# SEDIMENTATION HISTORY AND PROVENANCE ANALYSIS OF A LATE MESOZOIC RIFTING EVENT AT TAVAN HAR, EAST GOBI, MONGOLIA

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## INTRODUCTION

During the Late Jurassic-Early Cretaceous, extension in eastern China and southeastern Mongolia led to the formation of several intracontinental rift basins. One of these is the East Gobi Basin (EGB), which covers more than 1.5 million $km^2$ of southeastern Mongolia (Traynor and Sladen, 1995). Due to its remote location as well as political factors, few field-based studies have been done in the EGB, and even fewer are available in the English language. Geologists have attempted to reconstruct the tectonic accretion and continental evolution of Asia during the Paleozoic, as well as the intracontinental deformation that occurred in the Mesozoic. Their studies continue to point to a lack of detailed, internationally consistent information as an obstacle to further model constraint. In particular, more structural, sedimentary, and paleogeographic data are needed. This information can be found predominantly in the extensional basins within the region, in particular in the EGB where much of the potential data remain unrecorded.

This study contributes to the amount of primary field data and quantitative analyses available on the Mesozoic sedimentary deposits within the EGB, focusing in particular on the synrift deposits that were extensive in our field area. These data provide a basis for interpreting the sediment provenance and paleogeography of the Jurassic-Cretaceous rifting event, as well as for better understanding rift processes and basin evolution in general.

## History of Rifting

The origins of Mesozoic intracontinental rifting in Mongolia and China are poorly understood. The most accepted theory - that extension took place in a back-arc setting as the Pacific plate subducted under the north China plate - is questioned due to Mongolia's location well within the Asian continent (Graham *et al.*, 2001).

Our study area is located in the northeast EGB, where extension was characterized by rifting and half-graben formation. In the southeast, the EGB is separated from the contemporaneous Erlian basin of northeast China by an uplifted block of Precambrian-Paleozoic basement rocks and by the Zuunbayan fault. The Zuunbayan fault was probably active during Mesozoic rifting, but the type and extent of movement is not well understood. The northern edge of the basin is bounded by a series of Late Jurassic normal faults that were reactivated as reverse faults in the mid-Cretaceous.

## Methods

While in the field, exposures of Jurassic and Cretaceous sedimentary units were located using an unpublished map from the Mongolia University of Science and Technology (MUST), as well as by observation during field reconnaissance. Late Mesozoic rift sequence units exposed at Tavan Har include Khamarkhoovor (prerift), Tsagantsav and Hukhteg (synrift), and Bayanshire (postrift) (Fig. 1). In addition, samples from the Sharilyn Formation (early synrift) were

