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Climate-driven channel change of Orkhon River, Mongolia

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Motivation

Understanding surface water dynamics driven by local and regional climate changes in spatial and temporal scales is important in Mongolia today.

Rivers in the Mongolian Plateau play essential roles in surface water resources in Eurasia because they feed other large rivers (e.g., Ob, Yenisei) and lakes (e.g., Lakes Baikal, Dalai) in the North Arctic Ocean, Pacific Ocean and Central Asian internal drainage basins (Fig. 1).

This study intends to determine the long- and short-term valley geomorphic evolution and channel morphology of Orkhon River.

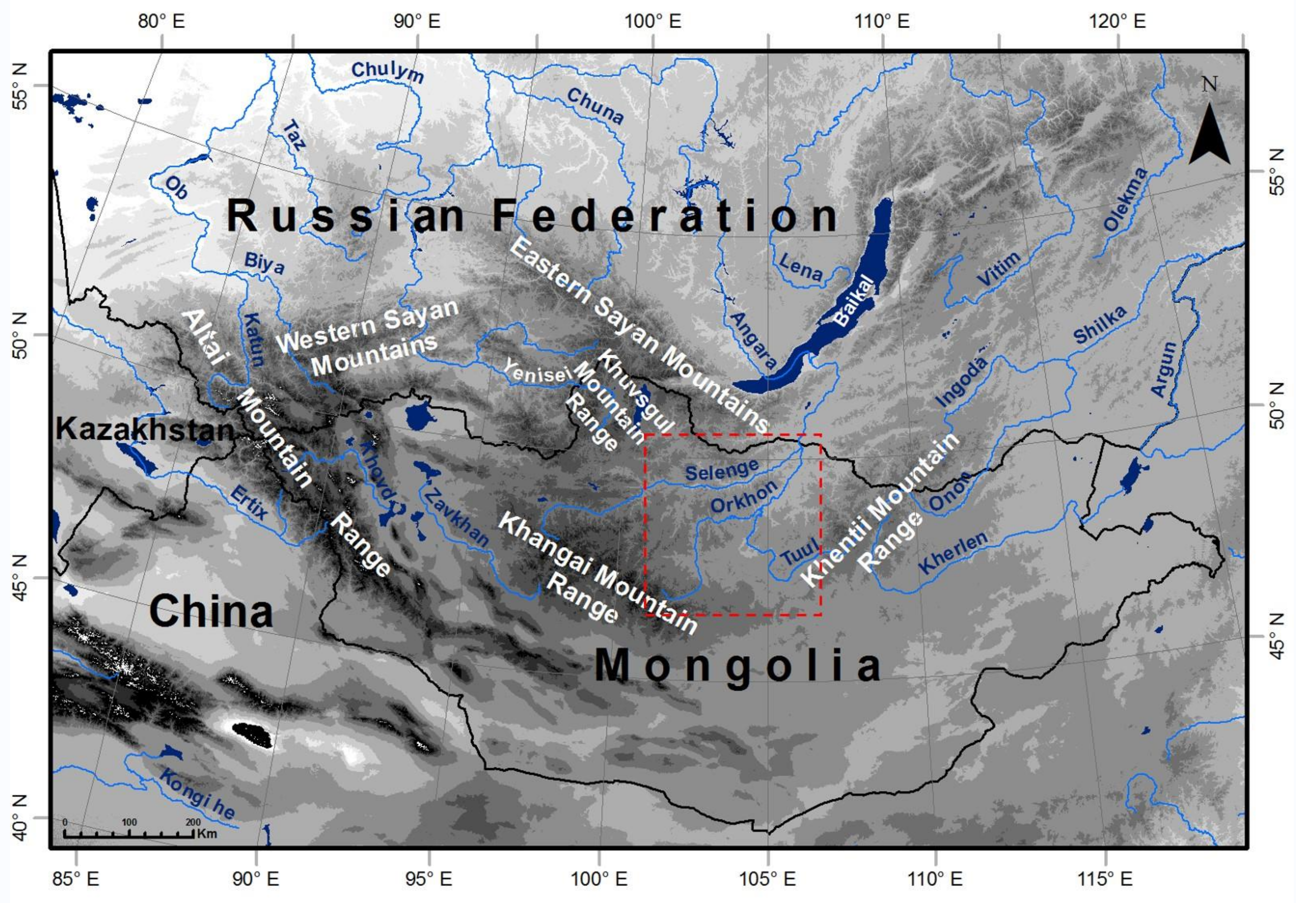

Fig. 1. Location of Orkhon River drainage basin in Mongolia (box).

Site description

Orkhon River is a major tributary of Selenge River, which is a headwater of Lake Baikal in the North Arctic Ocean drainage basin (Fig. 1). The river is the second longest river in Mongolia (Table 1), draining the Mt. Suvarga Khairkhan (3179 m a.s.l.) in the Khangai Mountain Range (Fig. 1).

