

Summary of Pre-Accretionary and Accretionary Metallogenic Belts of Mongolia

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INTRODUCTION

This report summarizes the major pre-accretionary and accretionary metallogenic belts of Mongolia. This study will be expanded in future years of the project. The major pre-accretionary and accretionary metallogenic belts of Mongolia are plotted on, and interpreted according to a preliminary schematic terrane map of Mongolia compiled at scale 1:10,000,000 by G. Badarch and O. Tomurtogoo in 1997 (Figure 1).

The major pre-accretionary and accretionary metallogenic belts herein summarized contain well-preserved deposits or occurrences of significant size. Numerous, small pre-accretionary occurrences exist in Mongolia, but cannot be displayed on Figures 2 and 3 at a scale of 1:10,000,000. Preliminary data on the mineral deposits and occurrences of Mongolia are summarized in the companion article by Dejidmaa and others (this volume). These data are derived from the following sources:

Guide to the geology and mineral resources of Mongolia, 1996, Jargalsaihan, D., Kazmer, M., Bara, Z., and Sanjaadorj, D., eds.: Geological Exploration Consulting Services (GCS) Co., 330 p., 2 sheets, scale 1:3,200,000.

State Geological Fund, May 1997, Location map of base metal (Cu) deposits and occurrences of Mongolia, Series 2, 1 sheet, scale 1:3,200,000.

State Geological Fund, May 1997, Location map of base metal (Pb, Zn, Ni, Co, Al) deposits and occurrences of Mongolia, Series 4, 1 sheet, scale 1:3,200,000.

State Geological Fund, May 1997, Location map of industrial metal (Pb, Zn, Ni, Co, Al) deposits and occurrences of Mongolia, Series 3, 1 sheet, scale 1:3,200,000.

State Geological Fund, 1995, D. Largsayhan, ed., Gold resources map of Mongolia, Series 5, 1 sheet, scale 1:3,200,000.

In future publications for the project, the compilation and synthesis of the metallogenic belts of Mongolia and their contained significant and major mineral deposits will be expanded. An article on gold

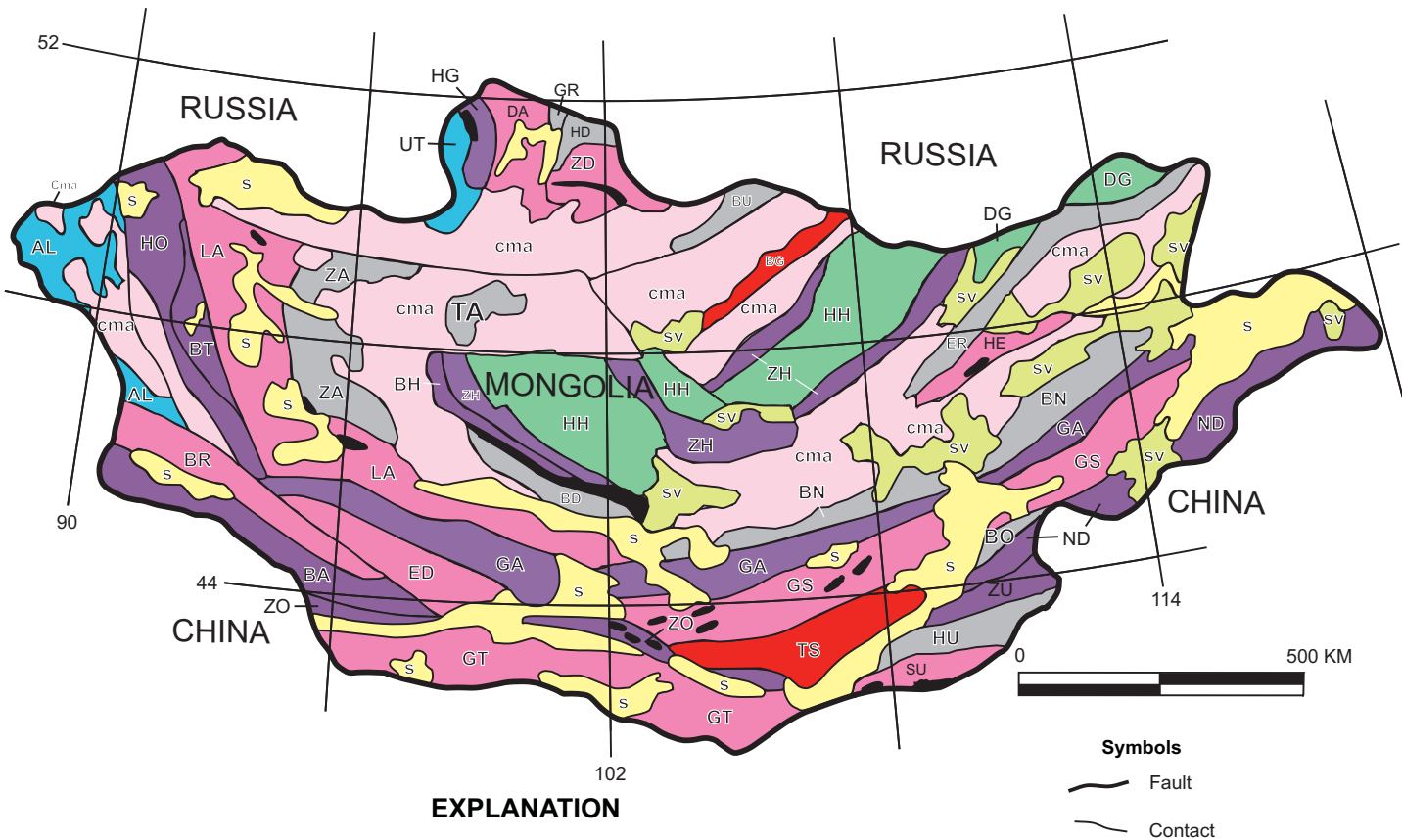
metallogeny of Mongolia that is related to this article was published by Dejidmaa (1996).

