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INTRODUCTION AND COMPANION STUDIES

This map portrays the geodynamics of Northeast Asia at a scale of 1:5,000,000 using the concepts of plate tectonics and analysis of terranes and overlap assemblages. The map is the result of a detailed compilation and synthesis at 5 million scale and is part of a major international collaborative study of the *Mineral Resources, Metallogenesis, and Tectonics of Northeast Asia* conducted from 1997 through 2002 by geologists from earth science agencies and universities in Russia, Mongolia, Northeastern China, South Korea, Japan, and the USA.

This map is the result of extensive geologic mapping and associated tectonic studies in Northeast Asia in the last few decades and is the first collaborative compilation of the geology of the region at a scale of 1:5,000,000 by geologists from Russia, Mongolia, Northeastern China, South Korea, Japan, and the USA. The map was compiled by a large group of international geologists using the below concepts and definitions during collaborative workshops over a six-year period. The map is a major new compilation and re-interpretation of pre-existing geologic maps of the region. The map is designed to be used for several purposes, including regional tectonic analyses, mineral resource and metallogenic analysis, petroleum resource analysis, neotectonic analysis, and analysis of seismic hazards and volcanic hazards.

The map consists of two sheets. Sheet 1 displays the map at a scale of 1:5,000,000, explanation. Sheet 2 displays the introduction, list of map units, and source references. Detailed descriptions of map units and stratigraphic columns are being published separately.

This map is one of a series of publications on the mineral resources, metallogenesis, and geodynamics,of Northeast Asia. Companion studies and other articles and maps , and various detailed reports are: (1) a compilation of major mineral deposit models (Rodionov and Nokleberg, 2000; Rodionov and others, 2000; Obolenskiy and others, in press a); (2) a series of metallogenic belt maps (Obolenskiy and others, 2001; in press b); (3) a lode mineral deposits and placer districts location map for Northeast Asia (Ariunbileg and others, in press b); (4) descriptions of metallogenic belts (Rodionov and others, in press); and (5) a database on significant metalliferous and selected nonmetalliferous lode deposits, and selected placer districts (Ariunbileg and others, in press a).

KEY CONCEPTS FOR COMPILATION OF MAP

This map portrays major geologic and tectonic units of the region. The map illustrates both the onshore terranes and overlap volcanic assemblages of the region, including cratons, tectonostratigraphic terranes, and overlap assemblages, major structures, and major offshore geologic features. Geologic mapping suggests that most of this region can be interpreted as a collage of fault-bounded tectonostratigraphic terranes that were accreted onto cratons and continental margins during the Paleozoic, Mesozoic, and Cenozoic eras.

A *tectonostratigraphic terrane* is defined as a fault-bounded geologic entity or fragment that is characterized by a distinctive geologic history that differs markedly from that of adjacent terranes (Jones and others, 1983; Howell and others, 1985). A tectonostratigraphic terrane (hereafter referred to as *terrane*) is a , stratigraphically coherent assemblage that formed before tectonic juxtaposition to adjacent units. A few terranes are mainly subduction-zone or accretionary-wedge complexes. Terranes are bounded by major faults or fault zones, termed sutures. Paleontologic, stratigraphic, and paleomagnetic evidence suggests that some terranes were originally widely separated from one another, or from the North Asian, Sino-Korean, or South China (Yangzi) Cratons. On the other hand, some terranes may have formed within a few hundred kilometers of one another and (or) near the same craton.

On the map, terranes are interpreted and colored according to inferred tectonic environments: (1) cratonal; (2) passive continental margin; (3) metamorphosed continental margin; (4) continental-margin arc; (5) island arc; (6) oceanic crust, seamount, and ophiolite; (7) accretionary wedge and subduction zone; (8) turbidite basin; (9) transform continental-margin arc, and (10) metamorphic for terranes that are too highly-deformed and metamorphosed to determine the original tectonic environment. For terranes with complex geologic histories color indicates the tectonic environment most prevalent during the history of the terrane. Terranes in early Precambrian crystalline basement of cratons are also delineated; color indicates major lithologies.

