDE IN EAST-WEST. PLANE OF MAIN FAULT DIPS TO WEST. GOLD MINERALIZATION OCCURS MAINLY IN A BRECCIA ZONE WHICH LOCATED BELOW THE FOOTWALL AND CONSISTES OF SILTY SLATE OF TRIASSIC. THE ABUNDANCE OF GOLD IN MAIN HOST ROCKS ARE: 3.70 PPB IN SLATE, 2.40 PPB IN SANDSTONE, 1.40 PPB IN CARBONATE ROCKS AND 1.90 PPB IN SILICOLITES. MAGMATISM WAS WEAK IN THE FIELD, ONLY SMALL AMOUNT OF DIABASE OCCUR AS REMAINS OR STRUCTURE LENTICULAR IN SEDIMENTARY ROCKS. TEMPRATURE: EARLY STAGE 187C, LATE STAGE 163C. PRESSURE: EARLY STAGE 40530000PA, LATE STAGE 30400000PA, IT IS ESTIMATED THAT DEPOSIT WAS FORMED BELOW SURFACE 1.8KM TO 1.2 KM. SALINITY OF HYDROTHERMAL FLUID INCREASED FROM 5.09% IN EARLY STAGE TO 11.71% IN LATE STAGE.

-- Deposit Description --

Deposit Size Medium

--Individual Ore Bodies--

Ore Body Number	1	*Ore Body Name*	
USGS Model Name	CARBONATE-HOSTED AU-AG	*Model Number*	26A
Deposit Type	HYDROTHERMAL BEDDED VEIN		
Deposit Form	POD		
Length	160 - 1520	*Units*	M
Width	90 - 613	*Units*	M
Thickness	1.78 - 4.88	*Units*	M
Strike	NORTH-SOUTH	*Dip*	

Deposit Desc Comm 30 OREBODIES WERE DISCOVERED AND PROVED RESERVES ARE MORE THAN TENS TONS AU. THE RESERVES OF FOUR MAIN OREBODIES IS ABOUT 80% OF TOTAL RESERVES. OREBODIES , WHICH DISTRIBUTED IN A ZONE ABOUT 140M IN WIDE, OCCUR IN THE BRECCIA ZONE ALONG THE FOOTWALL OF FAULT (F1). ALL OF MAIN OREBODIES OCCUR CLOSLY TO THE PLANE OF ORE-CONTROL FAULT. THE GRADE OF ORE IN MAIN OREBODIES TEND TO BE INCREASED IN DEPTH. INDUSTRIAL OREBODY IS 160M TO 1520M, EXTENTION 90M TO 813M IN DIP. THICKNESS IN INDIVIDUAL OREBODY VERIES FROM 1.78M TO 4.88M, AVE. 3.74M. AVERAGE AU CONTENT IN MINABLE OREBODIES IS 5.12 PPM AND THAT IN UNMINABLE ORE BODIES IS 3.6PPM. OCCURRENCE OF OREBODIES IS CONSISTENT WITH THAT OF ORE-CONTROL FAULT. OVERALL STRIKE IS N6E. BOTH DIP TO WEST. DIP ANGLE VERIES IN DEPTH, USUALLY 16 TO 35 DEGREE IN SHALLOW PART WHILE 60 TO 80 DEGREE IN DEPTH.

-- Exploration and Development --

Production Size Large

Development Status Developed Producer, Active

Owner BUREAU OF NATIONAL GOLD ADMINISTRATION ?

Expl/Devl Comments THE COMBINED AREA SICHUAN, GANSU AND SHANXI PROVINCE, LOCATED AT SOUTH SIDE OF QINLING MOUNTAIN WHICH TRENDS EAST-WEST, IS ONE OF SOURCES OF THE YANGTZ RIVER. THERE ARE A LOT OF GOLD PLACER DEPOSITS IN THE BRANCES OF YANGTZ RIVER SUCH AS HANSHUI, JIALINGJIANG, BAILONGJIANG, FUJIANG AND MINJIANG. THE RESERVES OF PLACER GOLD IN THIS DISTICT IS OVER ONE HUNDRED TONS AU ACCORDING TO COMPLETE STATISTICS. FOR EXAMPLE, THE ZHANGLA GOLD PLACER DEPOSIT, LOCATED AT UPPER COURSE OF MINJIANG, HAS PRODUCED MORE THAN 30 TONES

AU SINCE 1949. THE PLACER GOLD FROM THIS DEPOSIT WAS FAMOUS AS "ZHANGJIN" WITH HIGH GOLD CONTENT(AVE., > 98% AU). A STUDY SHOWS THAT THE GOLD PLACER DEPOSITS ARE STILL FORMING AT THIS AREA. THE EXPLORATION FOR PRIMARY GOLD DEPOSITS STARTED AT EARLY 1980'S. A LOT OF GOLD ANOMALY AND SOME POTENTIAL DEPOSITS WERE DISCOVERED. SEDIMENT-HOSTED GOLD DEPOSIT IS A MAIN TYPE. IT IS ESTIMATED THAT THE RESERVES OF PRIMARY DEPOSITS WOULD BE MUCH MORE THAN THAT OF PLACER DEPOSITS.

– Description of Workings –

Desc Workings Surface

– Reference –

Reference MAO, YUNIAN AND LI, XIAOZHUANG, 1994, THE MAIN GEOLOGICAL CHARACTERISTICS OF DONGBEIZHAI GOLD DEPOSIT IN JOINT AREA OF SICHUAN, GANSU AND SHAANXI PROVINCE: IN LIU, DONGSHENG (ED.), CHINESE CARLIN-TYPE DEPOSITS, UNIVERSITY OF NANJING PRESS, P. 317-342.

Reference WANG, K. R. AND ZHOU, Y. Q., 1994, MINERALOGY OF THE CARLIN-TYPE DONGBEIZHAI AND JINYA GOLD DEPOSITS, SOUTHWESTERN CHINA: INTERNATIONAL GEOLOGY REVIEW, 36. (2). P.194-202.

Reference ZHENG, M. H., ZHOU, Y. F. AND GU, X. X., 1991, ISOTOPIC COMPOSITIONS IN THE DONGBEIZHAI FINE-DISSEMINATED GOLD DEPOSIT, SICHUAN, AND THEIR GENETIC IMPLICATIONS: SCIENTIA GEOLOGICA SINICA. (2). P. 159-173.

Mineral Resources Data System (MRDS)

Report Title CHINA - Carbonated Hosted AU-AG
Issue Date 00/00/00
Current Date Thursday, April 10, 1997 *Current Time* 13:46:06
Number In Set of 1
Printed 1 of 1

Record Number	RE00761	*User Field*	
Record Type	Site	*File Link ID*	
Reporter	ZHIPING LI, S. G. PETERS		
Reporter Affiliation	USGS	*Report Date*	96 01
Site Name	BAGUAMIAO		

– Location Information –

District Name	CHUAN-SHAN-GAN		
Country	CHINA	*Country Code*	CH
State	SHAANXI	*State Code*	SX
County	FENGXIAN		
Physiographic Prov	04INTERIOR HIGHLANDS		
Latitude	34-55-12N	*Decimal Lat*	34.92
Longitude	106-54-00E	*Decimal Long*	106.9
Accuracy	EST		
Position	40 KM EAST OF FENGXIAN COUNTY TOWN		

– Commodity Information –

Commodity Type Metallic
Commodities AU
Major AU
Ore Materials PYRITE PYRRHOTITE CHALCOPYRITE ILMENITE MOLYBDENITE RUTILE NATIVE GOLD NATIVE SILVER
Non-Ore Materials SERICITE QUARTZ
Analytical Data 12 OREBODIES WERE DEFINED BY 1 PPM AU, OF THESE, GOLD CONTENT OF 10 OREBODIES IS ABOVE 5 PPM AU
Commod Comments COMPONENT OF METAL MINERALS IN ORE IS USUALLY LESS THAN 5%. PYRITE AND PYRRHOTITE ARE MAIN METAL MINERALS. ANALYSIS RESULT OF MINERALS BY ELECTRONIC PROB. IS AS FOLLOWS: PYRITE (4 SAMPLES): 46.73% FE, 53.08% S, 0.145% AU, 0.03% AG, 0.03% AS, 0.02% CU, 0.07% CO, 0.05% NI, 0.06% SE, 4.83 AU/AG, 1.4 CO/NI, 884.7 S/SE; PYRRHOTITE (2 SAMPLES): 59.22% FE, 40.18% S, 0.005% AU, 0.06% AG, 0.09% AS, 0.015% CU, 0.03% CO, 0.025% NI, 0.05% SE, 0.08 AU/AG, 1.2 CO/NI, 803.8 S/SE; CHALCOPYRITE (1 SAMPLE): 29.09% FE, 34.47% S, 0.07% AU, 0.03% AG, 0.00% AS, 34.11% CU, 0.03% CO, 0.01% NI, 0.12% SE, 2.33 AU/AG, 3.0 CO/NI, 289.5 S/SE. DISTRIBUTION COEFFICIENTS OF GOLD IN MINERALS ARE: >33.8% IN NATIVE GOLD, 17.50% IN PYRRHOTITE, 13.80% IN PYRITE, 22.69% IN QUARTZ, 5.35% IN SERICITE, 6.86% IN CARBONATE MINERALS.

– Geology –

Tectonic Setting SOUTH OF QINLING FOLDS
Regional Trends TIGHT FOLDS AND FAULTS TRENDING NWW
Local Structure SUJIAGOU - KUONGGUA MULTIPLE SYNCLINE
Alteration SILICIFICATION SERICITIZATION
Conc/Enrichment GOLD DERIVED FROM HOST ROCK. IT ENRICHED BY HYDROTHERMAL FLUID, WHICH WAS EVOLVED

	MAINLY FROM METEORIC WATER
Ore Control	BRECCIA ZONES PARALLEL TO THE AXIS OF FOLD
Age Mineralization	210 MA

Host Rock Type Name	Age	Host Rock Unit Name	Age
CARBONATE	M DEV	GUDOLING FORMATION	M DEV
SILTY SERICITE PHYLLITE	M DEV	XINGHUANGPU FORMATION	M DEV

Geology Comm DEVONIAN CABONATE AND PHYLLITE ARE THE HOST ROCK. HIGHANGLE FAULT AND BRECCIA ZONE CONTROL THE OREBODIES. DEPOSITS WERE MARKED WITH AG, AU, HG, SB, AS ANOMALY. THE COMPONENTS OF ORE ARE RELATIVELY SIMPLE. THERE IS NOT TOO MUCH DIFFERENCE IN COMPONENTS BETWEEN ORE AND HOST ROCK. PROCESSES OF ORE-FORMING CAN BE DIVIDED INTO THREE STAGE: (I). EARLY LOW-SULFIDES STAGE WAS WITH QUARTZ, ALBITE, TOURMALINE, CHALCOPYRITE, EARLY PYRRHOTINE AND PYRITE; AVE. TEMPERATURE 290C, G/L (GAS/LIQUID IN INCLUSION) 10-40; SALINITY 7.98% AVE.; (II) MAIN ORE-FORMING STAGE WAS WITH QUARTZ, PYRRHOTITE, PYRITE AND NATIVE GOLD, TEMPERATURE 260C AVE., G/L 5-20; SANILITY 6.53% AVE.; (III). LATE SULFIDE STAGE WAS WITH QUARTZ, CARBONATE MINERAL, GALENA, LATE PYRRHOTITE AND PYRITE, TEMPERATURE 200 C, SANILITY 3.4% AVE. H , O AND S ISOTOPE COMPOSITION: D (H2O) -117.9 - -53.5/1000, AVE. -79.4/1000; O (MINERAL) 12.64 - 19.84/1000, AVE. 15.70/1000; O (H2O) 4.44 - 9.14/1000, AVE. 5.64/1000; S (PYRITE IN HOST ROCK) 33/1000; S (PYRITE IN MAIN ORE-FORMING STAGE) 7.4 -15.4/1000, AVE. 10.7/1000; S (PYRITE IN LATE ORE-FORMING STAGE) 4.7/1000; S (PYHORRITITE) 6.8 - 15.4/1000.

-- Deposit Description --

Deposit Size Large

--Individual Ore Bodies--

Ore Body Number	4	*Ore Body Name*	
USGS Model Name	CARBONATE-HOSTED AU-AG	*Model Number*	26A
Deposit Type	HYDROTHERMAL BRECCIA-FILLING		
Deposit Form	LENSE		
Length	153	*Units*	M
Thickness	2.34-4.77	*Units*	
Strike	134	*Dip*	70

Ore Body Number	<	*Ore Body Name*	
USGS Model Name	CARBONATE-HOSTED AU-AG	*Model Number*	26A
Deposit Type	HYDROTHERMAL BRECCIA-FILLING		
Deposit Form	LENSE		
Length	500	*Units*	M
Width	220	*Units*	M
Thickness	1-11.12	*Units*	M
Strike	132	*Dip*	66-84

Deposit Desc Comm 12 OREBODIES ARE DISCOVERED. GOLD OCCUR MAINLY IN PYRRHOTITE, PYRITE AND QUARTZ

-- Exploration and Development --

Production Size Medium

Developmt Status 7W

Year of Discovery 1979 *Nature of Disc*

Expl/Devl Comments QUARTZ VEINS WERE FOUNDED IN XINGHUONGPU FORMATIONS (MIDDLE DEVONIAN) WHEN AG ANOMALIES WERE CHECKED IN 1979-1980, ANALYSIS RESULT OF QUARTZ VEIN WAS 1.64 PPM AU. BUT THE EXPLORATION WAS STOPPED BECAUSE THE QUARTZ VEINS WERE TOO SMALL. HIGH AU VALUE WAS DISCOVERED IN AG ANOMALY WHEN GEOCHEMICAL SECTIONS WERE MADE IN 1989. THE TRENCHING SAMPLES WERE TAKEN AS COULD BE DONE IN A CARLIN-TYPE DEPOSIT. MOST OF THESE SAMPLES WERE MORE THAN 1 PPM AU, AND THE THICKNESS OF OREBODY WAS MORE THAN 100 METERS. EXPLORATION WORKS ARE IN PROCESS BY NOW. BUT THE RESERVES ARE EXPECTED TO BE LARGE SIZE.

-- Description of Workings --

Desc Workings Surface

-- Reference --

Reference WEI, LONGMING AND CAO, YUANGUI, 1994, GEOLOGICAL CHARACTERISTICS AND GENESIS ANALYSIS OF BAGUAMIAO GOLD DEPOSIT, SHAANXI PROVINCE: LIU, DONGSHANG (ED.) CHINESE CARLIN TYPE DEPOSIT, P.286-305.

Reference CAO, YUANGUI, 1990, GEOLOGICAL SETTING, CONCENTRATION, AND SOURCE PROSPECT ON BAGUAMIAO-QINGYAGOU GOLD DEPOSITS.

Reference WEI, LONGMING, 1992, RESEARCH ON MECHANISM OF ORE-FORMING AND GENESIS FOR BAGUAMIAO GOLD DEPOSIT, SHAANXI PROVINCE.

Reference GUO, JIAN, SU, RUIXIA AND ZHANG, EN, 1992, ORE-CONTROL AND PROSPECT DIRECTION IN BAGUAMIAO GOLD DEPOSIT, FENGXIAN COUNTY, SHAANXI.

Reference WANG, MINLIANG, 1992, GEOLOGICAL CHARACTERISTICS AND GENESIS EXPLORE FOR BAGUAMIAO GOLD DEPOSIT, FENGXIAN COUNTY, SHAANXI PROVINCE

Reference WEI, LONGMING, 1994, STUDY ABOUT ORE-CONTROLED BY QUARTZ VEINS IN BAGUAMIAO GOLD DEPOSIT: ORE PRODUCT AND GEOLOGY, VOL. 7 NO. 5

Mineral Resources Data System (MRDS)

Report Title CHINA - Carbonated Hosted AU-AG
Issue Date 00/00/00 | *Number* In Set of 1
Current Date Thursday, April 10, 1997 | *Current Time* 13:48:08 | *Printed* 1 of 1

Record Number	RE00762	*User Field*	
Record Type	Site	*File Link ID*	
Reporter	ZHIPING LI, S. G. PETERS		
Reporter Affiliation	USGS	*Report Date*	96 01
Site Name	JINYIA		
Synonym Name	NAYUAN		

-- Location Information --

District Name	DIAN-QIAN-GUI		
Country	CHINA	*Country Code*	CH
State	GUANGXI	*State Code*	GX
County	FANGSHAN		
Physiographic Prov	04INTERIOR HIGHLANDS		
Latitude	24-31-12N	*Decimal Lat*	24.52
Longitude	107-00-30E	*Decimal Long*	107.00833
Accuracy	EST		
Position	14 KM NORTHWEST OF FANGSHAN COUNTY TOWN		

-- Commodity Information --

Commodity Type Metallic
Commodities AU (AS) AG CU PB ZN SB S
Major AU (AS)
Minor AG CU PB ZN SB S
Ore Materials PYRITE ARSENOPYRITE STIBNITE GALENA SPHALERITE CHALCOPYRITE TETRAHEDRITE MARCASITE ORPIMENT REALGAR, NATIVE ARSENIC
Non-Ore Materials QUARTZ CALCITE ANKERITE CLAY MINERALS
Analytical Data 5.36 PPM AU (177 SAMPLES), 5.75PPM (20 SAMPLES), 8.60PPM (17 SAMPLES) 6.81PPM (2 SAMPLES)

-- Geology --

Tectonic Setting ON SOUTHWEST YANGTZE CRATON, NEAR THE TRANGLE AREA OF PACIFIC, INDIA AND EUROASIA PLATES
Regional Trends SLOPE ZONE OF LINGYUN DOME UPLIFT, NORTHEAST OF FAULT VALLEY
Local Structure NORTH-SOUTH FAULTS WITH A SERIES OF ANTICLINES
Alteration CARBONATIZATION CHLORITIZATION SERICITIZATION AND KAOLINITIZATION
Ore Control BRECCIA ZONE IN BAIFANG FORMATION

Host Rock Type Name	Age	Host Rock Unit Name	Age
MEDIUM TO THICK SILT MUDSTONE INTERLAYERED ARGILLACEOUS SILTSTONE	M TRI	BAIFANG FORMATION	

Geology Comm HOSTED BY TURBIDITE OF BAIFENG FORMATION MIDDLE TRIASSIC. GOLD MINERALIZATION ZONE, 3.5 KM IN LENGTH AND 300-700M IN WIDTH, IS STRICTLY CONTROLED BY COMPRESSION BRECCIA ZONES. THERE IS NOT OBVIOUS RELATIONSHIP TO IGNEOUS ROCK. ONLY A FEW QUARTZ-PORPHYRY AND

DIABASE-PORPHYRY DIKES WERE FOUNDED OUTSIDE OF ORE FIELD. CHARACTERISTICS OF FLUID INCLUSION: HOMOGENEOU TEMPERATURE 305-130 C, HIGH CO2 (CO2/H2O 0.17-0.08).

