RESEARCH AND ASSESSMENT OF LANDSLIDE ALONG HIGHWAY NO.12 IN THE NORTHWEST VIETNAM.

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Abstract

Highway No.12, approximately 100km from Dien Bien city to Lai Chau town, is a life-line and plays an important roll in the development of economy and society of the Northwestern provinces. In fact, the highway is located in very dangerous mountain region with a complex geological characteristic that has caused a lot of serious landslides for years. The natural conditions: climate, topography, geological structure, tectonic activities and human activities are defined as the main factors causing landslide. The research also determined a series of "black points" along the highway for hazard mitigation.

Introduction

Highway No.12 goes along Dien Bien – Lai Chau fault zone in the North – South direction, started at center of Dien Bien city, through Muong Cha and to frontier pass Ma Luc Thang. This highway is very important transport, connecting two provinces Dien Bien and Lai Chau, but it located in area with disadvantage of natural condition as well as negative influence of humany activities, bears high potential of landslide.

For assessment of landslide the report refer following questions.

1. Situation of landslide

Every year in rainy season a long highway often happen many big landslides. For example: in 1994, at km 12 from Lai Chau Town fixed landslide with 2000m of length and hundreds meters of width; In 2002, 25 places with big landslide were defined, especially, among them one landslide block with 500m3 is biggest at Ma Thi Ho pass; In 2004 in scale of Lai Chau Town at every kilometer of the highway there were 5 to 6 blocks of landslide.

On the highway, serious landslides are concentrated in some parts, such as Ma Thi Ho pass, Huoi Leng commune and Lai Chau Town (Figure 1.1), Which are black points for transport activities.

Thus landslide on the highway No.12 often occurrences, causes dangerous for transport and threatens property and life. Situation of landslide is vary serious.