Orkhon River is fed by a few large Tamir, Tuul, Kharaa and Yeruu Rivers and many small rivers, and the river constitutes the largest drainage basin holding the maximum water resources in Mongolia (Table 1).

Table 1. Morphometric components of Orkhon River and its tributary and distributary rivers. After Orkhonselenge et al. In review.

#	Rivers	Tributary to terminus	Drainage basin (km²)	Length (km)	Width (km)		Depth (m)	
					Upstream	Downstream	Deep	Shallow
1	Orkhon	Selenge R.	132,835	1,124	10–60	120–150	4.0	0.5–1.5
2	Tamir	Orkhon R.	13,100	185	-	40–70	2.5–3.0	0.4
3	Selenge	Lake Baikal	282,000	992	60–70	100–250	4.5–5.0	4.0–1.0

Methods

Grain size and grain shape of sediments at the midstream of Orkhon River (Fig. 2A) were measured with Scanning Electron Microscope (SEM) Hitachi TM-1000. Geochemical characteristics of the sediments are detected with Energy Dispersive X-Ray Spectroscope (Swift-ED).

Sediments from paleofloodplains in the lower reach of Orkhon River (Fig. 2B) were mixed with the LicoWax in the Fine Vortex by FluXana and pressed with FluXana for round glasses at Spectro Xepos by Ametek. Major and trace elements including REE are detected.