PRE-ACCRETIONARY METALLOGENIC BELTS

Pre-accretionary metallogenic belts are interpreted as forming early in the history of terranes, before accretion to other terranes or to a continental margin. This type of metallogenic belts and contained mineral deposits and occurrences are unique to the host terranes. Typical examples of pre-accretionary metallogenic belts of Mongolia are those related to ancient island arcs, continental margin arcs, and passive continental margins and their derived terranes. For example, the Nuuryn metallogenic belt is related to (hosted in) an ancient island arc terrane. The Bayangol and southern Mongolian metallogenic belts are related to a continental margin igneous arc terrane. And the Khovsgol metallogenic belt is related to a passive continental margin terrane. The major pre-accretionary metallogenic belts of Mongolia are depicted in Figure 2, and the major characteristics of these belts are summarized in Table 1.

Pre-Accretionary Metallogenic belts Related to Island Arc Terranes

Metallogenic belts formed in ancient island arc terranes contain relatively more deposit types compared to terranes of other tectonic environments. For example, six deposit types are defined for the Nuuryn metallogenic belt (Figure 2, Table 1). (1) Deposit types related to ultramafic rocks (podiform Cr, serpentine hosted asbestos and talc-carbonate) and mafic rocks (gabbroic Ni-Cu and gabbroic Ti-magnetite). (2) Deposit types related to marine felsic to mafic rocks (Cu-Zn massive and stringer deposits that are often rich in Au and Ag). (3) Deposit types in chemical-carbonate rocks such as ironstone. (4) Au-sulphide-quartz veins and stockworks associated with disseminated Au, Au-Cu and Au-Cu-Fe skarns; (5) scheelite-quartz-stockwork greisen deposits associated with calc-alkaline granitic intrusions. And (6) deposit types related to intrusive porphyries (porphyry Cu-Au).



EXPLANATION

Tectonic Environments

Archean and Proterozoic Terranes

Cratonal

Early and Middle Paleozoic Terranes

- Passive continental margin
- Continental margin arc
- Island arc
- Turbidite basin
- Accretionary Wedge
- Ophiolite and oceanic crustal rocks