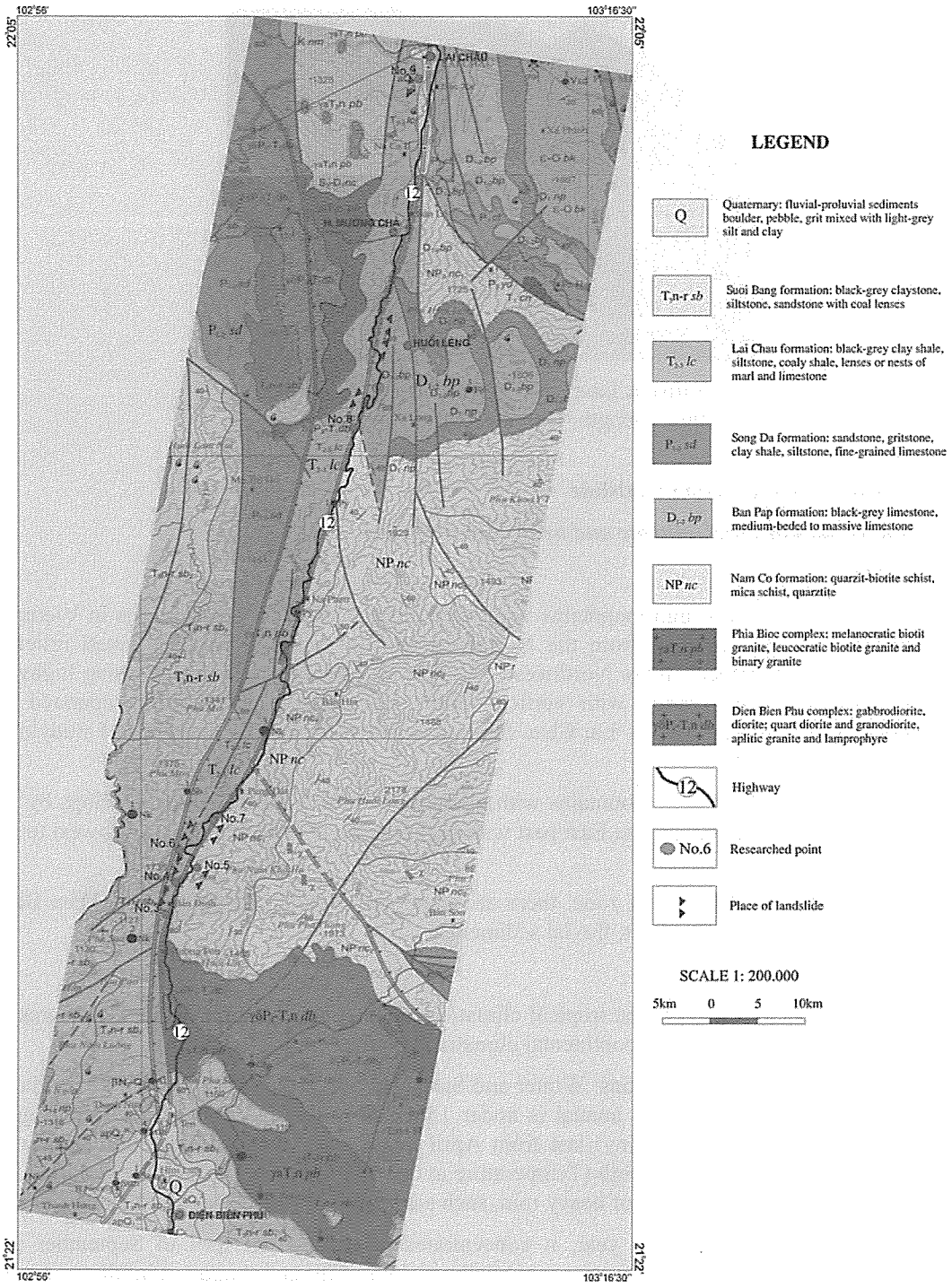

Figure1.1. Geological map along highway No12

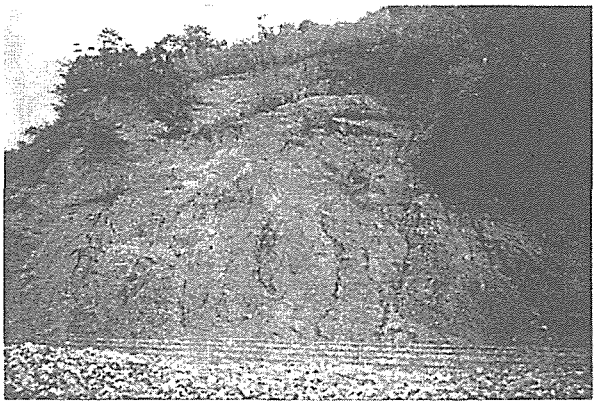

Foto1.1. Landslide in Huoi Leng Commune
(350m of length, 150m of high with many terras)

2. Natural factors affecting landslide

2.1. Characteristics of relief, climate and hydrological system

2.1.1 Relief features

The northwest area presents high mountains with steep slope and the most dangerous in Vietnam. The highness of relief decreases from the Northwest to East south. In the Northwest relief is characterized by development in the Northwest – East south orientation and relief along highway No.12 is narrow tectonic valley with vertical slope, many facets, intensively separated by hydrological system. If Dien Bien – Lai Chau fault zone is made a bonder the relief of study area can be divided in two parts:

The west part characterized high mountains with highness of 1000 to 3000 meters develops by the northwest – East south direction; The East part with highness decreasing from the Northwest to the East south.

On the Dien Bien – Lai Chau fault zone, there are some pull a parts basins (such as: Dien Bien, Chan Nua, Lai Chau) filled by basalt, fluvial sediments.

2.1.2 Climate features

The Northwest area is situated in the tropical climatic zone, but by influence of relief it expresses the more and less characteristics of continental climate.

In the Northwest there are two seasons: Winter and Summer. Winter last from November to March next year, average temperature per annual is under 150C; in some high mountain places it goes down to 0^0C. Summer (hot and rainy) last from April to October, average temperature variation between a day and a night is very high (Temperature at day can be more 35^0C, but at night it is 15 to 20^0C). In area there are 3 centers of heavy rain, such as: Dien Bien, Lai Chau and Muong Te.

Rainfall distributes not equally in year, it concentrates in months of April to September and occupies 80-90 percent of rainfall in year, especially in June, July and August rainfall per month reaches more 500mm concerning flash flooding and landslide occurrence in large scale.

2.1.3 Hydrological system.

A long highway No12, the main rivers such as Namlay, NamNa and Da follow after direction of deep faults. The rivers are Characterized narrow valleys with steep slope and speed of flow is changed. The main reveres and it's tributaries have separated area and formed very developed hydrological system. Sequence of erosion and tectonic movement in Cenozoic has created dangerous relief and high potential of flooding and landslide.