The map also depicts overlap units that occurred after accretion of terranes to each other or to a continental margin: (1) Paleozoic, Mesozoic, and Cenozoic sedimentary and volcanic rocks that are deposited across two or more terranes and generally formed after accretion of most terranes in the region; (2) Paleozoic, Mesozoic, and Cenozoic basins that occur within a terrane or on cratons; and (3) plutonic rocks. Post-accretion igneous units are identified by age-lithologic abbreviations and by name.

Overlap assemblages and basinal deposits formed mainly during sedimentation and magmatism. Overlap assemblages provide minimum ages on the timing of accretion of terranes. Some overlap assemblages and basinal deposits, as well as fragments of terranes, are extensively offset by movement along post-accretion faults. In offshore areas, the map depicts major oceanic plates, oceanic spreading ridges, and seamounts. For onshore units, the map also depicts active continental margin and island arc-related assemblages, orogenic belt assemblages, magmatic formations, and transform-plate-boundary-related assemblages. Also depicted are younger neotectonic features including active faults, active volcanoes, astroblemes, aulacogen, and rifts.

TECTONIC DEFINITIONS

The following definitions are used for the compilation, synthesis, description, and interpretation of metallogenic belts. The definitions are adapted from Coney and others (1980), Jones and others (1983), Silberling and others (1984), Howell and others (1985), Monger and Berg (1987), Nokleberg and others (1994a, b, 2001), Wheeler and others (1988), and Scotese and others (2001).

Accretion- Tectonic juxtaposition of two or more terranes, or tectonic juxtaposition of terranes with a craton margin. Accretion of terranes to one another or to a craton margin also defines a major change in the tectonic evolution of terranes and craton margins.

Accretionary wedge and subduction-zone terrane- Fragment of a mildly to intensely deformed complex consisting of varying amounts of turbidite deposits, continental-margin rocks, oceanic crust and overlying units, and oceanic mantle. Divided into units composed predominantly of turbidite deposits or predominantly of oceanic rocks, mainly basalt. Units are interpreted to have formed during tectonic juxtaposition in a zone of major thrusting of one lithosphere plate beneath another, generally along the margin of a continent or an island arc. May include large fault-bounded units with a coherent stratigraphy. Many subduction-zone terranes contain fragments of oceanic crust and associated rocks that exhibit a complex structural history, occur in a major thrust zone, and possess blueschist-facies metamorphism.

Collage of terranes- Groups of tectonostratigraphic terranes, generally formed in oceanic areas; insufficient data exists to identify separate units.

Craton- Chiefly regionally metamorphosed and deformed shield assemblages of Archean and Early Proterozoic sedimentary, volcanic, and plutonic rocks, and overlying platform successions of Late Proterozoic, Paleozoic, and local Mesozoic and Cenozoic sedimentary and lesser volcanic rocks.

Craton margin- Chiefly Late Proterozoic through Jurassic sedimentary rocks deposited on a continental shelf or slope. Consists mainly of platform successions. Locally has, or may have had an Archean and Early Proterozoic cratonal basement.

Cratonal terrane- Fragment of a craton.

Continental margin arc terrane- Fragment of an igneous belt of coeval plutonic and volcanic rocks, and associated sedimentary rocks that formed above a subduction zone dipping beneath a continent. Inferred to possess a sialic basement.

Deposit- Any lode or placer mineral occurrence, mineral deposit, prospect, and (or) mine.

Island-arc terrane- Fragment of an igneous belt of plutonic rocks, coeval volcanic rocks, and associated sedimentary rocks that formed above an oceanic subduction zone. Inferred to have a simatic basement.

Metamorphic terrane- Fragment of a highly metamorphosed or deformed assemblage of sedimentary, volcanic, or plutonic rocks that cannot be assigned to a single tectonic environment because the original stratigraphy and structure are obscured. Includes intensely deformed structural melanges that contain intensely deformed fragments of two or more terranes.