-- Deposit Description --

Deposit Size Large

--Individual Ore Bodies--

Ore Body Number	1	*Ore Body Name*	#1
USGS Model Name	CARBONATE-HOSTED AU-AG	*Model Number*	26A
Deposit Type	HYDROTHERMAL BRECCIA-FILLING		
Deposit Form	LENSE		
Length	400	*Units*	M
Width	215-410	*Units*	M
Thickness	1.29-8.61	*Units*	M
Ore Body Number	2	*Ore Body Name*	#2
USGS Model Name	CARBONATE-HOSTED AU-AG	*Model Number*	26A
Deposit Type	HYDROTHERMAL BRECCIA-FILLING		
Deposit Form	LENSE		
Length	400	*Units*	M
Width	200-400	*Units*	M
Thickness	1.14-2.45	*Units*	M
Ore Body Number	3	*Ore Body Name*	#3
USGS Model Name	CARBONATE-HOSTED AU-AG	*Model Number*	26A
Deposit Type	HYDROTHERMAL BRECCIA-FILLING		
Deposit Form	LAYERED LENTICULAR		
Length	350	*Units*	
Width	200-250	*Units*	
Thickness	3.00	*Units*	
Ore Body Number	4	*Ore Body Name*	#9
USGS Model Name	CARBONATE-HOSTED AU-AG	*Model Number*	26A
Deposit Type	HYDROTHERMAL BRECCIA-FILLING		
Deposit Form	LAYED		
Length	400	*Units*	M
Width	> 100	*Units*	M
Thickness	1.36-2.07	*Units*	M

Deposit Desc Comm 20 OREBODIES WERE DISCOVERED. THEY OCCUR AS STRATIFORM OR LENTICULAR CONTROLED BY SQUEEZE BRECCIA ZONES. ORE CAN BE DIVIDED INTO PYRITE, PYRITE-ARSENOPYRITE AND ARSENOPYRITE TYPES. GOLD IS CLOSLY RELATED TO PYRITE AND ARSENOPYRITE. THEY ARE 90.6-96.9% AS MICRIGRAINS NATIVE GOLD, 3.1-9.45% SOLID SOLUTION AND A SMALL AMOUNT COLLOID ABSORBED.

-- Exploration and Development --

Record Number RE00762 (....Continued)

Production Size Large
Developmt Status Developed Producer, Active
Discoverer ZHENGHAI LI
Year of Discovery 1981 *Nature of Disc*
Owner BUREAU OF NATIONAL GOLD ADMINISTRATION
Expl/Devl Comments REGIONAL GEOLOGICAL TEAM OF GUANGXI PROVINCE CHECKED THE NAYUAN (JINYA) SB PROSPECT IN 1970. JINYA GOLD DEPOSIT WAS DICOVERED BY ZHENGHAI LI BY COMPARING WITH GAOLONG AU-SB DEPOSITS IN 1986.

-- Description of Workings --

Desc Workings Surface
Workings Comments FIVE GEOLOGICAL RESEARCH REPORTS INCLUDE DETAIL STUDIES OF ISOTOPE, FLUID INCLUSION, ANALYSIS AND EXPERIMENT OF SINGLE MINERAL, ETC.

-- Reference --

Reference LI, ZHENGHAI, WANG, GUOTIAN, SHANG, DI AND FANG, YUEKUI, GEOLOGY AND GENESIS OF JINYA GOLD DEPOSIT, GUANGXI PROVINCE: IN LIU, DONGSHENG (ED.), CHINESE CARLIN-TYPE DEPOSITS, UNIVERSITY OF NANJING PRESS, P. 37-78.
Reference WANG, KUIREN AND ZHOU, YOUQIN, 1994, MINERALOGY OF THE CARLIN-TYPE DONGBEIZHAI AND JINYA GOLD DEPOSITS, SOUTHWEATERN CHINA: INTERNATIONAL GEOLOGY REVIEW, 36. (2). P. 194-202.

Mineral Resources Data System (MRDS)

Report Title CHINA - Carbonated Hosted AU-AG
Issue Date 00/00/00 *Number* In Set of 1
Current Date Thursday, April 10, 1997 *Current Time* 13:46:06 *Printed* 1 of 1

Record Number RE00763 *User Field*
Record Type Site *File Link ID*
Reporter ZHIPING LI, S. G. PETERS
Reporter Affiliation USGS *Report Date* 96 01
Site Name LIBA

-- Location Information --

District Name CHUAN-SHAN-GAN
Country CHINA *Country Code* CH
State GANSU *State Code* GS
County LIXIAN
Physiographic Prov 04INTERIOR HIGHLANDS
Latitude 34-06-00N *Decimal Lat* 34.1
Longitude 104-35-24E *Decimal Long* 104.59
Accuracy EST
Position NORTHWEST OF LIXIAN COUNTY TOWN

-- Commodity Information --

Commodity Type Metallic
Commodities AU
Major AU
Ore Materials PYRITE LIMONITE, CHALCOPYRITE, ARSENOPYRITE, SPHALERITE, GALENA, PYRRHOTITE, NATIVE EGOLD
Non-Ore Materials MUSCOVITE SERICITE QUARTZ
Analytical Data NO. 5 OREBODY AVERAGE 5 PPM AU. NO. 6 OREBODY AVERAGE 4 PPM AU

-- Geology --

Tectonic Setting NORTHWEST MARGIN OF YANGTZE CRATON
Regional Trends INTERSECTION OF REGIONAL FAULTS, WHICH WERE PRODUCED ETHER BY MOVING OF GROUND BLOCKS OR IGNEOUS INSTRUSIONS
Local Structure SOUTHWEST WING OF MAWU ANTICLING TRENDING NW, FAULTS AND SMALL ANTICLINES ARE POPULAR.
Alteration SILICIFICATION CARBONATIZATION ARGILLIZATION PYRITIZATION
Ore Control TWENTY FAULT BRECCIA ZONES ARE ORE-CONTROL STRUCTURES. OF THESE, A BRANCH FAULT OF LIXIAN-LUOBA-SOULONGKOU BASE RIFT TRENDING NOTHWEST IS MAIN ORE-CONTROL FAULT IN THE DEPOSITS

Host Rock Type Name	Age	Host Rock Unit Name	Age
SILTY PHYLLITE SILTSTONE AND PHYLLITE	M DEV	SHUJIABA FORMATION	

Associated Rock Type Name	Age	Associated Rock Unit Name	Age
GRANITE		ZHONG CHUAN	
SPESSARTITE DIORITIC PORPHYRITE, GRANODIORITE DIKES			

Geology Comm	MORE THAN TEN DISSEMINATED GOLD DEPOSITS AND PROSPECTS WERE FOUNDED IN LIXIAN-MINXIAN AREA (ABOUT 1000 SQAURE KM), GANSU PROVINCE, IN RECENT YEARS. OF THESE, LIBA IS THE BIGGEST ONE (RESERVES > 50 TONNES AU). DEVONIAN CLASTIC SEDIMENTARY ROCK IS THE HOST ROCK. DEPOSIT IS LOCATED 2 KM NORTH OF ZHONG CHUAN GRANITE BATHOLITH. DIKES SUCH AS SPESSARTITE ETC. ARE COMMON IN ORE FIELD. OREBODIES WERE CONTROLLED BY FAULTS. MICROGRAINS NATIVE GOLD IS CLOSELY RELATIVE TO THE PYRITE, ARSENOPYRITE AS WELL AS CLAY MINERALS.		

-- Deposit Description --

Deposit Size	Small		

--Individual Ore Bodies--

Ore Body Number	1	Ore Body Name	#5
USGS Model Name	CARBONATE-HOSTED AU-AG	Model Number	26A
Deposit Type	HYDROTHERMAL VEIN		
Deposit Form	VEIN LENTICULAR		
Length	2000	Units	M
Width	>250	Units	M
Thickness	6-7	Units	M
Ore Body Number	2	Ore Body Name	#6
USGS Model Name	CARBONATE-HOSTED AU-AG	Model Number	26A
Deposit Type	HYDROTHERMAL VEIN		
Length	600	Units	
Width	>250	Units	
Thickness	5-6	Units	

Deposit Desc Comm: 20 (?) OREBODIES ARE DISCOVERED. OF THESE, #5 AND #6 OREBODIES ARE MORE THAN 80% OF RESERVES.

-- Exploration and Development --

Production Size: Medium

-- Description of Workings --

Desc Workings: Surface

-- Reference --

Reference: LIU, MIAO, 1994, GEOLOGICAL CHARACTERISTICS OF LIBA GOLD DEPOSIT: IN LIU, DONGSHENG (ED.), CHINESE CARLIN DEPOSIT, UNIVERSITY OF NANJING PRESS, P. 160-202.

Mineral Resources Data System (MRDS)

Report Title CHINA - Carbonated Hosted AU-AG
Issue Date 00/00/00 — Number In Set of 1
Current Date Thursday, April 10, 1997 — Current Time 13:46:06 — Printed 1 of 1

Record Number	RE00764	User Field	
Record Type	Site	File Link ID	
Reporter	ZHIPING LI, S. G. PETERS		
Reporter Affiliation	USGS	Report Date	96 01
Site Name	SHUANGWANG		

-- Location Information --

District Name	CHUAN-SHAN-GAN		
Country	CHINA	Country Code	CH
State	SHAANXI	State Code	SX
County	TAIBAI		
Physiographic Prov	04INTERIOR HIGHLANDS		
Latitude	34-00-03N	Decimal Lat	34.00083
Longitude	107-18-00E	Decimal Long	107.3
Accuracy	EST		
Position	SOUTH OF TAIBAI COUNTY TOWN		

-- Commodity Information --

Commodity Type	Metallic
Commodities	AU
Major	AU
Ore Materials	NATIVE GOLD CALAVERITE PYRITE MARCASITE
Non-Ore Materials	ALBITE DOLOMITE CALCITE QUARTZ RUTILE APATITE

-- Geology --

Tectonic Setting	LATE MESOZOIC FENGXIAN-ZHENGAN SUBSISIARY FOLDS WHICH WERE LOCATED AT SOUTH OF QINLING FOLDS. THAT IS, TRANSFORM ZONE BETWEEN YANGTZ AND HUABEI CRATONS
Regional Trends	SUBSIDIARY FOLDS INCLUDE YUANBAZI MULTIPLE-SYNCLINE, XIBA MULTIPLE-ANTICLINE, XINGHUONGPU-SANGYUANBA MULTIPLE-SYNCLINE. THE BRECCIA ZONE, WHICH HOSTED SHUANGWANG GOLD DEPOSIT IS LOCATED AT NORTH WING OF XIBA MULTI-SYNCLINE.
Local Structure	DIRECTION OF OVERALL STRUCTURE LINE TRENDS BETWEEN 310-130, WHICH IS COMPOSED OF A SERIES OF FOLDS AND FAULTS. XIBA MULTIPLE-ANTICLINE IS THE MAIN STRUCTURE IN THIS AREA.
Alteration	ALBITIZATION DOLOMITIZATION
Ore Control	SHUANGWANG GOLD BRECCIA ZONE IS MADE UP OF 8 BRECCIA BODIES, OVERALL STRIKE IS 290-310, 11.5 KM IN LENGTH. THE BRECCIA BODIES OCCUR AS LENTICULAR, DIP TO 20-40 AND DIP ANGLE 50-80 AT EASTERN PART, WHILE DIP TO 200-220 AND DIP ANGLE 81-87 AT WESTERN PART. BRECCIAS ARE COMPOSED OF MIXED ROCKS, WHICH WERE CEMNETED BY ALBITE, ANKERITE AND CALCITE, AS WELL AS SMALL AMOUNTS OF QUARTZ PYRITE.
Age Mineralization	ANALYSIS OF 40AR/39AR FROM PYRITE: STAGE II WAS FORMED AT 183.09 +- 20.64 MA; STAGE IV WAS FORMED AT 168.0 +- 18.2 MA, ABOUT EARLY JURASSIC.

Host Rock Type Name	Age	Host Rock Unit Name	Age

CALCAEOUS SANDSTONE SILTSTONE INTERLAYED LIMESTONE(D2G1), MEDIUM TO THICK LIMESTONE BIOLIMESTONE INTERLAYED CALCAREOUS SLATE	M DEV	GUDAOLING FORMATION(D2G)	
SILTSTONE INTERLAYED ARGILLIC LIMESTONE(D3X1), LIMESTONE ARGILLIC LIMESTONE INTERLAYED SLATE(D3X2)	L DEV	XINGHUONGPU FORMATION(D3X)	
SILTSANDSTONE SLATE ARGILLIC LIMESTONE INTERLAYED SLATE	L DEV	JIULIPING FORMATION(D3J)	
Associated Rock Type Name	**Age**	**Associated Rock Unit Name**	**Age**
QUARTZ DIORITE ADMELLITE	213.5 MA(198.3 TO 212.8 MA)	XIBA	

Geology Comm DEPOSITS WERE LOCATED AT A TRANSFORM ZONE BETWEEN TWO CRATONS. LIMESTONES AND CLASTIC ROCKS OF DEVONIAN AGE ARE AS HOST ROCK. XIBA QUARTZ DIORITE, ADMELLITE IS AN IGNEOUS INTRUSION NEAR THE OREFIELD, BUT NO EVIDENCE SHOWS THE RELATIONSHIP BETWEEN GOLD MINERALIZATION AND THE IGNEOUS BODY. TWO SETS OF FAULTS APPEAR IN THE OREFIELD. FAULTS, WHICH TREND NORTHWEST, ARE MAIN ORE-CONTROLLING STRUCTURES, INCLUDING WANGJIALENG NORMAL FAULT, SHUANGWANG GOLD-BEARED BRECCIA ZONE, AND XIUSHIYA REVERSE FAULT. FAULTS WITH NORTHEAST TRENDING AND SMALL SIZE ARE POST GOLD MINERALIZATION. GOLD OREBODIES WERE HOSTED BY SHUANGWANG BRECCIA ZONE, WHICH CONSISTED OF 8 BRECCIA BODIES AND WAS DISTRIBUTED AS A "S" PATTERN. ALBITE BRECCIA ROCKS ARE MAIN COMPONENT OF BRECCIA BODIES, BUT MOST OF BRECCIA BODIES WERE MADE UP OF MIXED BRECCIAS WITH MULTIPLE SIZE AND SHAPE. THESE WERE PRODUCED BY BREAKING AND CEMENTING OF MULTIPLE HYDROTHERMAL ACTIVITY. THE COMPONENT OF BRECCIAS WERE LIGHT GREY TO BROWN SLATES OR SILTSTONE. MARBLE AND CRYSTALLINE LIMESTONE BRECCIAS WERE OBSERVED IN #I BRECCIA BODY. BRECCIAS USUALLY OCCUR AS JIGSAW STRIP, MULTIPL-ANGULAR AND IRREGILAR SHAPE. SIZE OF FRAGMENTS RANGED FROM 10 CM TO SEVERAL METERS. CEMENT OF BRECCIAS WERE THE PRODUCTS OF MULTIPLE HYDROTHERMAL ACTIVITY SUCH AS ALBITE, ANKERITE, CALCITE AND SMALL AMOUNTS OF QUARTZ, PYRITE. CRITERIONS OF JUDGMENT FOR PROSPECTING GOLD IN BRECCIA BODIES ARE AS FOLLWS: FAVORABLE BRECCIA BODIES TO GOLD MINERALIZATION ARE ALBITE BRECCIA, WHICH OCCUR AS LENTICULAR BOTH ON PLANE AND SECTION, AND SIZE OF BRECCIA RANGED BETWEEN 10 CM TO 50 CM. FOR EXAMPLE, STASTISTICS OF # 8 BRECCIA BODY ON THE SIZE OF BRECCIA AS INTERVAL >100 CM, 100-50 CM, 50-10 CM, <10 CM AND 608 SAMPLE SHOW THAT 80% SAMPLE WITH >2 PPM AU ARE RANGED FROM 10 CM TO 50 CM; POOR BRECCIA BODIES ARE WITH MARBLE, LIMESTONE BRECCIA AND OCCUR STATIFORM. THE SIZE OF BRECCIAS ARE USUALLY > 50 CM OR < 10 CM, SUCH AS SHEXINGDI, SHUIDIGOU AND QINGYAGOU, WHERE THE BRECCIA BODIES WITH FRAGMENTS <10 CM. ALL OF THEIR ANALYSIS OF GOLD ARE BELOW 0.3 PPM AU.

-- Deposit Description --

Deposit Size Medium

--Individual Ore Bodies--

Ore Body Number 1 *Ore Body Name* #8

USGS Model Name	CARBONATE-HOSTED AU-AG	*Model Number*	26A
Deposit Type	HYDROTHERMAL BRECCIA-FILLING		
Length	680	*Units*	M
Width	348	*Units*	M
Thickness	28.30	*Units*	M

Deposit Desc Comm 14 OREBODIES WERE DEFINED BY 1PPM AU, OF THESE, #8 IS THE BIGGEST ONE. OREBODIES ARE CONTROLLED STRICTLY BY BRECCIA BODIES WHICH OCCUR AS WEDGES. THERE ARE 6 STAGES IN ORE-FORMING PROCESSES ACCORDING TO THE RELATIONSHIP BETWEEN GOLD AND MINERALS. THEY ARE: 1. PYRITE-ANKERITE-QUARTZ-ALBITE, 2. QUARTZ-ALBITE-PYRITE-ANKERITE, 3. PYRITE-CALCITE, 4. PYRITE, 5. FLUORITE-DICKITE-CALCITE, 6. GYPSUM-ANHYDRITE. THE FAVORABLE TO GOLD MINERALIZTION IS 2, 3 STAGES. THE OXIDE COMPONENT OF TWO MIXED ORE SAMPLES IS ASSEMBLAGE AS FOLLOWS: I / IV SAMPLE, 44.00% / 44.89% SIO2, 12.13% / 12.16% AL2O3, 4.93% / 4.63% FE2O3, 6.26% / 0.00% NA2O, 0.53% / 0.55% K2O, 10.50% / 10.30% CAO, 4.94% / 4.71% MGO, 0.11% / - P2O5, 0.53% / 0.56% TI02. 2.66% PT AND 0.348% PD HIGH VALUE WERE FOUND BY ELECTRONIC PROB. IN PYRITE AND ANKERITE. S ISOTOPE +9.58 TO 9.65 PYRITE; H (H2O) ISOTOPE -103.9 TO -124.3 ALBITE, -65.3 TO -131.9 QUARTZ; O ISOTOPE +17.40 TO +16.51ALBITE, +17.78 TO 19.90 QUARTZ; O ISOTOPE (CO2) +15.06 TO +18.66 ANKERITE, +14.86 TO +15.34 CALCITE; C ISOTOPE (MINERALS) -4.47 TO -7.89 ANKERITE, -6.42 TO -6.72 CALCITE. ORE-FORMING TEMPERATURE AROUND 350 C, PRSSURE 1.4 TO 1.75 (X 100000000) PA. DEPOSITS WAS MARKED BY AU S CU, PB, ZN, CR, CO, NI, V ANOMALIES. THESE ANOMALIES WERE CONSISTENT WITH BRECCIA ZONES.

-- Exploration and Development --

Production Size Small

-- Description of Workings --

Desc Workings Surface

-- Reference --

Reference FAN, SHUOCHENG AND JIN, QINHAI, 1994, THE MODEL OF SHUANGWANG GOLD DEPOSIT, SHANXI: IN LIU, DONGSHENG (ED.), CHINESE CARLIN-TYPE GOLD DEPOSITS, UNIVERSITY OF NANJING PRESS, P254-285.