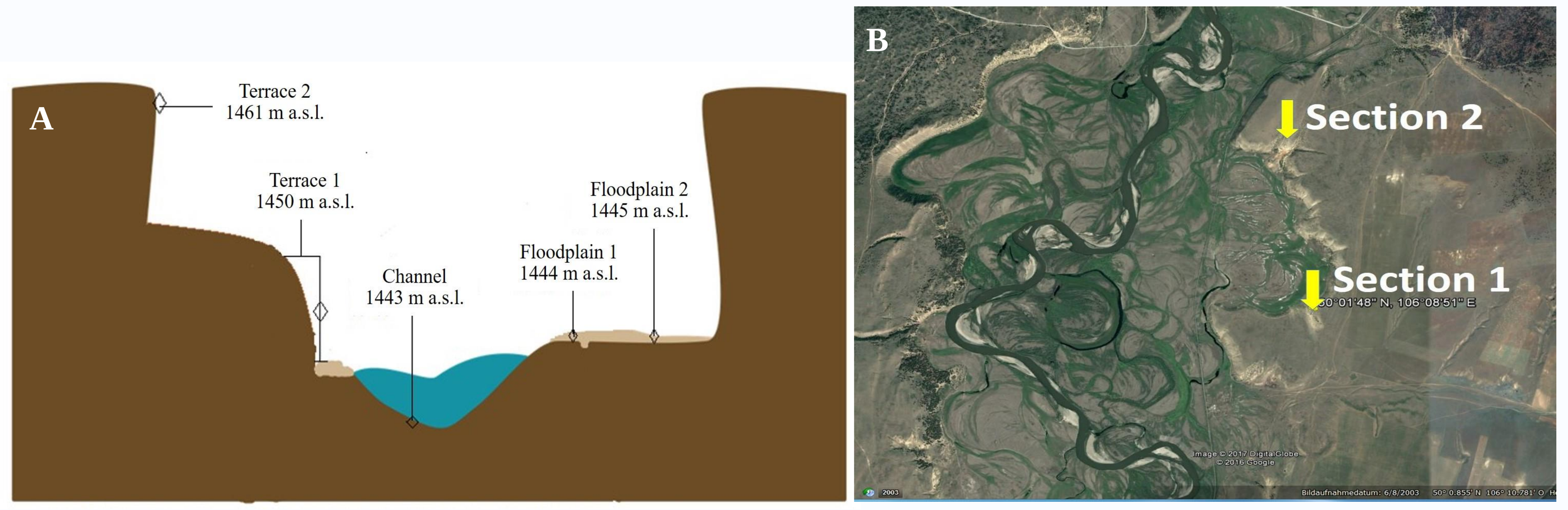

Fig. 2. Locations of sampling sites at the midstream (A) and paleofloodplains in the lower reach (B) of Orkhon River.

Geochemical Results

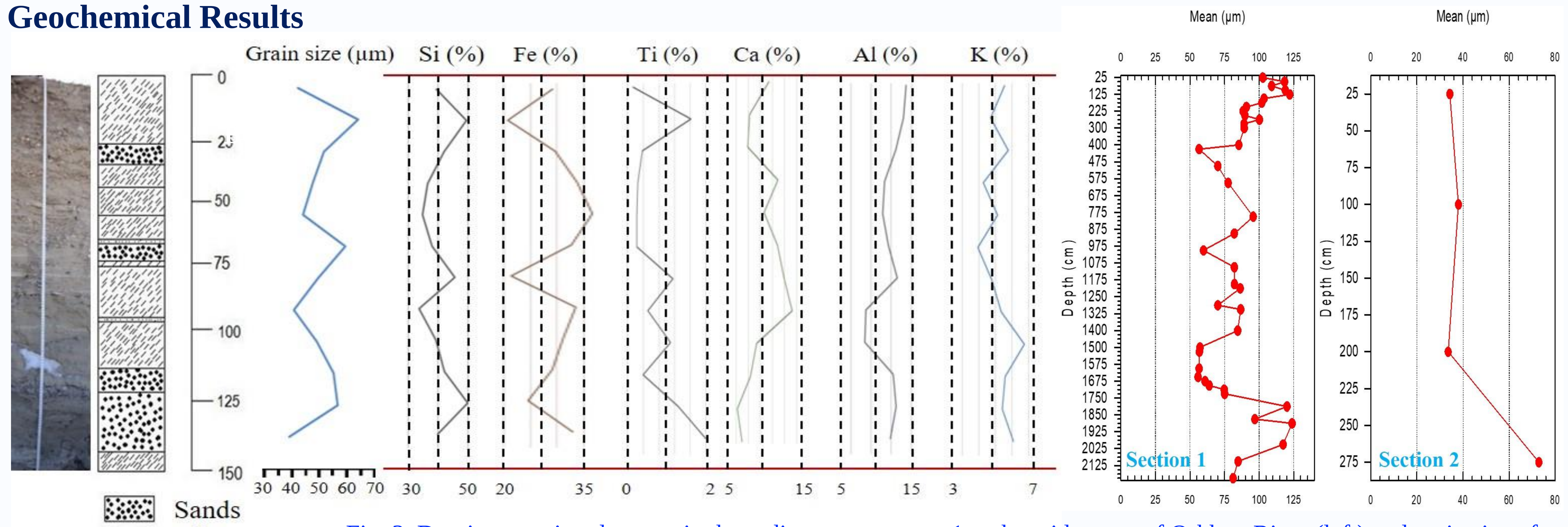

Fig. 3. Dominant major elements in the sediments at terrace 1 at the midstream of Orkhon River (left) and grain size of sediments at the downstream (right).