2.2. Geological structure a log highway No12 (Figure 1.1)

Geological structure characterized by following

- Sediment and metamorphic formations.

The highway No12 goes cross sediment and metamorphic formations:

1. Nam Co formation (NP *nc*).Namco formation distributes along the right side of highway from Muong Pon to Ma Thi Ho pass, has stratigraphic unconcordance with Ban Pap formation (D_{1-2} *bp*) and tectonic relation with Laichau formation (T_{2-3} *lc*). At Muong pon, the formation is penetrated by intrusive Dien Bien complex ($\delta\gamma D_1 - T_1$). Formation consist of biotite schist, two – mica quartz schist, quartz and sericite schist. Inside of fault zone rocks of this formation is deformed intensively and weathered with yellow color but outside it is very weakly deformed.
2. Ban pap formation (D1-2 bp). This formation distributes on the right of Highway from Ma Thi Ho pass to Muong Lay Town, having tectonic relation with Lai chau formation (T2-3lc). It composed of sandstone, gravelstone, marl and limestone.
3. Laichau formation (T2-3 lc). This formation has been seen in narrow belt, stretching along the highway and penetrates by Phiabiooc complex (γa T3n pb) in Muong lay. This formation composed of black shale siltstone, carbonate siltstone. All the rock of this formation located in Dien Bien – Lai chau shear zone and intensively deformed.
4. Basalt (βN2-Q1). Basalt effusive exposed in some hills in the North of Dien Bien city. Mainly composed of olivine basalt, weathered, intensively and become reddish soil.
5. Quaternary sediments (Q). Quaternary sediments distributed in Dien Bien Basin, composed of pepple, gravel, sand and silt. The highway goes cross quaternary sediments on not long distant from Dien Bien city to Thanh Nua commune. Dien Bien basin filled by quaternary sediments and in result to form Muong Thanh plane.

- Magmatic intrusions

  The highway No12 goes cross two complexes: Dien Bien complex (δγD1-T1) and Phia Bioc complex (γa T3n pb) located in the North from Dien Bien city. Dien Bien complex was deformed very weakly, structure of complex is not destroyed. In opposite Phiabioc complex was strongly deformed, the rocks of complex was compressed, created broken zone interbeds with sheared one.

- Structural form and activities of fault

1. Structural forms

   Structurally the highway is graben limited by two deep fault parallel each other, composed mainly of Lai Chau formation in the center, Namco, Ban pap formations and Dien Bien complex in East wing and Song Da formation in West wing. The graben is long and narrow. In late Triass the south part of west wing was subsided and magmatic activities formed intrusive massive penetrating graben in Muong lay and Muong pon.

   Besides mentioned graben, along Dien Bien – Lai Chau fault zone, there were some special pull apart basins, formed in Neogen – Quaternary time. Dien Bien Basin is biggest of them.

2. Activity of deep fault

   In study area and adjacent regions deep faults and faults developed mostly in three directions. North- South, North west – East south; North East – South west.

   In Dien Bien – Lai Chau zone the deep faults have the more 60km of depth and high seismisity. In Cenozoic: activity of deep fault passed through two phases: 1. Early phase from Eocene to Miocene, characterized lateral right strike while other deep faults in the North west Vietnam is lateral left strike ; 2. The late phase from Miocene to Quaternary for Dien Bien –

Lai Chau fault zone movement of deep faults occurrenced by mechanism of lateral left strike but other deep faults in the North west Vietnam by lateral right strike.

Based on deformed grade and structural forms tectonic movement in Cenozoic expressed the more intensively in the late phase, demonstrated by forming the many compressed areas and many pull apart basins. Sequences of tectonic activities in Neogen – Quaternary (the late phase) created tectonic setting in which Lai Chau, Suoi Bang formations and Phia Bioc complex were strongly sheared, structure of bedding and fissure was destroyed and finally formed geological bodies with high potential of landslide.

3. Humany activities and landslide

3.1. Deforestion for agriculture

The North west mountain area usually was rich in forest resource. However last year by deforestion, fire and over exploitation for agriculture to lead to decreasing forest area.

Duration 7 years (from 1995 to 2004) four provinces: Lai Chau, Dien Bien, Son La and Hoa Binh the area of destroyed forest is 3244600ha; in which only for Laichau in 1995 its was 2199ha.

Deforestion occurenced and now it still occurrences. Sequence of deforestion stimulates erosion, destroying soil, creating hazard of flood and landslide.