Mineral Resources Data System (MRDS)

Report Title CHINA - Carbonated Hosted AU-AG
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Current Date Thursday, April 10, 1997 **Current Time** 13:46:06
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Record Number	RE00765	*User Field*	
Record Type	Site	*File Link ID*	
Reporter	ZHIPING LI, S. G. PETERS		
Reporter Affiliation	USGS	*Report Date*	96 01
Site Name	LAERMA		
Synonym Name	EDOU AND QIONGME		

-- Location Information --

District Name	CHUAN-SHAN-GAN		
Country	CHINA	*Country Code*	CH
State	GANSU	*State Code*	GS
County	LAERMA		
Physiographic Prov	04INTERIOR HIGHLANDS		
Latitude	34-00-24N	*Decimal Lat*	34.00666
Longitude	102-19-12E	*Decimal Long*	102.32
Accuracy	EST		

Location Comments LOCATED AT THE COMBINATION AREA OF SHANXI, GANSU AND SICHUAN

-- Commodity Information --

Commodity Type Metallic
Commodities AU U HG SB MO Y PT(OS PD)
Major AU U
Minor HG SB MO Y PT(OS PD)
Ore Materials NATIVE GOLD PYRITE STIBNITE CINNABAR TENNANTITE
Non-Ore Materials QUARTZ BARITE DICKITE SERICITE PITCH
Analytical Data 1.0-24.6 PPM AU, THE HIGHEST CONTENT OF GOLD IS 66.0 PPM
Commod Comments CLASSIFICATION OF ORE COULD BE CARBON+SILICA MUDSTONETYPE (SIO2 > 86%) AND CARBONACEOUS ARGILLITE BY CHEMICAL COMPONENTS; OR VEINLET TYPE AND DISSEMINATED TYPE BY TEXTURE; OR BARITE, ANTIMONITE, CINNABAR-ORPIMENT-REALGAR ORE BY MINERAL COMPONENTS.

-- Geology --

Tectonic Setting WEST OF QINLING FOLDS
Regional Trends MAQU-DIEBU THRUST STRUCTURE
Local Structure EAST-WEST TRENDING FAULTS ARE THE MAINLY STRUCTURE
Alteration SILICIFICATION
Ore Control EDU SYNCLINE AND ANTICLINE ARE HOST STRUCTURE. RIGINAL RIFT IS MAIN CHANNAL OF HYDROTHERMAL FLUID
Age Mineralization 49.5 TO 12.7 MA

Host Rock Type Name	Age	Host Rock Unit Name	Age
CARBONACEOUS ARGILLIC SLATE	E CAMB	EDU GROUP IN TAIYANGDING FORMATION	

CARBONACEOUS SILICEOUS ROCKS, CARBONACEOUS SILTY SLATE	E CAMB	EDU GROUP IN TAIYIANGDING FORMATON	
CHERT CARBONCEOUS ARGILLIC SLATE	E CAMB	EDU GROUP IN TAIYANGDING FORMATION	
MIDIUM TO THIN BLACK CARBONACEOUS SILIC SLATE	E CAMB	YAXIANG GROUP IN TAIYANGDING FORMATION	
CARBONACEOUS SILICOLITES INTERLAYERED THIN HEMATITE LAYER	E CAMB	YAXIANG GROUP IN TAIYANGDING FORMATION	
SILTY SLATE WITH PYRITE AND SERICITE, CHERT	E CAMB	YAXIANG GROUP IN TAIYANGDING FORMATION	

Geology Comm LAERMA IS A CARLIN-TYPE DEPOSIT WHICH WAS FOUND AT WEST QINLING AREA IN EARLY 1980'S. HOST ROCK, CARBON + SILICA MUDSTONE, IS A SPECIAL FORMATION IN EARLY CAMBRIAN. INTERSECTION OF EDU SYNCINES AND EAST-WEST FAULTS WERE ORE-CONTROL STRUCURES. GOLD MINERALIZATION WITH SILICIFICATION ALTERATION WAS ASSOCIATED WITH STOCKWORKS, WHICH WERE COMPOSED OF QUARTZ, BARITE, DICKITE, ANTIMONITE. PROCESS OF METALLOGENICS PRESENTED HYDROTHERMAL EXPLOTION IN EARLY AND DIFFERENTIAL PRECIPITATION IN LATE STAGE. A MEDIUM SIZE U-HG DEPOSIT WAS FORMED BY THE SAME METALLOGENIC PROCESS. THERE ARE TWO KINDS OF IGNEOUS INTRUSIONS, ONE OCCURS AS DIKES ALONG FAULTS BROKEN ZONES SUCH AS DIABASE AND DIORITE. THESE DIKES WERE FAVORABLE FOR GOLD MINERALIZATION AND SOME OF THEM BECAME ENRICHED IN GOLD. ANOTHER ONE IS GRANODIORITE STOCKS (ABOUT 1.5 SQUARE KM) ASSOCIATED. VOLCANIC ROCKS INCLUDE RHYOLITIC TUFF, INTERLYED DACITE TUFF, AND TUFF BRECCIA ROCKS. THREE MINERALIZATION SUB- ZONES CAN BE DIVIDED FROM NORTH TO SOUTH AS FOLLOWS: 1. YAERMA-ZHOUQU AU-AS, FE-CU-P ZONE, EXTENDED ALONG NORTHWEST. GOLD MINERALIZTION OCCURRED IN CARBONATE AND CLASTIC FORMATION OF DEVONIAN AGE. HOST ROCKS ARE ARGILLIC LIMESTONE INTERLAYERED SILTY SLATE, CARBONACEOUS SLATE AS WELL AS DIORITE DIKES. ELEMENTS ASSEMBALAGE IS AU-AS-SB, PINGDING DEPOSIT AND JIUYUAN, HEBUDOU, CHABU, CAMA,YAERMA AND QINGKEYAN AU (AS-SB) PROSPECTS AS WELL AS LOUDA, EAST YAERMA HEMATITE (SIDERITE) DEPOSIT AND CUEGOSHAN, YIWA CU PROSPECTS WERE IN THIS ZONE; 2. BEHAI-BAIYI U-AU ZONE, TRENDS NORTHWEST, OCCUR IN CARBON+SILICA MUDSTONE OF TAIYANGDING FORMATION IN EARLY CAMBRIAN. HOSTED ROCKS ARE CARBONACEOUS SILICOLITES AND SILTY SLATES INTERLAYERED CHERT. METALLOGENIC PROCESS WAS WITH HYDROTHERMAL EXPLOTION BRECCIATION. DEPOSITS PROVEN ARE LAERMA (AU-U-HG), QIONGME (AU-U) AND YAXIANG (AU) PROSPECT AS WELL AS WENQUANGOU, SOUTH YIWA U (MO-V) PROSPECTS; 3. MAQU, NIMA-NANPING, MANAOKE AU-AS, HG-SB ZONE, TRENDS NORTHWEST, OCCUR IN CARBONATE AND CLASTIC FORMATIONS OF PERMIAN, TRIASSIC AGE. HOSTED ROCKS ARE SILTY SLATES, INTERLAYERED DOLOMITIC LIMESTONE AND DIORITE DIKES. PROCESS ARE WITH THE CHARACTERISTICS OF HYDROTHERMAL EXPLOTION AND LOW TO MEDIUM TEMPERATURE DIFFERENTCIAL PRECIPITATION. MANAOKE, SHIJIBA, GEERZHONGQU GOLD DEPOSITS AND BAXI, TUANJIE, QILICUN, JIAWUCHI GOLD PROSPECTS AS WELL AS NIMA HG-AS PROSPECT WERE FOUND IN THIS ZONE. COMPONENTS IN FLUID INCLUSION: IN GAS 705.74 PPM (?) H2O, 49.85 PPM CO2, 4.66 PPM N2, 1.05 PPM CO, 0.62 PPM CH4; IN LIQUID 2.14 PPM K, 2.18 PPM NA, 5.24 PPM CA, 0.63 PPM MG, 4.26 PPM F, 8.06 PPM CL, 24.45 PPM SO4, 4.27 PPM HCO3; SALINITY 63.01 G/L (20.9 TO 185.9 G/L). TEMPERATURE: IN QUARTZITE OR GREY QUARTZ STOCK WITH BARITE (MAIN GOLD MINERALIZATION STAGE) 212 TO 370 C, IN QUARTZ-DICKITE-BARITE VEINLET (SECONARY GOLD MINERALIZATION) 163 TO 240 C, IN BARREN QUARTZ, ANTIMONITE-BARITE

VEIN 116 TO 188 C. ISOTOPE: IN QUARTZ VEIN +16.96 AVE. (+13 TO +20) O (QUARTZ), +8 TO +12 O (H2O), +13.15 AVE. IN BARITE; -101.3 H (QUARTZ); +8.75 S (PYRITE), +13.56 AVE. S (BARITE).

– Deposit Description –

Deposit Size Medium

--Individual Ore Bodies--

Ore Body Number	1	*Ore Body Name*	
USGS Model Name	CARBONATE-HOSTED AU-AG	*Model Number*	26A
Length	50-300	*Units*	M
Thickness	1-25	*Units*	M

Deposit Desc Comm 55 OREBODIES WERE DISCOVERD, GENERALLY 50 M TO 300 M LONG, THE LONGEST IS 1350 METER LONG, 1- 25 METER WIDE; GOLD VALUE IS 1.0-24.6 PPM, THE HIGHEST 66.0 PPM. OF THESE, 12 ARE INDUSTRAL OREBODIES. OREBODIES OCCURED AS STATIFORM IN AXIS OF SYNCLINE AND BOTH WINGS. THEY DISAPPEARED SHARPLY IN EDU FORMATION, WHILE DISAPPEARED GRADULLY IN YAXIANG FORMATION ALONG FAULT BRECCIA ZONE. GENERAL SHAPE OF OREBODIES LOOKED LIKE A MUSHROOM WHICH WERE CONTROLED BY INTERSECTION OF FAULTS.

– Exploration and Development –

Production Size Small

– Description of Workings –

Desc Workings Surface

Workings Comments REGIONAL (22.5 SQURE KM) 1/200,000, 1/50,000 SOIL WORK AND SEDIMENTS OF RIVER GEOCHEMICAL WORK WERE DONE. VALUE OF ELEMENTS IN SEDIMENTS OF RIVER ARE 25.59 PPB AU, 10.88 PPM SB, 2.5 PPM HG AND 58PPM AS. 5 COMBINAED ANOMALIES WERE DEFINED BY AU, HG, SB, AS, AG, MO, W, BA, CU, ZN, V AND NI. OF THESE, #P3 IS THE LARGEST AND HAVE BEEN PROVEN TO BE A GOLD MINERALIZATION. PRIMARY GEOCHEMISTRY, ANALYSIS OF SINGLE MINERALS, METALLURGY AND DRILLING ETC. DETAIL EXPLORATION WORK HAS BEEN DONE THE DEPOSIT.

– Reference –

Reference LI, YADONG AND LI, YINGTAO, 1994, GEOLOGICAL CHARACTERISTICS AND GENESIS MODEL OF LAERMA DISSEMINATED-TYPE GOLD DEPOSITS, GANSU PROVINCE: IN LIU, DONGSHENG (ED.), CHINESE CARLIN-TYPE DEPOSITS, UNIVERSITY OF NANJING PRESS, P226-253.

Mineral Resources Data System (MRDS)

Report Title CHINA - Carbonated Hosted AU-AG
Issue Date 00/00/00 — *Number* In Set of 1
Current Date Thursday, April 10, 1997 — *Current Time* 13:48:06 — *Printed* 1 of 1

Record Number	RE00767	*User Field*	
Record Type	Site	*File Link ID*	
Reporter	ZHIPING LI, S. G. PETERS		
Reporter Affiliation	USGS	*Report Date*	96 01
Site Name	JINLONGSHAN		

– Location Information –

District Name	CHUAN-SHAN-GAN		
Country	CHINA	*Country Code*	CH
State	SHAANXI	*State Code*	SX
County	ZHENAN		
Physiographic Prov	04INTERIOR HIGHLANDS		
Latitude	33-24-00N	*Decimal Lat*	33.4
Longitude	109-07-18E	*Decimal Long*	109.12166
Accuracy	EST		
Position	SOUTHEAST OF ZHENAN COUNTY TOWN		

– Commodity Information –

Commodity Type Metallic
Commodities AU HG SB
Major AU
Minor HG SB
Ore Materials PYRITE ARSENOPYRITE ANTIMONITE SPHALERITE CHALCOPYRITE
Non-Ore Materials QUARTZ CALCITE SERICITE BARITE CLAY MINERALS
Analytical Data JINLONGSHAN SUBDISTRICT: #1 OREBODY 1.47-10.02 PPM AU, HIGHEST 33.68 PPM AU; #3 OREBODY 1.08-33.53 PPM AU; #16 OREBODY 1.13-52.58 PPM AU; #6 OREBODY 1.00-16.47 PPM AU. YIAOJIAN SUBDISTRICT: #10 OREBODY 1-11.20 PPM AU; #7 OREBODY 1.55-11.63 PPM AU. QIULING SUBDISTRICT: #1 OREBODY 1.52-5.80 PPM AU; #4 OREBODY 1.05-14.36 PPM AU. GULOUSHAN SUBDISTRICT: #2 OREBODY 1.00-10.16 PPM AU; #3-1 OREBODY 1.00-5.15 PPM AU; #3-2 OREBODY 1.03-4.12 PPM AU.

– Geology –

Tectonic Setting INTRACONTINENTAL RIFT
Regional Trends A SERIES OF FOLDS AND FAULTS WHICH TREND EAST TO WEST
Local Structure DUCTILE FOLDS SHEAR ZONES
Alteration SILICIFICATION CARBONATIZATION
Ore Control STRONG COMPRESSIONAL PLASTIC DEFORMED ZONES WERE DISTRIBUTED ON THE CORE AS WELL AS TWO WINGS OF ANTICLINES

Host Rock Type Name	Age	Host Rock Unit Name	Age
MEDIUM- THICK FERRUGINOUS AND CALCAREOUS QUARTZ SANDSTONE	M DEV	DAFANGGOU FORMATION	
SANDSTONE SILTSTONE SHALE THICK	M DEV	YANGLINGGOU FORMATION	

MICROMETER IN DIAMETER, APPEAR TO BE CONCENTRATED WITH SULFIDES AND CLAY MINERALS; HIGHEST GOLD GRADES ASSOCIATED WITH ASSEMBLAGE PYRITE-ARSENOPYRITE-MARCASITE-ANKERITE, LESSER AMOUNTS WITH PYRITE-ARSENOPYRITE-MARCASITE, A CROSS CUTTING PYRITE-REALGAR-STIBNITE-QUARTZ ASSEMBLAGE DOES NOT CONTAIN GOLD

-- Deposit Description --

--Individual Ore Bodies--

Ore Body Number 1 *Ore Body Name*

USGS Model Name CARBONATE-HOSTED AU-AG *Model Number* 26A

Deposit Type SEDIMENTARY-ROCK HOSTED DISSEMINATED GOLD

Deposit Desc Comm DEPOSIT CONTAINS NINE KNOWN OREBODIES; MAIN ORE-BEARING ZONE MORE THAN 1,000 M LONG AND SEVERAL TENS OF METERS WIDE

-- Exploration and Development --

Development Status Occurrence

Expl/Devl Comments A FEW EXPLORATION SAMPLES FROM OLD WORKINGS GAVE ANALYSES OF 1-3 G/MT AU, WITH MAXIMUM OF 13.4 G/MT; EXPLORATION AND DRILLING IN PROGRESS

-- Description of Workings --

Workings Comments DEPOSIT ORIGINALLY MINED FOR REALGAR, MANY OLD TUNNELS PRESENT

-- Reference --

Reference CUNNINGHAM, C. G., ASHLEY, R. P., CHOU, I-M., HUANG, Z., WAN, C., AND LI, W., 1988, THE NEWLY DISCOVERED SEDIMENTARY-ROCK HOSTED DISSEMINATED GOLD DEPOSITS IN THE PEOPLE'S REPUBLIC OF CHINA: U. S. GEOLOGICAL SURVEY OPEN-FILE REPORT 88-220, 15 P.

-- Reserves Only --

Item	Acc	Amount	Th Units	Year	Grade
AU	EST	0.005	MT	1988	AVERAGE UP TO 5 G/MT AU IN NINE OREBODIES

Resv Source Info CUNNINGHAM AND OTHERS, 1988.

Mineral Resources Data System (MRDS)

Report Title CHINA - Carbonated Hosted AU-AG

Issue Date 00/00/00 *Number* In Set of 1

Current Date Thursday, April 10, 1997 *Current Time* 13:46:06 *Printed* 1 of 1

Record Number W700367 *User Field*

Record Type Site *File Link ID*

Reporter PAIDAKOVICH, MATTHEW E.

Reporter Affiliation USGS *Report Date* 88 06

Updater PAIDAKOVICH, MATTHEW E.

Updater Affiliation *Update Date* 88 07

Site Name GETANG DEPOSIT

-- Location Information --

Country CHINA *Country Code* CH

State GUIZHOU *State Code*

Latitude 25-15-00N *Decimal Lat* 25.25

Longitude 105-16-00E *Decimal Long* 105.26666

Accuracy EST

Position 27 KM NORTHWEST OF ANLONG

-- Commodity Information --

Commodity Type Metallic

Commodities AU

Major AU

Ore Materials GOLD; (PYRITE, STIBNITE, MARCASITE, ARSENOPYRITE, REALGAR, CINNABAR)

Non-Ore Materials CHALCEDONIC QUARTZ, ILLITE, CALCITE, DOLOMITE, FLUORITE, BARITE, LIMONITE

-- Geology --

Tectonic Setting NEAR BURIED SOUTHWESTERN MARGIN OF PRECAMBRIAN YANGTZE CRATON

Regional Trends DEPOSIT LOCATED ON EASTERN LIMB OF GETANG DOME, A NORTHWEST-TRENDING ANTICLINE ABOUT 50 KM LONG; PERMIAN ROCKS EXPOSED IN INLIER AT CENTER OF DOME

Local Structure BRECCIA HORIZON MAY MARK SUPERIMPOSED BEDDING-PLANE THRUST FAULT; ROCKS DIP 10 DEG. NE, CUT BY HIGH-ANGLE REVERSE FAULTS OF SMALL DISPLACEMENT

Alteration SILICIFICATION; GOLD CONTENT OF ORE INCREASES WITH DEGREE OF SILICIFICATION

Conc/Enrichment OXIDIZED ORE CONTAINS LIMONITE

Ore Control GOLD CONCENTRATED AS DISSEMINATIONS IN BASAL BRECCIA HORIZON, ALSO OCCURS WITH LIMONITE IN OXIDIZED ROCKS

Host Rock Type BASAL KARST CARBONATE BRECCIA

Host Rock Age LPERM LATE PERMIAN

Host Rock Type Name	Age	Host Rock Unit Name	Age
		LONGTAN FORMATION	LPERM LATE PERMIAN

Geology Comm PRELIMINARY FLUID INCLUSION HOMOGENIZATION TEMPERATURES IN QUARTZ AVERAGE APPROX. 120 DEG. C; JASPEROID AND SILICIFIED LIMESTONE CONTAINING PYRITE AND STIBNITE OVERLIE THE DEPOSIT; GEOCHEMICAL ANOMALIES OF ARSENIC AND MERCURY ARE PRESENT; GOLD OCCURS

PRINCIPALLY AS GRAINS LESS THAN 0.5 MICROMETERS IN DIAMETER, LOCALLY UP TO 3 MICROMETERS; MAOKU FORMATION IS MASSIVE GRAY LIMESTONE WITH KARST UNCONFORMITY AT TOP, AND IS OVERLAIN BY LONGTAN FORMATION, AN ARGILLACEOUS LIMESTONE CONTAINING COAL LAYERS, SILICIFIED SHALE, AND CLASTIC ROCKS NEAR TOP

-- Deposit Description --
--Individual Ore Bodies--

Ore Body Number 1 *Ore Body Name*
USGS Model Name CARBONATE-HOSTED AU-AG *Model Number* 26A
Deposit Type SEDIMENTARY-ROCK HOSTED DISSEMINATED GOLD
Deposit Form LENTICULAR OREBODIES

Deposit Desc Comm OREBODIES CROP OUT DISCONTINOUSLY ALONG 3-15 M THICK BRECCIA HORIZON OVER DISTANCE OF 1,000 M; GRADE INCREASES FROM 2-3 G/MT AU IN UNOXIDIZED ORE TO 4-5 G/MT IN LIMONITE-BEARING OXIDIZED ORE, AND RISES LOCALLY TO 50 G/MT

-- Exploration and Development --

Developent Status Occurrence
Expl/Devl Comments PRESENTLY BEING DRILLED ON A 40-M GRID

-- Description of Workings --

-- Reference --

Reference CUNNINGHAM, C. G., ASHLEY, R. P., CHOU, I-M., HUANG, Z., WAN, C., AND LI, W., 1988, THE NEWLY DISCOVERED SEDIMENTARY-ROCK HOSTED DISSEMINATED GOLD DEPOSITS IN THE PEOPLE'S REPUBLIC OF CHINA: U. S. GEOLOGICAL SURVEY OPEN-FILE REPORT 88-220, 15 P.
Reference CUNNINGHAM, C. G., 1988, WRITTEN COMMUNICATION.