Metamorphosed continental margin terrane. Fragment of a passive continental margin, in places moderately to highly metamorphosed and deformed, that cannot be linked with certainty to the nearby craton margin. May be derived from either a nearby craton margin or a distant site.

Oceanic crust, seamount, and ophiolite terrane. Fragment of part or all of a suite of deep-marine sedimentary rocks, pillow basalt, gabbro, and ultramafic rocks that are interpreted as oceanic sedimentary and volcanic rocks and the upper mantle. Includes both inferred offshore oceanic and marginal ocean basin rocks, minor volcaniclastic rocks of magmatic arc derivation, and major marine volcanic accumulations formed at a hotspot, fracture zone, or spreading axis.

Overlap assemblage- A post-accretion unit of sedimentary or igneous rocks deposited on, or intruded into, two or more adjacent terranes. The sedimentary and volcanic parts either depositionally overlie, or are interpreted to have originally depositionally overlain, two or more adjacent terranes, or terranes and the craton margin. Overlapping plutonic rocks, which may be coeval and genetically related to overlap volcanic rocks, link or stitch together adjacent terranes, or a terrane and a craton margin.

Passive continental margin terrane- Fragment of a craton margin.

Subterrane- A fault-bounded unit within a terrane that exhibit similar, but not identical geologic history relative to another fault-bounded unit in the same terrane.

Superterrane- An aggregate of terranes that is interpreted to share either a similar stratigraphic kindred or affinity, or a common geologic history after accretion. An approximate synonym is *composite terrane*.

Tectonic linkage- The interpreted association of a suite of coeval tectonic units that formed in the same region and as the result of the same tectonic processes. An example is the linking of a coeval continental-margin arc, forearc deposits, a back-arc rift assemblage, and a subduction-zone complex, all related to the underthrusting of a continental margin by oceanic crust.

Tectonostratigraphic terrane- A fault-bounded geologic entity or fragment that is characterized by a distinctive geologic history that differs markedly from that of adjacent terranes (Jones and others, 1983; Howell and others, 1985).

Transform continental-margin arc. An igneous belt of coeval plutonic and volcanic rocks, and associated sedimentary rocks that formed along a transform fault that occurs along the margin of a craton, passive continental margin, and (or) collage of terranes accreted to a continental margin.

Turbidite basin terrane- Fragment of a basin filled with deep-marine clastic deposits in either an orogenic forearc or backarc setting. May include continental-slope and continental-rise turbidite deposits, and submarine-fan turbidite deposits deposited on oceanic crust. May include minor epiclastic and volcaniclastic deposits.

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LIST OF MAP UNITS

[Geologic time scale units are according to the IUGS Global Stratigraphic Chart (Remane, 1998). For this study, the term *Riphean* is used for the Mesoproterozoic through Middle Neoproterozoic (1600 to 650 Ma), and the term *Vendian* is used for Neoproterozoic III (650 to 540 Ma)]

TECTONOSTRATIGRAPHIC TERRANES

(Arranged alphabetically by map symbol within each section)