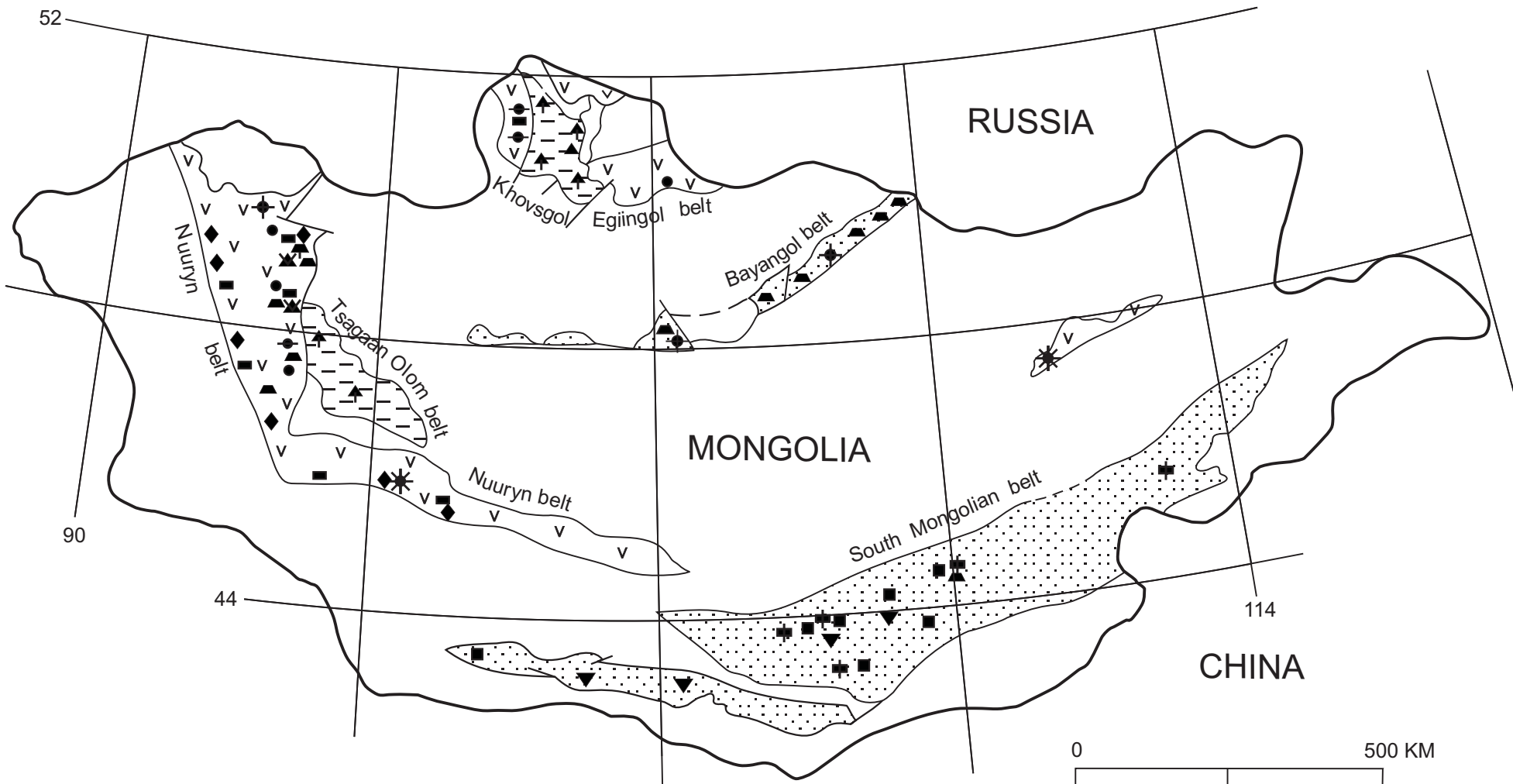
Middle Paleozoic to Cenozoic Overlap Assemblages

- cma Devonian and Carboniferous continental margin arc
- sv Cretaceous and Cenozoic sedimentary and volcanic rocks
- s Cenozoic overlap sedimentary rocks

