Mudflows of Central Asia

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Abstract: The types of mudflows in loess soils and conditions of slopes watering are distinguished. Transferring of potential energy into kinetic is esteemed, depending on the mechanism of soils failure, stability of slope and stream movement. The role of a relief, properties, thickness and volume on the velocity and length of the flow is evaluated.

Key words: loess soil, mudflow, process, pressure, movement

Introduction

The mudflows in mountain regions of Central Asia are widespread in loess soils, take place in water rich years, presenting the greatest damage and threat to the life of people. From 165 sites with volume from 0.2 - 1.0 up to 5.0 - 40.0 million m^3 on 30 % has taken place casualties. The mudflows are most dangerous because of sudden formation the movement takes place in a few minutes, high speed of displacement and large extent of propagation.

Results and discussion

The nature of formation of mudflows is connected with landslides, and it's motion with debris flow. At the moment of development of landslide its energy from potential passes to kinetic, therefore mud stream, as the process is defined by kinetic energy. It is possible to distinguish three groups:
To the first group the mudflows are referred, which were formed in canyons, the development starts from bottom to top, the displacement takes place by several breakoffs. The transit area has steep gradient 20 – 30°, large extent 0.8-1.2 km and small width 40-60 m. Therefore displaced masses of soils can't be accumulated directly in this zone, and are propagated downwards by channels of streams to distance up to 3-4.5 km (Saribulak, Beshbodom, Mozorsay).
To the second group are referred mudflows formed in upper parts of canyons, having a steep gradient and large extent of transit area. The sliding masses at impact with valley bed or board loosed sharply the structure, fragmented and simultaneously from shock receive powerful dynamic impulse permitting them to move with considerable speed downwards by channel.
To the third group referred mudflows originated at additional influence of surface water. They are formed in canyons, running into larger streams. The transit area in place of confluence of two beds has flat area, where the ground accumulated and bridges over chan-

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nel of stream. There is accumulation of surface water in lake, then fluid washed ground giving new push to movement of mud masses (Krankul).

The cause of their formation - melting of snow cover, intensive rainfalls and rising of ground water table (GWT). Two types of watering of slopes are distinguished:

I type - the slopes with dominance of infiltration watering - loess soils, which have been broken up by fractures, drain precipitations on depth up to waterproof soils. The surface water discharge concentrates on erosive depressions, located in canyons upper parts.

II type - covering loess soil simultaneously handicap discharging ground water from massif and well occlude precipitations through different fractures, water-worn, contributing to infiltration of surface water on depth. In zone of contact of loess soils with sand layer, boulder beds, conglomerates, chalkstones and other water-permeable soils the overflow of ground waters movement starts.

The watering of slopes is connected with formation of ravine erosion, suffosion and pseudo-karst.

- The ravine erosion - deep, side and regressive erosion, changing height and steepness of ravine boards, and also water collection area is regulating the order and succession of landslide - ravine processes. It is interdependent and interconnected processes. Most active they are developed in zones, where more than 30 years ago have taken place mass formation of landslides. Deep landslides are formed on slopes with deep and steep ravines, draining aquifers. Ravines are more oriented hill up, where the edges of ravine have depression like slopes, favourable for concentration of surface water (Shungak, Mozorsay, Beshkaragach, Khoramsay, Sulisay, Solnechniy).
- Suffosion process is connected to underground erosion in zone of contact of different lithologic layers in the base of slope the undulations producing its slackening will be formed and overlying strata is settled. The zone of slip is nearly flat, on which one the saturated lower strata move up to canyon channel, carrying away less humidified. Shear in overlying soils is not observed or plays secondary role. The hydraulic gradients are changed from 0.25 up to 0.28 on boundary of two heterogeneous soils with intrastratal fluid wash.
- The pseudo-karst process in loess differs from karst by limited area and high speed of development. The fractures, narrow erosive courses promote an infiltration of precipitations in underlayers, in a zone of contact with waterproof soils. The landslides take place with formation of karst falls of semicircular shape. The walls of fall have by perimeter close to vertical value of 18-20 m and identical steepness 87-90°. On slipping surface there is not slip but underground fluid wash.

  The mechanism of soils failure is connected with sharp loss of strength, formation of hydrodynamic pore pressure, thixotropic liquefaction and fragmentation.
- The pore pressure will be formed as a result of troubled access of oxygen to this water, the anaerobic conditions will be formed and the water starts to excrete hydrogen sulphite and methane, producing additional gas pressure. At the expense of increase of gas pore pressure is increased, and in zone of slip the strength of soils is diminished. At occurrence of fractures there is separation of dissolved gas and formation of explosion, since the restrained gas demands larger volume at output. Origin of explosion and diabrotic smell was repeatedly remarked at displacement of large landslides-flows (Kynar).

Liquefaction takes place at seismic motion on flat slopes in saturated sand-clay and loess soils. In loop system, between two aquicludes, on depth the pore stress will be formed, soils are passing instantaneously from three-phase into a two-phase state. There is one-time displacement, and mud mass flows out from zone of origin, forming gletcher shape mudflow (Okuli-poyon).