ACH Anui-Chuya terrane (Continental margin turbidite) (Early to late Paleozoic) (Gorny Altai)
□□ Agardag terrane (Oceanic) (Vendian and Cambrian) (Southern Tuva)
AI Amil terrane (Accretionary wedge, type A) (Vendian and Cambrian) (Western Sayan)
AL Alambai terrane (Accretionary wedge, type B) (Vendian and Early Cambrian) (South Salair and northern Gorny Altai)
AM Akiyoshi-Maizuru terrane (Accretionary wedge, type B) (Carboniferous and Permian) (Japan)
AN Angurep terrane (Metamorphic) (Middle Silurian and older) (South Salair)
ANV Aniva terrane (Accretionary wedge, type B) (Middle Triassic through early Late Cretaceous) (Southern Russian Far East)
AO Agoi terrane (Metamorphic) (Pre-Paleozoic) (Eastern Tuva)
AR Argunsky terrane (Passive continental margin) (Paleoproterozoic through late Paleozoic) (Northeast China, Transbaikalia)
AT Altai terrane (Continental margin turbidite) (Precambrian and Cambrian through Devonian) (Southern Gorny Altai, Northwest China, Mongolia)
AV Atamanov terrane (Granulite-paragneiss) (Paleoproterozoic) (Yenisey Ridge)
AY Ayansk terrane (Passive continental margin) (Ordovician through Late Carboniferous) (Yakutia)
BA Beitianshan-Atasbogd terrane (Island arc) (Devonian through Carboniferous) (Northwest China, Mongolia)
BD Badzhal terrane (Accretionary wedge, type B) (Permian through Jurassic) (Southern Russian Far East)
BG Bayanleg terrane (Accretionary wedge, type A) (Ordovician to Devonian) (Gobi Altay)
BH Bayanhongor terrane (Oceanic) (Neoproterozoic) (Western Mongolia)
BI Birusa terrane (Paragneiss) (Paleoproterozoic to Neoproterozoic) (Eastern Sayan)
BK Belaya-Kitoy terrane (Metamorphic) (Archean?) (Eastern Sayan)
BL Baladek terrane (Metamorphic) (Paleoproterozoic through Ordovician) (Southern Russian Far East)
BLK Belokurikha terrane (Metamorphic) (Late Permian and older) (Northern Gorny Altai)
BM Baikal-Muya terrane (Island arc) (Neoproterozoic) (Transbaikalia)
BR Baratal terrane (Accretionary wedge, type B) (Late Neoproterozoic through Early Cambrian) (Southeastern Gorny Altai)
BRG Barguzin terrane (Metamorphic) (Late Neoproterozoic) (Transbaikalia)
BS Borus terrane (Accretionary wedge, type B) (Early Cambrian) (Northwest Sayan)
BU Bureya terrane (Metamorphic) (Neoproterozoic and older through Triassic) (Southern Russian Far East)
BY Baydrag terrane (Cratonal) (Neoproterozoic and older) (Northwest Mongolia)
BZ Bazibai terrane (Metamorphic) (Late Neoproterozoic and Cambrian) (Eastern Sayan)
CA Central Angara terrane (Passive continental margin) (Neoproterozoic) (Yenisey Ridge)
Central Aldan superterrane (Yakutia)
CANM Nimnyr terrane (Granulite-orthogneiss) (Paleoproterozoic) (Yakutia)
CAST Sutam terrane (Granulite-paragneiss) (Late Archean) (Yakutia)
CACG Chogar terrane (Granulite-orthogneiss) (Archean) (Yakutia)
CH Chuja terrane (Paragneiss) (Late Archean through Neoproterozoic) (Transbaikalia)
CHN Cheongjin terrane (Accretionary wedge, type B) (Permian) (Korea)
CHR Charysh terrane (Continental margin turbidite) (Cambrian through Devonian) (Northwestern Gorny Altai)
Central Taimyr superterrane (Taimyr Peninsula)
CTC Chelyuskin terrane (Island arc) (Neoproterozoic) (Northeast and Central Taimyr Peninsula)
CTF Faddey terrane (Metamorphic) (Neoproterozoic and older) (North-East Taimyr Peninsula)
CTK Kolosovsky terrane (Passive continental margin) (Late Neoproterozoic) (Central Taimyr Peninsula)
CTM Mamont terrane (Metamorphic) Mesoproterozoic and Neoproterozoic) (Taimyr Peninsula)
DB Dibinsky terrane (Accretionary wedge, type A) (Late Neoproterozoic) (Eastern Sayan, Mongolia)