Terranes

- AL Altay terrane (Passive continental margin)
- BA Baruunhuuray terrane (Accretionary wedge)
- BD Baidrag terrane (Cratonal)
- BG Bayangol terrane (Continental margin arc)
- BH Bayanhongor terrane ((Accretionary wedge)
- BO Bargyn owoo terrane (Cratonal)
- BN Buyant terrane (Cratonal)
- BR Baaran terrane (Island arc)
- BT Baatar Hayrhan terrane (Accretionary wedge)
- BU Buteel terrane (Cratonal)
- DA Darhad terrane (Island arc)
- DG Dochgol terrane (Turbidite basin)
- ED Edren terrane (Island arc)
- ER Ereen Davaa terrane (Cratonal)
- GA Govi Altay terrane (Accretionary wedge)
- GR Gargan terrane (Cratonal)
- GS Gurbansaihan terrane (Island arc)
- GT Govi Tien Shan terrane (Island arc)
- HA Harhorin terrane (Accretionary wedge)
- HE Herlen terrane (Island arc)
- HG Hug terrane (Accretionary wedge)
- HH Hangay Hentey terrane (Turbidite basin)
- HO Hovd terrane (Accretionary wedge)
- HU Hutag terrane (Cratonal)
- LA Lake terrane (Island arc)

Figure 1. Schematic terrane and overlap assemblage map of Mongolia. Compiled by G. Badarch and O. Tomurtogoo, 1997.



Deposit Types

- ☀ Podiform Cr
- Serpentine-hosted asbestos, talc-carbonate
- ◆ Gabbroic Cu, Ni-Cu, Ni (PGE, Au)
- Gabbroic Ti-Fe
- ◆ Cyprus type Cu-Zn-Ag (Au)
- ▲ Ironstone
- ▲ Phosphorite

EXPLANATION

- Au-sulfide-quartz vein/stockwork associated with disseminated replacement Au
- ▲ Cu (Au, Ag); Cu-Fe-Au (Ag), Cu skarn
- ▲ W (sheelite) skarn
- Porphyry Cu-Au (Ag); Mo-Cu (Au, Ag)
- ▼ High sulfide epithermal Au
- ◆ Gold-(tourmaline)-quartz vein/stockwork, breccia zone/pipe

Tectonic Environments


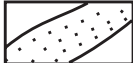

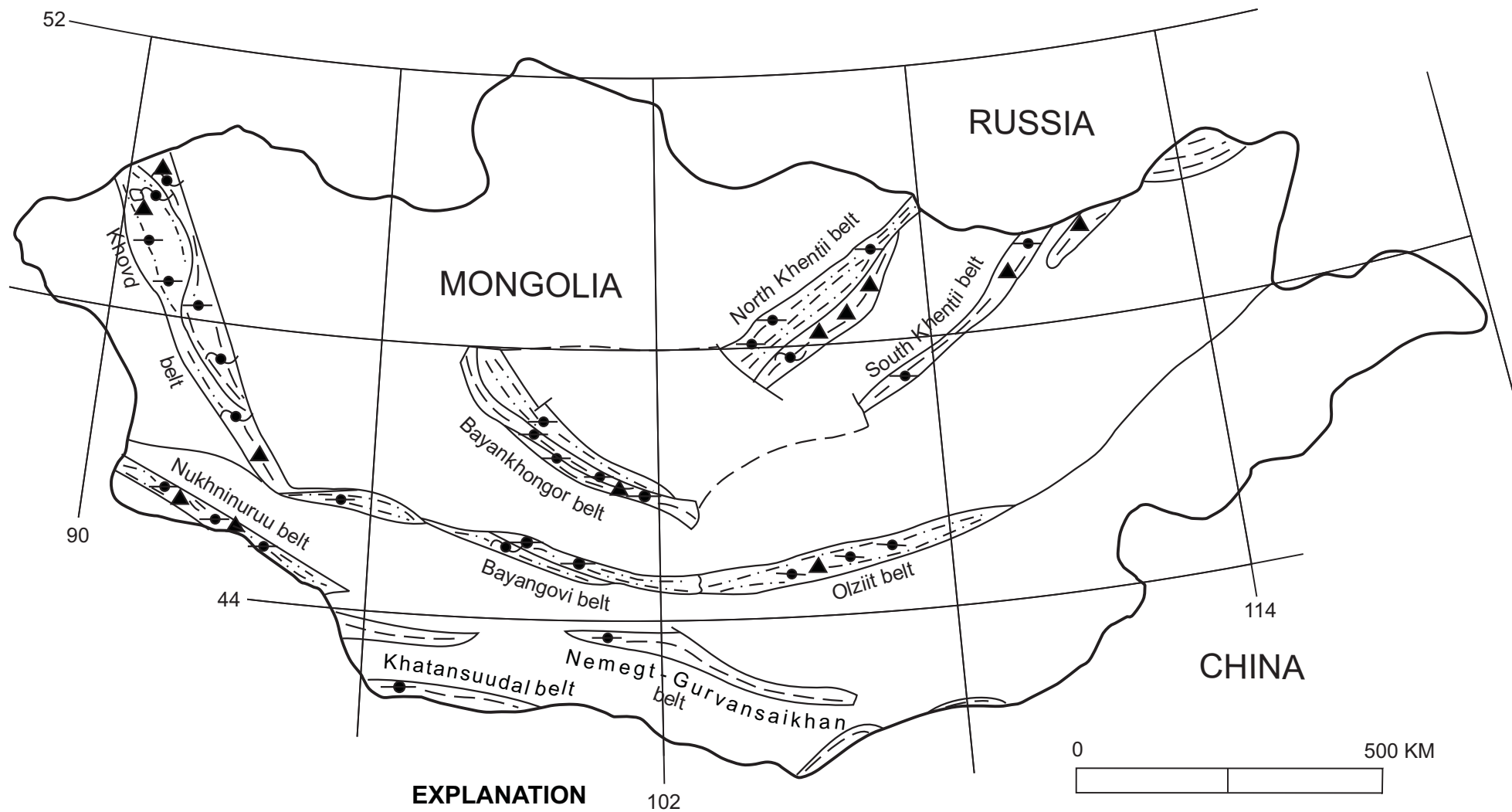
-  Island arc
-  Active continental margin
-  Passive continental margin containing abundant carbonate rocks

