the affected areas and zonation by the degree of mud flow hazard. On developed and undeveloped territories of Arshan and its environs, hazardous, potentially hazardous and non-hazardous areas have been distinguished. A map of mudflow hazard is necessary for sound management of the territories and for further sustainable development. Availability of large-scale charts (maps, plans) of mudflow hazard zones of the territory will allow to work out full measures that contribute to protection of the population and infrastructure from mudflow processes. The works are intended to prevent and or reduce economic losses by development of natural hazards. In the future, there is need to develop limitation plan schemes to the general plans of Arshan village, which allows to determine the impact of mud flow on economic facilities, to select the location for reliable and safe facilities.

In conclusion, it should be noted that the mud flows in Arshan village on June 28, 2014 may serve an example of natural disasters that should be considered when selecting and evaluating engineering construction sites by the degree of hazard. The caused economic damage from the mudslides in the village is conditioned by the geographical location (Arshan settlement is situated at the altitude of 893 m at the exit point of the Kyngarga River on the northern outskirts of the Tunka valley at the foot of the southern slope of Tunka bold mountains) as well as by geological and geomorphological features (the village occupies a part of ancient alluvial fan of the Kyngarga River and the streams, flowing into it from the east and originating from the kar valleys filled with moraine sediments). The devastating mudslide formed as a result of high intensity rainfall in the mountainous region. The depth of freezing and thawing of seasonally frozen layer at the top of the mudflow source is an important factor in formation of the solid component of the mudflow. Fall of the same amount of precipitation in July and August contribute to even larger potential mudflows. Integrated monitoring of the geological environment, development and implementation of early mudflow protection measures are required.

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ALGORITHM OF NATURAL CATACLYSM IN SE ALTAI AT THE PLEISTOCENE/HOLOCENE BOUNDARY AND ITS EFFECTS ON GEOSYSTEMS DYNAMICS

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Introduction. Current available information about formation and degradation of the Chuya-Kurai glacial system has been systematically analyzed, based on the results of scientific research carried out by different authors in different years, funded by RFBR grants (No. 01-05-65151;. 01-05 -79087; 02-05 -79185; 05-05 -64182; 08-05 -00037; 13-05 -00111) and scientific programs of the Institute of Monitoring of Climatic and Ecological Systems (IMCES SB RAS) and the Tomsk State University. This article gives a critical review of extremely controversial and contradictory statements advocated by their authors [1, 2] in violation of basic principles of research in the area of natural processes dynamics – before giving characteristics to some natural phenomena, its genesis must be determined. Incorrect views on the problem and ignoring objective, well-known laws of geosystem dynamics has led some authors to extremely controversial, contradictory conclusions, leading away from scientific truth.

Scientific facts forming the base of the new interpretation of formation and degradation processes occurring in the Chui-Kurai glacial system are the following.

1. Abrasion-accumulative forms of relief. The genesis of benching is determined by strict consistency of altitudes around the Chuya-Kurai basin perimeter, their well-planned configuration, which naturally varies depending on the slope steepness; the presence of accumulative breaking waves, formed by detrital sediment sorted by its hydraulic size; the presence of lagoons boarded by channel banks and other factors.

Conclusion: emptying of the lake occurred gradually and at an almost uniform pace [3, 4, 5]. Water discharge from the lake ($Q=S(t.h)\cdot h$) was gradually decreasing from its maximum Q_{max} = 79.8 m^3/s during the highest level period, to its minimum Q_{lim}, = m^3, at the stage of final emptying of the glacial lake [3].

Conclusion: emptying of the lake occurred gradually and almost uniformly [3, 4, 5], at some almost uniform pace. The flow rate ($Q=S(t.h)\ h$) was gradually decreasing from its maximum Q_{max} =79.8 m^3/s during the highest level period, to its minimum Q_{min}=1,27 m^3/s, and to Q_{lim} = 0 at the stage of final emptying of the glacial lake [3]. At the same time, the total water discharge of the Chuya River have been rising up to 80-90 m^3/s due to increasing water yield from tributary valleys releasing form ice, and from ice melting.

2. The problem of "gigantic ripples" from the point of view of systematic analysis of genesis. Analyzed facts [5, 6]: spatial patterns of surface dissection in the Kurai basin, longitudinal profiles of thalwegs in inter-ridge depressions; well-planned dissection of the basin bottom. Analysis of the ridges lithology was conducted, classification of the detritus forming the ridges, by its hydraulic size,detailed geomorphological analysis of the basin, its bottom and surrounding spaces. Study of the Chuya river bed slope correlation with the basin bottom altitude was done, as well as the analysis of the longitudinal profile of supposedly existed ancient high-speed water current (50 m/s at the depth of 400 m). Such current, according to peremptory statements of some authors [7], created a giant whirlpool within the Kurai basin, which, in their opinion, was the only possible cause of "giant ripples". The poriness ratio of moraine deposits was estimated with the purpose to quantify the volume of water accumulated in the deposits and its subsequent draining towards the basin boarders (eastern and southern), which led to the development of brook-type erosional dissection of the surface. Detailed (in 1:5000 scale) geomorphological survey of the Kurai basin was performed, with geological description (and granulometric analysis) of the ridge cross-sections by opening them with excavations of 1.5 - 2.0 m in depth, etc.

