

## ГЕОТЕКТОНИК

TERRANE ANALYSIS AND ACCRETIONARY TECTONICS  
IN MONGOLIA

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The territory of Mongolia lies in the central part of the Central Asian Orogenic Belt, formed largely by subduction and accretion of juvenile material from the Neoproterozoic through the Paleozoic. It is fringed by the Siberian craton in the north and by the Tarim and Sino-Korean cratons in the south. Previous important summaries, syntheses and models of formation are: Zonenshain, [21], Dergunov et al., [7], Ruzhentsev and Pospelov, [17], Ruzhentsev and Burashnikov, [16], Fedrovskii et al., [8], Byamba, [6], Hendrix et al., [10], Tomurtogoo, [20], Badarch and Orolmaa [1], Zorin, [22]. Most authors have proposed the closure of small ocean

basins, the obduction of ophiolites, the collision and accretion of island arcs and microcontinents, and the formation of multiple suture zones. In contrast, Sengor et al, [18] envisaged continuous oceanward migration of a single arc-subduction zone during the Neoproterozoic and Paleozoic to create the entire Altaid collage; the model emphasizes the growth of arcs on extensive and prominent accretionary prisms and a minor role for ophiolite formation.

We have subdivided the geology of Mongolia into thirty seven terranes and several overlap and stitch complexes. The terranes are classified into cratonal, passive

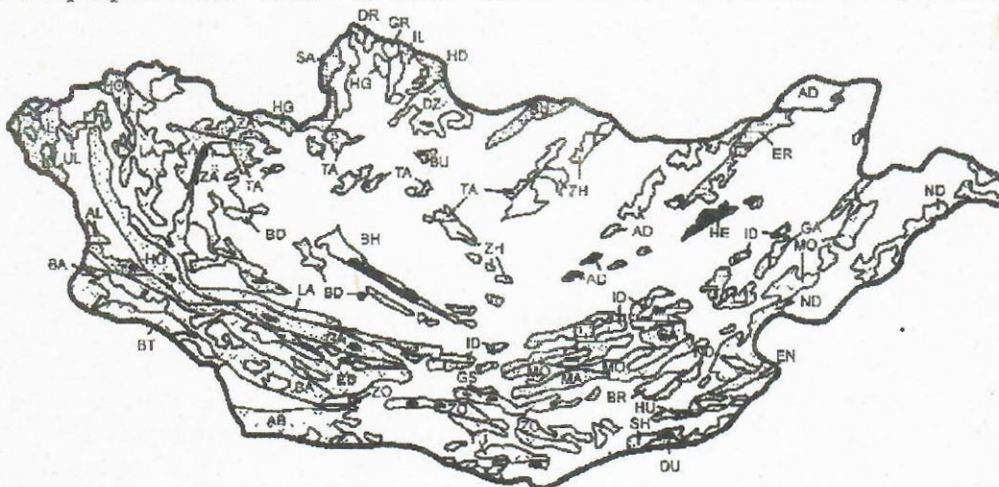


Fig. 1. Generalized terrane map of Mongolia

Cratonal terranes: BD - Baydrag, GR - Gargan, TA - Tarvagtay, ZA - Zavhan,  
 Passive continental margin terranes: AL - Altai, HU - Hutag Uul, ID - Idermeg, SA - Sangelin, ZH - Zag-Haraa, Metamorphic terranes: BU - Buteel, ER - Ereendavaa, HD - Hamardavaa, TS - Tsel  
 Continental magmatic arc terranes: BR - Barga, TU - Tsagan Uul  
 Island arc terranes: AB - Atasbogd, BA - Baaran, BT - Baytag, DR - Darhad, ED - Edren,  
 GS - Gurvansayhan, IL - Ilchir, LA - Lake, MO - Mandalovoo, ND - Nuhetdavaa, UL - Ulgey  
 Accretionary wedge terranes: AD - Adaatsag, BH - Bayanhongor, DU - Duulgant, EN - Enshoo, GA - Gobi-Altai, HE - Herlen, HO - Hovd, HU - Hug, MA - Manlay, SU - Sulinheer, ZO - Zoolen. Black areas denote fragments of ophiolites and melanges.



continental margin, metamorphic, continental magmatic arc, island arc, and accretionary wedge (Fig 1). The overlap and stitch assemblages includes Paleozoic to Mesozoic volcano-plutonic belts, passive margin shelf sequence, backarc, forearc, foreland and intermountain sedimentary basins, and collision-related granite belts. Strike-slip faulting has dismembered many terranes such as island arcs and ophiolites. The subdivision allows us to make much-needed, detailed studies of individual terranes and their boundaries in order to confirm or modify their character and make-up. The geologic history of terranes and overlap assemblages is highly complicated because of dismemberment and translation during strike-slip faulting.