Figure 2. Major pre-accretionary metallogenic belts, and associated mineral deposits and occurrences of Mongolia.



- EXPLANATION**
- Gold-quartz vein deposits and occurrences
 - ◌ Cu-Ag-quartz vein line stockwork occurrences
 - ▲ Ironstone and iron-manganese-stone occurrences

- Tectonic Environments**
- Accretionary wedge terranes defined by G. Badarch (1997)
 - Possible accretionary wedge terranes defined by metallogenic features

Figure 3. Major accretionary metallogenic belts and associated mineral deposits and occurrences of Mongolia.

Pre-Accretionary Metallogenic belts Related to Passive Continental Margin Terranes

Metallogenic belts formed in passive continental margin terranes or overlap assemblages contain mostly deposits formed in carbonate and sedimentary rocks and consist of phosphorite, bauxite, and ironstone deposits and occurrences (Figure 2, Table 1).

Pre-Accretionary Metallogenic belts Related to Continental Margin Igneous Arc Terranes

Examples of pre-accretionary metallogenic belts formed in continental margin igneous arcs are the Bayangol and the South Mongolian belts that contain different deposit types (Figure 2, Table 1). This difference may be related to different levels of erosion of these belts and host terranes. For example, the Bayangol belt, related to calc-alkaline granitic intrusions, contains widespread Fe skarn deposits and lesser Cu-Au and Cu skarn deposits. In contrast, the South Mongolian metallogenic belt contains abundant porphyry Au-Cu deposits and related deposit types, including high-sulphide epithermal Au, replacement alunite, replacement kaolinite, and replacement pyrophyllite deposits and occurrences (Figure 2 and Table 1.).

ACCRETIONARY METALLOGENIC BELTS

Accretionary metallogenic belts are defined according to the following features: (1) Occurrence in accretionary wedge terranes as interpreted by G. Badarch (Figure 1). The hosting accretionary wedge terranes all contain mildly to intensively deformed and metamorphosed complexes of turbidite formations and lesser amounts of oceanic rocks, mostly ultramafic intrusive rocks. And (2) occurrence of specific deposit types that are characteristic of accretionary or collisional tectonic settings. A type example is Au-quartz vein deposit type that is clearly structurally controlled, is hosted in deformed and metamorphosed terrigenous formations, and has a close spatial relation and probably genetic relation to synorogenic calc-alkaline granitic plutons. The major accretionary metallogenic belts defined in this study are the North Khentii, South Khentii, Bayangol, Khovd, Bayangobi, Olziit, Nukhniinnuruu, Nemeegt-Gurvansaikhan, and Khatansuudal belts (Figure 3, Table 2).