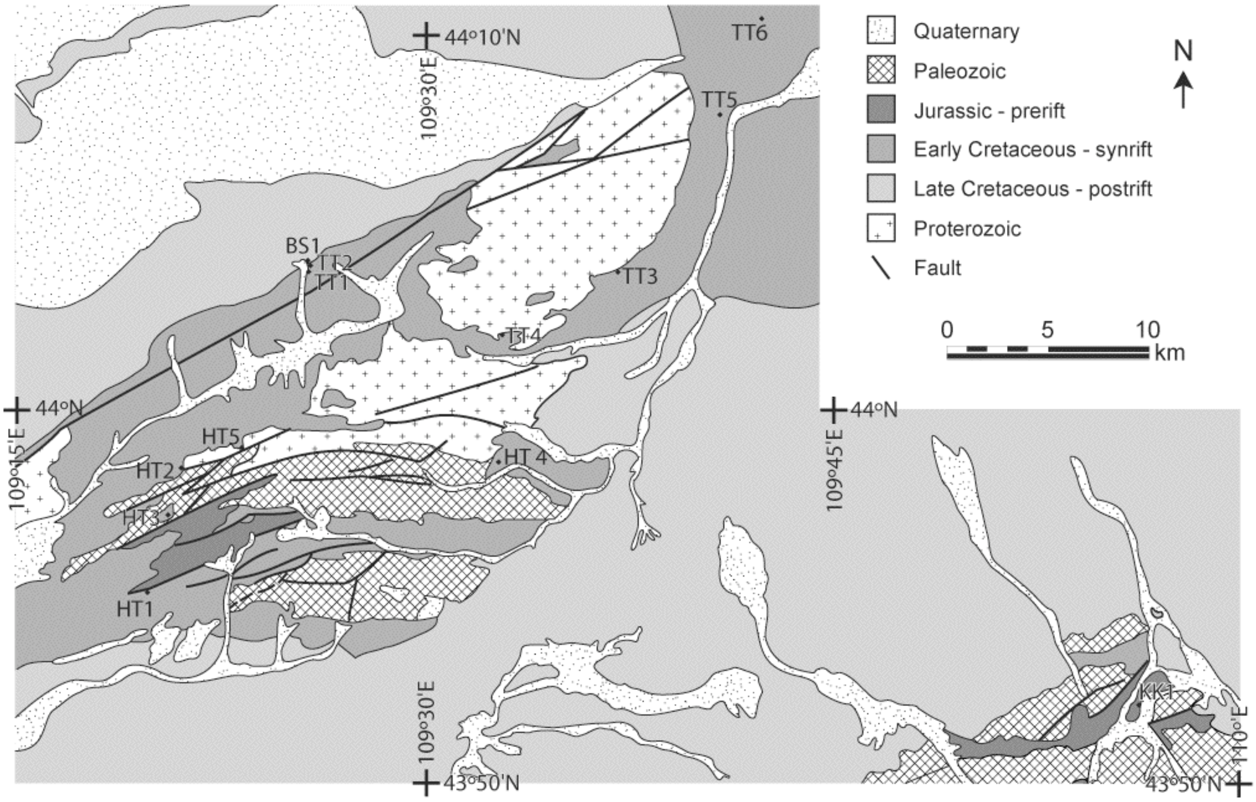


**Figure 1.** Map of Tavan Har field area, showing location of late Mesozoic rift-related sediments. HT=Hukhteg; TT=Tsagantsav; BS=Bayanshire; KK=Khamarkhoovor (Revised from unpublished map from MUST).

obtained from 40 km north of our field area.

At each location, procedures included counts of conglomerate clasts, measurement of paleocurrent indicators, and collection of medium-grained sandstones for point counting. In addition, detailed descriptions and measured sections were completed for the synrift Hukhteg and Tsagantsav formations.

Fourteen sandstone samples were made into standard thin sections and point-counted using a modified Gazzi (1966)-Dickinson (1970) method (Ingersoll *et al.*, 1984). These include samples from all major outcrops of prerift, synrift and postrift units in and north of the field area, and therefore provide a complete, if preliminary, representation of the rift sequence.

# RESULTS

## Rift Sequence Formations

The following are brief descriptions of the rift sequence units. Measured stratigraphic columns of Hukhteg formation are shown in Figure 2.

The Lower to Middle Jurassic Khamarkhoovor Formation begins with sandstone and conglomerate beds, and grades into fine-grained sequences of shale, sandstone, and coal seams (Graham *et al.*, 2001).

The Upper Jurassic Sharilyn Formation uncomformably overlies the Khamarkhoovor. It fines upward from a massive clast-supported conglomerate to interbedded mudstone and fine-grained sandstone. Ash in the upper part of this unit has been dated as 155±1 Ma (Graham *et al.*, 2001).

Outcrops of the Lower Cretaceous Tsgantsav Formation are found mostly in the northern part of the study area. It is marked at its base by basalt and ash layers or by distinctive blue-green basaltic conglomerate and breccia. The basalt has been dated at 126±1 Ma (Graham *et al.*, 2001). The upper part of the formation contains lacustrine deposits.

The Early Cretaceous Hukhteg Formation is found primarily in the southern part of the study area. It is characterized by coarse conglomerate with abundant basalt clasts that grade into lacustrine deposits.

The Upper Cretaceous Bayanshire Formation uncomformably overlies the Tsagantsav in the northwest, and also ~20 km northeast of the study area. This unit contains conglomerate with well-rounded clasts and finer-grained fluvial and lacustrine beds.