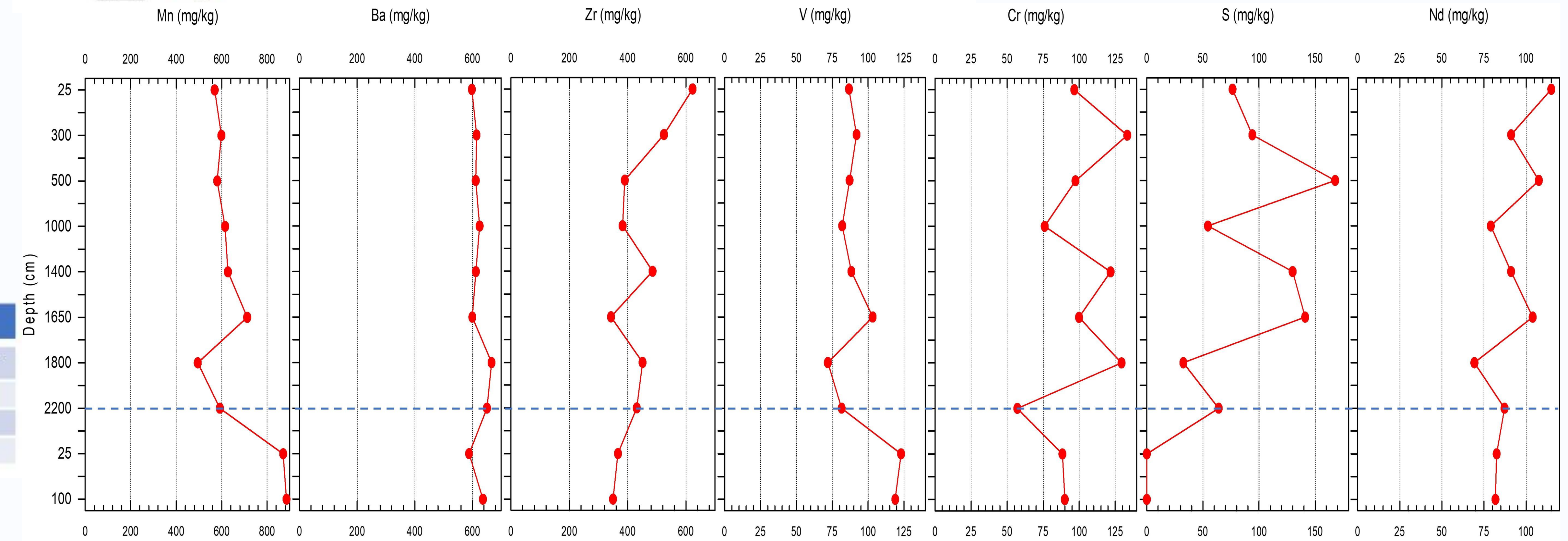

Fig. 4. Dominant trace elements in the sediments in the paleofloodplains at the downstream of Orkhon River. Dashed line borders the Sections 1 and 2 (Fig. 2B).

