Rock Pile, a Particular Type of Debris Accumulation in Huanren, Liaoning Province, China

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Abstract

In Huanren County of Liaoning Province, China, the construction of Tianshifu-Huanren railway met with the problem of rock pile, a particular type of debris accumulation. Regarding to the rock pile, the basic engineering geological problems, such as distribution, origin, deformation and failure model, haven't been reported before. Field surveys and large-scale mapping were carried out in order to clarify the geological features and geological setting of this kind of debris slopes. This paper presents a preliminary summarization on the characteristics of distribution, texture and slope stability of the debris accumulation. It is believed that the debris accumulation is formed by glaciation during the late Quaternary. Jointed quartz sandstone is breaked into rock blocks in the superficial part under the glacial loading and ablation. Rock blocks were accumulated in site or transported by glaciers and deposited in near slopes. The debris accumulation is preserved due to the strong weather resistance of quartz sandstone. Though sliding failure is rarely found, slow creep activity is observed in some area of the debris accumulation. Vegetation or bare ground is a sign of stable or creep state of a slope.

Keywords: Huanren county of China, rock pile, engineering geological characteristics

1. Introduction

In Huanren County of Liaoning Province, China, the construction of Tianshifu-Huanren railway met with the problem of rock piles. Rock piles are widely distributed on the slopes, some surfaces of which are covered with vegetation, the others are totally bare. The thicknesses of the piles range from several meters to dozens of meters, the maximum reaches 50 meters. The railway was formerly designed to cross the debris slopes by tunnel, however, as the route exploration progressed, designers became to worry about the feasibility of the tunnel construction and the long-term stability of the debris slope. Little has been known about the engineering geological problems so far, such as distribution, origin, deformation and failure model due to limited reports. To solve these problems, a large-scaled (1:2000 and 1:10000) engineering geological survey including the interpretation of remote sensing was carried out in Huanren County.

2. Regional distribution of rock pile

The distribution of rock piles is concentrative in the area of Huabozishan- Daqianshiling-Yantongshan in Huanren county, eastern Liaoning province, covering an area of nearly four hundred square kilometers (figure 1). Rock piles are also scattered in other areas of eastern Liaoning province and southern Jilin province.

The rock piles are widely spread on slopes, and can be classified into two kinds--bare rock piles and vegetation-covered rock piles --according to whether they are covered with vegetation.

Bare rock piles have no vegetation on their surfaces, and mainly exist on slopes with a slope angle between 30° and 38° . Multiple bare rock piles, separated or locally-connected, are often clustered in a col (figure 2).

In the outer areas around the bare rock piles are the vegetation-covered rock piles. Vegetated mainly by pine, oak and small shrubs, the vegetation-covered rock piles mainly distribute on mountain ridges and relatively gentle slopes with slope gradient generally within 30 °. Bare rock piles are also found in 10 to 15 ° platform in some slope toe.