-- Reserves Only --

Item	Acc	Amount	Th Units	Year	Grade
AU	EST	0.010	MT		

Resv Source Info CUNNINGHAM, C. G., 1988.

Mineral Resources Data System (MRDS)

Report Title CHINA - Carbonated Hosted AU-AG
Issue Date 00/00/00 *Number* in Set of 1
Current Date Thursday, April 10, 1997 *Current Time* 13:46:06 *Printed* 1 of 1

Record Number W700368 *User Field*
Record Type Site *File Link ID*
Reporter PAIDAKOVICH, MATTHEW E.
Reporter Affiliation USGS *Report Date* 88 06
Updater PAIDAKOVICH, MATTHEW E.
Updater Affiliation *Update Date* 88 07
Site Name SANCHAHE DEPOSIT

-- Location Information --

Country CHINA *Country Code* CH
State GUIZHOU *State Code*
Latitude 25-31-00N *Decimal Lat* 25.51666
Longitude 105-37-00E *Decimal Long* 105.61666
Accuracy EST
Position 45 KM NORTHEAST OF ANLONG

-- Commodity Information --

Commodity Type Metallic
Commodities AU
Major AU
Ore Materials GOLD, PYRITE; (PYRITE, ARSENOPYRITE, REALGAR, CINNABAR, MARCASITE, BARITE, FLUORITE, STIBNITE)
Non-Ore Materials QUARTZ, CALCITE

-- Geology --

Tectonic Setting NEAR BURIED SOUTHWESTERN MARGIN OF PRECAMBRIAN YANGTZE CRATON
Regional Trends DEPOSIT LOCATED ALONG CREST OF 40 KM-LONG NW-TRENDING ANTICLINE THAT EXPOSES PERMIAN STRATA IN CENTER
Local Structure LOCATION OF OREBODIES INFLUENCED BY REVERSE FAULTS TRENDING PARALLEL TO CREST OF DOME
Alteration WALL ROCK ALTERATION
Conc/Enrichment OXIDATION CAUSED SOME GOLD ENRICHMENT AT OR NEAR GROUND SURFACE
Ore Control MINERALIZATION AND WALL ROCK ALTERATION IS PRINCIPALLY IN VICINITY OF FAULTS
Host Rock Type SANDY SHALES CONTAINING THIN COAL BEDS; ARGILLACEOUS CARBONATES, ARKOSIC SHALES
Host Rock Age LPERM PERM LATE PERMIAN; PERMIAN, EARLY TRIASSIC

Host Rock Type Name	Age	Host Rock Unit Name	Age
		LONGTAN FORMATION	LPERM LATE PERMIAN
		CHANGXING FORMATION	PERM PERMIAN; EARLY TRIASSIC

Mineral Resources Data System (MRDS)

Report Title	CHINA - Carbonated Hosted AU-AG		
Issue Date	00/00/00		*Number* in Set of 1
Current Date	Thursday, April 10, 1997	*Current Time* 13:46:06	*Printed* 1 of 1

Record Number	W700369	*User Field*	
Record Type	Site	*File Link ID*	
Reporter	PAIDAKOVICH, MATTHEW E.		
Reporter Affiliation	USGS	*Report Date*	88 06
Site Name	CEYANG DEPOSIT		

-- Location Information --

Country	CHINA	*Country Code*	CH
State	GUIZHOU	*State Code*	
Latitude	24-59-00N	*Decimal Lat*	24.98333
Longitude	105-45-00E	*Decimal Long*	105.75
Accuracy	EST		
Position	7 KM WEST OF CEHENG		
Location Comments	DEPOSIT CROPS OUT ALONG GUIZHOU-GUANGXI HIGHWAY		

-- Commodity Information --

Commodity Type Metallic
Commodities AU
Major AU
Ore Materials GOLD; (PYRITE, ARSENOPYRITE, CHALCOPYRITE)
Non-Ore Materials CLAY MINERALS

-- Geology --

Tectonic Setting NEAR BURIED SOUTHWESTERN MARGIN OF PRECAMBRIAN YANGTZE CRATON

Regional Trends AT SOUTHERN END OF 30 KM-LONG LUGONG ANTICLINE, WHICH EXPOSES PERMIAN ROCKS ALONG CREST; AXIS OF ANTICLINE TRENDS NORTH-SOUTH, APPROX. PARALLEL TO MARGIN OF YANGTZE CRATON AND TO STRIKE OF FACIES CHANGES

Local Structure LARGE NORTHEAST-TRENDING REVERSE FAULTS CLOSELY RELATED TO GOLD DISTRIBUTION; NORTHWEST-TRENDING STRIKE-SLIP FAULTS COMMONLY DISPLACE NORTHEAST-TRENDING FAULTS

Alteration SILICIFICATION, PYRITIZATION

Ore Control OREBODIES IN SILICIFIED AND PYRITIZED ZONE AT INTERSECTION OF ARKOSIC SHALES AND NORTHEAST-TRENDING FAULTS

Host Rock Type ARKOSIC SHALES
Host Rock Age MTRI MIDDLE TRIASSIC

Host Rock Type Name	Age	Host Rock Unit Name	Age
		XINYUAN FORMATION	MTRI MIDDLE TRIASSIC

Geology Comm DEPOSIT MARKED BY GOLD AND ARSENIC GEOCHEMICAL ANOMALY; XINYUAN FORMATION SHALES OVERLIE PERMIAN ARGILLACEOUS CARBONATES; DISSEMINATED GOLD GRAINS GENERALLY ABOUT A MICROMETER IN DIAMETER, BUT LARGER ONES PRESENT AND APPEAR SPATIALLY RELATED TO CLAY

	DALONG FORMATION	PERM PERMIAN
	YELANG FORMATION	ETRI EARLY TRIASSIC

Geology Comm DEPOSIT CONTAINS A THALLIUM ANOMALY, WITH ORE CONTAINING UP TO 100 PPM THALLIUM; FINE-GRAINED DISSEMINATED GOLD IS CLOSELY ASSOCIATED WITH PYRITE, ARSENOPYRITE, QUARTZ; SOME PYRITE CONTAINS GOLD; LONGTAN FORMATION IS OVERLAIN BY CHANGXING AND DALONG FORMATIONS AND YELANG FORMATION

-- Deposit Description --
--Individual Ore Bodies--

Ore Body Number	1	*Ore Body Name*	
USGS Model Name	CARBONATE-HOSTED AU-AG	*Model Number*	26A
Deposit Type	SEDIMENTARY-ROCK HOSTED DISSEMINATED GOLD		
Deposit Form	LENTICULAR OREBODIES		

Deposit Desc Comm DRILLING HAS DEFINED SEVERAL OREBODIES 65-200 M LONG, 6-15 M THICK, GRADING 3.9-5.2 G/MT AU

-- Exploration and Development --

Developent Status Occurrence
Year of Discovery *Nature of Disc* Geochemical Anomaly
Expl/Devl Comments DISCOVERED BECAUSE ASSAYS OF SAMPLES COLLECTED DURING MERCURY RECONNAISSANCE PROGRAM CONTAINED ABOUT 3 G/MT AU; CURRENT DRILLING

-- Description of Workings --

Workings Comments OLD MERCURY AND ARSENIC MINES ARE PRESENT IN THE AREA

-- Reference --

Reference CUNNINGHAM, C. G., ASHLEY, R. P., CHOU, I-M., HUANG, Z., WAN, C., AND LI, W., 1988, THE NEWLY DISCOVERED SEDIMENTARY-ROCK HOSTED DISSEMINATED GOLD DEPOSITS IN THE PEOPLE'S REPUBLIC OF CHINA: U. S. GEOLOGICAL SURVEY OPEN-FILE REPORT 88-220, 15 P.

MINERALS, PYRITE, ARSENOPYRITE, CHALCOPYRITE

-- Deposit Description --
--Individual Ore Bodies--

Ore Body Number	1	*Ore Body Name*	
USGS Model Name	CARBONATE-HOSTED AU-AG	*Model Number*	26A
Deposit Type	SEDIMENTARY-ROCK HOSTED DISSEMINATED GOLD		

Deposit Desc Comm SIX OREBODIES IDENTIFIED TO DATE, IN ZONE UP TO 2,000 M LONG, ARE 35-130 M LONG, 1-3 M THICK, GENERALLY CONTAIN 3-5 G/MT AU, WITH MAXIMUM GRADE 7 G/MT

-- Exploration and Development --

Development Status Occurrence

-- Description of Workings --

-- Reference --

Reference CUNNINGHAM, C. G., ASHLEY, R. P., CHOU, I-M., HUANG, Z., WAN, C., AND LI, W., 1988, THE NEWLY DISCOVERED SEDIMENTARY-ROCK HOSTED DISSEMINATED GOLD DEPOSITS IN THE PEOPLE'S REPUBLIC OF CHINA: U. S. GEOLOGICAL SURVEY OPEN-FILE REPORT 88-220, 15 P.

Mineral Resources Data System (MRDS)

Report Title CHINA - Carbonated Hosted AU-AG
Issue Date 00/00/00 *Number* In Set of 1
Current Date Thursday, April 10, 1997 *Current Time* 13:46:06 *Printed* 1 of 1

Record Number	W700370	*User Field*	
Record Type	Site	*File Link ID*	
Reporter	PAIDAKOVICH, MATTHEW E.		
Reporter Affiliation	USGS	*Report Date*	88 06
Updater	PAIDAKOVICH, MATTHEW E.		
Updater Affiliation		*Update Date*	88 07
Site Name	BANOI DEPOSIT		

-- Location Information --

Country	CHINA	*Country Code*	CH
State	GUIZHOU	*State Code*	
Latitude	24-48-00N	*Decimal Lat*	24.8
Longitude	105-39-00E	*Decimal Long*	105.65
Accuracy	EST		
Position	ABOUT 10 KM SOUTH OF YATA DEPOSIT (GUIZHOU PROVINCE)		

-- Commodity Information --

Commodity Type Metallic
Commodities AU
Major AU

-- Geology --

Tectonic Setting NEAR BURIED SOUTHWESTERN MARGIN OF PRECAMBRIAN YANGTZE CRATON
Regional Trends ALONG SOUTHERN EDGE OF SMALL (15-KM-LONG) EAST-WEST-TRENDING DOME THAT HAS PERMIAN HOUZIGUAN LIMESTONE EXPOSED IN CENTER
Local Structure OREBODIES ARE ALONG FAULT THAT IS PARALLEL TO AXIS OF DOME
Ore Control IN CARBONATE BRECCIA ALONG FAULT
Host Rock Type CARBONATE BRECCIA
Host Rock Age MTRI MIDDLE TRIASSIC

Host Rock Type Name	Age	Host Rock Unit Name	Age
		XINYUAN FORMATION	MTRI MIDDLE TRIASSIC

Geology Comm REPORTEDLY SIMILAR TO GETANG DEPOSIT (GUIZHOU PROVINCE)

-- Deposit Description --
--Individual Ore Bodies--

Ore Body Number	1	*Ore Body Name*	
USGS Model Name	CARBONATE-HOSTED AU-AG	*Model Number*	26A
Deposit Type	SEDIMENTARY-ROCK HOSTED DISSEMINATED GOLD		

Deposit Desc Comm CONTAINS SEVERAL GRAMS OF GOLD PER TONNE

-- Exploration and Development --

Development Status Occurrence

-- Description of Workings --

-- Reference --

Reference CUNNINGHAM, C. G., ASHLEY, R. P., CHOU, I-M., HUANG, Z., WAN, C., AND LI, W., 1988, THE NEWLY DISCOVERED SEDIMENTARY-ROCK HOSTED DISSEMINATED GOLD DEPOSITS IN THE PEOPLE'S REPUBLIC OF CHINA: U. S. GEOLOGICAL SURVEY OPEN-FILE REPORT 88-220, 15 P.

Reference CUNNINGHAM, C. G., 1988, WRITTEN COMMUNICATION.

-- Reserves Only --

Item	Acc	Amount	Th Units	Year	Grade
AU	EST	0.007	M T		

Resv Source Info CUNNINGHAM, C. G., 1988.

Appendix III:

CHINESE CARLIN-TYPE GOLD DEPOSIT EXAMPLES:

III-1. Geologic features, metallogenic process and prospect on the Lannigou gold deposit, Zhengfang County, Guizhou Province, P.R. China.

III-2. A New Type Gold Deposit, the Greatwall -- Its Characteristics and Potential in Eastern Hebei Province, P.R. China

Appendix III-1.

GEOLOGICAL CHARACTERISTICS, FORMING MECHANISM AND PROSPECT ON THE LANNIGOU GOLD DEPOSIT IN ZHENGFENG COUNTY, GUIZHOU PROVINCE

Lou, Xiaohuan
(117th Geological Team, Guizhou Province Bureau of Geology)

(Translation by Zhiping Li, and Review by Greg C. Ferdock and Stephen G. Peters)

INTRODUCTION

The Lannigou gold deposit is located on the bank of the Beipanjang River in southeast Zhengfeng County, Guizhou Province. It was originally an orpiment prospect discovered by the Regional Geological Survey Team, Bureau of Geology of Guizhou Province, *in* 1986, and was evaluated by the 117th Geological Team of the Bureau. This deposit has been listed as one of the "892 National Plan" projects because its orebodies are thick and rich, having significant economic potential. Through exploration, the Lannigou gold deposit has become one of the largest deposits in the Dian-Qian-Gui area in the past six years (1987 to 1992). The No. 1 orebody, located in the Huang-Chang-Gou block, has been proven to be large in size, while the deposit as a whole is extra-large in size. This deposit is considered to be mineable because of its uniform thickness, even grade, good hydrogeology, metallurgy of the ore and suitability for open pit mining.

This paper attempts to build a geological model of the deposit through understanding of the geological characteristics, structure-metallogeny processes, and mechanism of formation in the Lannigou gold deposit, then, will discuss prospecting directions and criterion for further exploration and development. Discussion of new ideas about ore-formation theory and how it would be helpful to find other structure-related gold deposits, such as the Lannigou deposit, *in* the Dian-Qian-Gui area. Some mistakes or misunderstanding may be found in this paper because of time and reference limitations. However, the author welcomes any comments and suggestions from readers. The author would like to thank the many colleagues who are working on this deposit for allowing me to cite portions of their exploration data in this paper.

REGIONAL GEOLOGICAL SETTING

The Lannigou gold deposit is located at the southwest margin of the Yangtze Craton, *in* the northern Nanpanjang orogenic fold zone, at the joint area of the Tethyan-Hemalayan and Pacific Ocean tectonic plates. Regionally, tectonic

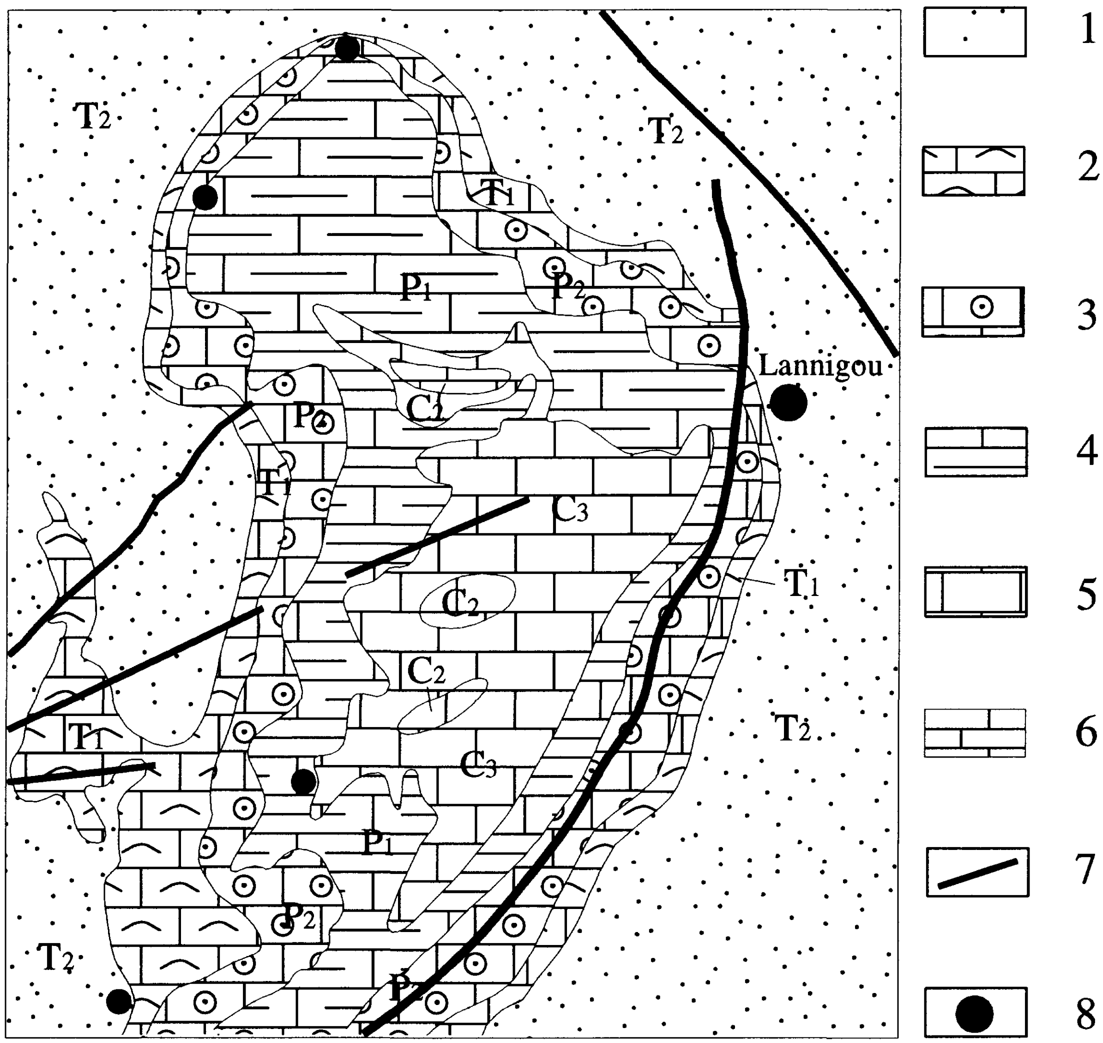

Figure 3-1-1. Laizishan short-axial anticline structure
1, 2-the Triassic stratigraphy (T2b, T1l), which are located on the east-west flanks; 3, 4, 5,6-Carbonaceous to Permian limestone, bioclastic limestone located in the core; 7-Faults surrounding the fold are related to Carlin-type gold mineralization such as the Lannigou deposit; 8-Gold deposit.

units belong to the northwest-trending Wangmei deformation zone, which is a triangular-shaped area surrounded by NNE-, NW-, and EW-striking structural zones.

