Glacio-eustatic variability in the sedimentation pattern over northern Japan during the past 600 Ka

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Introduction:

Ocean floor sediments provides undisturbed sediment records to reconstruct the sedimentation pattern using various proxies during different glacial and interglacial cycles. The Japan Sea is a semi-enclosed marginal sea affected by global sea-level fluctuation, expansion of seasonal and permanent sea-ice cover that having a significant influence on the neighbouring regional climate. The expansion and magnitude of sea-ice in the Japan Sea are interlinked with the glacial-interglacial sea-level fluctuation. Climatic phenomenon like East Asian Winter Monsoon (EAWM) also has the significant influence on sedimentation pattern in the Japan Sea. The different clay minerals along with sediments grain size derived energy conditions provides information related to weathering intensity in the provenance, source and environmental changes in the depositional basin. Crystalline clay minerals like illite, chlorite and smectite are formed during cold periods, while during warm and humid periods generally kaolinite and metal oxides are formed.

Objective: To assess glacio-eustatic control, provenance and sedimentation pattern in the northern Japan Sea over the last 600 Ka.

Study Area and Methodology:

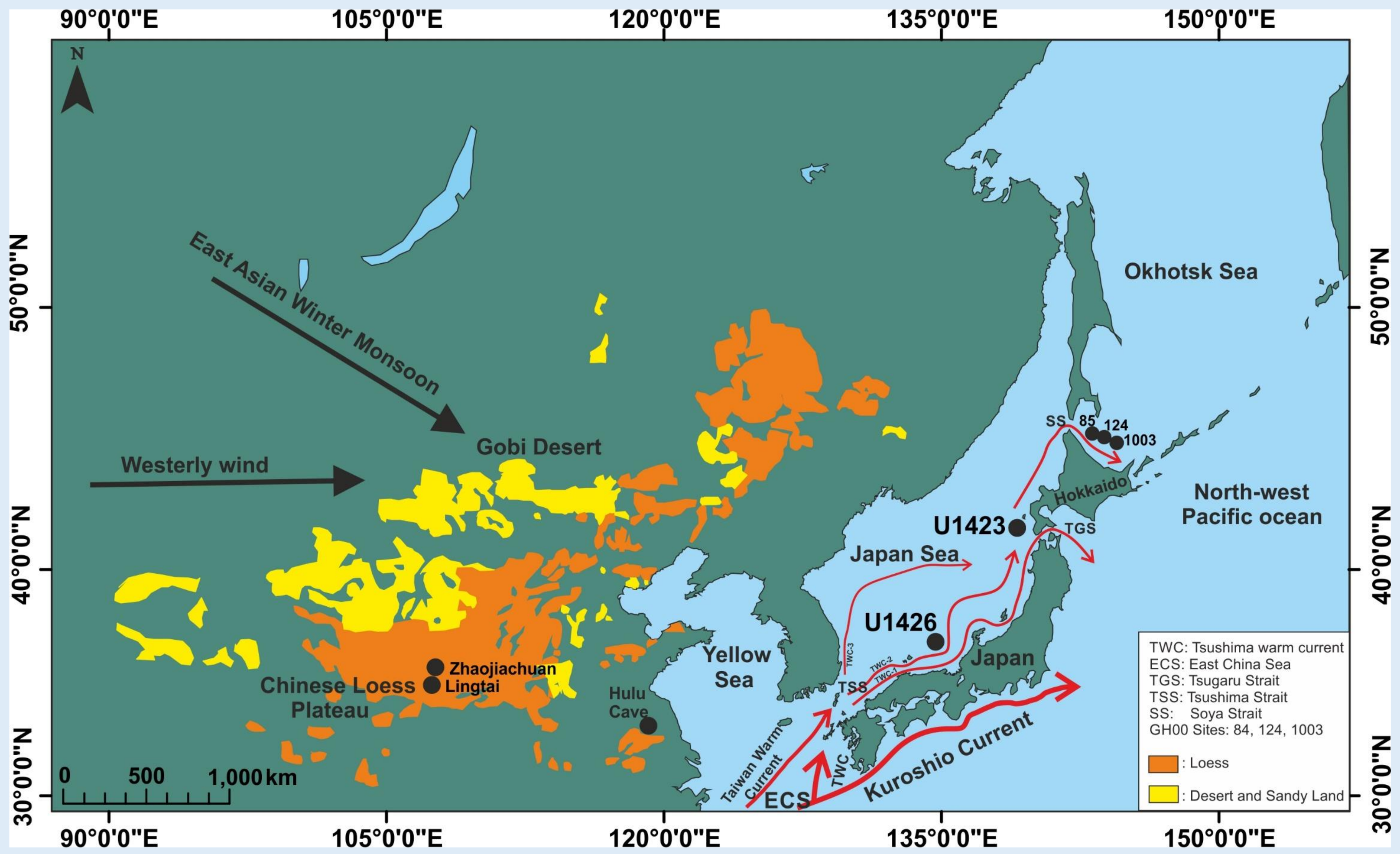

