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## Permian peri-glacial deposits in the Harahorin area, north-central Mongolia

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**INTRODUCTION** The Harhorin area of north-central Mongolia is located in the Khangai-Khentei Belt of the Central Asian Orogenic Belt. The area consists mostly of early Carboniferous Khangai-Khentei accretionary complex (Kurihara et al., 2009) with some cover sequences and younger igneous rocks. One of the cover sequences, Urmegtei Formation, contains dropstone-bearing peri-glacial deposit. Here we show the result of geological and chronological studies of the peri-glacial deposit and discuss the implications.

**GEOLOGIC SETTING** The study area consists mainly of the following geologic units.

*The Yashil Formation* is the local formation name of the Khangai-Khentei accretionary complex.

*The Urmegtei Formation* is an upward-fining cover sequence, which consists, in ascending order, of conglomerates, sandstones, and varved sandstone and mudstone beds with granite dropstones. The formation has been sheared with NW-striking and SW-dipping structural foliation and N-trending stretching lineation showing downward increasing strain. From shear-sense indicators we interpret that the top-up-to-the-north (dextral) oblique thrusting formed these structural elements.

*Felsic dikes* cut the Urmegtei Formation and have been sheared with the formation.

*Undeformed porphyritic granite batholith* cuts all the above sheared rocks.

**AGE DATING** We measured U-Pb zircon ages of the following three samples using LA-ICP-MS equipped in the Hirata Laboratory of Kyoto University and in the Earthquake Research Institute of the University of Tokyo.

1. A *granite dropstone in the Urmegtei Formation* contains zircons with many inclusions and microcracks. We chose 3 clear zircon grains for analysis and calculated <sup>206</sup>Pb/<sup>238</sup>U weighted mean age of 273.0±4.9 Ma from analytical data, suggesting that the dropstone was supplied from an Early Permian (Kungurian) granite body (ICS, 2009).

2. 17 zircons from a *sheared felsic dike* have <sup>206</sup>Pb/<sup>238</sup>U weighted mean age of 246.5±4.0 Ma.

3. 10 zircons from the *undeformed granite batholith* have <sup>206</sup>Pb/<sup>238</sup>U weighted mean age of 217.5±8.7 Ma.

### DISCUSSION

*Brief geologic history:* The age of sedimentation of the Urmegtei Formation is constrained between 278 Ma (Artinskian of Early Permian) and 242 Ma (Anisian of Middle Triassic), because the Formation contains a dropstone of 273.0±4.9 Ma and was cut by a felsic dike of 246.5±4.0 Ma. The dated felsic dike was sheared with the Urmegtei Formation and was cut by the undeformed granite batholith of 217.5±8.7 Ma, suggesting that the shearing of the Urmegtei Formation was terminated between 251 Ma (Induan of Early Triassic) and 208 Ma (Norian of Late Triassic).

*Implications of the peri-glacial deposit:* The Earth in Late Carboniferous age was in an icehouse mode and a global warming trend took place from Sakmarian of Early Permian. In the Northern Hemisphere, 278-242 Ma glacier-related deposits were detected only in the Wordian (Middle Permian) to Wuchiapingian (Upper Permian) of the Verkhoysk, Kolyma and Omoron areas of northeastern Siberia (Ustritskiy, 1973). From the circumstantial evidence and our present study, we propose the following tectonic history. (1) The Khangai-Khentei accretionary complex, probably covered by the Urmegtei Formation, must have formed in a subduction zone that was connected to the continental-margin or island-arc terrane in the present-day northeastern Siberia, i.e. the Verkhoysk, Kolyma and Omolon areas. (2) In Wordian to Wuchiapingian ages, the accretionary complex was in an arctic area near the northern end of the Angara block (present-day northeastern Siberia), where the Urmegtei Formation was deposited. (3) The Khangai-Khentei accretionary complex, approximately 2,000 km apart from northeastern Siberia at present, must have dextrally displaced to the present position. If the dextral oblique thrust shearing in the Urmegtei Formation and the 246-Ma felsic dike is a consequence of the dextral displacement, the displacement must have been terminated by 208 Ma.

Keywords: Permian, peri-glacial deposit, U-Pb age, tectonics, Khangai-Khentei belt, Mongolia