Conclusion. All these, recently published works violate a generally accepted fundamental methodological principle of research for scientific truth – first and foremost, the genesis of natural phenomenon or object must be determined. Violation of this principle inevitably implies unreliability of the suggested theory and highly questionable form of evidence. Formation of a whirlpool in geomorphological conditions of the basin, leading to the formation of ridges as the bottom-type form of detriment movement, contradicts to the laws of hydrodynamics. First of all, the ridges morphology is not consistent with the typical morphology of ridges formed in high-speed flows. Secondly, there are no signs of alleged existence of the gigantic flow, especially on its rounding parts. Thirdly, the longitudinal profile of this "flow bed" is characterized by variations of relative heights counting hundreds of meters (up to 200 meters!). Hence, at the protrusions of longitudinal profile, according to the laws of high-speed currents, the flow bed should contain ravines, with some layer of sediments accumulated in the lowerings. We conducted a research for their existence, and no such facts were found.

The ridges were formed by a complex of processes [5], by mostly temporary watercourses leading to the formation of thalwegs with plumos-type graphic patterns. The water source came from the morain sediments, which porosity reached 25%, and from on-surface sediments.

3. The question of functional connection of water filling of the basin and the ice dam formation. Publications, analyzed by us, attach no importance to this issue, as it is believed that the dam was formed by intersection of the Chuya river valley by the glaciers of Maashey, Chibitka and other valley glaciers coming down from the Kurai Ridge [3, 4]. According to this position, formation of the ice dam and filling of the basin did not occur simultaneously: first the dam was formed, and then the water basin. It is possible to physically substantiate this phenomenological model by assuming that catastrophic sliding of glaciers took place, for example, due to a powerful earthquake or to any other similar phenomena, which caused formation of a dam of 700 m in height. This variant cannot be excluded, but it is not the only possible one. In our article and report, planned for publication, we discuss yet another variant – simultaneous filling of the reservoir and increasing the dam height due to accumulation of ice on its surface. The process was very similar to those currently occurring in mountain river valleys in Siberia and the Far East. The described mechanism for the dam formation is more probable than the first one, as it is backed up by the facts: absence of large masses of large-sized blocks of moraine material at the boarder where the ice dam met the water mass [3], as it should have been in case of the first variant of the dam formation.

The dam destruction. As it was found by other authors [3, 4], the dam's width was about 15 km and its relative height was over 700 m. (If we take into account the Chuysky glacier in the valley, which is a natural continuation of the dam, then even more.) The dam's fast, but not instant destruction, would be possible due a powerful earthquake. This variant, however, is incontrovertibly excluded. Benching and terraces, surrounding the perimeter of the Chuya-Kurai basin, definitely are of abrasion-type origin [3, 4, 5, 6] – this is a scientifically and practically verified fact, as well as the fact that the lake's runoff was even. It is clear that non-recognition of this fact is due to a firm belief into infallibility of the idea [2].

Conclusion Formation of the ice dam on the Chuya-Kurai glaciosystem was one of the exceptional (at least, rare) phenomena. It is a result of interrelated processes of the water flow damming by the ice dam in the conditions of a very slow river runoff (due to ice filling of the river valleys) and freezing processes occurring in the dam and the glacier located behind it. The dam destruction happened as a result of natural process of the water current immersion into the glacier body, due to global warming and water flow increase.