Fig 1. The IODP sites U1423 and U1426 in Japan Sea with surface current directions (Red arrow), East Asian Winter Monsoon and Westerly wind direction (Black arrow); GH00 Sites: 84, 124, 1003 in the Okhotsk sea, and Zhaojiachuan, Lingtai sections on the south central Chinese Loess Plateau (Das et al. 2020). The interpolated ages ranges from **600 Ka to Holocene** with average time resolution per sample ~10 kyr.

Core sediments of site U1423 (40.05 CCFD)

→ Grain size analysis → End member modeling → EM1 (high energy condition), EM2 (low energy condition)

→ Clay mineralogy analysis

Results and Discussion:

- The mean grain size data suggest the dominance of silt size fraction over the sand and clay (Fig 2).
- The grainsize distribution pattern is related to glacial-interglacial periodicity, EAWM wind strength, permanent/seasonal sea sea ice present at the studied site.
- The end member modelling of grain size data suggest the presence of two different energy conditions (EM1 and EM2) that varied with the time and influenced by the glacio-eustatic changes over the Japan Sea.

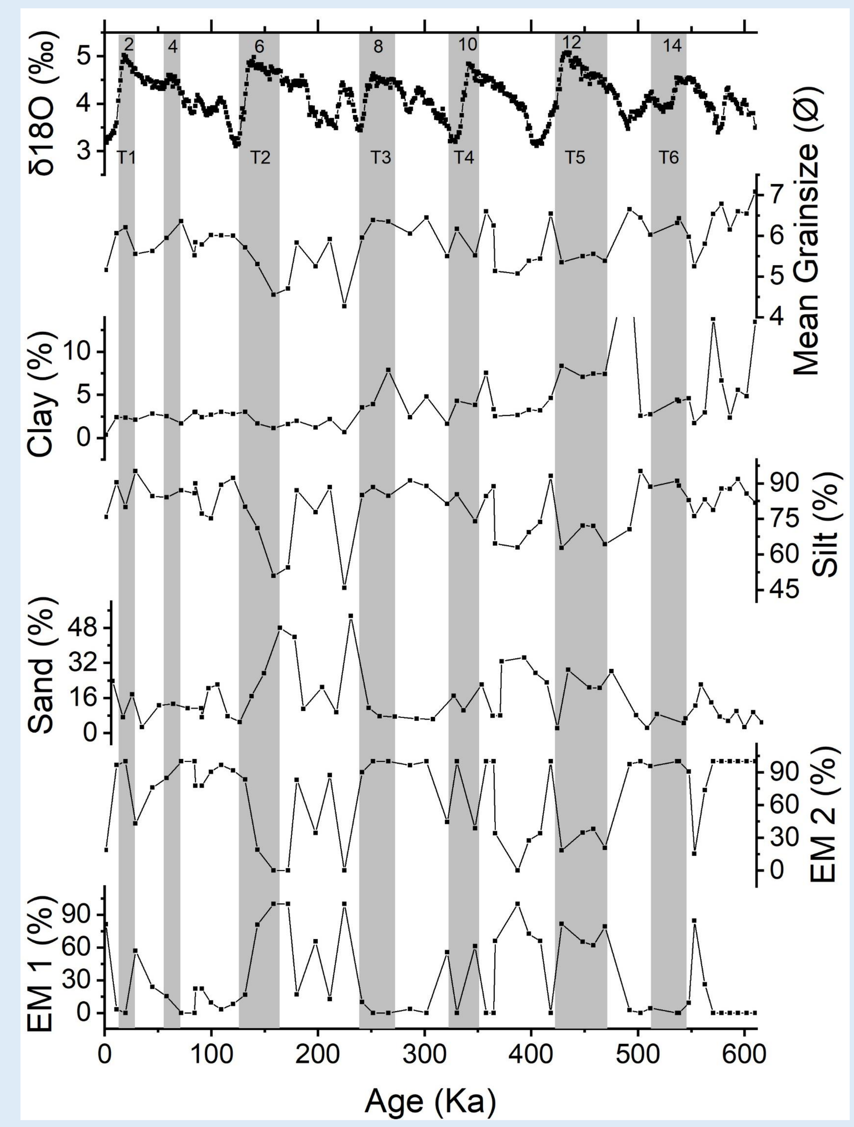

Fig 2. Energy conditions prevailing over past 600 Ka based on End Member Modelling of grain size data and grain size distribution pattern compared with LR04 benthic stack (Lisiecki and Raymo, 2005). Glacial intervals are marked by grey bars. Terminations events (T1-T6) marked after Cheng et al. (2016).