The cratonal terranes include the Zavhan, Byadrag, Tarvagtay and Gargan terranes. The Zavhan composite terrane consists of Lower Proterozoic tonalite, granite-gneiss, amphibolite, quartzite, and marble, Upper Riphean bimodal volcanic rocks that yield a U-Pb zircon age of 750 – 725Ma [5]. The terrane is overlain by Vendian to Lower Cambrian dolomite, limestone, sandstone, argillite and diamictites [12]. The Baydrag terrane is composed of Archean to Lower Proterozoic tonalite gneiss, marble, quartzite, amphibolite, charnockite and Riphean sediments. A U-Pb age on zircon from biotite plagiogneiss is  $2646 \pm 45$ Ma [3]. The terrane is overlain by Ordovician conglomerate and coral-bearing limestone, Devonian to Permian sedimentary and volcanic rocks and intruded by Cambrian to Ordovician and late Paleozoic granite. The Gargan and Tarvagatay terranes, located in northern Mongolia also consists of Archean to Lower Proterozoic gneiss, schist, marble and quartzite, overlain by Vendian to Lower Cambrian limestone.

The passive continental margin terranes are Sangilen, Zag-Haraa, Idermeg, Altai and Hutag Uul terranes. The Sangilen and Idermeg terranes consists of Lower Proterozoic gneiss, amphibolite,

schist, Riphean marble and quartzite, overlying by Vendian to Lower Cambrian sediments and stitched by Middle Cambrian to Ordovician granite plutons. The Zag-Haraa terrane contains Middle Cambrian to Lower Ordovician turbidite sandstone and argillite, covered by Devonian bimodal volcanic and sedimentary rocks. The Altai terrane consists of Middle to Upper Cambrian sandstone, siltstone grading upward into coarse grained sandstone and conglomerate unconformably overlying by Silurian conglomerate, sandstone, siltstone, minor basalt, andesite, rhyolite, and fossil-rich limestone and intruded by diorite, granodiorite and granite, that yield K-Ar age of 400-456Ma [7]. The terrane is overlain by Devonian to Permian volcanic and sedimentary rocks. The Hutag Uul terrane consists of Proterozoic marble and quartzite, Devonian volcanic and sedimentary rocks, intruded by Devonian granodiorite and granite. The Hutag Uul terrane is overlain by Permian marine sediments and granite.

The metamorphic terranes comprise the Hamardavaa, Buteel, Ereendavaa and Tsel terranes. First two terranes contains Lower Proterozoic high-grade metamorphosed rocks, including gneiss, schist, amphibolite, marble that has a Pb-Pb ages of  $1120 \pm 110$ Ma and Upper Riphean to Lower Cambrian schist, quartzite, rhyolite, marble [2]. These terranes are overlain by Silurian marine sediments and intruded by Middle Ordovician and Devonian granodiorite and granite. The Ereendavaa terrane consists of Lower Proterozoic (?) plagiogneiss, amphibolite, marble, Middle to Upper Riphean schist, metasandstone, phyllite, conglomerate and unconformably overlying Silurian conglomerate, sandstone, siltstone containing abundant fossils, including *Tuvaella gigantea* of Siberian affinity [21] and Devonian rhyolite, trachyrhyolite, dacite, andesite, tuff, conglomerate, sandstone, siltstone with plant fossils. The terrane is intruded by Proterozoic, Middle to Upper



Cambrian and Devonian granite and is overlain by Middle Carboniferous to Permian volcanic and sedimentary rocks. The Tsel terrane consists of Late Archean to Lower Proterozoic (?) polymetamorphosed and polydeformed tonalite gneiss, amphibolite, migmatite, pegmatite, schist with relics of granulites (2200 Ma, Pb-Pb zircon), Lower to Middle Riphean (Jargalant complex) amphibolite, metasandstone, siltstone, containing macrofossils and Gashunnur dike complex (320-321 Ma Sm-Nd). The postaccretion and stitch complexes includes Devonian and Carboniferous sediments and Permian granite. The Tsel terrane is interpreted as a displaced fragment of Precambrian continental crust or deep eroded basement of island arc [13, 3].

