Migration of the Mu Us desert and its implications for advance/retreat of the East-Asian summer monsoon rainfall belt during the last two glacial-interglacial cycles: Evidence from particle size of Chinese loess

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In northern China, desert margin migration can be well documented in the downwind loess deposits, since recent studies have shown that the grain size of Chinese loess is principally controlled by source-to-sink distance rather than wind intensity. In order to investigate the migration of the Mu Us desert during the last two glacial-interglacial cycles, contour maps of grain size from 53 loess sections were constructed for MIS 2, 3, 4, 5, 6 and 7. All the grain-size isolines show a near north-south gradient for both glacials and interglacials, indicating a dominant dust source region in north and an approximately north-south dust transport pathway for dust deposits on the Loess Plateau, at least for the past two glacial-interglacial cycles. Using the grain-size isolines of MIS 2 as a reference, we derive a northerly desert retreat of ~160 km, ~19 km, ~225 km and ~223 km for MIS 3, 4, 5 and 7, respectively, and a southerly desert advance of ~29 km for MIS 6, that could be preliminarily regarded as the relative migration distance for the East-Asian summer monsoon rainfall belt. In addition, the inferred climate conditions in MIS 3 are cool and humid in northern China, while the driest and coldest interval of the last two glacial periods occurs in MIS 6.

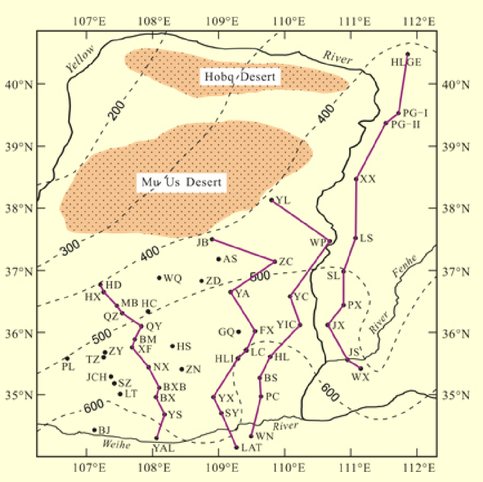

Fig. 1. The sampling localities (53 sections) and mean annual precipitation isohyets (mm, dashed lines) in the Loess Plateau.

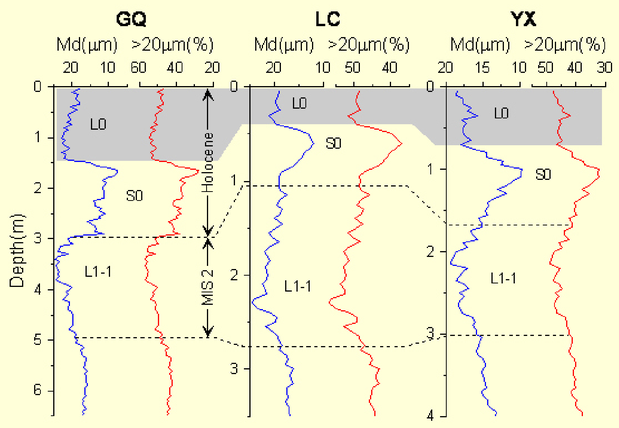

Fig. 2. Changes in median grain size (Md) and >20 μm particle content for the L0–L1-1 portion at GQ, LC and YX. The shaded zones indicate the late Holocene loess (L0). Given that the location of the southeast margin of the Mu Us desert during the LGM was similar to that of the present (Sun et al., 1998), and that the mean velocity of winter monsoon winds during the LGM was thought to be higher than during the Holocene, the great similarity of grain-size distribution between L0 (late Holocene) and L1-1 (LGM) suggests the dominant effect of source-to-sink distance on the downwind loess grain size rather than wind intensity. It follows that the meridional displacement of loess grain-size isolines provides a good measure for estimating desert margin migration.