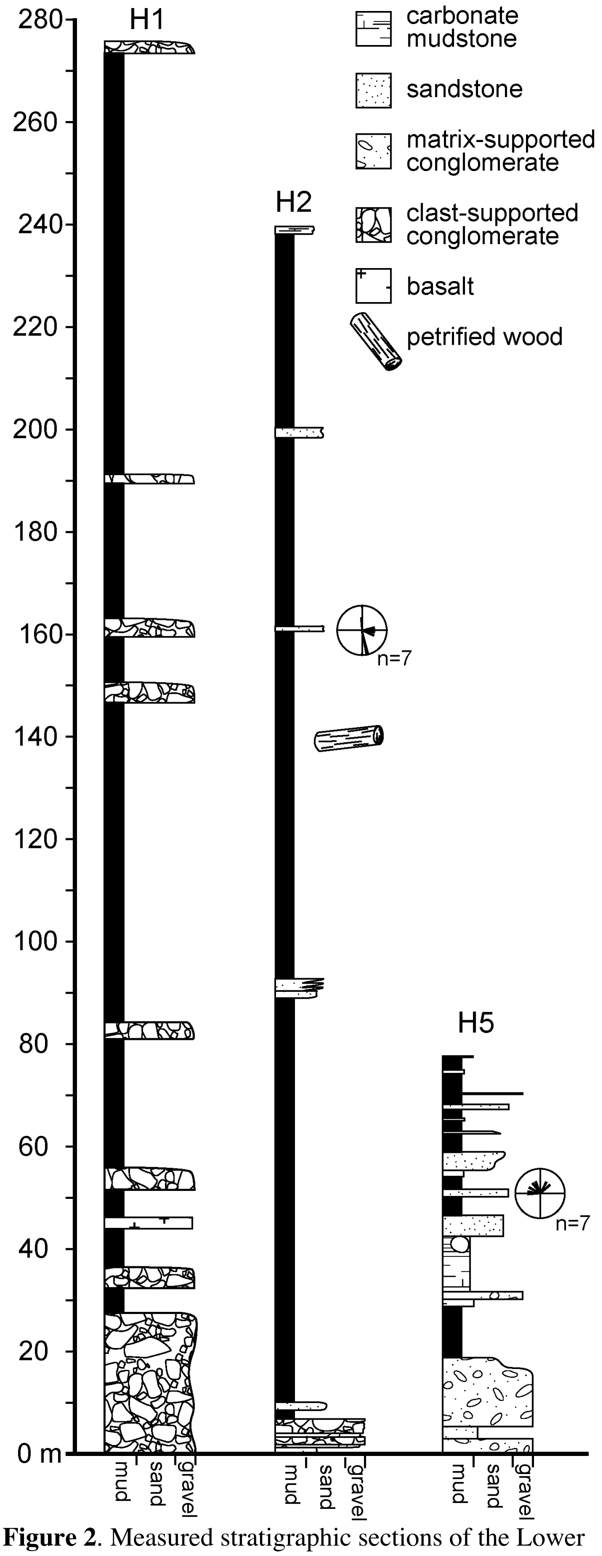


**Figure 2**. Measured stratigraphic sections of the Lower Cretaceous Hukhteg formation.

## Sandstone Point-Counts

Point-count results were tabulated into percentages of monocrystalline quartz (Qm), feldspar (F) and lithics (Lt), and of polycrystalline quartz (Qp), volcanic and metavolcanic lithics (Lvm), and sedimentary and metamorphic lithics (Lsm), which are plotted on ternary diagrams (Fig. 3). The interpretations were developed by Dickinson and Suczek (1979) to estimate the tectonic provenance of sandstones when sedimentation is influenced primarily by tectonics.

The prerift and synrift sandstones plot closest to a magmatic arc provenance on both the QmFLt and QpLvmLsm diagrams. The prerift sample differs from the synrift samples primarily by the larger percentage of quartz. Postrift sediments plot within a continental block provenance on the QFLt diagram. On the QpLvmLsm diagram, one postrift sample shows a relatively quartz-rich magmatic arc source, while the other plots between an arc and recycled orogen.

