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Fabric analysis of till clasts in the upper Urumqi River, Tian Shan, China

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Abstract

In-situ measurement of clast fabric within till and other sediment was performed at locations in Hayisa (HY), Upper-Wangfeng (UW), Lower-Wangfeng (LW) and Balatigou (BL), in the upper Urumqi River in the Tian Shan of NW China. Subglacial tills have stronger fabric of both *a*-axis and *a–b*-plane than supraglacial till. This can be explained as a result from the different stress and transport histories of till clasts. The preferred orientation of *a*-axes of till fabrics intersect the former ice-flow direction at a sharp angle ($62\pm16^{\circ}$); whereas the *a–b*-plane, with its normal intersecting the former ice-flow at $84\pm4^{\circ}$, is oriented approximately parallel to the ice flow direction. Thereby, subglacial relief appears to strongly influence the till fabric. In particular, the *a*-axis fabric is more sensitive to landforms than that of the *a–b* plane. In simple straight troughs, such as the Wangfeng Valley, fabric varies little. In the complex section of the trough, such as the Hayisa Lipolith, fabric characteristics are different at different sites of the Hayisa Drumlin. The fabric data can be used to understand glacial sedimentary processes in the study area.
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1. Introduction

Fabric analysis is the study of the preferred orientation of clasts within sediment. For more than 70 yr, fabric analysis has been widely applied in material sciences and geosciences (Wenk, 1985). Recently, both theory and practice of fabric analysis have rapidly advanced with the advancement of measuring devices and processing techniques (Mills, 1977; Hooyer and Iverson, 2000; Benn and Ringrose, 2001; Henriksen et al., 2001; Sakai et al., 2002). Traditional in-situ fabric measuring is the most effective method in the fabric analysis of coarse-size clastic deposits.

The formation of till deposits is essentially controlled by dynamic processes. Up to now, fabric analysis is still one of the main methods to obtain information about former glacier dynamics. Till fabrics provide important evidence on glacier movement orientation, sedimentary processes and environmental conditions. The spatial variation of fabric and its origin in local settings are significant for the study of glaciogenic deposits. It is still debated whether fabric can be used to distinguish different types of till. For example, Dowdeswell et al. (1985) and Dowdeswell and Sharp (1986) believed that fabric varies with different till types and that the eigenvalues of *a*-axis of tills can be effectively used to distinguish till types. In contrast, Bennett et al. (1999) argued that fabric data are unable to independently determine origin of tills. Their results indicate that the application of one uniform model in explaining till fabric is neither reliable nor practical. Therefore, further study is necessary for application of fabric parameters for the reconstruction of Quaternary glaciations and regional sedimentary history.

The upper Urumqi River is located on northern slope of the Kalaucheng Mountain in the middle of the Tian Shan of China. It is one of the most-studied Quaternary glacier-covered areas in the world (Fig. 1). Several, mostly qualitative, previous fabric studies on tills in this area have been published since the 1980s (Cui, 1981; Li et al., 1981; Feng and Qin, 1984; Li and Zhou, 1984; Yi and Cui,

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2001; Yi et al., 2002). This paper attempts to quantify diversity and variation of fabric characteristics in a variety of settings and for different till types.

2. Geological profile and study methods

The Urumqi River originates from Glacier No. 1 and flows eastward. The study area is located within the Daxigou Valley (Fig. 1). A glaciated lopolith is in its western part, called Hayisa Lopolith, about 1 km wide and with many bedrock exposures. A circular hill, the Hayisa Drumlin, is situated in the center of the lopolith. The middle part of the study area is the Wangfeng Valley. There are widespread lower moraines in the more western part and higher moraine ridges in the eastern part. The eastern part of the study area is a deeply incised valley. There are uncemented deposits in the side tributary gullies of the main valley.