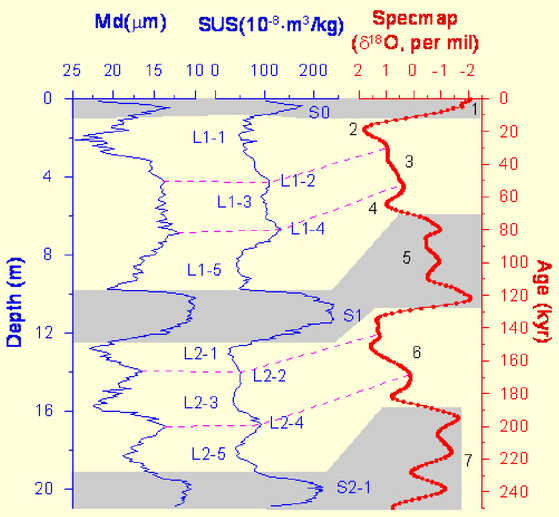

Fig. 3. Correlation of median grain size (Md) and magnetic susceptibility (SUS) of Chinese loess with marine oxygen isotope record (Imbrie et al., 1984).

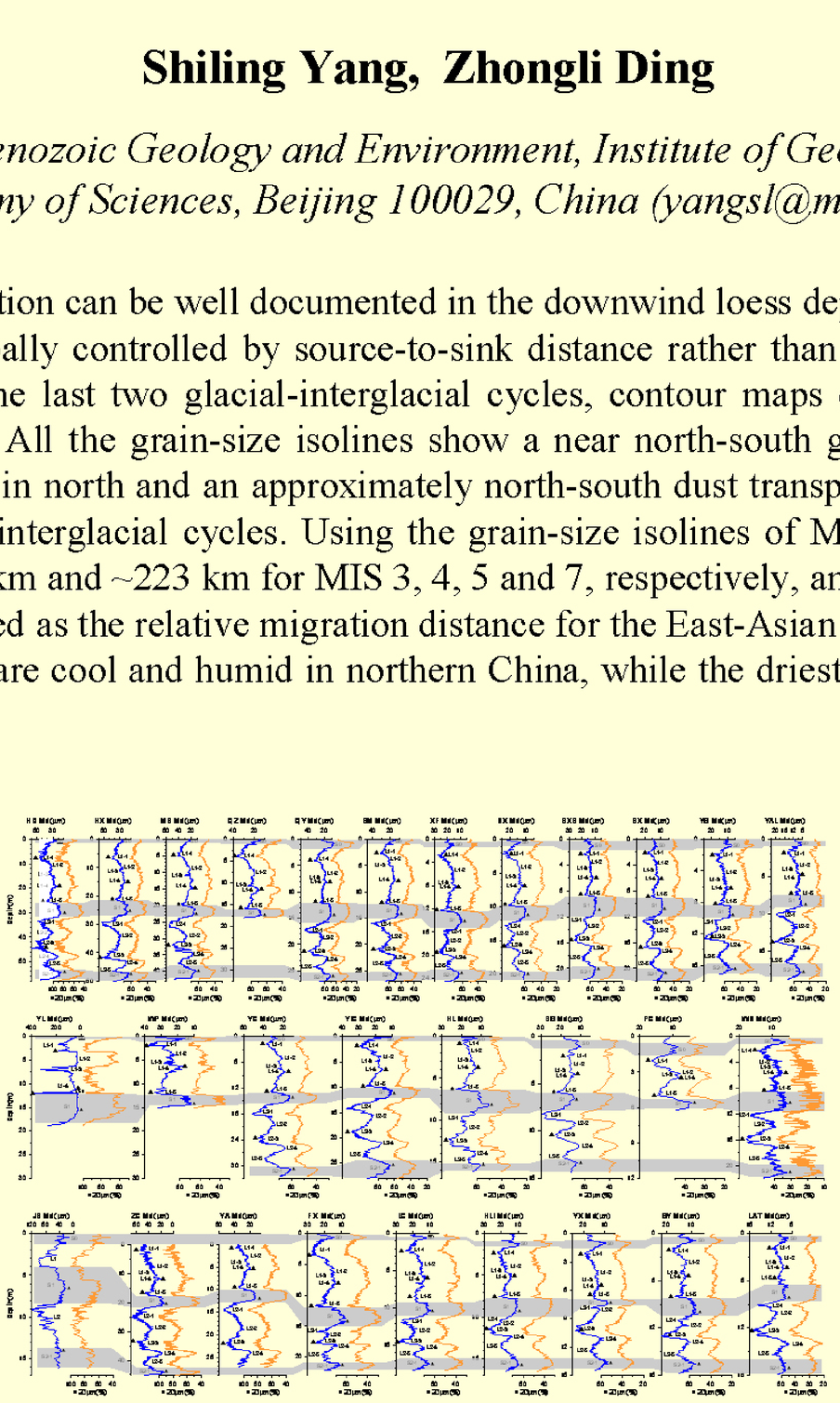

Fig. 4. Changes in median grain size (Md) and >20 μm particle content for the HD-YAL (upper panel), YL-WN (middle panel) and JB-LAT (lower panel) transects. The stratigraphic positions