DL Daldyn terrane (Granulite-orthogneiss) (Middle Archean) (Yakutia)
DN Dongujimqin-Nuhetdavaa terrane (Island arc) (Cambrian through Middle Devonian) (China, Mongolia)
DR Derba terrane (Passive continental margin) (Late Neoproterozoic) (Eastern Sayan)
DZ Dzhida terrane (Island arc) (Late Neoproterozoic and Early Cambrian) (Transbaikalia, Mongolia)
DZA Dzhanchy terrane (Accretionary wedge, type B) (Late Carboniferous and Permian) (Southern Russian Far East)
DZE Dzhebash terrane (Accretionary wedge, type A) (Late Neoproterozoic and Early Cambrian) (Northwestern Sayan)
ED Edren terrane (Island arc) (Devonian and Early Carboniferous) (Southwestern Mongolia)
East Aldan superterrane (Yakutia)
EBT Batomga composite terrane (Granite-greenstone) (Late Archean) (Yakutia)
EUC Uchur terrane (Granulite-paragneiss) (Paleoproterozoic) (Yakutia)
ER Eravna terrane (Island arc) (Late Neoproterozoic and Early Cambrian) (Transbaikalia)
GA Govi Altai terrane (Continental-margin turbidite) (Cambrian through Devonian) (Mongolia)
GG Gargan terrane (Cratonal) (Archean and Paleoproterozoic) (North Huvsgol, Mongolia, Eastern Sayan)
GL Galam terrane (Accretionary wedge, type B) (Cambrian through Early Carboniferous) (Southern Russian Far East)
GN Gonzha terrane (Passive continental margin) (Late Archean(?), Paleoproterozoic(?), and early Paleozoic) (Southern Russian Far East)
GR Gar terrane (accretionary wedge, type B) (Proterozoic?) (Southern Russian Far East)
GS Gurvansayhan terrane (Island arc) (Silurian through Early Carboniferous) (Southern Mongolia)
HD Hangay-Dauria terrane (Accretionary wedge, type A) (Silurian through Late Carboniferous) (Transbaikalia, Mongolia)
HE Heilongjiang terrane (Accretionary wedge, type B) (Ordovician and Silurian) (Northeastern China)
HG Hegenshan terrane (Accretionary wedge, type B) (Devonian through Permian) (Southeastern Mongolia, Northeastern China)
HI Hida terrane (Metamorphic) (Jurassic) (Central Japan)
HL Herlen terrane (Oceanic) (Late Neoproterozoic through Early Cambrian) (Eastern Mongolia).
HM Hamar-Davaa terrane (Metamorphic) (Paleoproterozoic through Early Cambrian) (Mongolia and Transbaikalia)
HU Hug terrane (Accretionary wedge, type B) (Neoproterozoic) (Northern Mongolia, Eastern Sayan)
HV Hovd terrane (Continental-margin turbidite) (Neoproterozoic through Silurian) (Mongolia Altay)
HX Hutagunl-Xilinhot terrane (Metamorphic) (Paleoproterozoic and Neoproterozoic) (Mongolia, Northern China)
IB Izu-Bonin terrane (Island arc) (Miocene through Quaternary) (Japan)
ID Idermeg terrane (Passive continental margin) (Proterozoic and Cambrian) (Eastern Mongolia)
IG Igarka terrane (Island arc) (Neoproterozoic) (Yenisey Region)
IH Ih Bogd terrane (Oceanic) (Neoproterozoic and Early Cambrian) (Gobi Altay, southwestern Mongolia)
IL Ilchir terrane (Oceanic) (Neoproterozoic through Ordovician) (Eastern Sayan, Mongolia)
IM Imjingang terrane (Accretionary wedge, type B) (Devonian) (Korea)
IS Isakov terrane (Island arc) (Neoproterozoic) (Yenisey Ridge)
JI Jiamusi terrane (Metamorphic) (Neoproterozoic and older and Early Cambrian) (China)
JT Japan trench terrane (Accretionary wedge, type A) (late Tertiary and Quaternary) (Western Pacific Ocean)
KA Kan terrane (Cratonal) (Paleoproterozoic) (Eastern Sayan)
KB Khabarovsk terrane (Accretionary wedge, type B) (Triassic through Middle Jurassic) (Southern Russian Far East)
KBG Kabarga terrane (Accretionary wedge, type A) (Neoproterozoic and early Paleozoic) (Southern Russian Far East)
KBN Kalba