Accretionary metallogenic belts contain unique deposit types (Table 2). The main deposit types are Au-quartz and Au-carbonate-quartz concordant vein deposits (Figure 3, Table 2). These two types have

clearly-defined structural control and exhibit a close space and genetic relationship to calc-alkaline gabbro to granodiorite intrusions. These deposits generally occur in parallel veins, saddle reef veins, and networks of veins that are always concordant with host terrigenous rocks. In many cases, the distribution of the veins is controlled by anticlinal axes, shear zones, and a greenschist facies metamorphic grade.

A second, lesser deposit type in accretionary metallogenic belts is possibly ironstone or iron-manganese-stone deposit (Figure 3, Table 2). These deposit types are widespread in Mongolia.

The third, lesser deposit type in accretionary metallogenic belts is Cu-Ag-quartz vein or linear stockwork (Figure 3, Table 2). The type is widely distributed in the Khovd metallogenic belt, especially in the Ordovician-Silurian Biji unit.

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- Dejidmaa, G., 1996, Gold metallogeny of Mongolia, *Mongolian Geoscientist*, no. 1, p. 6-29.
- Dejidmaa, G., Chimed, L., and Badarch, G., 1998, Preliminary table of lode and placer deposits and occurrences of Mongolia, this volume.
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- State Geological Fund, 1995, D. Largalsayhan, ed., Gold resources map of Mongolia, Series 5, 1 sheet, scale 1:3,200,000.

TITLES TO FIGURES

1. Schematic terrane map of Mongolia at scale 1:10,000,000. Compiled in 1997 by Gomborsuen Badarch.

2. Major pre-accretionary metallogenic belts and associated mineral deposits, and occurrences of Mongolia.

3. Major accretionary metallogenic belts and associated mineral deposits, and occurrences of Mongolia.

Table 1. Pre-accretionary metallogenic belts and associated mineral deposits, and occurrences of Mongolia

No.	Metallogenic belt	Host terrane (Tectonic Environment)	Host Rocks	Deposit type	Examples
1	Nuur	Nuur (Early Paleozoic island arc)	Deposits related to marine mafic to felsic extrusive rocks	Cyprus Cu - Zn - Ag (Au) massive and stringer-impregnation sulfide	Borts Uul deposit, Gozgor and Narandavaa occurrences and others.
			Deposits in carbonate and chemical - sedimentary rocks	Iron formation	Bayan Airag Uul, Hulj gol occurrences
			Deposits related to calc - alkaline granite intrusive	Au-sulfide quartz vein and stockwork associated with disseminated Au	Hyargas, Budag Hond, Tsetserleg Nuruu occurrences
				Au-Cu skarn	Togloy occurrence
				W (scheelite) greisen	Morit Uul occurrence
			Porphyry pluton hosted deposits	Porphyry Au-Cu	Beger group occurrence
			Deposits related to mafic and ultramafic rocks	PGE-rich podiform Cr	Hantaishir group
				Serpentine-hosted asbestos	Hyargas occurrence
				Talc-carbonate	Hyargas, Hotol occurrences
Gabbroic Ni-Cu, gabbroic Ti -Fe	Jargalant and Uet Ondor occurrences				
2	Bayangol	Bayangol terrane (Early Paleozoic continental margin arc)	Deposits related to calc-alkaline granite intrusives	Au-Cu-Fe skarn, Cu skarn, Fe skarn	Oyut Tolgoy and Daagandel occurrences; Tomortey, Bayangol, Tomortolgoi deposits
			Deposits related to mafic-ultramafic intrusives	Asbestos skarn	Baishin hudag
				Gabbroic PGE rich Cu - Ni	Nomgon , Hotol occurrence

