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Landslides at Qingjiang River in the Downstream Area of Shuibuya Dam Site, China

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ABSTRACT: To enhance the general knowledge of landslides in China, the DAAD (German Academic Exchange Service) is financing an investigative project. As part of this project, at the Qingjiang (清江) River, a 10 km² area downstream of the Shuibuya (水布垭) dam site was geologically and geotechnically mapped to gather information concerning landslides and their correlation to lithology, slope angles and texture. The geological mapping contained the characterization of the lithological units. The characterization of the shape of landslides and the classification of rocks into units with similar geotechnical behavior is contained in the geotechnical map. Samples were taken and investigated using X-ray diffraction to identify the clay minerals and geotechnical tests to determine the effective shear angle and cohesion of rocks and soils. Geotechnical mapping showed a close connection between lithology, slope angle and texture concerning the occurrence of landslides. Most landslides occur on the northern bank of the Qingjiang River where the dip angle of the bedding is nearly parallel to the slope, resulting in potential and effective slide planes. On the southern bank only sporadic and small landslides occur because the bedding is antipodal to the slope angle. This pilot work is a base for further and more detailed investigations in this area.

KEY WORDS: landslide, geotechnical mapping, geological mapping, shear test and X-ray diffraction, Shuibuya dam site.

INTRODUCTION

Landslides annually cause a great amount of casualties within the Chinese population and great losses in the Chinese economy. The number of casualties reached 232 killed and 2 missing people in 2003 and 283 killed and 69 missing people in 2004. The economic losses amount to a total of 730 billion US $ in 2003 and 475 billion US $ in 2004 (Zanetti, 2005, 2004).

The DAAD (German Academic Exchange Service) is financing a project to investigate landslides. The project is a cooperation between China University of Geosciences (CUG) and the University of Karlsruhe, which collaborated closely with the Reconnaissance Bureau of the Yangtze River Water Conservancy Commission. The aim of this project is to enhance the general knowledge of landslides to avoid casualties and economic losses in future.

Within this project, the area downstream the Shuibuya dam site was geologically and geotechnically mapped.

AREA DESCRIPTION AND METHODS

Area Location

The investigated area is located in Hubei Province (see Fig. 1). It lies about 150 km southwest of Yichang at the Qingjiang River which is a branch of the Yangtze (Changjiang) River. The biggest settle-

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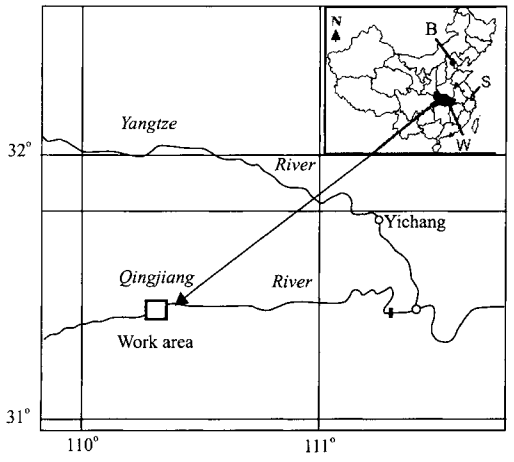

Figure 1. Investigated area (box) within Hubei Province (marked black). Abbreviations: B. Beijing; S. Shanghai; W. Wuhan (slightly adapted after Xiao et al. (2001)).

ment in this area is the village of Shuibuya (Xiao et al., 2001).

METHODS

During the investigation of the area, the following methods were applied in the field: geological mapping (scale: 1 : 10 000); geotechnical mapping (scale: 1 : 5 000).

The laboratory investigations were carried out at China University of Geosciences (Wuhan) and at the Technical University of Karlsruhe: X-ray diffraction (RDX); direct shear test (DIN 18137); plasticity (DIN 18122, part 1).

RESULTS

Geological Survey

The outcropping rocks are Ordovician to Permian in age. The Ordovician, Carboniferous and Permian rocks consist mainly of limestones, the Silurian rocks of sand-, silt- and claystones and the Devonian rocks are quartzitic sandstones which were all sedimented in a marine facies. The Ordovician rocks consist mainly of limestone, which is low karstified. It contains several clayey layers and is well bedded. The Silurian rocks consist of sand- and siltstone with alternating layers of varying clay contents. On the basis of the varying clay contents, the Silurian is subdivided into four groups. During the Devonian, a quartzitic sandstone which is highly jointed was sedimented. The Carboniferous limestone is sparsely jointed and well bedded. High karstification is found within the low jointed, micritic Permian limestone. The dip direction of the bedding varies between 260° and 280° and the dip angle between 20° and 30°. One big thrust fault was found inside the area, with a strike of approximately 225° and a dip of 75°. The actual geological settings are presented in the cutout of the geological map in Fig. 2 (Xu and Li, 1998; Jian et al., 1996; Wu et al., 1996).

Geotechnical Survey

The geotechnical mapping was arranged with the objective to classify the rocks in this area concerning their mechanical and lithological properties and the determination of rock parameters, which are responsible for the development of landslides. The most important parameters were the texture and the lithological composition of the rocks. The rocks were classified into solid rocks, rocks with changeable strength and unconsolidated rocks. 15 active and inactive landslides were mapped and investigated. Other geotechnically important structures (e. g. rock falls) were also marked on the geotechnical map. A high correlation between the classified rocks and the strata were found in this area, because the strata are very homogeneous and show no great changes or lateral variations in their facies. So the geotechnically classified areas coincide with the borders of the strata. The geotechnical map is shown in Fig. 3.

The solid rocks are limestones and sandstones. The Ordovician, Carboniferous and Permian strata consist of limestones. The Ordovician rocks contain frequent joints and clayey layers. Within the limestones, no landslide could be found. But in the transition from the Permian to the weaker Silurian rocks steep walls are developed. In the range of these steep walls, many rock falls occur. The Devonian strata consist of sandstones, which are highly jointed. The only landslide in solid rocks inside the work area was found within the Devonian.

The rocks with changeable strength consist of siltstones with varying contents of clay and sand. All Silurian rocks belong to this group. They contain a large amount of joints and the material is highly fragmented. All except two landslides within the tested area could be found in the area of the Silurian sediments.

All Quaternary deposits are unconsolidated rocks comprised of collovium, rock fall masses or alluvial sediments. The thickness and the distribution of the Quaternary sediments vary widely. The thickness of the colluvium varies between 0 and 1 0 m throughout