Four profiles, viz. Hayisa (HY), Upper Wangfeng (UW), Lower Wangfeng (LW) and Balatigou (BL), respectively, were investigated (Fig. 1 and Table 1). The HY profile, a natural one formed by recent incision of the river, is located in the left bank of the river near the Hayisa Hydrometric Station, in the South side of the Hayisa Drumlin (Fig. 1). This profile comprises a till layer, which is consolidated and about 4–8 m thick and underlying lower bedrock. The three measured sites are distributed within the till layer in the stoss (TS07), lee (TS09) and top sides (TS08) (Fig. 3). The UW and LW profiles are about 500 and 100 m away, respectively, to the West from the Wangfeng Road Maintenance Station (RMS) and are located within road cuttings along Daxigou section of the Urumqi–Korla National Road (Fig. 1). The UW, deposited during the Last Glaciation (Yi et al., 2002, 2004), comprises two till layers. The lower is pale yellow till with compact texture and high silt content; while the upper grey unit has loose texture and dipping coarse beds. The six measuring sites were situated in the UW: the TS10, TS11 and TS12 within the upper layer and TS4, TS5 and TS6 within the lower layer (Fig. 4). The LW is composed of till older than the UW (Wang, 1981; Yi et al., 2002, 2004). Sampling of TS3 and TS2 was undertaken in this profile (Fig. 5). The clasts are very coarse in the upper part of the LW. Especially in the more western part (TS3) of the exposure, the clasts reach several meters in diameter. The BL is about 200 m away, to West from the Balatigou RMS, and situated in a gully on the North side of the Urumqi River (Fig. 1). Measurement site TS1 is located within this profile (Fig. 6).

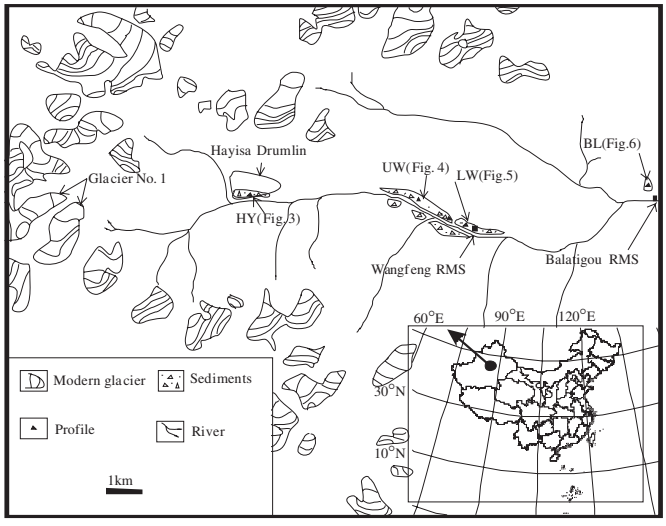

Fig. 1. Location of the study area and distribution of measuring profiles.

The error of in-situ measurement of clasts fabric is closely related to its fieldwork method, especially to profile selection. Some scientists, such as Millar and Nelson (2001a, b) and Klein and Davis (2002), think that large errors will result if only the clasts that are distributed on the exposed surface are measured. To help eliminate this error, the fabrics measured in this study were performed in deep pits. A total of at least 100 clasts (except for TS01 with 70) with long axis $\geqslant 3$ cm were counted in each site. The measured items included the length of the three axes and the attitudes of the *a*–*b*-plane and *a*-axis. The total number of the measured clasts was 1170. Information for the samples is summarized in Table 1.

The procedures included:

(a) In-situ measurement of the attitudes of *a*-axis (the largest of three axes) and *a*–*b* plane (the maximum oblate plane) of clasts.

Table 1
Distribution and number of fabric sites, Urumqi Riverhead, NW China

District	Altitude above sealevel (m)	Strike of valley (deg.)	Location	Total number	Sampling number
Hayisa	3500	085	Left bank of Daxigou in the downstream from weather station	3	TS07, 08, 09
Upper Wangfeng	3300	125	Upper layer of road-cutting profile	3	TS10, 11, 12
			Lower layer of road-cutting profile	3	TS04, 05, 06
Lower Wangfeng	3200	120	Road-cutting profile	2	TS02, 03
Balatigou	2800	085	Gully profile	1	TS01

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