Along the tectonic boundary from Leiping - Xingyi - Zhengfeng - Anshun, sedimentation was controlled by a paleo-tectonic environment, which differed from the late Paleozoic to the early Mesozoic. In the northwestern area of the basin, sediments developed in a broader, restricted platform environment, locally a tidal flat in the early Triassic. Resultant stratigraphic units, from lower to higher, are the Huanglong group (Middle to upper Carbonaceous) and Maping group (upper Carbonaceous), consisting of light gray massive limestone and bioclastic limestone; the Qixia and Maokou groups (lower Permian) consisting of cherty limestone, limestone, and bioclastic limestone, and argillite and tuffaceous argillite in "the Dachang Layer"; the Wujiaping group (upper Permian) consisting of limestone and reef limestone; the Yielang and Anshun groups (Triassic) consisting principally of argillite, limestone, and dolomite. Brittle deformation, such as faults and joints, are better developed in these rocks, and often form a grid-shaped structural pattern, developed by the intersection of N-S, NE and NW trending faults.

By contrast, sediments formed in the southeastern area developed in a chasm basin environment, resulting in a set of thick detrital materials of terrigenous origin. Also, the structural style in this area is characterized by ductile deformation, such as tight folds and thrust structures. Most of the thrust structures trend to northwest and some, north to south. Northeast-striking faults are present as shear-faults cutting the thrust structures. The fold axes of this area trend mainly northwest and east- west, and a few northeast. Recumbent folds are usually associated with the thrust structures.

Structures observed are typical of "thin skin" deformation, and are the products of the Indosinian-Yanshanian Orogeny. Structures can be roughly divided into four stages on the basis of field observations of structural pattern and determination of the regional stress field, which varied from north-south, east-west, northeast-southwest, and northwest-southeast (Zheng, 1989). The specific structural pattern observed in the Lannigou orefield was formed by a multiple and varied stress field, from which the Laizishan short-axial anticline and Banchang thrust fault that played an important role in the evolution of the deposit, were formed (fig. 1).

The Laizishan short-axial anticline is 25 km long and 12 km wide and generally trends to the NNE. Its core consists of middle-upper Carbonaceous to Permian limestone, bioclastic limestone, and reef limestone, and argillite, tuffceous argillite of the "Dachang Layer" which is interbedded between lower and upper Permian strata. Total thickness of the strata in the core is about 1,300 m. Triassic strata is exposed mainly on the east and west limbs of the fold. The west limb consists principally of platform carbonate rocks, while fine-grained clastic rocks, formed in shelf-chasm facies, are present on the east limb. Total thickness of the strata is about 1,000 m. The two limbs of this fold are asymmetric; the dip angle of the eastern limb is around 20° to 40°, and 5° to 20° on the western limb. Well developed, arc-shaped faults surround the anticline and are often associated with Au, As, Hg and Sb mineralization.

The Banchang thrust is located 3 km northeast of the gold deposit, along a line from the Baiceng to Banchang and Pingbe. It is about 60 km long and 1 to 13 km wide, and consists of four parts; the front fold zone; the upper nappe system; the lower nappe system; and the thrust decrement zone (Chen, 1992). The associated fault breccia zone, is about 30 to 100 m wide and filled with compression breccia, mud, oval structural lenses [phacoids] and associated, strong silicification. Minimum horizontal movement of this structure is 1.5 km, and about 800 m vertical. Direction of thrusting

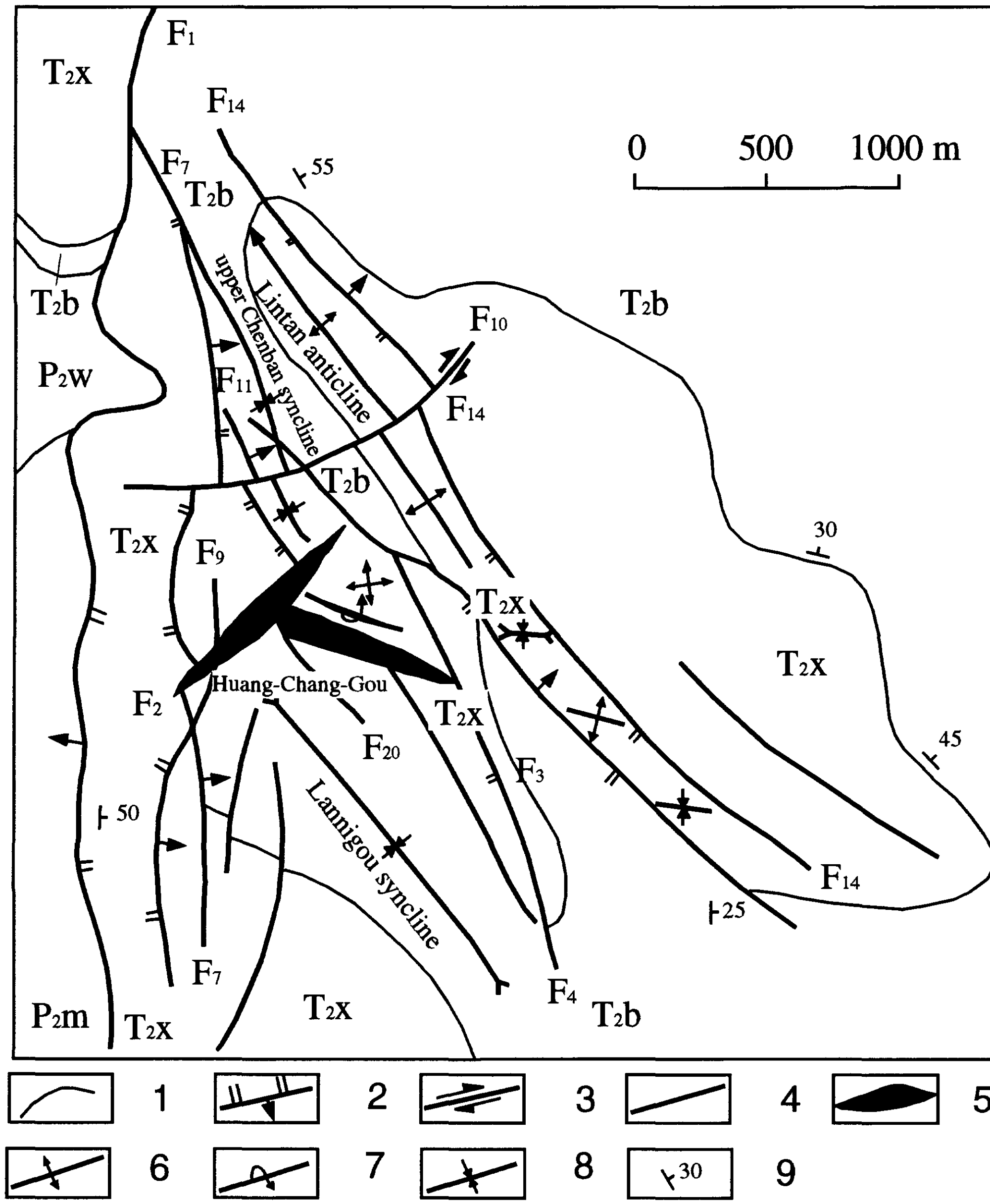

Figure 3-1-2. Geological map of the Lannigou gold deposit
T2b - Bianyang group; T2x - Xinyuan group; T1l - Luolou group; P2w - Wujiaping group; P1m - Maokou group. 1 - Boundary of stratigraphy; 2 - compression fault; 3 - shearing fault; 4 - undefined fault; 5 - ore-control fault; 6 - axial of anticline; 7 - axial of over-turned anticline; 8 - axial of syncline; 9 - dip and angle.

was northeast to southwest with a sinistral shear component.

Igneous rocks are limited in this area, except for a few small alkalic, ultramafic intrusions (porphyry cascadite, fasinite, and cuselite) exposed in Zhengfang to Baiceng about 27 km northeast of the deposit.

The Lannigou, Bannian, Yangyou, Banqi and Yata deposits, *in* addition to the Pegao and Loudong gold prospects, as well as the Qingping and Tangxinzhai gold anomalies and other As, Sb, Hg mineralization present in this area, all surround the Laizishan short-axial anticline. The principal type of mineralization found is sedimentary rock-hosted disseminated gold along with associated metals.

GENERAL GEOLOGY OF THE OREFIELD

Stratigraphy

Two distinct sets of Triassic sedimentary rocks host the ore deposits. Upper Triassic rocks are exposed in the western limb of the Laizishan short-axial anticline and are shallow sea carbonate rocks formed in a continental shelf environment of the Yangtze craton. Early to Middle Triassic rocks are exposed in the eastern limb and host the main ore block of the deposit. They are up to 1,000 m thick terrigenous clastic rocks, such as flyschoid, calcitite, and turbidite formed in an abyssal environment of the Youjang rift basin. Stratigraphic units involved include the Luolou group, the Xinyun (Xuman) and the Bianyang groups (fig. 3-1-2).

Middle Triassic

(1) **Bianyang** group (T_2b) consists of thin- to medium-thick layered, fine-grained sandstone, siltstone that are interbedded with argillite or alternating beds of sandstone and argillite. The sandstone has a fine granular texture, while the argillite displays a microcrystalline texture. The principal clastic component of the sandstone is quartz, which is well sorted and round, forming about 80% of the rock. Hydromica clay minerals, calcium and silica are present in the sandstone as porous cement, forming about 10 to 20%, the remaining detrital fraction of the rock contains clastic debris, feldspar, anatase, rutile and other minerals. Bouma turbidite sequences observed include, B-C, B-D, D-E as well as A, D and E segments. Some sedimentary features such as flute groove casts, load structures, and evenly, oblique, and convoluted bedding are also present in the rocks. Bivalve fossils and fossil fragments are often present in the argillite and silty argillite. The thickness of the Bianyang group is about 268.73 m, and is conformable with underlying strata.

All of the main orebodies of the Lannigou deposits occur in these rocks, the bottom of this group being most favorable for hosting gold orebodies.

(2) **Xinyuan** group (T_2x) is divided into four segments **(Formations?)** based on their lithology, from top to bottom they are:

Fourth segment (T_2x^4, 10 to 46.56 m thick) consists of thin to medium-thick gray, dark gray argillite, *in* which there is a significant component of bivalve fossils and fragments. Limestone or marl, about 0 to 10 m thick, is interbedded within the middle of this segment [Formation].

Third segment (T_2x^3) include three members:

3rd member (T_2x^{3-3}, 30 to 109.78 m thick) is composed of thick or massive, light colored or gray, fine-grained sandstone and less argillaceous siltstone, and is often interbedded with thin to laminated argillite. The sandstone contains coarse cubic pyrite, and scattered pelletal pyrite. Strong gold mineralization is associated the F_3 fault that cuts through this stratigraphic unit.

2nd member (T_2x^{3-2}, 50 to 209.99 m thick) consists of argillite and interbedded lenses of fine-siltstone.

1st member (T_2x^{3-1}, 20 to 67.44 m thick) is made up of sandstone in the upper part, and alternating beds of argillite and sandstone in lower and middle parts.

Second segment (T_2x^2, 0 to 121.78 m thick) is composed of argillite, argillaceous siltstone interbedded with fine-grained sandstone which contains a plethra of bivalve fossils and fragments.

First segment (T_2x^1, 0 to 147.46 m thick) consists mainly of thin to medium-thick argillite, thin micritic limestone, and limestone with an argillaceous interbed. Fine-grained sandstone is present in both upper and bottom segments of this unit.

The Xinyuan group tends to decrease their thickness or disappear to the west (in Huang-Chang-Gou area), while increasing their thickness to the east (Lannigou and Lintan area). It is unconformable with the underlying strata.

Lower Triassic

(1) Luolou group (T_1l, 0 to 76.25 m thick) is distributed in the northern area of the Chenban block in the deposit, and consists of gray to dark gray limestone, interbedded with some argillite and tuffceous argillite. Many ammonite fossils are found in this unit.

(2) Lixue limestone (Lx) is located in the southern orefield, and composed chiefly of calcirudite, limestone breccia, micritic limestone, and bioclastic limestone.

Permian

Wujiaping group (P_2w) is comprised of bioclastic limestone and reef limestone.

Structure and Mineralization

The Lannigou gold deposit is located on the western side of the Banchang thrust structure, at the protruding nose-like portion of the eastern limb of the Laizishan short-axial anticline (fig. 3-1-2). Structures in the orefield are similar to the regional structural grain. As a result of this influence, the two main structures are north-south-trending in the western orefield, while northwest-trending structures are present in the eastern orefield. Another two sets of structures, trending WNW and NE, are present in the central orefield (fig. 3-1-2). Different orientation, ranks of alteration, and breccia in fault zones, control gold mineralization (orebodies). The No. 1 orebody, host of most of the reserve in the deposits, is controlled by the F_3 fault, the most important host-structure in the Huang-Chang-Gou block. The F_2 fault controls the No. 2 orebody and the F_{11} NNW fault in the Chenban block, and the F_{14} NW fault in the Lintan block, are also important ore-control structures.

North-South Structures include the F_1, F_7, and F9 faults, which are present in western part of the orefield. These faults are compressional and are components of the thrust structure. Of these, F_1, the largest fault crossing through the whole orefield, is 8,000 m long, 5 m wide, has a low to medium dip angle to the west. This fault is filled with well-developed tectonite, and is locally associated with gold mineralization and alteration. F_1 is considered to be a thrust fault, and part of the Peping giant thrust structure, of which, Permian carbonate is an outlier sitting on Triassic clastic rocks. The F_7 fault, about 3,000 m long, is associated with strong alteration and mineralization in the Huang-Chang-Gou block, is present on the eastern side of the F_1, and usually dips east with a medium dip angle. The F_9 is a small fault with associated weak alteration and mineralization (fig. 3-1-2).

Northwest Structures include the Lannigou syncline, Lintan anticline and the F_{14}, F_5, F_4, F_{11} faults. These structures formed by lateral compression along a northeast-southwest direction. Length of the axial line in the folds is from 200 to 3,500 m, and about 400 to 1,000 m wide across the limbs. All the folds have gentle-dipping southwest limbs and steeply-dipping northeast limbs. The core of the anticline consists of the third segment of the Xinyuan group strata, while the Bianyang group is exposed in the core of the synclinal structure. The F_{14} fault, which roughly traces the axis of the Lintan anticline, is about 4,000 m long, and dips 60° to the northeast. This fault cuts the northwest end of the Lintan anticline, and is associated with orebody mineralization. The mineralized zone is about 200 m long, 2 to 3 m thick, containing high grade up to 30 ppm Au from individual samples. The F_5 fault is present in the southwest, and is similar to the F_{14} fault in scale and occurrence, but has been found to contain only weak alteration and no gold mineralization. The F_4 fault, with related weak gold mineralization, dips 45° to the northeast, is located to the west of the F_5 fault and cuts F_5 at its north end. The F_{11} fault to the east of F_7, and intersects F_7 at its north end, and also cuts F_2 in its south end, but is offset by the F_{10} fault in the middle. This fault has NNW strike, ENE dip direction, 55° to 75° dip angle, 4 to 10 m wide fault zone, and is associated with strong silicification and pyritization. It is another important ore-control structure in the deposit. The present proven mineralized zone is about 300 m long, with large thickness and large prospect potential (figs. 3-1-2, 3-1-3, 3-1-4).

Northeast Structures comprise a group of shear faults, which include the F_2 fault in the Huang-Chang-Gou and the F_{10} fault in the northern end of this area. Of these, the F_2 fault is a ore-control fault.

The F_2 fault is located on the west slope of the Huang-Chang-Gou block, is 500 m long, 5 m wide, up to 10 m wide at the intersection with the F_3. It dips 45° to 80° southwest, with inverse dip directions to the northwest on the surface. Highly round tectonic lenses [phacoids] fill parts of this fault, but no not show evidence of tension. The F_2 fault has offset the F_3 fault, according to their relationship and the arrangement of the tectonic lenses, and shows a dextral shear sense. The No. 2 orebody, 270 m long, occurs in the F_2 fault, and has a consistent occurrence within the fault. This orebody has a large thickness and is high grade at the intersection of the F_2 and F_3 faults. However, the ore zone thins and disappears away from this intersection towards the northeast and southwest along the strike of the F_2 fault. The No. 2 orebody is controlled by both the F_2 fault and the F_3 fault (fig. 3), and is currently the second largest orebody in the deposit.

WNW Structures are well developed in the Huang-Chang-Gou block, and are also present in the northern end of the orefield (i.e. the F_{80} fault).

The F_3 fault, *in* general, trends 290^o, dips varying between 55^o to 85^o to the NNE. The F_3fault has been proven to be at least 700 m long, from where its western end joins with the F_2 fault, its eastern end still open. The depth, *in* dip direction, is about 570 m, and still open. The F_3 fault has an "S"-shape both in horizontal and vertical planes, illustrated in the western part to the 2^{nd} exploration line. Its dip becomes more planer with depth to the NNE in the lower part of the section (fig. 4).

More detailed field research shows that the F_3 fault actually is a strongly strained structural deformation zone, as

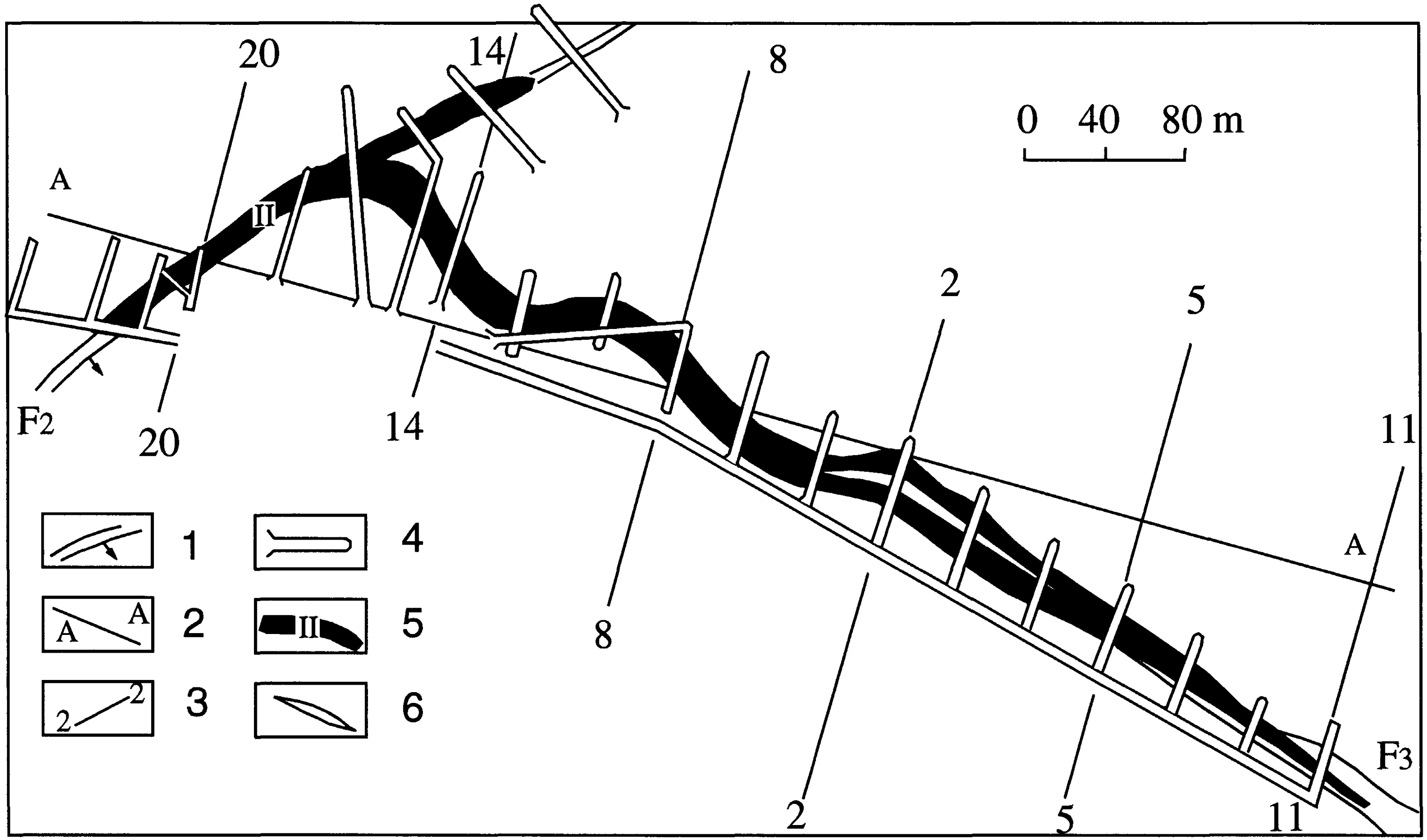

Figure 3-1-3. 4th level map (600 m) of the Huang-Chang-Gou block in the Lannigou gold deposit

1- ore-control fault; 2 - strike line; 3 - exploration line; 4 - tunnel; 5 - orebody; 6 - stone in the orebody.