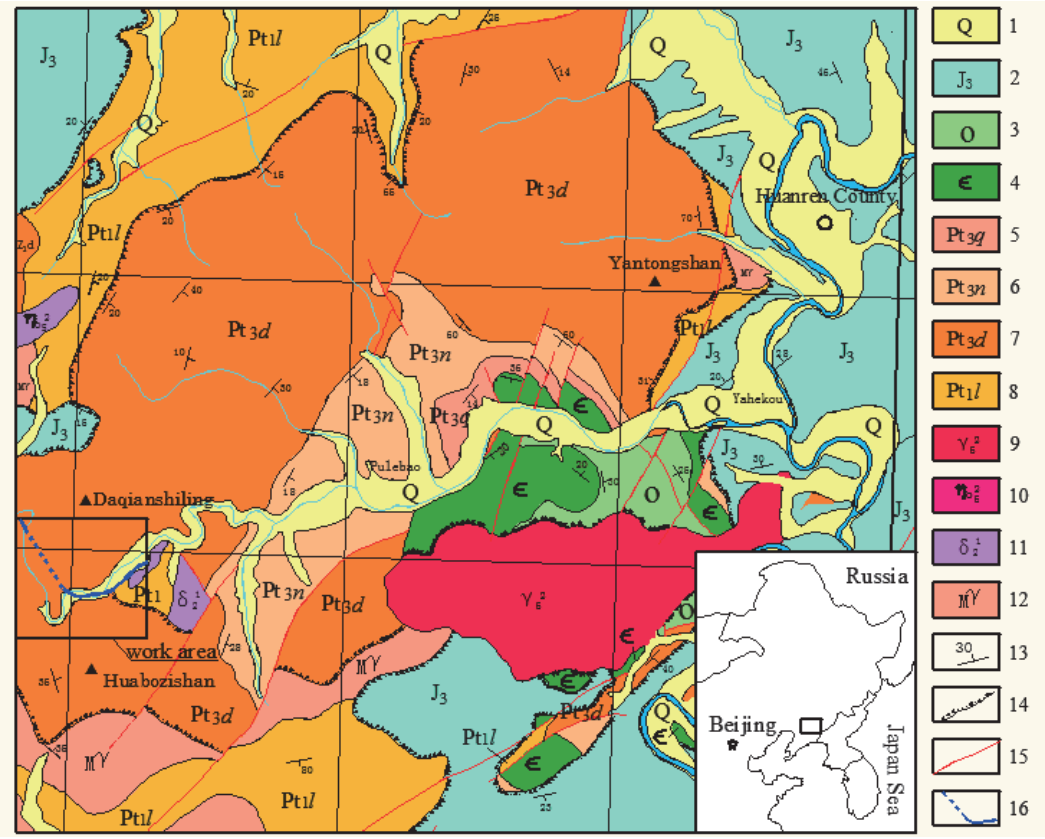

Fig. 1 Geological map in Huanren area. The distribution of rock piles is consistent to the outcrop region of the Diaoyutai Formation (Pt_3d). Based on Huanren geological map of scale 1:200 000; grid spacing in the map is 10 km. 1- Quaternary sand-gravel soil; 2- pyroclastic and sandy conglomerate of the late Jurassic; 3- limestone and limited shale of Ordovician; 4- limestone and shale of Cambrian; 5- Qiaotou group of the Neoproterozoic, interbed of quartz sandstone and arenaceous; 6- Nanfen formation of the Neoproterozoic, shales with intercalations of marls; 7- Diaoyutai formation of the Neoproterozoic, quartz sandstone; 8- Liaohe group of the Paleoproterozoic, metamorphic rock such as gneiss, amphibolites, migmatite; 9- Jurassic intrusive rock of granite; 10- Jurassic intrusive rock of adamellite; 11- Proterozoic intrusive rock of diorite; 12- migmatite; 13- attitude of bed; 14- angular unconformity; 15- fault; 16- Tianshifu-Huanren railway line in Daqianshiling, the dash line shows the tunnel.

Fig. 2 Bare rock piles are clustered in cols.

Bare rock piles differ from each other in shapes. The shape can be strip, cone, saddle-shaped and skirt-shaped., etc., but they have a common characteristic, namely their long axes are generally in the directions along the longitudinal slope (vertical to the contour lines, as shown in figure 3).

A few rock piles, usually with small coverage area, directly accumulated under cliffs, but more rock piles are absent steep cliffs behind their slope.

The distribution of the rock piles is closely related to the Diaoyutai Formation, Neoproterozoic (see figure 1), in other words, the rock piles are the unique features of the Diaoyutai Formation, and they are rarely occurred in other stratums. It is showed by the rock piles distribution map of Lvjiabao (figure 3) that rock piles are widely spread in the distribution area of Diaoyutai Formation, and rarely occurred in metamorphism rocks, mainly leptite, of the Liaohe Group and in the intrusive rocks, mainly quartz diorites, of the late Jurassic. The Diaoyutai Formation consists of light grey quartz sandstones, the most of which are thick-bedded.

3. The texture characteristics of the slope debris accumulation around the entrance of the Daqianshiling tunnel

A engineering geological mapping at a scale of 1 : 2000 has been conducted in the slope areas around the entrance of Daqianshiling tunnel. The results are shown in figure 4. Three kinds of accumulations can be discriminated on the slope, namely bare rock piles, vegetation-covered rock piles and colluvial deposits.

Large areas of bare rock piles occur in the north (rock pile A and C), the south (rock pile B) and the upper part (rock pile D) of the slope of the tunnel entrance. The coverage area of rock pile B, the largest one among them, is about 400m×400m. The bare rock piles are simply made up of accumulated rock blocks. The blocks, which are hard and angular, consist of quartz sandstones and pebbled quartz sandstones. The general diameters of the blocks are between 0.5 m and 1.5 m while the maximum can reach 2 m to 3 m and the minimum only dozens of centimeters. The rock piles are of aerial structure, without fine grain filling, and nonsorted (figure 5).