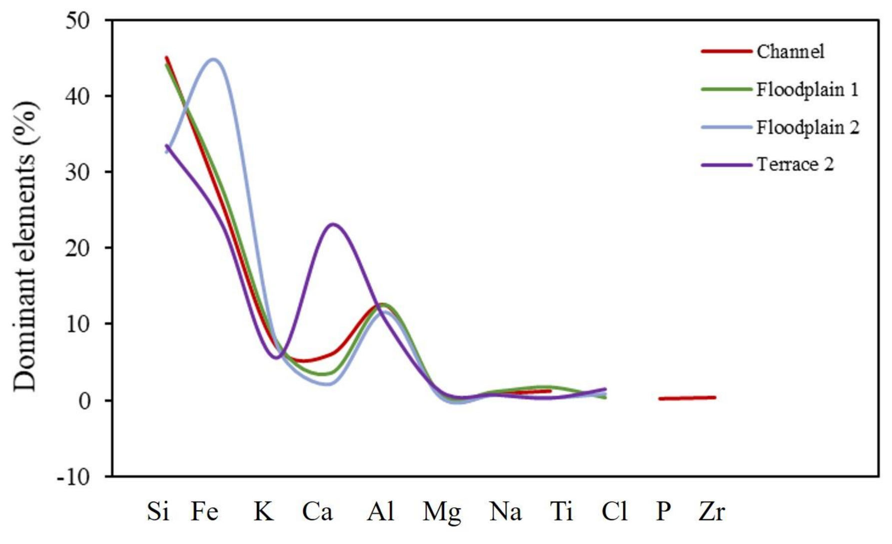

Fig. 5. Dominant major elements in the sediments at terrace 2, floodplains and channel at the midstream of Orkhon River (Fig. 2A).

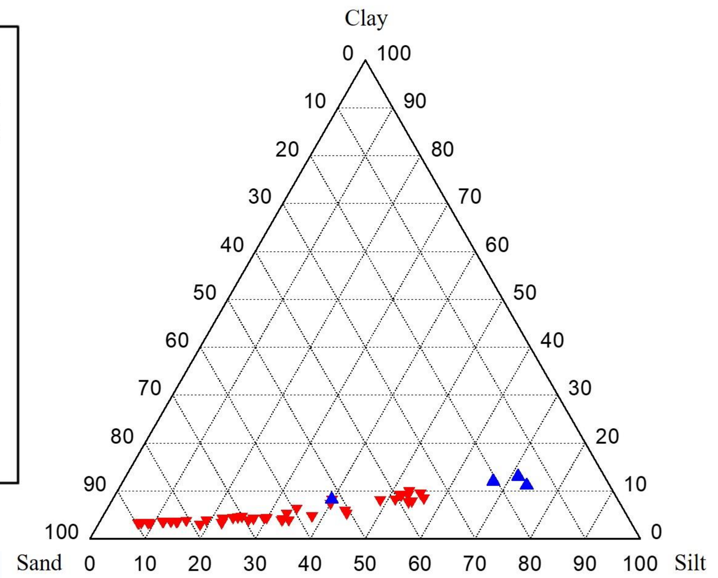

Fig. 6. Grain size distribution of the sediments in the paleofloodplains at the downstream of Orkhon River (Fig. 2B): Sections 1 (rombo) and 2 (triangle).

Geochemical imprints in the sediments in the middle and lower reaches of Orkhon River imply that the sediments are transported by fluvial processes at the midstream and fluvial and aeolian processes at the downstream.

Channel configuration

In recent years flash floods frequently occur in semiarid Mongolia due to the rapid climate changes during the past two decades. The recent flooding in 2021 resulted in formations of new channels, islands and oxbow lakes, reconstructions of abandoned channels and disappearances of islands and floodplains at the midstreams and downstreams of Orkhon River (Fig. 10).

Fig. 10. Flooded midstream (A) and downstream (B) of Orkhon River after the flooding on August 6, 2021.

Geomorphological Results

Channel types of Orkhon River show single sinuous at the upstreams (Fig. 7), multiple sinuous or anastomosing and meandering at the midstreams (Fig. 8) and braiding and meandering at the downstreams (Fig. 9).