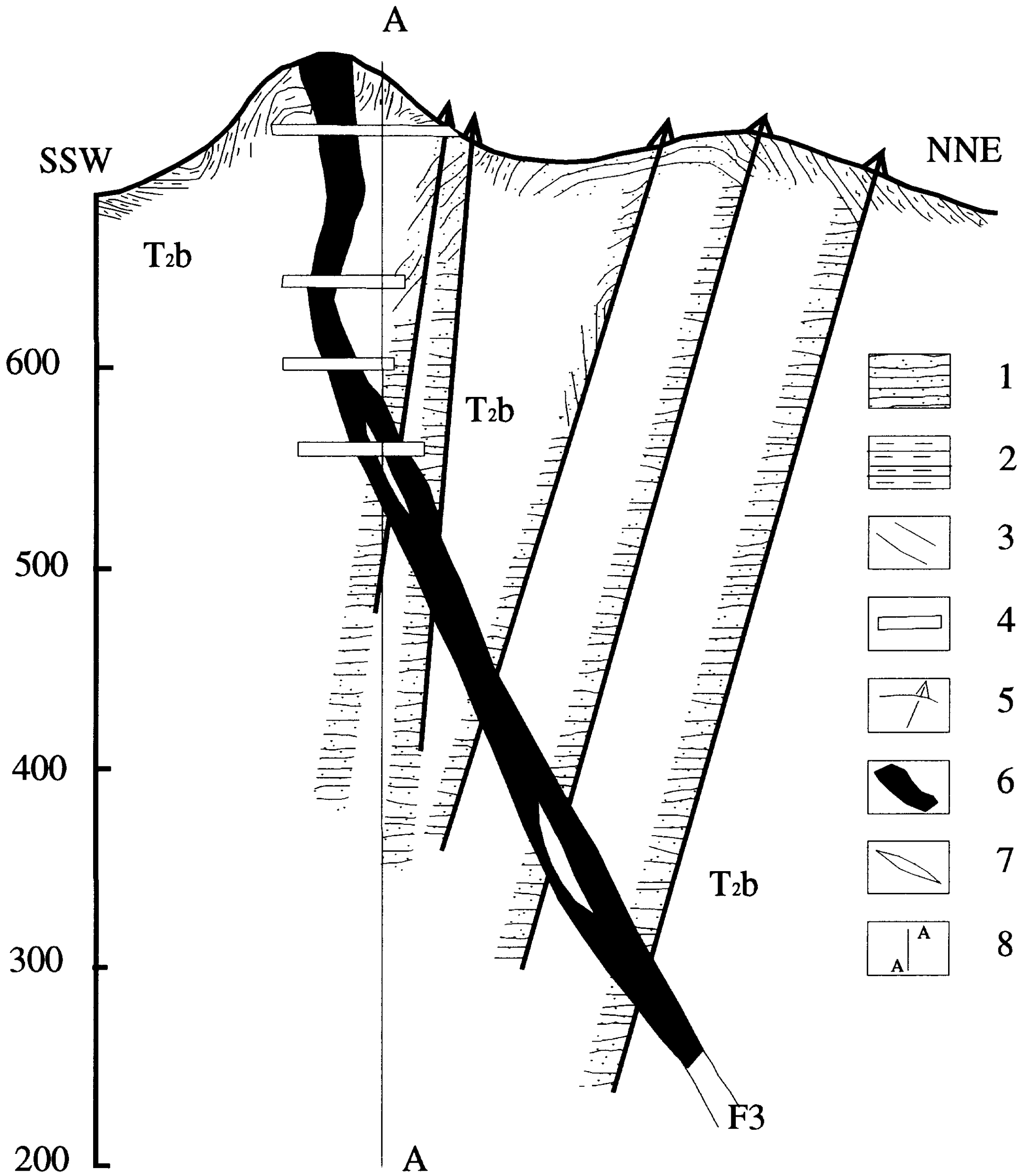

Figure 3-1-4. Exploration section of the Hunag-Chang-Gou block in the Lannigou gold deposit

T2b - Bianyang group of the middle Triassic: 1 - sandstone; 2 argillite; 3 - fault zone; 4 - strike-tunnel; 5 - drill hole; 6 - gold orebody; 7 - stone in the orebody; 9 - center line.

well as a strong mineralization zone. Both boundaries of this strained zone (fault plane) are similar. The width of the fault zone is about 8 to 20 m, maximum up to 30 m, and varies along both strike and dip. Rocks in the fault zone have undergone strong deformation, and different kinds of tectonites, such as tensional breccia, compression cataclastic rocks, and mylonite. Hard rocks, such as sandstone, were deformed into lenses or phacoidal bodies, and are en echelon in the fault zone, while soft rocks, such as argillite, became foliated schist, mud and fill into the fractures of the lenses, or wrap around them. The size of the sandstone lenses, dependent upon the thickness of the original rocks, varies from several centimeter to 1 meter, the maximum long axis is about 3 to 4 m. These structural lenses have medium roundness and a smooth surface. Additionally, sliding, splitting, and joint planes, which have the same occurrence as those sandstone lenses, are well-developed in the fault zone, which combine into a group of conjugate joints (fig. 3-1-5). The rocks in the strongly strained structural zone have undergone both dynamic and dynamo-hydrothermal metamorphism.

The strata on the both the footwall and hangingwall are complete except for some weak silicification or striped pyrite along bedding. Many small drag folds are present in the strata, and in general, drag synclines are present in the hangingwall, while the drag anticlines occur in the footwall (fig. 3-1-6). These drag folds indicate that the fault is dextral with a tensional component.

The structures in the orefield are typical "thin skin" tectonics, and have a complicated pattern. Each group of these structures has been identified as either hosting a gold orebody or gold mineralization. They may have been formed in the Yanshanion Orogeny according to the analysis of the structural characteristics of the regional structures.

GEOLOGIC CHARACTERISTICS OF THE ORE DEPOSITS

Shape, Occurrence and Size

The No. 1 orebody, which is controlled by the F_3 fault in the Huang-Chang-Gou block, has a slaty shape, similar in occurrence to the fault zone, and in general, trends 299° and dips to the NNE at 55° to 85°, with local inverse of dip direction. The orebody has an "S"-shape in map view in the western part of the 2nd line. It also shows an "S"-shape cross section above the 560-meter elevation, but becomes more planer and dips to NNE below that elevation.

The topographic expression of the outcrop of the No. 1 orebody about 155 m long, and extends along the east-west dividing range in the eastern part to the 2nd line. The orebody is situated high on a central upland surrounded by a low valley and is amenable to channel exploration and open-pit mining. The No. 1 orebody is exposed for 500 m along strike on the surface, and joins the No. 2 orebody on its West End, while the east part of the orebody, to the 11th line is not exposed on the surface (fig. 3-1-7). The controlled maximum strike length of the orebody is 680 m, and 570 m down dip, and is still open to depth and to the east.

Factors controlling grade and thickness of the No. 1 orebody

(1) **Strain-Intensity of the Structure**: The strain intensity in the F_3 fault is not uniform so that the mineralization intensity is different from place to place. The types of tectonites in the F_3 fault include mylonite (rare), different-sized cataclasite and local whole sandstone, argillite blocks with bedding (about 3 m thick) that form unmineralized phacoids in the orebody. Highly strained, small fragmental cataclastic rocks, usually are associated with rich orebodies, while large-fragmental cataclastic rocks are present in

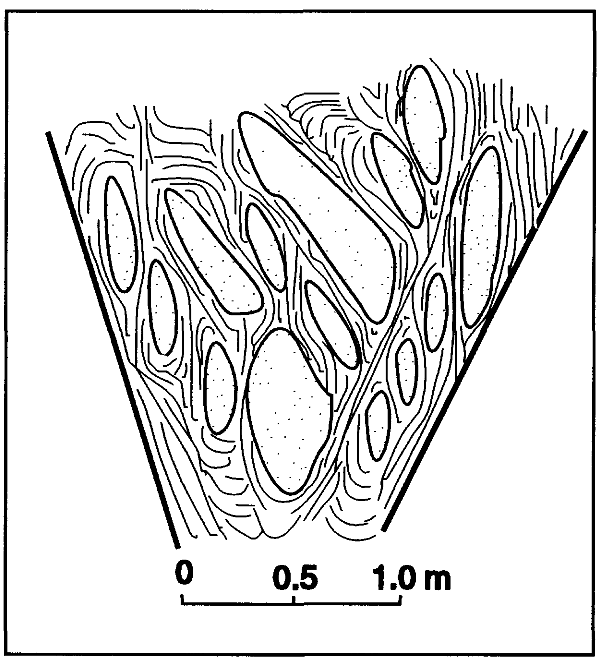

Figure 3-1-5. Phacoid development in main No. 1 shear zone of the Lannigou deposit.

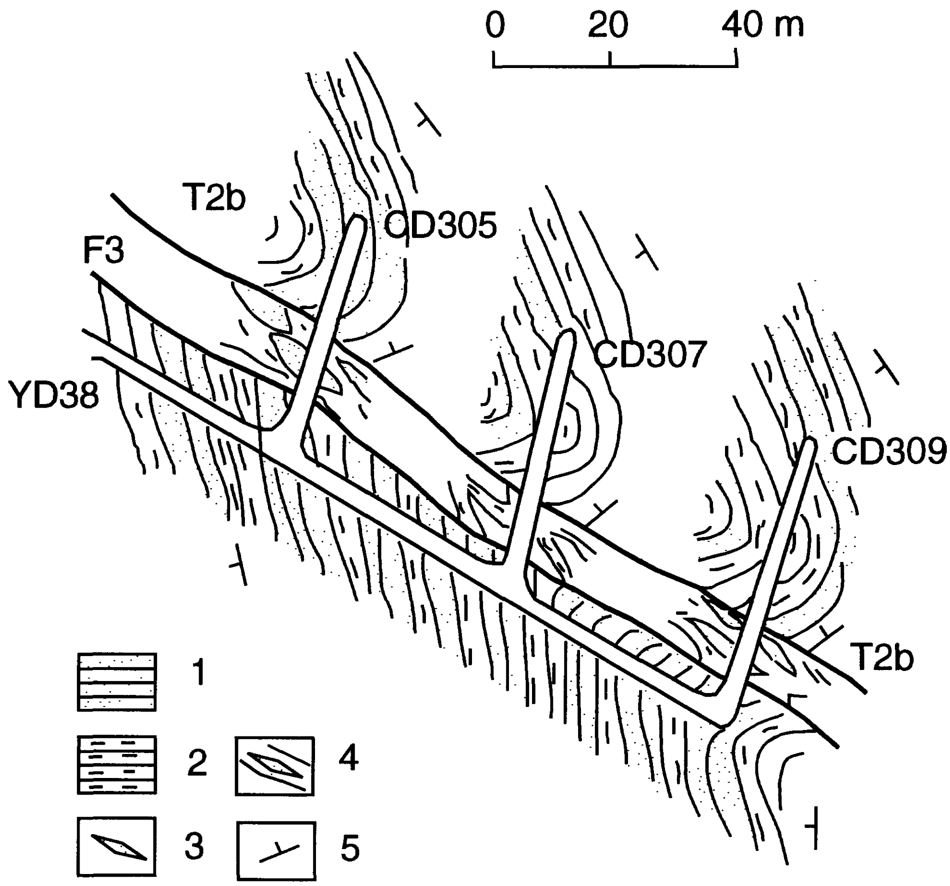

Figure 3-1-6. Part of 3^{th} level map (640 m) of the Huang-Chang-Gou block in the Lannigou gold deposit.
T2b - Bianyang group of middle Triassic: 1 - sandstone; 2 - argillite; 3 - structural lenses; 4 - fault; 5 - occurrence of stratigraphy. YD38 - strike-tunnel; CD307 - cross tunnel.

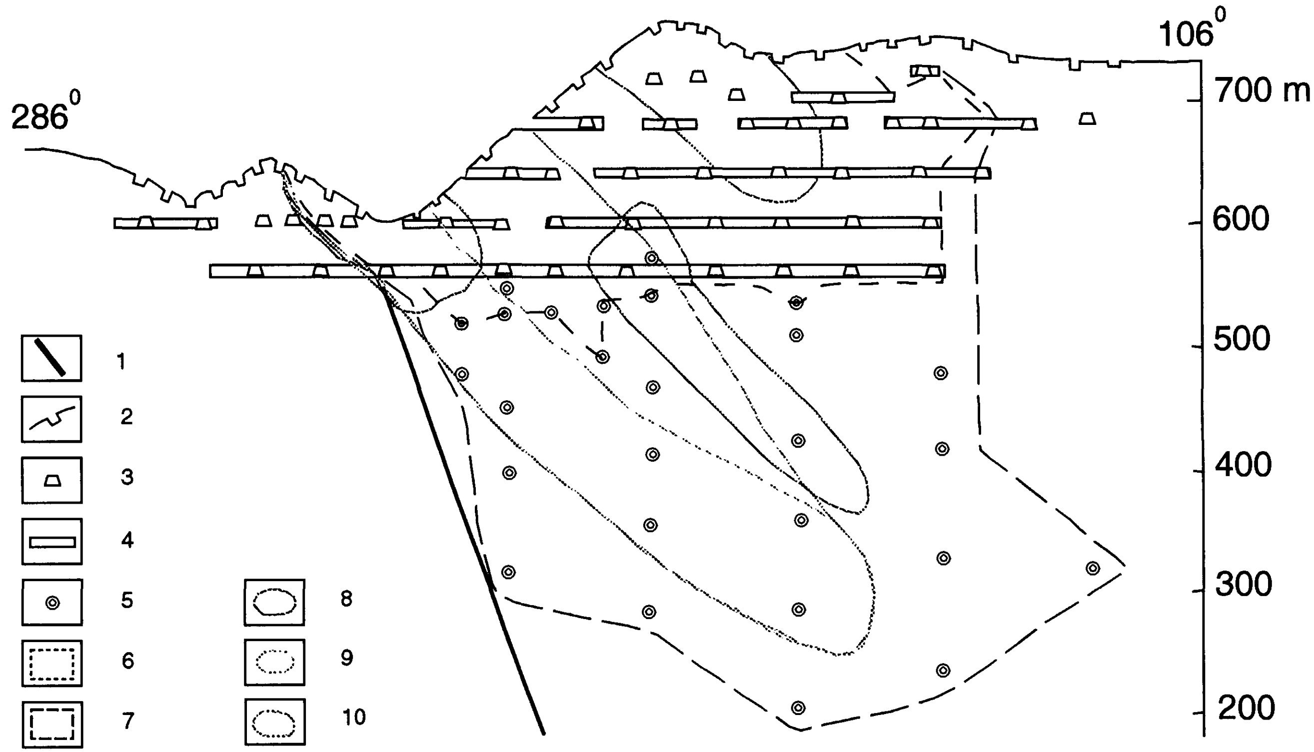

Figure 3-1-7. Projection of the No.1 orebody of the Huang-Chang-Gou block in the Lannigou gold deposit
1 - the intersection line of F2 and F3; 2 - trench; 3 - cross tunnel; 4 - strike-tunnel; 5 - drill hole; 6 - C-reserve block; 7 - D-reserve block; 8 - Au-enriching zone; 9 - As-bearing zone; 10 - Hg-bearing zone.

poor orebody blocks. In general, the tensional portions of the F_3 fault usually host rich, thick gold orebodies, and also represent the location of large areas of strain intensity within the structure. A positive correlation exists between the type of tectonite and grade of mineralization. The syndeformational relation between the gold grades and strain is also identifiable on the microscopic level. Au-bearing pyrite and arsenopyrite are concentrated in or near joints and fractures, and diminish away from these structural planes. Larger strain intensity has produced more joints and fractures with resultant strong mineralization and higher gold grade.

(2) **Lithology**: Gold mineralization in the F_3 fault occurs preferentially with specific lithology. Thin to medium-thick, fine-grained sandstone, siltstone and argillite. These observations are further verified where the F_3 fault extends to the east into the $T_2x^{3\text{-}3}$ single massive sandstone or T_2x^4 single argillite, gold mineralization rapidly weakens or disappears. Furthermore, mineralization and alteration is very strong in some favorable rock units outside of the F_3, even in areas where the host-rock is weakly tectonized. The ore-fluid was concentrated within 3 m of the fault, where both the width of the fault and thickness of the orebody are large. The author considers that this resulted from structure-metallogenic processes, resulting from sealing of the F_3 fault and formation of an aquiclude. If the fault was formed before the orebodies and ore-fluid moved along the fault, then it is hard to imagine the ore-fluid becoming "effluent" out of the fault. However, if the fault and orebodies were formed at almost same time, the ore-forming system would still be in an open state, and the above could result.

(3) **Alteration**: hydrothermally generated pyrite and arsenic rich pyrite are important gold-hosting minerals. Gold assays of up to 123.05 ppm have been obtained from pure pyrite samples. However, not all pyrites contain gold based on SEM and TEM analyses, and observations of crystal morphology and size. Part of the orebody in the F_3 fault contain less gold in areas consisting mostly of pyrite, however, other parts of the orebody containing a combination of pyrite, orpiment, realgar, cinnabar, and stibnite have high gold concentrations. This situation holds true for the other minerals as well. Pure cinnabar contains less gold, while pure orpiment, realgar, and stibnite contain almost no gold. This phenomenon indicates that the Au-bearing pyrite was formed together with cinnabar, orpiment, realgar, and stibnite. On the other hand, the rich orebodies were formed by overprints of multiple metallogenic processes.

The No. 1 orebody has an average thickness of 10.70 m, and varies from 5.77 m to 19.77 m, up to 33.01 m; gold assay values average 7.01 ppm, with variation coefficient in grade of 81%, and varies from 4.01 to 11.01 ppm Au, up to 13.82 ppm Au. There are three gold-rich blocks in the No. 1 orebody (fig. 3-1-7). The first one, #Au-1, is present at the west end of the orebody adjacent to the junction of the F_2, F_3 faults, and is 15.80 m thick (average), with 8.46 (average) ppm Au grade, and a higher As and Hg trace element content. The second one, #Au-2, which is in the center of the No. 1 orebody, is 21.83 m (average) thick, with an average grade of 8.53 ppm Au. Most of this zone is overlain with high grade Hg zones. The third one, #Au-3, located to the east of the No. 1 orebody, is 19.14 m (average) thick and 9.20 ppm Au (average) in grade. The thickness of the three gold-rich blocks are 5.10 to 11.13 m larger than the average thickness (10.70 m) of the No. 1 orebody, and the grades are 1.45 to 1.29 ppm (Au) higher than its average gold grade (7.01 ppm). Based on a rough calculated result, the total area of these three gold-rich blocks forms only 16% of the whole No. 1 orebody, but their reserves form about 40% of its total. Most of the unmineralized phacoids are present outside of these gold-rich blocks.