The continental magmatic arc terranes includes Barga and Tsagaan Uul terranes, located in southern Mongolia. The Barga terrane is composed of Riphean marble, stromatolitic limestone, quartzite, sandstone and argillite, Lower to Middle Cambrian metasediments containing olistostrome, Ordovician to Silurian penetratively deformed fossiliferous sandstone, argillite, phyllite with blocks of limestone, Devonian subduction-related andesite, dacite, rhyolite, tuffaceous sandstone, siltstone, argillite containing brachiopods and plant fossils. It is intruded by Tsagan Suvarga intrusive complex that has  $40\text{Ar}/39\text{Ar}$  ages of  $364 \pm 3.5$  Ma [15]. The Tsagaan Uul terrane consists of Proterozoic schist, migmatite, quartzite, marble, Ordovician and Silurian shallow marine limestone, sandstone, siltstone, andesite, tuff, Devonian pillow basalt, andesite, tuff, chert, sandstone, siltstone containing corals and brachiopods, Lower Carboniferous shallow marine sediments; it is intruded by Middle to Upper Devonian granodiorite.

The island arc terranes include Atasbogd, Baaran, Baytag, Darhad, Dzhida, Edren, Gurvansayhan, Ilchir, Lake, Mandalovoo, Nuhetdavaa and Ulgey terranes. The Dzhida, Lake, and

Ulgey terranes of western and northern Mongolia consists of Vendian to Lower Cambrian ophiolite, melange, subduction-related basalt, andesite, seamount volcanic and volcanoclastic rocks. Ophiolites have a similar isotopic age from south to north: Khantayshir ( $568 \pm 4$  Ma, U-Pb zircon), Dariv ( $573 \pm 6$  Ma, U-Pb zircon), and Agardagh in Siberia just north of Mongolia ( $569 \pm 1.1$  Ma, U-Pb zircon) [9]. The rest of island arc terranes occurs in southern Mongolia and consist of Ordovician to Lower Devonian dismembered ophiolite, melange, subduction-related basalt, andesite and volcanoclastic rocks.

The accretionary wedge terranes is divided into units composed of dominantly turbidites or of oceanic rocks. The former include Hovd, Gobi-Altai, Manlay, Enshoo, and Dulgant terranes that consists of a disrupted assemblage of pillow basalt, diabase, gabbro, chert, minor limestone, sandstone and ultramafic rocks. The age of these rocks range from Cambrian to Carboniferous. The Hug, Bayanhongor, Adaatsag, Herlen, Zoolen and Sulinheer terranes belongs to an accretionary wedge, containing mainly of oceanic rocks. The Hug terrane consists of Shishged ophiolite, Middle Riphean metabasalt, tuff, chert, phyllite, minor dolomite, metamorphosed in blueschist facies and retrograded in greenschist facies. A Rb-Sr ages of blueschist metamorphism is  $829 \pm 23$  Ma and greenschist metamorphism is  $624 \pm 52$  Ma [19]. The Bayanhongor terrane contains a full ophiolite stratigraphy, dated at  $569 \pm 21$  Ma (Sm-Nd whole rock) and sedimentary melange, shale, chert, limestone, island arc volcanics [4]. The Herlen and Adaatsag terranes consists of Vendian to Cambrian dismembered ophiolite, melange, basalt, andesite, and volcanoclastic sediments [20]. The Zoolen and Sulinheer terranes situated in southern Mongolia consists of tectonic sheets, slivers, and melanges that contains greenschist metamorphosed Silurian to Devonian and Carboniferous to Permian



tholeiitic basalt, andesite, tuff, chert, sandstone, argillite and limestone.

The overlap and stitch assemblages are Zavhan and Hovsgul (Vendian to Middle Cambrian) sedimentary basins, Telmen (Middle Cambrian to Ordovician) and Hangay (Upper Carboniferous to Permian) plutonic and Selenge, Deluun, South Mongolian (Middle Carboniferous and Permian) volcanic-plutonic belts. These assemblages records an amalgamation and accretion of different terranes, during the development of Paleasian, South Mongolian, Sulinheer and Mongol-Okhotsk oceans. The tectonic setting for Hangay-Hentiy basin is controversial, either forearc basin, nor accretionary wedge or superimposed basin. The Noyon basin is interpreted as foreland style basin that record latest accretion of terranes in southern Mongolia.

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