

GEOLOGY OF THE TAVAN HAR AREA, GOBI, MONGOLIA

ROBERT J. CARSON, Whitman College

B. BAYANMÖNH, Mongolian University of Science and Technology

A. BAYASGALAN, Mongolian University of Science and Technology

CARI L. JOHNSON, University of Utah

KEVIN R. POGUE, Whitman College

KARL W. WEGMANN, Washington Division of Geology and Earth Resources

INTRODUCTION

Keck research projects have occurred in many nations, but this was the first to have a goal of fostering cross-cultural communication between American and foreign students and faculty, using geoscience as common ground for exchange. A total of ten Mongolian students and nine American students participated in the research, which was supervised by two Mongolian and four American geologists. In addition, Professor Ch. Minjin of Mongolian University of Science and Technology spent the first week with us and led the reconnaissance investigations.

Tavan Har, our area of study, is bound by latitudes 43°40' and 44°10'N and longitudes 109°15' and 110°15'E in southeastern Mongolia. This 5000-km² area lies toward the east end of the Gobi (Desert) about 100 km north of China. This is the general vicinity where from 1922 to 1930 Roy Chapman Andrews led expeditions which found mammal and dinosaur fossils, including dinosaur eggs.

Precipitation in Mongolia decreases from north to south. South of Ulaanbaatar there is steppe and, closer to China, desert. We crossed no rivers south of the Tull Gol, which flows west through the capital. Streams flowed only briefly after the few rainstorms we experienced (August is Mongolia's wettest

month). Strong winds blew much of the time. Daytime temperatures were 20-40°C, with the nights much cooler. Our base camp (figure 1), located at 43°55'13"N, 109° 25'45"E, was in an area of Paleozoic argillite with limey and sandy lenses and layers.

GEOLOGIC SETTING

Mongolia is made of many terranes, which were continental fragments, island arcs, and sea floor. These terranes were caught in a vice as the Siberian craton and North China block came together beginning in the Paleozoic. Our research area included two terranes. The northern Ulaan-Uul terrane consists of Proterozoic (?) igneous and metamorphic rocks. The southern Hövsgöl-Ulaanbadrah terrane includes: Paleozoic sedimentary rocks and volcanics; Devonian (?) and Carboniferous intrusives; and Jurassic conglomerate (with sandstone) and granite/granodiorite. The two terranes are intruded by Permian granite/granodiorite/diorite.

Late Jurassic and Early Cretaceous rifting resulted in subsidence and the accumulation of fluvial and lacustrine sediments (host of an oil field near the study area) as well as basaltic and rhyolitic volcanism. The area is overlain by flat-lying Upper Cretaceous sandstone and mudstone. Relative stability in the Cenozoic led to the development of extensive pediments. The widespread bedrock and regs

(surfaces with desert pavement) are interrupted by scattered dune fields and a meteor impact crater. See figures 2 and 3 for a simplified geologic map and stratigraphic column, respectively.

STUDENT PROJECTS

Kate D. Krug

“Petrologic and Field Analysis of the Tavan Har Intrusive/Metamorphic Complex, Southeast Gobi Desert, Mongolia”

Medium grade metamorphic rocks of multiple lithologies crop out in the Tavan Har area. The rocks were previously mapped as basement material composed of greenschist, gabbro, and gneiss. Traverses of ten valleys and ridges showed the lithologies to include: greenschist/stone, gabbro, granite, diorite, gneiss, and multiple generations of felsic intrusives. We created a cross-section with NW-SE trending transects through the range. The cross-section expresses the field relationships between units. The second

generation of felsic intrusives crosscuts all other units in the field, making it the constraining unit for the Tavan Har suite of crystalline rocks.

Megan Berney Roberts & Khuut Tsetsegmaa

“Suspected Carboniferous Rocks of Tavan Har Region, Southeastern Mongolia”

The Zuun Gashuun Formation in the Tavan Har area of the eastern Gobi consists of fossiliferous marble, argillite, and quartzite. The formation was originally mapped as Ordovician, but the abundance and size of the crinoids in addition to a spiriferid brachiopod provide evidence that the rocks are Carboniferous. Other fossils in the area include bryozoans, corals, and algae. The lithologies and fossils indicate that the rocks were probably deposited on a low relief, felsic microplate that was subject to oscillating shallow carbonate seas.



Figure 1. Base camp at Tavan Har. The four-wheel-drive vehicles are parked to the right of the storage ger and cook tent. The hills in the middle ground are mostly Paleozoic argillite. In the background is an extensive Quaternary pediment.