3	South Mongolian	Middle-upper Paleozoic continental margin arc	Porphyry and granitic pluton-hosted deposits	Porphyry Au-Cu	Kharmagtai, Uhaa Hudag, Ovoothyar occurrences
				High-sulfide epithermal Au	Shuteen, Ikh Shanhai occurrences
				Au-sulfide-(tourmaline)-quartz vein or stockwork	Ovoothyar, Shine occurrences
				Au-sulfide- tourmaline-quartz breccia zone/ explosive pipe	Ovoothyar, Kharmagtai occurrences
				Alunite replacement	Shuteen, Ikh Shanhai occurrences
				Kaolinite replacement	Shuteen, Ikh Shanhai occurrences
				Prophyllite replacement	Tsogt Tsetsiy Group occurrences
4	Hovsgol	Lower Paleozoic passive continental margin or post-accretionary overlap assemblages	Carbonate and chemical sedimentary rocks	Phosphorite	Urandosh, Jankhai, Mankhan Uul, Burenhaan deposits
				Ironstone bauxite	Khachim Gol, Sayhangol occurrences
5	Tsagaan Olom			Phosphorite	Tsagaan Olom group occurrences

Table 2. Accretionary metallogenic belts and associated mineral deposits, and occurrences of Mongolia

No.	Metallogenic Belt	Host Terrane	Host Rocks	Deposit Type	Examples
1	North Hentey	Zag terrane (Early Paleozoic accretionary wedge)	Deposits in chemical-sedimentary rocks	Ironstone	Eroo gol group, Huj gol, Buugert group
			Deposits related to regionally metamorphosed rocks	Cu-Ag vein and linear stockwork	
			Deposits related to calc-alkaline granite intrusive	Au quartz vein (anticline axis control)	Bumbat, Nariyn gol deposits, Zaamar group occurrences
2	South Hentey	Zag terrane (Early Paleozoic accretionary wedge)	Deposits in chemical-sedimentary rocks	Ironstone	Navchit gol, Oborhondlon, Delger Ondor, and Berh Uul, occurrences
			Deposits related to regionally metamorphosed rocks and calc-alkaline granite intrusive	Au-quartz vein	Balj gol and Baruun muhar groups
3	Bayanhon-Hongor	Bayanhongor terrane (Precambrian to middle Paleozoic accretionary wedge)	Deposits related to regionally metamorphosed rocks and calc-alkaline granite intrusives	Au - quartz vein, Au-carbonate-quartz vein	Burd gol, Han Uul, Dovont occurrences (Bayanhongor area)
4	Hovd	Hovd terrane (Lower to middle Paleozoic accretionary wedge)	Deposits related to regionally metamorphosed rocks and calc - alkaline granite intrusive	Au quartz vein	Altantsogts, Hovd occurrences in Shar hooloy district
				Cu-Ag quartz linear stockwork	Bij group occurrence in Manhan area
			Deposits in chemical - sedimentary rocks	Ironstone	Uureg nuur group
5	Bayangovi	Gobi Altai terrane (Lower to middle Paleozoic accretionary wedge)	Deposits related to regionally metamorphosed rocks and calc-alkaline granite intrusive	Au - (carbonate) quartz vein (saddle reef veins and stockwork in sandstone)	Bayangovi group, Oortsog and Bituugiyn hyar occurrences
				Cu - Ag quartz vein and linear stockwork	Bayangovi group occurrence
6	Olziyt	Gobi-Altai terrane (Lower middle Paleozoic accretionary wedge)	Deposits related to regionally metamorphosed rocks and calc-alkaline granite intrusives	Au - (carbonate) quartz vein (saddle reef veins)	Olon Ovoot and Antsavyn, Dayangar occurrences

7	Nuhniy Nuruu	Baytag terrane (Middle Paleozoic accretionary wedge)	Deposits related to regionally metamorphosed rocks and calc-alkaline granite intrusives	Au - (carbonate) - quartz vein (saddle reef veins)	Haltar Uul - Ereen uul group occurrences
			Deposits in chemical - sedimentary rocks	Ironstone	Suultolgoi occurrence
8	Nemegt-Gurvan-Sayhan	Zoolon and Gurvan-sayhan terranes (Early and middle Paleozoic accretionary wedge)	Deposits related to regionally metamorphosed rocks and calc-alkaline granite intrusives	Au (carbonate) quartz vein	Nemegt occurrence
9	Hatansuudal	Naransevestey terrane (Lower middle Paleozoic accretionary wedge)	Deposits related to regionally metamorphosed rocks and calc-alkaline granite intrusives	Au (carbonate) quartz vein (parallel and ladder veins)	Talyn Meltes and Hatansuudal occurrences