Rock piles existing in areas covered with a lot of vegetation outside the bare rock piles are called vegetation-covered rock piles. On the surface of this kind of rock piles lies a thin layer of humus soil which consists of dead plants that have begun to decay and few minerals. The humus soil is only tens of centimeters in thickness, many rock blocks are still exposed to the slope surface, from which accumulation structure can be clearly observed. The parts below the humus soil layer are rock block accumulation with a structure similar to that of the bare rock piles.

The yellow colluvial deposits, consisting of rock blocks and rubble with silty clay filling in interspaces, is located on the slopes outside the tunnel entrance. Most sizes of the blocks, which compose of over 50 percent of the layer, are between 0.2 m and 0.5 m. The rubbles usually range in size from 0.02 m to 0.15 m. Both of the rubbles and rock blocks are sub-angular and made up of quartz sandstones (figure 6). The soil consists mainly of yellow clay and silty soil and has a content of 10 percent or so. It shows a lush vegetation in the colluvial deposit area.

The vegetation-covered rock piles lie over the colluvial deposits. A construction road has been made on the slope lying in the front edge of rock piles, from where the contact relationship of two kinds of debris accumulations can be observed (Figure 7). On the whole, the gray overlying layer stretches out like fingers where were once a relatively low-lying area. All of the above indicate that the rock piles form after colluvial deposits.

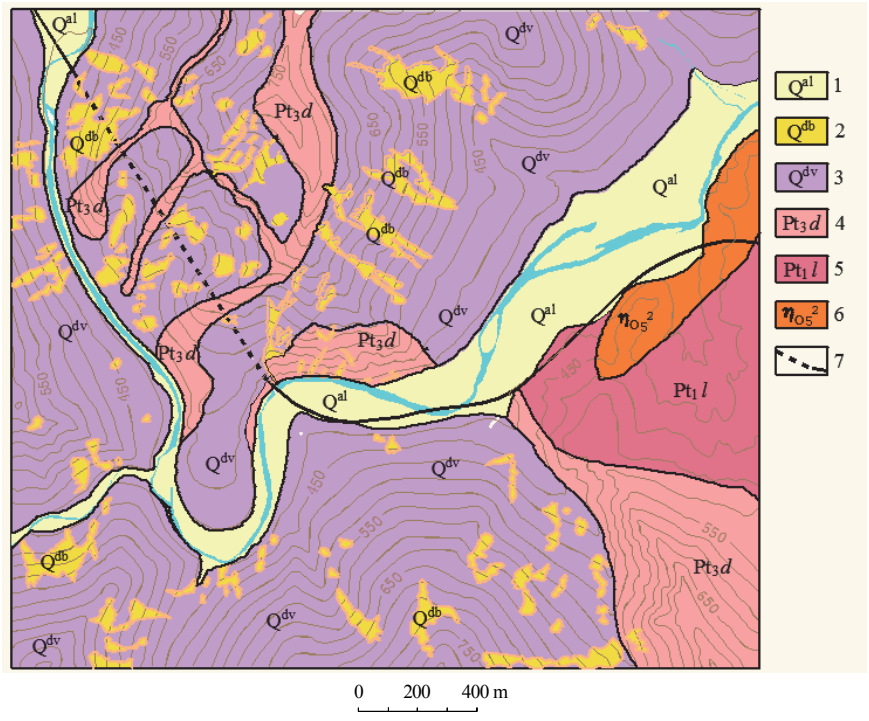

Fig. 3 Distribution of rock piles in Lvjiabao. 1- alluvial deposit of Quaternary; 2- bare rock pile; 3- vegetation-covered rock pile; 4- Diaoyutai formation of the Neoproterozoic; 5- Liaohe group of the Proterozoic; 6- intrusive rock of the Late Jurassic; 7- railway in construction, the dash line is tunnel