# DISCUSSION

## Sandstone Point-Counts

According to Dickinson and Suczek (1979), intracontinental sedimentation is mainly quartzo-feldspathic. Therefore, because the EGB is known to have been fully within the amalgamated Asian continent by the Jurassic, the apparent magmatic arc provenance of much of this sedimentation appears anomalous. However, these results can be easily explained by recognizing that much of the Paleozoic basement rock in southern Mongolia is made of accreted arc sequences. Similar results were found by Hendrix *et al.* (2001). We can therefore interpret the volcanic sands as coming from older rocks that were exposed and eroded during the late Mesozoic.

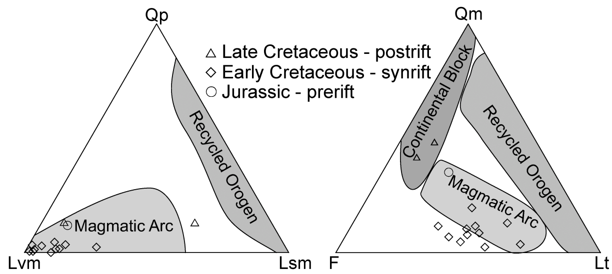


**Figure 3.** Diagrams showing tectonic origin of point-counted sandstones (Dickinson and Suczek, 1979).

# RECONSTRUCTION

The data discussed above provide a basis for reconstructing the paleoenvironment and paleogeography of the rift sequence within theTavan Har field area, using what is known about the general geologic history of the EGB to provide a basic context. In particular, the variation in volcanic composition of sandstones can be used to estimate uplift and topography in the area during the rift sequence (Dickinson and Suczek, 1979).

## Prerift

Deposition during the Early-Middle Jurassic was due to erosion of a regional Permian fold belt (Traynor and Sladen, 1995). In our field area, deposition reflects braided streams that later shifted to meandering streams and swamps. This suggests continued erosion of topographic highs in a humid climate.

Sandstone composition during this period suggests multiple erosion cycles of Paleozoic arc sequences and possibly granitic crust. The prerift period ended with a period of erosion, creating an uncomformity below the oldest synrift deposits.

## Early Synrift

Extensional tectonics commenced in the Late Jurassic, with normal faults forming along weak zones between accreted terranes and arc sequences. In the northeast EGB, newly exposed remnant arc materials were carried by braided stream and alluvial systems, leaving coarse conglomerate and sandstone deposits in the developing basin. Fluvial and lacustrine systems developed within subbasins, followed by a drier period represented by red beds late in the sequence.

## Late Synrift

In our field area, the Early Cretaceous was marked by renewed faulting and related extrusive volcanics, depositing ash and basalt, as well as coarse angular conglomerate composed again of Paleozoic arc materials. More exposed basalt flows and predominantly basalt conglomerate are found in the northern part of the study area, implying that igneous processes originated nearby to the north.

More mature conglomerate overlies these beds, resulting from the continued erosion of topographic highs with shallower slopes. Intermittent ash beds were deposited as extrusive processes continued some distance from from Tavan Har. The redevelopment of finer-grained fluvial and lacustrine systems implies reduced uplift and a shift in drainage patterns. Paleocurrent measurements indicate that water flowed from the south, east and west into the subbasin.

## Postrift

In the mid-Cretaceous, regional compression led to a reactivation of normal faults in the area, deforming the synrift strata. Flatter terrain in the area led to more mature sediment deposition in fairly high-energy fluvial and lacustrine systems. Available paleocurrent data show the source area to be in the east.

# CONCLUSIONS

Detailed studies in relatively small areas, such as Tavan Har, can provide a great deal of data on the local as well as regional tectonic and sedimentary history. Numerous such studies within central Asia could provide much of the information needed to identify and constrain explanations of Late Mesozoic deformation. In addition, provenance studies of Asian rift basins show that nonmarine sediments in these basins differ from those in more thoroughly studied regions, with important implications for interpreting basin histories worldwide.

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