3.2. Straightening the highway

The highway No12 has many curve parts. Straightening the highway has destroyed old slopes and created new slopes.

Researching 10 places on the highway from Dien Bien city to Lai Chau Town. We can remark that there are many places with high potential of landslide. Following is special cases:

1. Research place No4

   Position by GPS: 21^0 33' 52" (N)

   103^0 00' 59" (E)

   It is situated in the north of Ban Dinh, on the left side from Dien Bien to Lai Chau. Here straightening curve part is taken place (Fig 3.1).

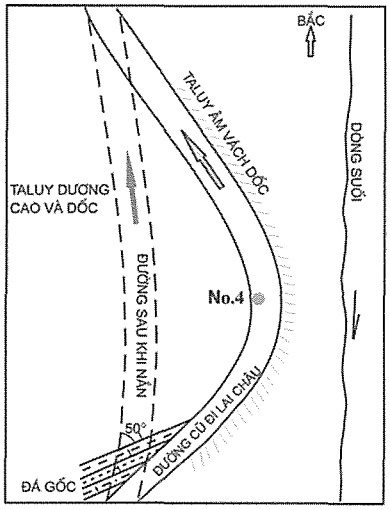

Figure 3.1. Simple outcrop map of research place No.4

Photo 3.1. Picture taken in research place No.4

After straightening, the new part of highway has high and steep slope (450). This slope composed of broken rocks, brecia and loose soil, somewhere are exposed springs. Geotechnic measures are not still applied for new slope, thus potential of landslide is very high.

2. Research place No7.

   Position by GPS : 21^0 37'13" (N)

   103^0 02'13" (E)

   The research place belong to the curve part located on the right of Highway from Dien Bien to Laichau. Here the curve part is straightened. The new slope composed of two parts: the first part from Highway surface to 6m of highness, characterized by sediment layers compressed, broken and intensively weathered; the second one over 6m of highness composed of old alluvial, weathered with red brown colour.

Photo 3.2. A new steep slope on the right side of Highway No.12

   The steep slope consist of different lithocompositions, intensively broken rocks and loose soil, bearing high potential of landslide in rainy season. Thus this place is dangerous for transport.

3. Research place No8.

   Position by GPS : 21^0 51'03" (N)

   103^0 07'21" (E)

   The research place is on the left of highway in the peak of MaThiHo pass. Ma Thi Ho pass characterized complexly geological structure. Geological formations (siltstone, coal beary shale) were strong compressed, they are broken, microfolded and penetrated by dykes.