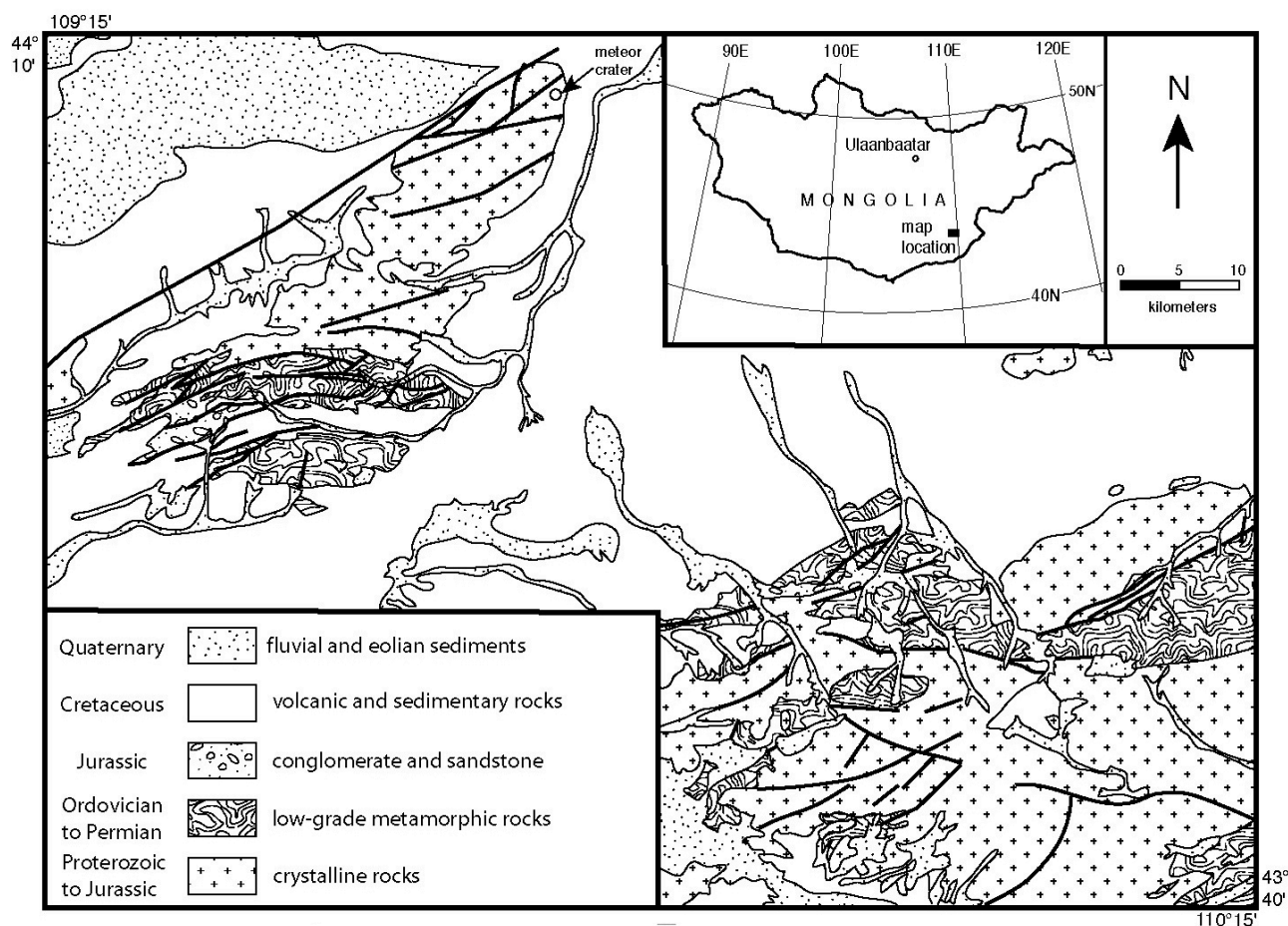


Figure 2. Geologic map of Tavan Har area, eastern Gobi.

Ts. Gansukh & A. Battsetseg

“Mineral Prospect in the Northwestern Tavan Har Area”

The investigation is located near 43°58’N, 109°34’E, at an elevation of 865 m. The bedrock is the Middle-Upper Ordovician Sangiin-Dalai Formation. A detailed geologic map at a scale of 1:2500 was created, and two trenches were logged. The sandstone, schist, metasandstone, mudstone, and metamudstone have higher grades of arsenic and zinc.

N. Purevdorj & B. Tuya

“Hematite Mineralization Zones in the Southeastern Tavan Har Area”

The investigation is located near 43°47’N, 109°52’E, at an elevation of 1150m. Hematite dikes cut through andesite of the Middle-Upper Carboniferous Ulziit-Uul Formation. A 1:2500- scale geologic map was made of a 0.5

x 0.4 km area. Hematite mineralization zones were revealed in two trenches.