for constructing the contour maps are marked in solid triangles in each section. The shaded zones indicate interglacials. The grain-size variation pattern of other sites is similar to that from the three transects.

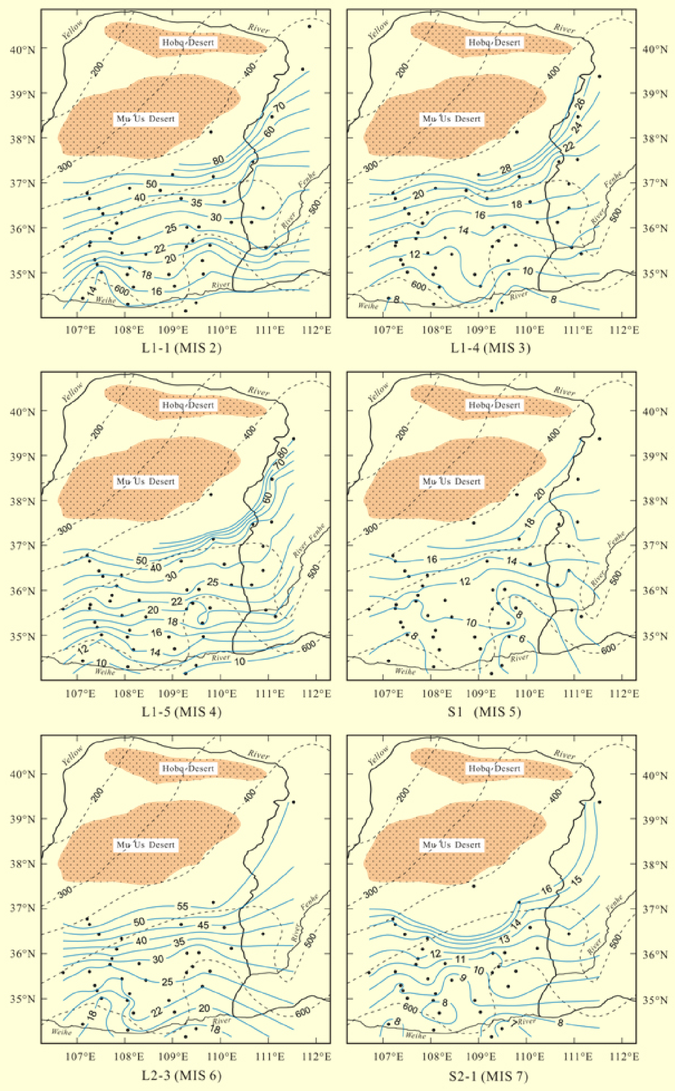

Fig. 5. Median grain-size (μm) contour maps for MIS 2, 3, 4, 5, 6 and 7. The dashed lines indicate the present-day mean annual precipitation isohyets (mm).