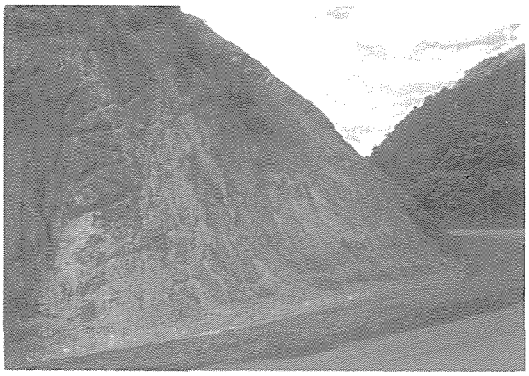

Photo 3.3. Veins of marl cut mudstone, coal-claystone

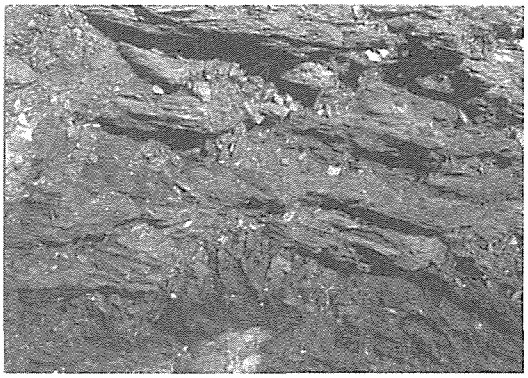

Photo 3.4. Folded coal-claystone of Lai Chau formation

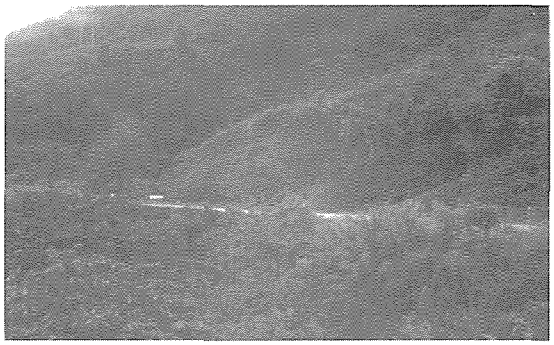

Photo 3.5. Shattered coal-claystone of Lai Chau formation

Photo 3.6. Major landslide block on Ma Thi Ho pass

From Dien Bien side to peak of pass slope steep is over 700, rocks presented coal bearing clayers follated and broken with exposed springs. Thus potential of landslide is very high (Photo 3.5). From peak of pass to Lai Chau, there was a big block of positive slope landslide (Photo 3.6).

Ma Thi Ho is the more dangerous place that here slope is very high and steep, highway surface is narrow with negative slope steep and deep. Besides that, the slope composed of broken, follated rocks and loose soil.

4. Research place No9.

Position by GPS : 22^0 03'09" (N)

103^0 03'26" (E)

The research place is situated in Lai Chau town. Lai Chau town located in valley of Nam Na river, population settlement distributes on the right bank of river. Valley of Nam Na river characterized steep slope and mountain relief on the both sides of slope.

Photo 3.7. Landslide block on the west side of Nam Lay valley

Photo 3.8. Landslide block composited form shattered rock

The whole Town located in Dien Bien – Lai Chau fault zone. By cross –section from West to East relief has following feature: From bottom of valley to slope at the west side highness of relief increases and slope form has terrace structure. It is result if vertical block movement; From bottom of valley to slope at the East side, the relief is high mountains with many high and steep scarps.

In this area the geological formations were intensively deformed, sheared and broken. Here flash flooding usually was to occurrence and seriously damaged Town.

In the future, this area became water lake, so all the Town will be covered by water. The population of the town has to migrate to highland. By influence of rising water, slopes of broken rocks and loose soil became very weak, that why landslide will happen in large scale and threaten people in new settlement.

Conclusion

Based on analyses of all of the condition we have some conclusions:

1. Highway No.12 located in area with disadvantage natural condition, characterized by intensively separated relief forming many valleys deep and narrow, remarkable amplitude of temperature avariation between a day and a night, many big center of heave rain. All of the natural condition express very high potential of landslide.
2. Highway No.12 runs along Dien Bien- Lai Chau fault zone having expressed strongly tectonic activity in Neogen – Quaternary time, so that geological formations were deformed, follated, sheared, broken and returned into loose situation. The features and high seismirity of fault zone are main factor destroying stability of slope and stimulating landslides.
3. Humany activities such as deforestion, opening and straightening highway, leading to erosion in large scale, forming new steep slopes. They are major reasons of flash flooding and serious landslides.
4. All of natural factor and humany activities have formed very dangerous geoenvironmental setting so that highway No12 became hazard and risk for transport in rainy seasons, directly threaten property and life, negatively affect s economic and social development.

References

1. Donald P. Coastes. (1997). *Geology and Society*. A Downed and Culver book.
2. *Environmental risks and hazards, 1994*. Edited by Susan L.
3. *Geological and mineral resources map of Vietnam (Kim Binh-Lao Cai sheet), scale 1:200.000.* Department of geology and minerals of Vietnam. Hanoi, 2005.
4. *Geological and mineral resources map of Vietnam (Phong Sa Ly-Dien Bien Phu sheet), scale 1:200.000.* Department of geology of geology and minerals of Vietnam. Hanoi, 2005.
5. Hue T.T. (2004). *National independent project "Research, assessment on geohazards of Vietnam and hazard mitigations", phase II: the northern mountainous provinces".* Institute of Geology, Vietnam institute of Science and Technology.
6. *Natural hazards mapping*. Report No.218. Geological Survey of Japan, 1994.
7. Price N.J and others. (1990). *Analysis of Geological Structures*. Cambridge University press.
8. Roberts Yats. (1997). *The Geology of Earthquakes*. Oxford University press, 1997.
9. *Statistical report of Lai Chau people's committee on landslide, muddy flood.* Division of Northern Geological Mapping. Hanoi, January, 1996. (in Vietnamese)
10. *Structural Geology Workshop*. Robertson Petroleum Training Centre, 1997.
11. *Wrench fault tectonics*. Selected papers by American Association of Petroleum Geology, 1984.