Joseph Graly & Molor Erdenebat

“Petrology, structure, and geochemistry of igneous dikes in the Hövsgöl - Ulaanbadrah Terrane, southeastern Mongolia”

The complex consists of several hundred near vertical dikes intruded into a felsic pluton. The dikes studied range in latitude from 43°40’40” to 43°48’30” N and in longitude from 109°50’40” to 110°07’10”E. Mafic, felsic, and intermediate compositions are present. Dikes intrude in sub-parallel, arcuate, or radiating swarms. In many cases, relative age relationships can be established as younger swarms consistently crosscut older swarms. At least six generations of dike swarms are present.

AGE		LITHOLOGY	
Cenozoic	Quaternary	fluvial and eolian sediments	
	Cretaceous	Upper	conglomerate, sandstone, mudstone
Lower		basalt, rhyolite	
Mesozoic	Upper Jurassic	granite, granodiorite	
	Jurassic	conglomerate, sandstone	
	Upper Permian	diorite, granodiorite, granite	
Paleozoic	Permian	rhyolite, dacite	
		sandstone, volcanics	
		rhyolite, andesite	
	Upper Carboniferous	diorite, granodiorite, granite	
	Carboniferous	Upper	andesite, dacite, tuff
		Lower	volcanics, sandstone, mudstone
	Devonian ?	granite	
	Upper Ordovician ? (Carboniferous ?)	sandstone, mudstone, limestone, argillite	
shale, limestone, mudstone, argillite			
Precambrian ?	Upper Proterozoic ?	greenstone, garnet gneiss, diorite, granite	
	Middle Proterozoic ?	schist, metavolcanics	

Figure 3. Geologic units present in the Tavan Har area (composite for both Ulaan-Uul and Hövsgöl - Ulaanbadrah terranes. Shaded portions are intrusive and metamorphic rocks.

Sarah Davidson & Hashgerel Bat-Erdene

“Sedimentology of the Cretaceous intercontinental rift sequence in Tavan Har, southern Mongolia”

Uplift and subsidence related to a Late Jurassic - Early Cretaceous intercontinental rift event led to sediment deposition that includes eolian, lacustrine, and deltaic facies. All units in the area are non-marine, and consist primarily of conglomerates, lacustrine sequences, and volcanic rocks. The earliest synrift deposits are marked by coarse conglomerates with primarily volcanic and metasedimentary lithologies, as well as basalt and ash beds. Later synrift units include lacustrine and additional volcanic deposition. Synrift units are typically slightly folded, and are unconformably overlain by undeformed postrift sediments. Postrift sediments are generally terrestrial conglomerates and

sandstones. Detailed descriptions of these units can help us understand changes in sediment provenance, paleogeography and depositional environments throughout the rifting event.

Justin Gosses & Hashgerel Bat-Erdene

“Sedimentology of the Tsagantsav Formation, Tavan Har, Southeastern Mongolia”

The Tsagantsav Formation, one of several Cretaceous rift formations in southeastern Mongolia and northern China, is of earliest Cretaceous age. It overlaps unconformably and is faulted against Proterozoic and Paleozoic rocks. The basal unit of the Tsagantsav, a conglomerate, originates from local basement material. It is overlain by lacustrine sediments, including shales, sandstones, and water-laid tuffs. Many of the lacustrine deposits exhibit decimeter scale cycles of calcareous sandstone, calcareous shale, and non-calcareous shale. The shales contain mollusk, gastropod, fish, and plant fossils. These lacustrine deposits, being interbedded with basalt and exhibiting rapid facies changes both laterally and stratigraphically, support the interpretation of the Tsagantsav as a lacustrine syn-rift environment.

Phillip Kast & Nuramkhan Manchuk

“New Evidence for Quaternary Faulting in Southeast Mongolia”

The first known Quaternary fault in southeast Mongolia is located in the Tavan Har area. It is unusually wide, displaying a shear zone with gouge and breccia over 400 m in width. The combination of ductile and brittle shearing observed suggest a long history of movement. The fault may reactivate the boundary between the Ulan-Uul and Hövsgöl-Ulaanbadrah terranes, placed in the area by previous mapping. Over 15 km of the fault trace has been mapped: it trends northeast-southwest, then, further northeast, curves to trend east-west. Crosscutting relationships observed in two trenches suggest Quaternary

motion. Several lines of evidence suggest left-oblique motion. Air photos may reveal offset streams and large scale features related to terrane suturing.

Peter Anderson and Magsarjar Ochirbat

“The Tavan Har Impact Crater, Eastern Gobi, Mongolia”

The impact crater of the northeastern Tavan Har region is located in greenschist facies metamorphic rocks with both felsic and mafic protoliths. The crater has a diameter of 1.75 km and covers an area of 137 hectares. At least two episodes of deformation have affected the country rock, the first deformation event forming a foliation plane that is parallel to subparallel to bedding. The second deformation event folded foliation and produced spaced axial plane fracture cleavages. The two foliations produce an intersection lineation which, when viewed in the structure, shows the beds to be generally striking northeast-southwest and overturned on the northeastern rim of the crater. The lineations on the northwest and southeast rims of the crater dip away from the crater center and are support for the impact origin of the crater. Dikes of various lithologies were intruded after the deformation events and strike parallel to foliation. Scattered outcrops of breccia with calcareous cement are possible dikes related to the impact.