Channel types of Orkhon River

Fig. 7. Straight sinuous upstreams

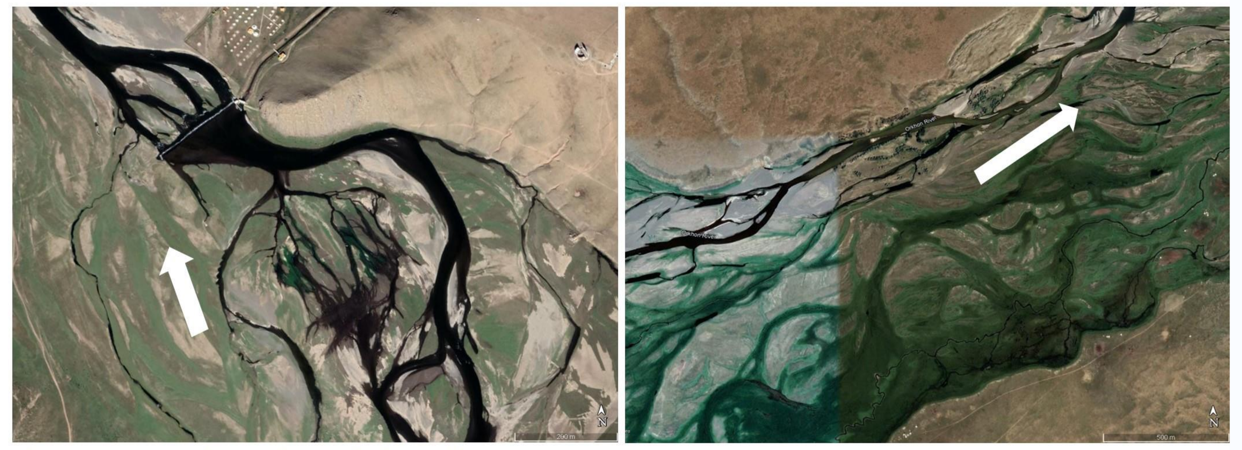

Fig. 8. Anastomosing and meandering midstreams

Fig. 9. Braiding and meandering downstreams

The long-term channel migration of Orkhon River shows the formation of an oxbow Lake Ugii by braiding its paleochannel called Khugshin Orkhon at the midstream of Orkhon River (Fig. 11).

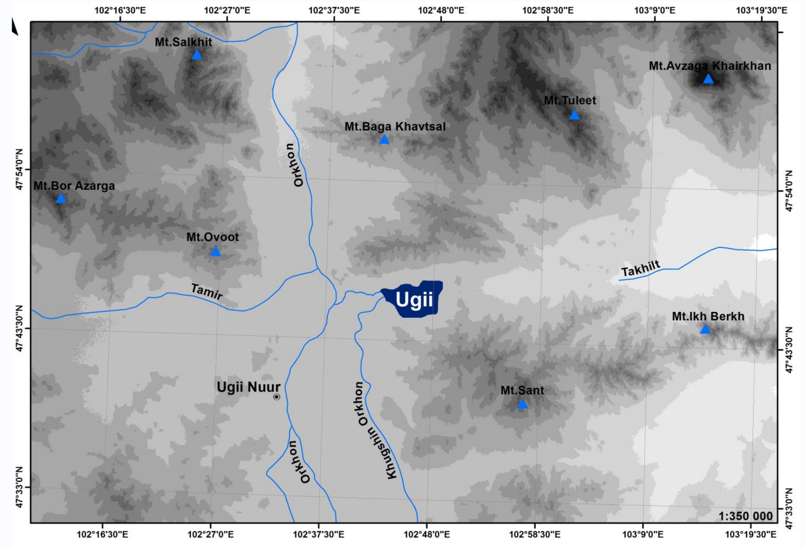

Fig. 11. Physiography of Khugshin Orkhon and Lake Ugii at the midstream of Orkhon River.

Preliminary Conclusions

Channel morphology of Orkhon River, especially at the midstreams and downstreams, is spatially modified as more braided due to catastrophic flooding caused by recent climate changes in warming and drying during the last 50 years.

Future tasks

- Fluvial geomorphic changes of Orkhon River over spatial and temporal scales
- Spatial and temporal patterns of river aggradation and incision of the river

References

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