- The fragmentation is formed at slope, when boundary of landslide developed, mass of soils is prepared for displacement, however, main movement does not take place. A trigger for beginning of landslide is the resonant effect as a result of simultaneous climbing on slope of two bulldozers. At natural moisture 22-24 % takes place instantaneous fragmentation of loess soils on small-sized comas (3-5 cm) and all mass is simultaneously slipped. The angle of exit of slipping surface is identical for different types of failure and nearly 4-6°, and don't depend on initial strength.

Table 1. Mud flows formed in Central Asia

№	Site name	Initiation date	V, мм^3	L, m	H, m	t
1	*Shungak*	12.03.69	4.5	1.5	1.0-1.5	15-20 min
2	Karankul	20.04.69	5.0	3.3	3.0-5.0	2 day
3	Zarkent	05.05.69	0.5	0.9	1.5-3.0	10 min
4	Mozzorsay	12.06.69	0.9	3.1	1.5-2.0	10 hour
5	Kaynar	25.07.80	0.2	0.8	1.5-2.0	8-10 min
6	Pustinlik	20.03.90	2.5	1.6	3.5-4.5	30-40 min
7	Jauz	11.07.93	0.6	1.1	8.0-13.0	5-6 min
8	Beshkaragach	18.03.94	1.0	2.0	2.0-3.0	1.5 hour
9	Kashkasay	21.03.94	0.6	0.8	2.0-3.0	20 min
10	Khoramsay	28.03.94	0.8	0.8	1.5-2.5	10 hour
11	Karakishlok	16.04.94	0.8	1.6	1.5-2.0	2-3 min
12	Sulisay	27.11.94	2.0	3.1	2.5-3.5	2 day
13	Nishbash	04.04.95	0.5	1.8	2.0-3.0	30 min
14	Langar	12.05.98	22.0	2.0	8.0-10.0	18 day
15	Kayragach	17.04.99	2.8	1.1	3.0-4.0	15 day
16	Sharkilama	17.04.02	0.7	1.1	1.0-1.5	20 min
17	Solnechniy	10.12.02	0.9	2.1	0.8-1.2	40 min
18	Yaldomich	31.05.69	1.2	4.2	0.5-1.0	10 min
19	Okuli-Poyon	23.01.80	40.0	7.0	1.5-2.0	10 min
20	Besh-Bulak	19.04.94	15.0	5.0	2.5-3.0	40 min
21	Novoabad	27.05.96	30.0	5.0	1.5-2.0	20 min
22	Besh-Bodom	13.03.69	5.0	4.0	2.0-3.0	15 min
23	Sari-Bulak	27.11.86	4.5	4.0	2.5-3.5	4 day

By the mechanism of movement the mudflows referred to mixed type, i.e. slip passes to flow. By succession the displacement are subdivided into one-time, series with numerous breakoffs in short time interval and large separate breakoffs with large time period.
Mass of soils is in very fragmented state and moves as viscous-plastic or viscous-flow media. The transferring of potential energy into kinetic is permanently controlled by canyon bed. Nature of mud masses movement is pulsation-translational, and the initial velocity much more exceeds final, average speed of movement is from 1.0 up to 3.5 m\s, maximum - 8.0 m\s. Propagation velocity depends from turbulence factor (K = 0.7-1.0).
At the beginning phase of displacement the landslide consists from two strata – the upper is low humidified (12-17 %) and lower - water saturated (28-32 %). During movement at the expense of additional shocks on canyon bed and boards, mass is displaced and becomes more homogeneous. The analysis of moisture values and density measured after flow stop has shown, that they vary within the limits 4-6 %. The gripping of new material from channel bed does not occur, the much more volume remains on channel boards, cushions its undulations and decreases friction of driving mass. The volume of a mudflow is usually 60-80 % from volume of landslide. The length is 30-50 times exceeds its width, thickness of 2.5-3.0 m. The increase of soils moisture affects on viscosity decrease and propagation velocity value, but does not make influence to the length of flow. The growth of volume of dislodged soils does not influence to speed-up, but augments extent of mudflow. On sites, where mud mass bridges over canyons will be formed small lakes, with volume from 30-40 thousand up to 1.0 million m^3. The water in such lake is step-by-step filtrated and in 10-20 hours or few days wash out fall of ground.

CONCLUSIONS

1. The synchronism in time of landslides – mud flows formation and time of spring temperature rise, melting of snow, maximum precipitation and springs discharge or ground water table rise is connected with closeness of the ground water feeding and discharge zones to each other.
2. The initial processes - ravine erosion, suffosion, pseudo-karst presents paragenetic connection with site and nature of watering of landslide.
3. Despite of different conditions of soils failure - underground fluid wash, liquefaction, fragmentation, shear slip has the secondary role and does not depend on type of failure and initial strength.
4. The extent of mud flow depends from volume of landslide, the average speed is varied from 1 up to 3.5 m\s, the thickness is slightly varied lengthwise of flow and not exceed 2.0-3.0 m.

Acknowledgements

This work was supported by the Science Technologies Center of Coordinating Council for Science and Technological development of Cabinet of Ministers of the Republic of Uzbekistan. Grant 23/01