- The relatively coarser sediments are deposited in the higher energy condition at the end or during the glacial periods except for MIS 4, 8 and 14 suggesting deposition of grains due to the melting of seasonal/permanent ice sheets (Fig. 2).
- The eolian dust brought from the Chinese loess deposits are relative finer in size (Fig 2).
- During the glacial phases, illite and kaolinite show a decreasing trend than the interglacial phases suggesting less terrigenous input (Fig 3).
- The high illite and decreased smectite suggest a higher degree of physical weathering.
- Higher Chlorite/Illite ratio indicates arid condition, while higher Kaolinite/Chlorite ratio represents humid condition (Fig 4).

*Smectite/(Illite+Chlorite) ratio is directly linked with the chemical weathering and intensification of monsoon (Fig. 4).

*The significant increase in Smectite/(Illite+Chlorite) ratio after 450Ka suggest a higher degree of chemical weathering in the nearby source area rocks, which varied over time (Fig. 4).

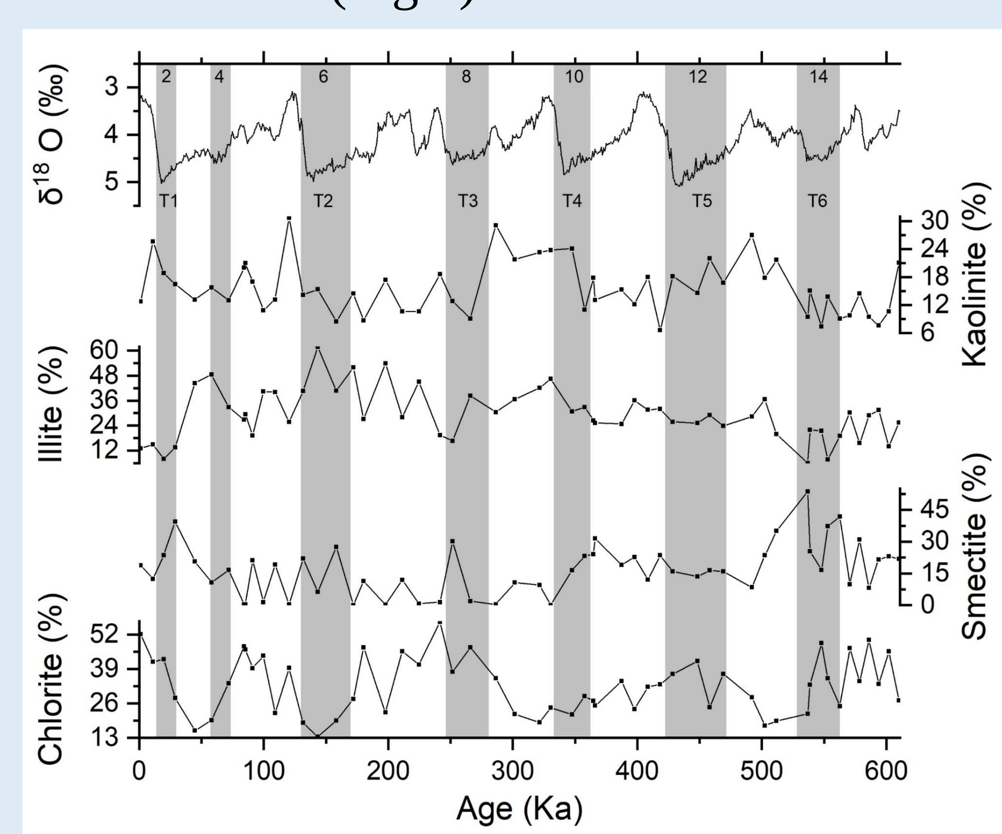

Fig 3. Variations in clay minerals over last 600 Ka compared with the LR04 benthic stack (Lisiecki and Raymo, 2005)