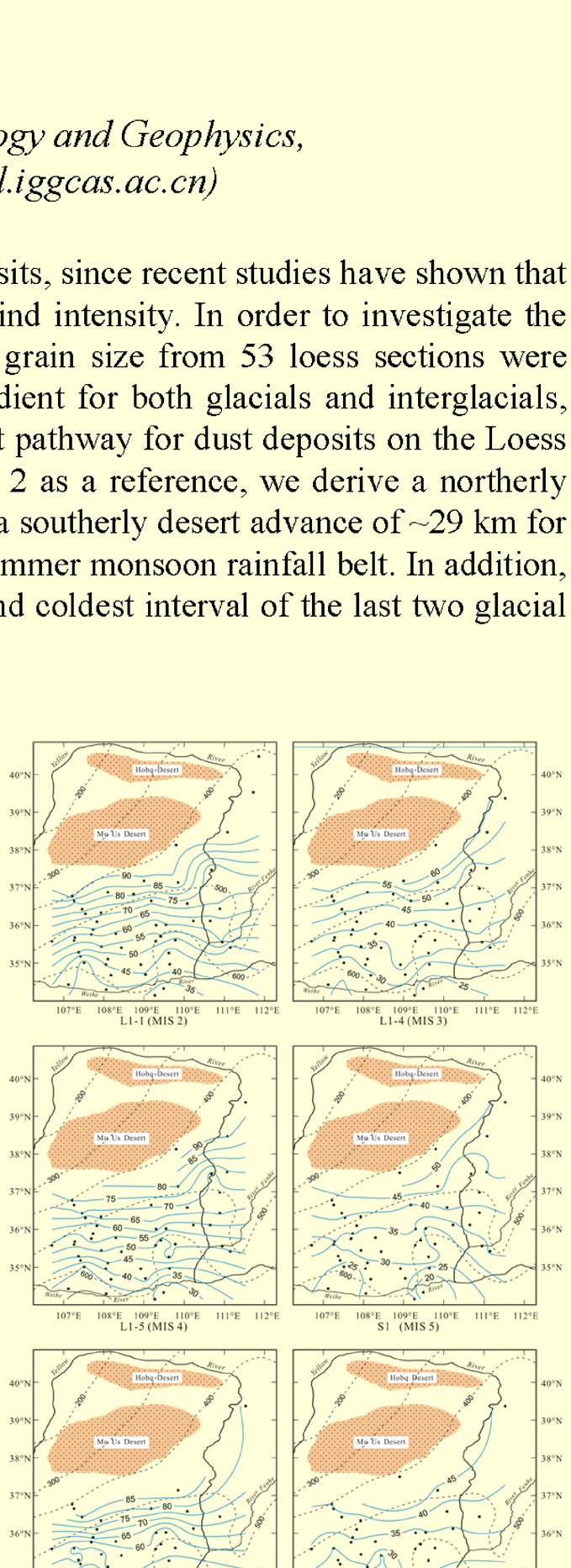

Fig. 6. >20 μm particle content (%) contour maps for MIS 2, 3, 4, 5, 6 and 7. The dashed lines indicate the present-day mean annual precipitation isohyets (mm).

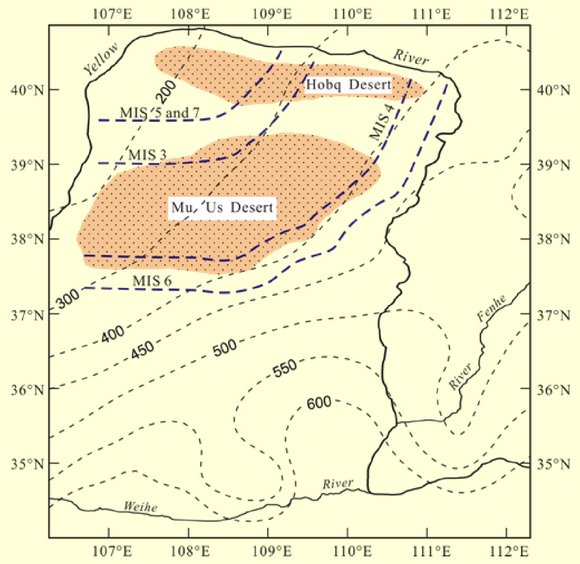

Fig. 7. Southeast margin of the Mu Us desert (heavy dashed lines) estimated from loess grain size for MIS 3, 4, 5, 6 and 7. The southeast margin of the Mu Us desert during MIS 2 lay in a location similar to that of the present (Sun et al., 1998). The light dashed lines indicate the present-day mean annual precipitation isohyets (mm).