Jonah Stinson & Erdenebat Odontuya

“Seif Dunes of the Eastern Gobi, Mongolia”

Seif dunes (Figure 4), a sinuous variety of longitudinal sand dunes, are located along the southeastern rim of the Tavan Har crater in the Gobi of southeastern Mongolia. Peaks of the eroded crater rim act like a snow fence to cause deposition of sand downwind of the crater, resulting in a number of one-kilometer-long dunes running subparallel to one another at S80°E. This orientation reveals the area’s prevailing wind direction, which is also indicated by the orientation of grooves in sand-abraded bedrock on the crater rim.

Although the dominant wind direction is from the west, bimodal seasonal winds from the north and south preserve sinuous morphology by changing the steepest slip faces from side to side and “wagging the tails” of the dunes. Satellite imagery reveals a large area of unconsolidated sediment to the northwest that is considered the likely source area for these dunes.

Kate Ritley & Erdenebat Odontuya

“Yardangs and Dome Dunes of Mongolia’s Gobi”

Northeast of Tavan Har is a 5-km² area characterized by yardangs, dome dunes, and other eolian features. The yardangs, which are aerodynamic, wind sculpted hills, are eroded from Upper Cretaceous cross-bedded, weakly consolidated sandstone and mudstone, and are oriented along a northwest-southeast axis, with a steep northwest side and a gently sloping southeast side. Yardangs typically indicate uni- or bidirectional winds. However, abutting the yardangs are numerous dome dunes, which indicate highly variable wind directions, as evidenced by beds dipping in all directions within the dunes. These dome dunes are also transitional to other types of dunes, such as longitudinal dunes with long axes in a northwest-southeast direction. Other wind-related landforms in this area include the

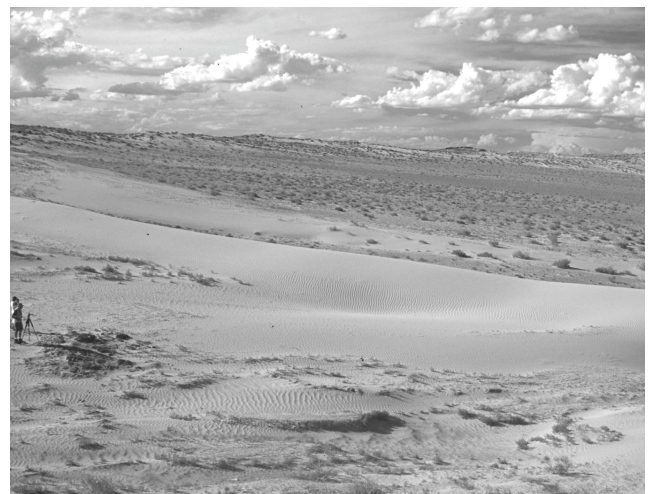


Figure 4. Seifs (longitudinal dunes) in the Tavan Har meteor crater. The bedrock rim of the crater is greenschist facies metamorphic rocks with felsic and mafic protoliths.

following: coppice dunes, or vegetated sand mounds, which appear to be positive feedback features; vegetation-anchored sand pedestals; inactive, semi-consolidated dunes undergoing erosion; and desert pavements. The yardangs and longitudinal dunes indicate dominant winds from the northwest, yet the dome dunes suggest highly variable winds.

MAJOR SCIENTIFIC ACCOMPLISHMENTS

1. The Proterozoic (?) igneous and metamorphic rocks have greater diversity than previously recognized: mafic, intermediate, and felsic plutonic, volcanic, and medium-grade metamorphic lithologies.
 2. Based on macrofossils in limestone pods, much of the argillite, formerly believed to be Ordovician, is Carboniferous.
 3. The Lower Cretaceous rift-related rocks include a diverse suite of lithologies (fluvial and debris-flow conglomerates, lacustrine mudstones and carbonates, and air-fall tephra) and fossils (fish, bivalves, gastropods, and plants).
 4. Based on cleavage orientation and probable impact breccia, the Tavan Har crater with an uplifted rim is the result of meteor impact.
 5. The fault system trending northeast across the northwestern Tavan Har area includes an active fault (late Quaternary movement, mostly strike-slip).
 6. The Tavan Har area has a variety of eolian landforms including yardangs, sand-blasted bedrock, "desert pavement", ventifacts, and longitudinal and dome dunes; these features indicate a prevailing wind from the west, with secondary north, south, and probably east winds.
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