The No. 1 orebody also contains anomalous As, Hg, and C. Their amounts in the ore are, As 0.12 to 1.10% (average 0.53%), Hg: 10 to 1000 ppm (average 108 ppm), and C: 1 to 2% (average 1.55%). As, Hg, and C are unevenly distributed in the orebody, of these, As and Hg are concentrated in a block (fig. 3-1-7), *in* which the amount of As and Hg is 3 times higher than the average of the whole orebody. Carbon mainly is enriched near the hangingwall and footwall and decreases in the center. Additionally, the orebody contains S: 1.35% (average), and Sb: (0.004%).

All the gold-rich blocks, As-Hg-rich block and the whole No. 1 orebody rake to east at about 45°.

Beside the No. 1 orebody, the No. 2 orebody is another important orebody in the deposit, and there also are several small orebodies, which are controlled by secondary structures, and present at the junction of the F_2, F_3 faults or the footwall and hanging wall of the orebody. These small orebodies only take a small percentage in the total reserve of the deposit.

Quality of the Ore

Composition of the Ore

(1) Chemical Composition: The result of element analyses of the ore is shown in table 1. The ores contain anomalous amounts of As, Hg, C, and S beside Au; Ag, Cu, Pb, and Zn are minor trace elements in the ores.

Table 1. Chemical composition of the ores

Element	SiO_2	Fe(Tot)	Al_2O_3	CaO	MgO	K_2O	Na_2O	TiO_2
%	65.80	3.40	10.20	4.88	1.80	2.44	0.45	0.45
Element	P_2O_5	Au	Ag	As	S	C(Tot)	Sb	Hg
%	0.24	5.80*	0.68*	0.43	1.67	1.84	0.0036	0.034
Element	Pb	Zn	Cu	LOI				
%	0.0053	0.01	0.0009	8.10				

* ppm; Analysis by the Metallurgical Design Institute of Guizhou Province

(2) Mineral Composition: Mineral Composition of the ores is shown on Table 2. Ore minerals form about 4% of the ores, of these pyrite forms about 80% of ore minerals. Quartz is the principal non-ore mineral, others include clay and carbonate minerals.

Table 2. Mineral composition of the ore

Mineral	Quartz	Clay minerals	Carbonate minerals	Pyrite	Arsenopyrite
%	54.25	21.80	13.58	3.20	0.62
Mineral	Carbon	Orpiment and Realgar	Other sulfide	Other mineral	
%	0.36	0.10	0.07	6.02	

Texture and Distribution of the Ore

(1) **Texture**: Pyrite, cinnabar, and orpiment (realgar) are often present in the ore with euhedral, sub-euhedral, and granular textures; part of these ore minerals are disseminated in the ore as xenomorphic grains.

Poikilitic textures are formed by clay minerals and quartz enclosing the ore minerals; the margin of pyrites are often altered into a girdle-band texture by arsenopyrite [ARSENIAN-PYRITE]; the earlier pyrites usually have a cataclastic texture.

(2) **Distribution of the ore**: Ore minerals are disseminated through the orebody and are classified into star-disseminated, open-disseminated, and thickly-disseminated, according the percentage of ore minerals. Ore with star-disseminated structure contains few minerals such as pyrite, arsenopyrite, and cinnabar; open-disseminated ore consists mainly of pyrite and arsenopyrite; thickening-disseminated ore contains cluster pyrite.

Additionally, some veinlets of pyrite, cinnabar, stibnite, orpiment (realgar) are present in or near the joints and fractures planes.

Metallurgical Property of the Ore

There are four characteristics of ore in the Lannigou deposit. The first, 81.89% of the gold is enclosed in pyrite and arsenopyrite, and the rest of the gold is present in the interspace between minerals. Pyrite contains 123.05 ppm Au; arsenopyrite contains 115.32 ppm Au, of these, 52.46% is submicroscopic gold. Second, only gold is currently of interest, but if the preparation methods are improved, As, Hg, C, and S may be beneficiated. Third, most ores are refractory with little oxide. Fourth, most gold is native gold, with a fineness greater than 90%. Based on these characteristics, ore-type of the Lannigou deposit is classified as As-bearing, low sulfide, refractory ore.

The Metallurgical Design Institute of Guizhou Province and The Changchun Institute of Gold have completed the bench-scale experiments, and recommend that the following metallurgical processes should be taken in the Lannigou gold deposit:

Preparation + concentrate ore furnacing + clinker leaching. The index for this process will be:

Floating recovery rate: 93.74% (Assay of tailings ore is 0.43 ppm Au)

Leaching recovery rate of clinker: 89.19%

Exchange rate: 99.98%

Total recovery: 83.59%.

Alteration

A combination of epithermal alteration is typical in the Lannigou gold deposit, and closely associated with gold mineralization. The width of the alteration zones is large, but they are basically distributed along and within the fault zones. Silicification and pyritization are the most important alteration types, and arseno-pyritization, carbonatization, and argillitization are also significant in the deposit. Some alteration associated with cinnabar, orpiment (realgar) is locally present in the deposit.

Silicification

Three periods of silicification are identified in the deposit. The earliest event consists of fine-grained quartz together with chalcedony, and is usually present as veinlets in fractures, which often are associated with some pyrite, arsenopyrite, carbonate, and illite. Middle-period silicification is characterized by a network structure that is made up of 1-mm-wide quartz veinlets, and co-exists with significant pyrite, arsenopyrite, carbonate, and illite. Late silicification is identified as coarse quartz crystals with clean crystal planes, coexisting with carbonate, orpiment (realgar), cinnabar, stibnite, and less sphalerite minerals.

Pyritization

The amount of pyrite usually varies from 1% to 3% in poor ore and 8% to 10% in rich ore. Argillaceous siltstone contains an average 3.20% pyrite, and up to 20%. Pyrites are mainly disseminated in the ore within the fault zone. Corresponding to the three periods of silicification, pyrites were also formed in three stages. Pyrites are classified as As-bearing or non-arsenian pyrite according to the SEM analyses. Gold is predominantly related to As-bearing pyrite, and Au assays have a positive relationship to the As content in the pyrite. Most As-bearing pyrites have girdle-banded texture, this texture being observed on a number of morphological shapes of crystals including pentagonal dodecahedron, octahedron, and cubic as well as round granular shapes. Their grain size is typically 0.01 to 0.5 mm, although some pyrites, which are enclosed by quartz and clay, are less than 0.01 mm. Pyrites are unevenly distributed in the orebody, but usually concentrate in fractures or joint planes, and become less concentrated away from these structural planes. Pyrites clearly increase their size and rank of crystal shape outside of the fault, and are present as veins in the fractures or as strips along the host rocks.

Arsenopyrite

Arsenopyrite is one of the primary ore minerals in the deposit, and is also an important gold-hosting mineral. Their size are smaller than pyrite, and vary from 0.005 mm to 0.074 mm, but their crystals are usually better developed than pyrite, being present as euhedral and sub-euhedral prisms, needle-shape, radiating aggregates, and rarely in granular shape. A crystal intergrowth of arsenopyrite and pyrite has been found in this deposit.

Carbonatization

Carbonatization (carbon introduction) includes dolomitization (ankerite) and calcite introduction. The earlier is dolomitization; the later is calcite introduction, which is associated with cinnabar, stibnite, orpiment and realgar.

Argillization

Argillization is largely illite. The illite or illite-quartz veins usually are associated with pyrite and arsenopyrite.

Geochemistry

Secondary Halo

Based on the analysis of the soil samples, 34 elements were detected. They are Si, Fe, K, Ca, Al, Mg, Na, Ti, As, Sn, Cr, V, Ba, Zr, P, Mn, Mo, Pb, Sb, Cu, Ni, Co, Sc, Zn, Y, Ga, Sr, Be, Ag, Yb, Nb, W, Au, Ag, Hg. Of these elements, Au values varied from 1 ppb to larger than 3,000 ppb, averaging 1.26 ppb; standard deviation 4.13 and variation coefficient 328%.

As calculated, the background value for gold in soil in the orefield is 1.26 ppb (the average Au value for sediments of the drainage system, which are within the whole southwest Guizhou province, a total area of 31128 km^2, is 2.1 ppb; Zhang, 1989). Seventeen (17) anomalies were defined using 20 ppb as the low anomaly value (fig. 3-1-8), of these the Au5 anomaly is 2.14 km^2, average 104.7 ppb Au, maximum 3000 ppb Au.

Geological field work confirms that the distribution of Au anomalies corresponds with the main fault zones, and their size is controlled by these structures. For instance, the Au5 anomaly, which has a large size, high value, tidy shape, and complete elemental assembly, results from ore-controlling faults. These are the WNW F_3, NNE F_2 faults in the Huang-Chang-Gou, and the NNW F_{11} fault in the Chenban, and the NW F_{14} fault in the Lintan blocks. Additionally, gold mineralization or orebodies have been found in the structures that correspond to the Au3, Au10, Au12, Au14, Au15 anomalies.

Primary Halo

In order to study the primary geochemistry halo, 12 elements (Au, As, Sb, Hg, Ba, Ag, U, Tl, Cu, Pb, Zn, and Cr) have been analyzed. The variation of Au, As, Sb, Hg, Tl, Ag seem to follow some rules in the orebodies, host rocks of the hangingwall and footwall. For instance, As, Sb, Hg are similar to Au lower in the host rocks of the hanging and foot-wall. However, the values of As, Sb, and Hg in the hangingwall are clearly larger than the footwall, that is, it shows the properties of a head geochemical halo. The values of Ba and U are just the opposite.

Correlation analysis shows that As, Tl, and Cr have a clear positive relationship with Au; Ba, U, Pb, and Zn have a clear negative relationship with Au, while the relationship between Sb, Hg and Au is not clear. Au-As-Tl-Cr-Cu, an element assemblage similar to the Jinyia gold deposit in the Guangxi District, is defined as the element combination of the Lannigou gold deposit based on the R-cluster analysis method. However, it is different from the Banqi and Yata gold deposits, which contain a Au-As-Sb-Ag-Hg element assembly. The Au-As-Tl-Cr-Cu element combination reflects the characteristics of the fine-grained clastic rocks of terrigenous origin (Zhang, 1992).

DISCUSSION ON THE MECHANISM OF METALLOGENY

Analysis for Stress-deformation of the ore-control faults

The main ore-controlling fault, F_3, shows complicated structural properties. This fault has undergone multiple structural reactivation during its long history. The author applied structural interpretation, stereographic methods to analyze the formation, evolution, stress function, and the deformation pattern for the fault F_3, referring to the regional stress field as background.

Structural interpretation shows that the F_3 fault was formed by tracing and developing a set of extensive joints, which formed as a result of east-west compressional stress. Subsequently, with lateral compression and the regional stress-field turning to the northeast-southwest, the large-scale northwest-trending structural system was formed, which included the Lintan anticline, Lannigou syncline, F_{14}, F_5 faults, a series of compressional structures and northeast shearing structures. Controlled by this regional stress field, the hangingwall of the F_3 fault moved sinistrally upward along a 250° azimuth and dip angle of 60°. The formation of northwest-trending structures caused the boundary conditions to change. Then, the regional stress field changed into northwest-southeast compression. As a result, those existing structures, such as the north-south, northwest, and northeast-southeast structures, were deformed into an "S"-shape. Some northeast compressional structures (folds and faults) were formed at the this time. Driven by this regional stress field, extension and dextral sliding took place on the F_3 fault. Its hangingwall moved along a 90° < 60° structure plane. The last structural movement for the F_3 fault resulted from a local stress field with north-west compression. This stress field also developed a series of WNW-ESE

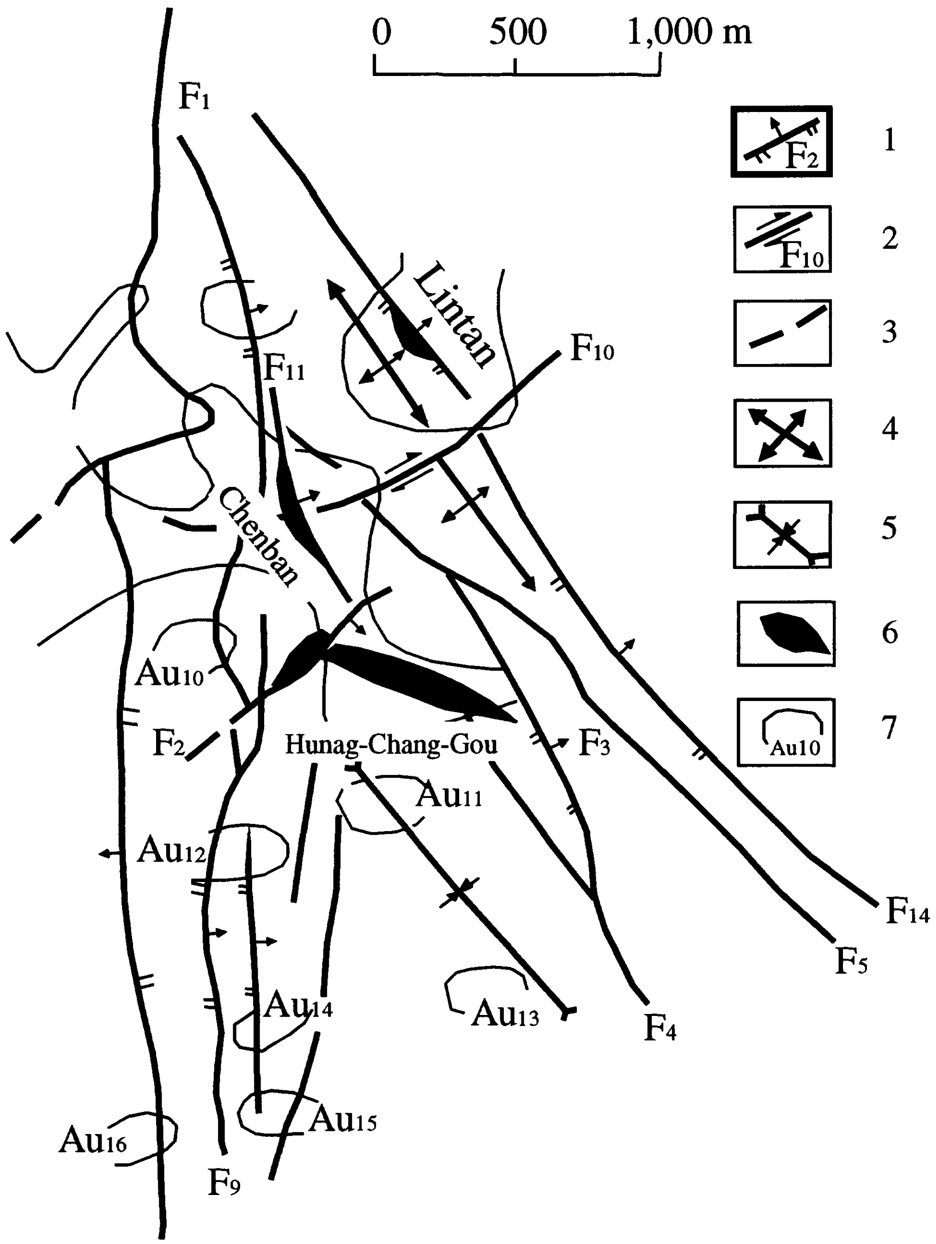

Figure 3-1--8. Distribution of soil geochemical anomaly in the Lannigou gold deposit.

1 - compression fault; 2 - shearing fault; 3 - undefined fault; 4 - axial of anticline; 5 - axial of syncline; 6 - gold

small folds, which overlay each other (fig. 3-2-2). According to the tensile strength and friction sliding theories, differential stress, enough to produce a new fault, is much more than that needed to overcome frictional forces and cause sliding along a pre-existing fault. Therefore, once the fault is formed, friction sliding along the existing fracture plane must be the primary activity of the F_3 under subsequence stress processes.

Based on the structure interpretation above, the F_3 fault must have undergone an evolutionary history of multiple compression, moving and deformation, that is, from sinistral shearing, thrust dextral sliding, extension ⇒ approximately south-north compression.

Exploration experience, combined with modern structural theory and experimentation, *in*dicates that structural movement and deformation is not only a simple mechanical process, but also a chemical process. These processes may directly or indirectly affect the formation of ore deposits or alter an existing orebody, which can cause enrichment or impoverishment, and concentrate scattered useful elements in the source strata into an ore deposit (Chen, 1983).

Evidence of Structure-Metallogeny

Relationship between Metallogeny and Structures

(1) Space relation: It is very common to find an orebody controlled by a fault-breccia-alteration zone and the No. 1 orebody in the Huang-Chang-Gou is present along such a zone controlled by the F_3 fault. The thickness of the orebody is subject to the space within the fault zone. Gold content is positively related to fracture spacing. Gold-bearing pyrite and arsenopyrite are concentrated in structural planes in or near the fault zone. Three steps of structural activity correspond to three periods of metallogeny. In the second period of metallogenic process, the main step of ore formation, the orebody occupied positions within the fault zone where pressure reduced and space extended, resulting from dextral sliding and extension. The orebody and its three gold-rich, As-Hg-bearing zones, is the result of both multiple structure movements and metallogenic processes.

(2) Temporal Relations: A metallogenic date of 82.9 ± 6.3 Ma was obtained using the fission-track dating method for the deposit by Professors Yang and Zhang from the Institute of Geochemistry, Chinese Academy of Sciences. This date is directly measured using quartz from a pyrite-quartz vein in the deposit, and considered to be the formation age of both Au-bearing pyrite and the fault-structure-material (hydrothermal quartz). The age belongs to the Yanshanion era, and is almost the same as the formation age of the structures.

(3) Stress Minerals: For specific structural stress processes, macroscopic strains are consistent with microscopic strain (rock, minerals, and crystal deformation). Stress minerals are very common in the deposit, and include stretched crystals or flattening of pyrite, orpiment (realgar), and cinnabar. Earlier hydrothermal quartzes are ground into sugar- or powder-like fragments. Vein quartz exhibits strain-shadow resulting from kinetic crystallization. Comb quartz, perpendicular to the wall, represents extensional conditions; while quartz parallel to the wall indicates a compressional environment. All of these phenomena correspond to the shear, extension and compressional properties of the F_3 fault in multiple structural-metallogenic processes.

(3) Material Resource: The orefield formed in early Permian to middle Triassic sediments developed in a continental slope environment at the margin between the continental platform and deep sea basin. Research on the Au-bearing ability of sedimentary formations formed in a transition environment between margin slope and chasm-basin from early to middle Triassic (especially, the middle Triassic), have been completed by many people. These works include the research on the available Au-bearing potential of the Bouma sequence, on other kinds of rocks in the section, and on the whole stratigraphic package, all resulting in similar conclusions. Zheng and Zhang (1989) indicated that the siltstones in the strata have an average of 20.37 ppb Au, and 17.40 ppb Au in the argillite, much higher than in other rocks, indicating the ore-forming materials already existed in this area prior to structural disruption and hydrothermal alteration.