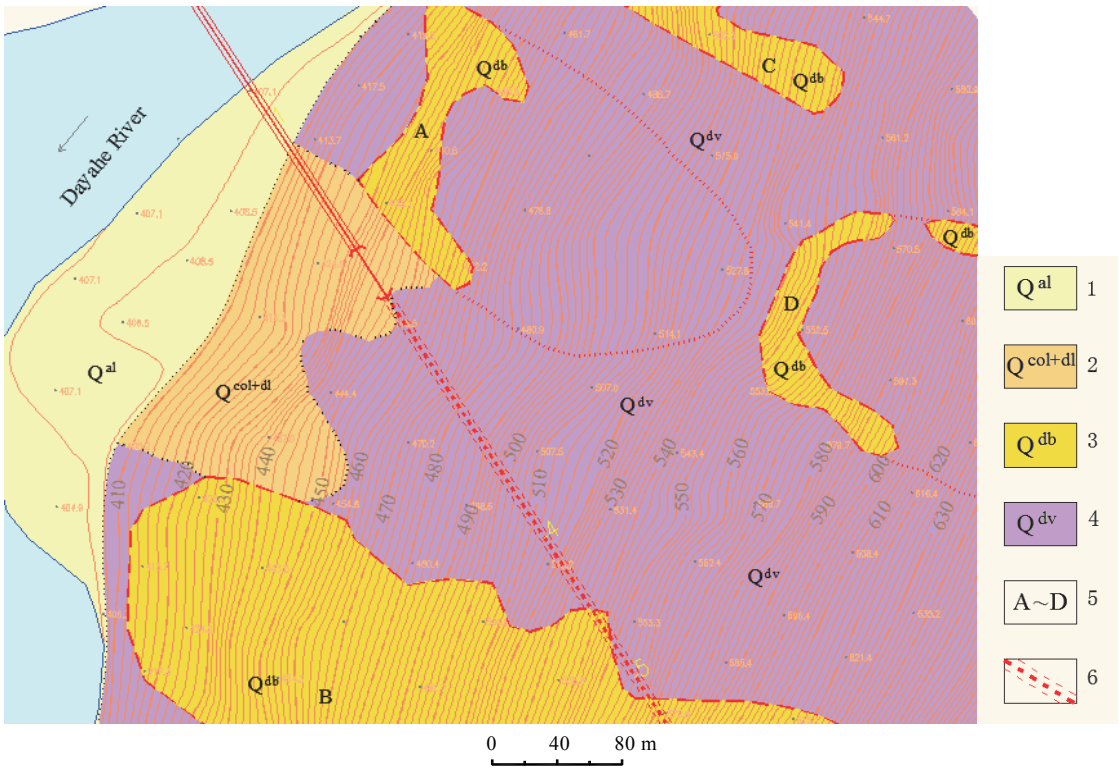

Fig. 4 Engineering geological map of Daqianshiling tunnel entrance slope. 1- alluvial; 2- colluvial; 3- bare rock pile; 4- vegetation-covered rock pile; 5- number of bare rock piles; 6- Daqianshiling tunnel

Fig. 5 Open structure of rock pile

Fig. 7 Rock piles lying over colluvial deposit.

Fig. 6 Yellow colluvial deposit consisting of rock blocks and rubble with silty clay filling in interspaces

4. Results and discussion

The rock piles in the area of Huanren county are probably not the product of rock avalanche. Coarse grained debris accumulation on hill side are usually categorized into a kind of debris originated from rock avalanche. Some researchers hold this view that the rock piles in Huanren county belong to talus (Qu and Liu 2011, Li 2013). However, some phenomena don't support the view. Firstly, most of the slopes covered by rock piles have no steep cliff at slope head. And then, the texture and block size of the rock piles changes very little from the top to the foot of the slopes. This phenomenon is not in accordance with the avalanche deposits which are supposed to differ greatly among different parts, such as the average size of rock blocks is much larger in

the front than in the back of the slope. Moreover, rock piles are also found on the platform, or river terrace, in slope foot. With a low gradient surface, the rock piles on the platform differ to a talus.

The debris accumulations in Huanren county are probably the product of glaciation during the late Quaternary. Under the loading by thick glaciation and followed unloading by glacial ablation, it is speculated that jointed quartz sandstone is breaked into rock blocks in the superficial part. Rock blocks accumulated in site or transported by glaciers and deposited in the near slopes. On the view of glaciation, some features of rock piles can be well explained, such as even sizes, poorly graded, and appearance in gentle slopes. Nevertheless, more concrete evidence of glaciation as well as the formation and accumulation mechanism remains to be further researched.

Bare rock piles and vegetation-covered rock piles probably represent two kinds of states of the debris slopes—stable and active. The appearance of the bare rock piles, with a long axis direction vertical to the contour lines, indicates a sign of activity under gravity. There is a relatively steep slope at bare rock piles, on which slope the rock blocks are prone to move downward. Tilted and saber-like trees in the transition zone between bare and vegetation cover debris accumulations also indicate the creep activity of the bare slope. It is the continuous deformation and lack of fine-grained filling that make the vegetation difficult to maintain in bare rock block accumulation.

Acknowledgements

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