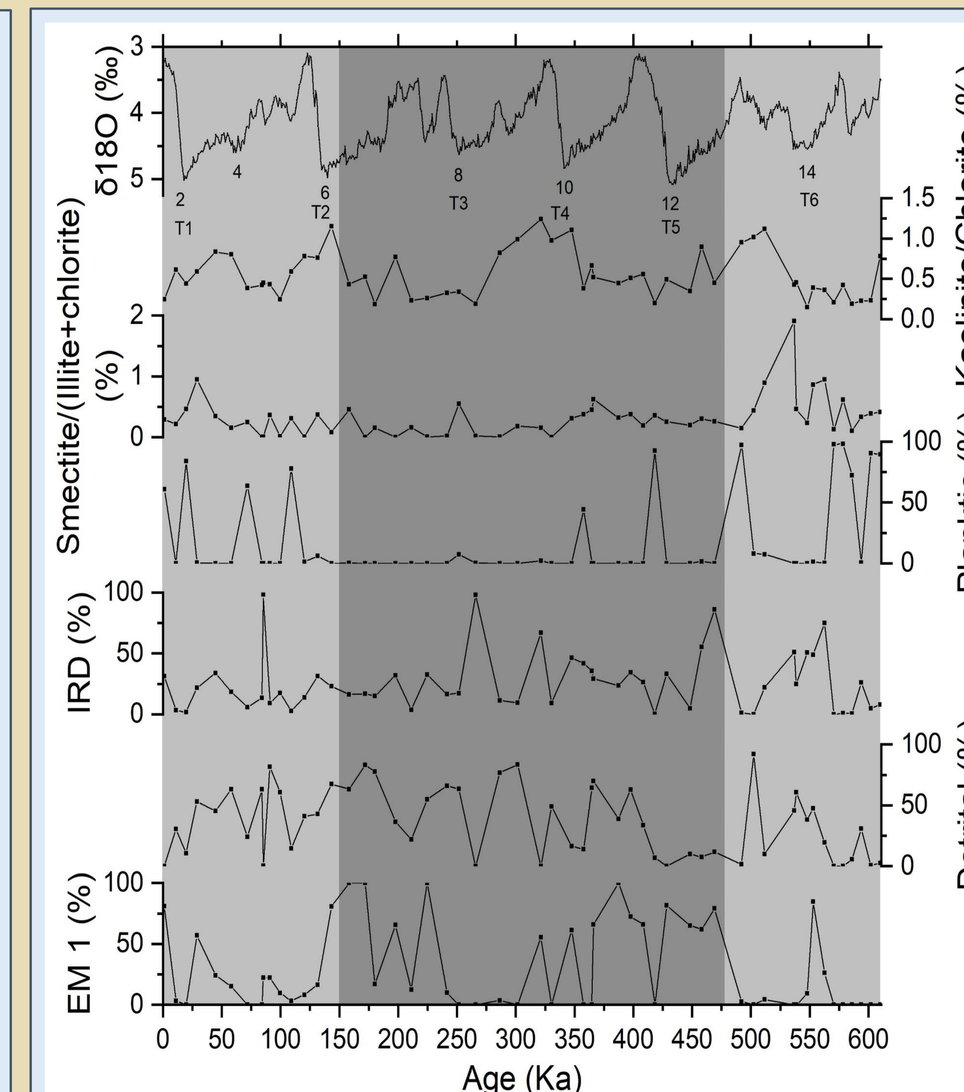

Fig 4. Variations of clay mineral, high energy condition (EM1), planktic foraminifera, Ice Rafted Debris (IRD), and detrital (%) (Das et al. 2020) in Japan Sea over last 600 Ka

- The decrease in IRD and increase in detrital suggest presence of seasonal ice sheet in the northern Japan Sea between ~ 450 and 150 Ka in low energy condition. Exception during MIS 6 may be linked to the expansion of seasonal ice sheet marked by dominance of detrital.
- The strong EAWM during this period caused expansion of seasonal sea ice formation for longer duration and its melting caused high energy conditions during that period.

Conclusions:

The low Smectite/(Illite+Chlorite) ratio between ~450-150 Ka suggest the source of sediment is eolian dust influx from Chinese loess plateau but after 150 Ka the source became from volcanic island characterised by high Smectite/(Illite+Chlorite) ratio and clearly suggest intensification of EAWM took place at ~450 to 150 Ka. The overall study suggests phase-wise variability in presence of permanent/seasonal ice sheets and EAWM strength over the last 600 ka.

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