Suppose a 50-tonne gold deposit were formed if the background value of Au is 20.37 ppb, and 90% of Au were leached out from the host rocks, then, only 1 cubic kilometer of the host rock would be enough to supply the required ore-forming materials for the deposit. Since the strata is over 1,000 m thick in this area, there is a plentiful resource for the metallogeny. On the other hand, the Nanpanjang orogenic fold zone has undergone regional metamorphism and light metamorphic rocks may exist in this area (Zhang, 1992). Therefore, with such a strong and widely regional metamorphic thermal event, it is possible for gold in the sedimentary formation to be remobilized, transported and precipitated in favorable structures, forming ore deposits. The ore-forming temperature of the Lannigou deposit varied between 172° to 265°, about the lower limit of metamorphic rocks. Therefore, the regional structure and thermal event are the heat-resource, and have provided the ore-forming environment for the deposit, and the F_3 fault, which slid with extension, producing pressure-reduced and space-extended zones, provided the space for hosting the orebody.

Discussion on the Mechanism of Structure-Metallogeny

The Lannigou gold deposit is considered to have been formed by structure-metallogenic processes. In other words, the structural process and metallogenic process took place at almost the same time and place, and started by the same mechanism and co-developed. Structural movement is the proposed driving mechanism, which produced the fault and fault zones, while strong mechanical energy was transferred into thermal energy, heating groundwater into hydrothermal fluid. The power from the structural movement drove the hydrothermal fluid, moving and leaching Au from the host rocks, concentrating on favorable structures, such as the F_3 fault, which had pressure-reduced and space-extended [dilated] zones within them, where minerals were precipitated and the orebodies finally formed. Multiple periods of structural activity resulted in the overprinting of gold metallogeny, which was also a key factor in the development of the orebodies, as it allowed them to thicken, enrich, and become uniform.

There is an indication of gold in all of the strata from middle and upper Xinyuan group to lower Bianyang group in the orefield, and the width of the Au-host strata is large in the orefield. Gold mineralization of orebodies also is present in all of the N-S, NW, NWW, and NE faults zones, indicating multiple periods and simultaneous nature of structure-metallogeny.

PROSPECT DIRECTION AND CRITERION

Prospect Direction

Sedimentary environment, structural background, host rocks, alteration, and mineral assemblages are important factors when exploring for this type of gold deposit. It is necessary to emphasize that sedimentary facies and structural background are the basis for prospecting this type of gold deposit.

Specific Sedimentary Facies

According to conclusions from a former researcher, there are three sedimentary environments (or facies) with high gold value. The first one is early to late Permian argillite and tuffceous argillites, which were formed in a littoral-tidal-flat-lagoon environment (Dachang group or equivalent), with an average gold value >36 ppb. The second is a set of argillite, siltstone, and marl formed in the tidal-flat or sub-tidal shallow sea in the late Permian (Changxing group) and tidal flat environment in the early Triassic (Yielong group), with average Au grade of 8 ppb. The third one is the sedimentary strata formed at the margin of the continental slope, of these, siltstone contains 20.37 ppb Au and argillite contains 17.40 ppb Au. The statistical geochemical data from the known deposits and prospects show that the host rocks are the same as the resource strata. Therefore, it is important to prospect in these three sedimentary facies.

Specific Structure Background:

The principal structures, namely the short-axial anticline and dome structures, combined with the arc faults that surround them, control the distribution of gold fields (zones). This structural pattern is considered to be the ore-forming and ore-control structural model in the Dian-Qian-Gui area. For instance, the Gaolong gold deposit is controlled by the Gaolong short-axial anticline that is associated with a set of arc faults such as the F_3, F_4, F_9, F_{12}, F_{20} faults. The Gedang gold deposit is controlled by bedding parallel faults in the two limbs of the Jiusai dome. The Naban dome and the F_1 fault in its south limb, control the Banqi gold deposit; while the Zimudang gold deposit is controlled by the Huijiapu anticline and faults parallel to its north limb. Therefore, recognition of these specific structures is extremely important toward exploration of this region.

As a typical prospect example, the close relation between sedimentary facies and ore-control structures in the Laizishan short-axial anticline will be illustrated as follows, and their lithology, structural pattern and deformation features are much different in its both limbs.

(1) Lithology Difference: The western limb of the anticline consists of carbonate rocks (local argillite, siltstone), while the eastern limb is composed of clastic turbidites of terrigenous origin.

(2) Structure Pattern: Northeast-trending faults are well-developed in the western limb, and also a few of NW and N-S faults. In the eastern limb, northwest faults are the main structure, and less so the N-S and NE faults.

(3) Deformation Difference: The principal deformation style encountered in the western limb is brittle, and is associated with the intersection of different groups of faults. As a result, a grid-like structural patterns were formed in this limb. Ductile deformation is shown as both folds and fractures in the eastern limb; linear structures are present as structural zones.

However, there are two commonalties found on both limbs; first, both of them contain Au-bearing sedimentary rocks, secondly, both sides of the Laizishan anticline have a similar structural background. Ore-forming materials were remobilized, moved, and concentrated in the favorable structures. As a result, the Lannigou, Bannian, Ceyang, and Pogao gold deposits (prospects) are present surrounding the Laizishan anticline. In general, ore-forming material (resource beds) and the ore-forming environment are the two most important factors for prospecting for similar gold deposits.

Prospect Criterion

Prospect criterion include macroscopic and microscopic structures, alteration minerals, and geochemistry.

Structure Criterion

The close relation between gold deposits and structure imply that they are genetically related to each other. Structural activities and hydrothermal activities are derived from the same mechanism, and have undergone similar evolutionary processes. Experience shows that the potential for a gold occurrence in a fault with multiple activity stages is significantly greater than that of a fault with a single stage of activity.

(2) Alteration Criterion: Wide spread hydrothermal alteration in the host rocks is another important feature in disseminated type gold deposits. Silicification and pyritization are common however, if they co-existed with stibnite, orpiment (realgar), cinnabar or one or two of them, the possibility of finding a gold deposit is significantly enhanced. On the surface, silicification is associated with strong limonitization.

(3) Minerals Criterion: Hydrothermal quartz and pyrite are the most common minerals in these deposits. Hydrothermal quartz is usually present in different sized veins, which often intersect each other, and commonly appear with a cataclastic texture or are ground into powder-like grains. They have undulatory extinction in thin section and often enclose sulfide minerals. Pyrites usually are present as fine-grained, xenomorphic grains, or as idiomorphic crystals with pentagonal dodecahedron, octahedron and cubic morphologies, that often appear to have a girdle-band in microscopic view. SEM analyses show these pyrites contain As, and their Au grades are positively related to the amount of As. Arsenopyrite is another important gold-host mineral, it is characterized by its euhedral crystals, which form needle and prism shapes. Additionally, ankerite and calcite often co-existed with the gold-host minerals of pyrite and arsenopyrite.

CONCLUSION

The large Lannigou gold deposit, Zhengfeng County of Guizhou Province, is tectonically located at the eastern limb of the Laizishan short-axial anticline, which is part of the Yiadu-Ziyun northwest-trending structural zone. Sediments hosting gold mineralization are divided into two facies formed in the early to middle Triassic, the first is a continental slope facies formed between the margin of a platform and a deep rift basin, the second is a group of clastic rocks of terrigenous origin. These rocks not only host the ore but are also the resource strata for the ore-forming materials. The orebodies are clearly controlled by structures. Both structures and gold mineralization are consistent not only in space but also in time and are likely coeval. That is, deposits are formed by the structure-metallogeny process. In general, ore-controlling structures, typical epithermal alteration and mineral assemblies are the common features of these disseminated type gold deposits, and also are the prospective criterion.

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Appendix III-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

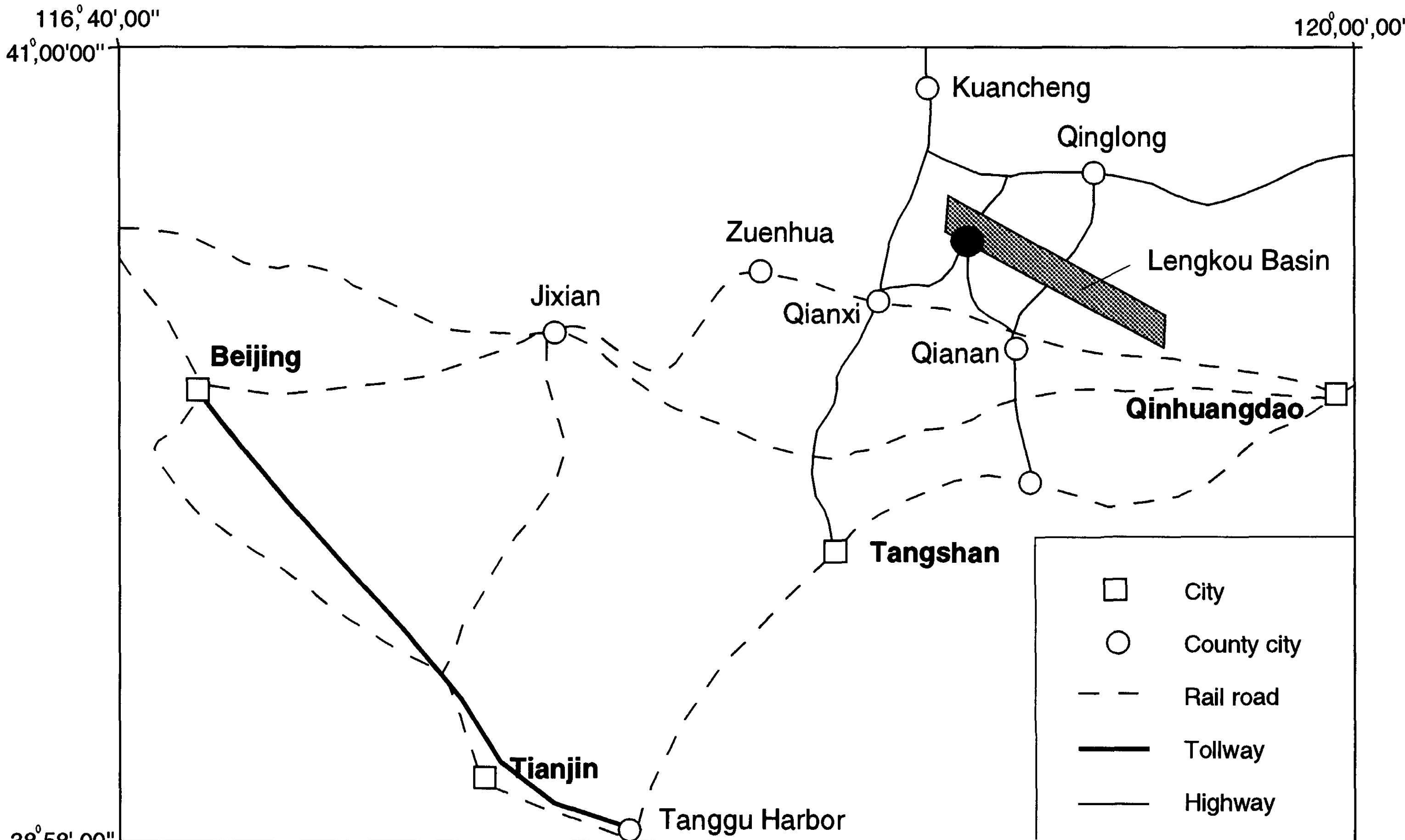

Figure 3-2-1. Location and Transportation map of the Greatwall gold deposits

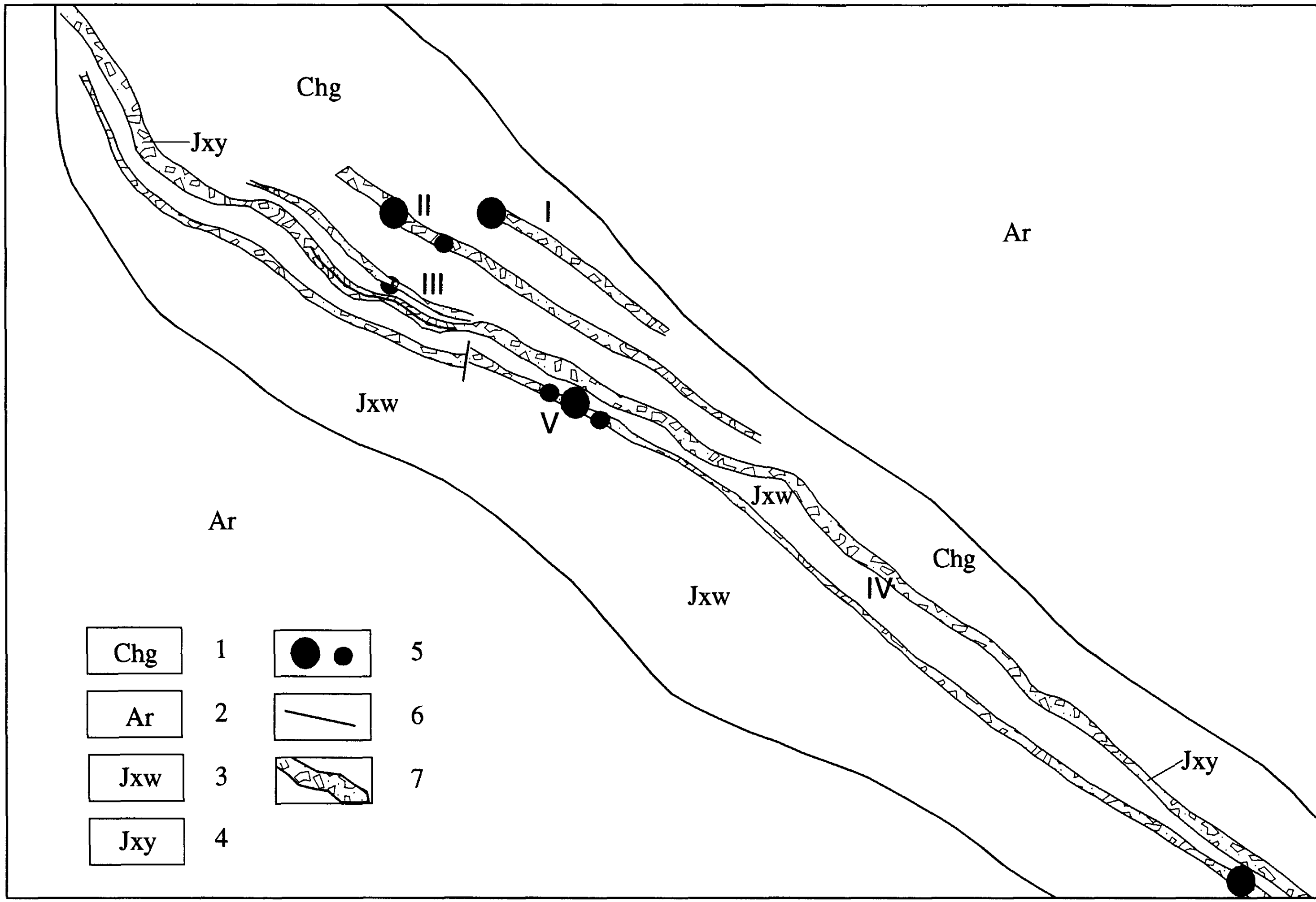

Figure 3-2-2. Geology and gold deposits in Lengkou basin, Jidong area, China. Showing the gold deposits are controlled by five breccia bodies northwestern-trending. 1-Gaoyuzhuang group of the Greatwall system (Chg); 2-Archaeozoic stratigraphy (Ar); 3-Wumishan group of the Jixian system (Jxw); 4-Yangzhuang 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.

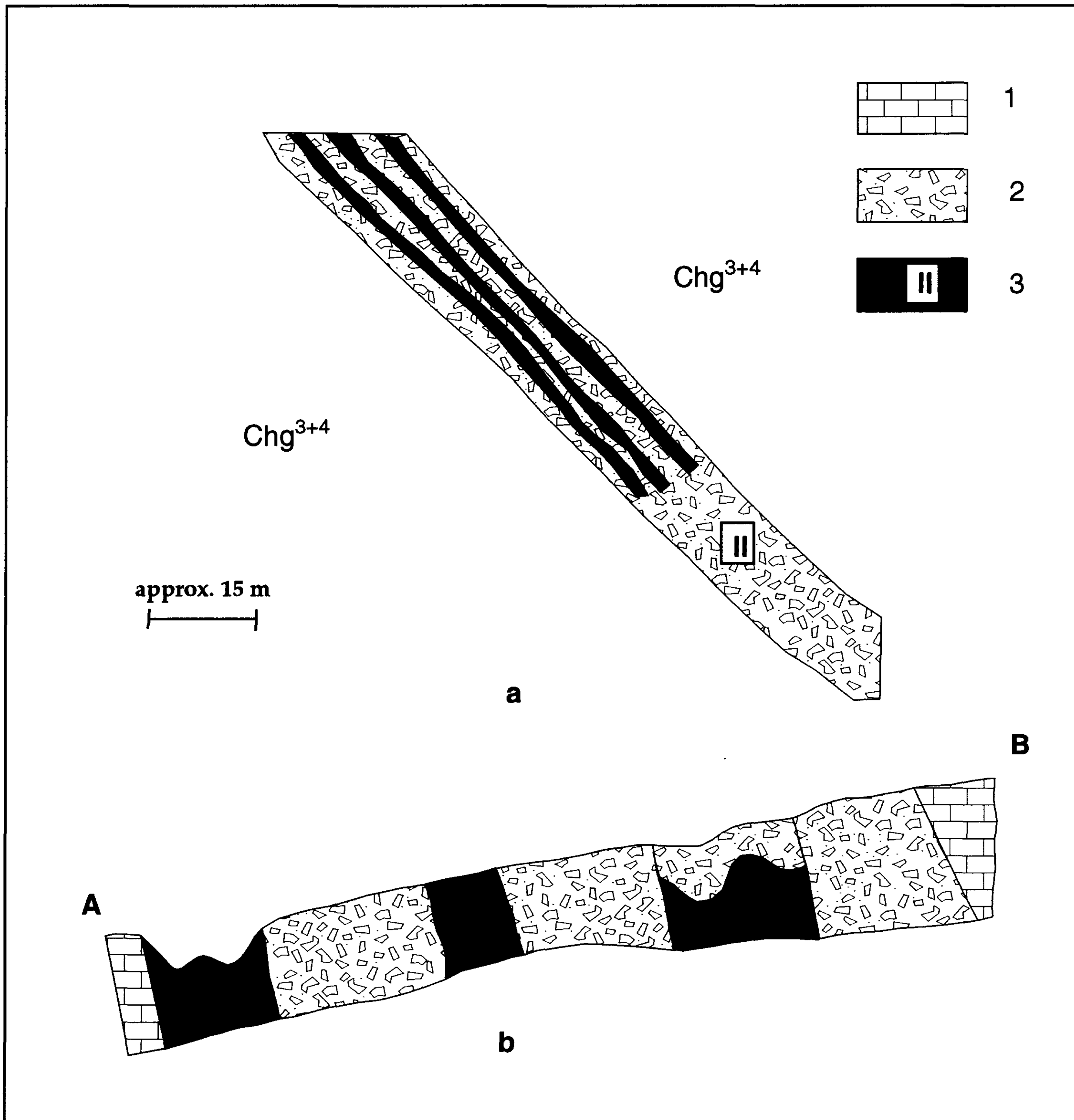

Figure 3-2-3. Stratabound breccia bodies control the No. II orebody in the Qingheyian gold deposit, a Greatwall type deposit. a - plane map; b - section; 1 - dolomitic limestone, 2 - breccia, 3 - orebodies; Chg^{3+4} - Gaoyuzhuang group of the Greatwall system.