4. The question of functional interconnection of the basin emptying processes and erosion-accumulation processes in the downstream current. All publications [1, 2] devoted to the Chuya-Kurai geomorphological phenomenon describe the dynamics of the Chuya-Kurai water basin emptying as a result of functionally disconnected processes, acting by the following scheme: formation of the dam by valley glaciers – formation of the lake – a uniform runoff of the lake, accompanied by the formation of abrasion benches, which were simultaneously modelled by the lake's ice – climate warming, increased river runoff – water reservoir overflow – formation of water flow in the damming glacier. Further on, this logical and generally agreed dynamics is presented by some authors with violation of the overall logics of hydrodynamic and erosion-accumulative processes and their functional relationships. Strange as it may seem, but the fact that the entire layer of sediments in the Chuya river downstream was formed at the instant breakthrough of the lake, is considered as indisputable. It is strongly and not rightly argued that the flow rate in the stream was [2] "... 50 m/s and more ...", and the flow depth was 400-500 m! In this flow, as this author states, the layers of *parallel layered* sandy/silty deposits were accumulated, with the layers' slope of up to 2° towards the direction of the river flow. We have conducted a research and proved the presence of cross-bedding in the sections, as a reliable fact testifying that the stream was meandering, which is also confirmed by the presence of erosional terraces in these valleys. Obviously, known patterns of erosion and accumulation processes are not taken by these authors into account, such as the following: 1. Saturation of a water flow by weighted and transported detrital material up to some critical value is accompanied by its accumulation and formation of a convex longitudinal profile. 2. Formation of terraces at the river entrenchment occurs only in the event of simultaneous river bed offset in the horizontal plane. 3. Cross-bedding of alluvial deposits is a reliable evidence of the migratory meandering channel. 4. Flows of high current speeds do not meander, and the presence of incised meanders testifies to the river entrenchment due to tectonic tilt of the surface towards the direction of the current.

Algorithm of erosion and accumulation processes dynamics in the downstream current. Formation of a glacier dam has caused a significant decrease of water flow in the downstream current, with a deficit of detritus in the flow bed. This has resulted in the river entrenchment and deepening of valleys in downstream parts of Chuya and Katun rivers. Development of erosion and accumulation processes during the ice dam destruction occurred in several stages.

The processes algorithm. The first stage – beginning of the dam erosion and ablation of glaciers. Climate warming → increase of water flow in the Chuya-Katun basin → water overflow through the dam → formation of concentrated water bed in the glacier (average annual flow rate, which led to the reservoir level lowering up to 1 m/year, and according to the only trustworthy data presented by P.S. Borodavko [3] in his nomogram, was 80 m^3/s) → flow rate and flow velocity increase (due to melting ice) in the downstream part → flow saturation with moraine material up to some critical value P_{lim}, when the transported material traveled mainly in the form of slurry muddy-rocky flows, with subsequent layers creeping over the previous ones. Thus, the layer of sediments was formed, where a series of terraces was cut, as observed today in the lower reaches of the Chuya river, having a relative height of 90 meters from the water level. The aligning process for the river longitudinal profile in its downstream current has started, with reduction of its slopes and the flow transporting capacity → which led to the accumulation rate increase (positive feedback)

The second stage of the process started with a sharp decrease in the flow rate, due to the reduction of water levels, accumulated in the lake, down to 1800 m and a sharp decrease in the lake surface area – from 2660 km^2 to 500 km^2 (nomogram [3]). The flow rate from the lake was 16 m^3/s. In the downstream part of the glacier, its surface area increased (due to its dissection), total water flow also increased (presumably, it was no less than the current modern level – 42 m^3/s), as well as the amount of transported solid material. The slopes of the Katun and Chuya rivers longitudinal profiles were being reduced, which led to the increased debris accumulation rates. The major part of debris consisted of crashed stony and gravel material. Sporadic muddy-stony flows were formed. These sediments correlate with the cuts on the terrace complex of Chuya and Katun rivers of up to 150 m in height (abs. alt. 894 m, with a total deposit layer thickness of 246 m).

The third stage. The ablation processes in the Altai glacier basin were accelerated, causing a significant increase of water flow and debris amount in the Chuya and Katun river basins. Due to the continuing decrease of longitudinal profile slopes of the valley bottom, planned river channel deformations increased, with simultaneous erosion of the slope sediments, consisting of boulders, crushed stone and sand material. From each 1 km of the valley, the river beds received at least 3 mln m^3 of debris of various sizes. Assuming that each 100 m^3 of slope sediments contained at least one boulder (rock fragments over 1 m in diameter), the alluvial deposits filling the valley contained up to 40,000 boulders per 1 km.

The deposits of this stage contain terraces with a relative height of 200 m (altitude of 944 m).

The fourth stage – culminating accumulation of deposits and filling the Katun and Chuya valleys with fluvioglacial and diluvial sediments up to an altitude of 990 m. This is the highest level of alluvial deposits accumulation, which we have noticed. They markedly differ from previously deposited material by a higher sorting level of debris, mainly represented by small and medium pebbles with silty filler. They are characterized by parallel layering of sediments and high (almost maximum) roundness of the composing material. The bottom of the Katun and Chuya valleys at that time represented an accumulative alluvial plain with numerous flow-though lakes, similar to oxbow lakes. Its modern analogues are accumulative valleys – sandurs, formed in periglacial areas of Aktru glaciers (upper river Aktru) and the Taldura river, which are fed from the Taldurinskiy glacier. Averaged many-years accumulation rate on the Aktru sandr, which we measured using 180-year-old larche trees, growing here, was 65 cm. Thus, the sediments accumulation rate on this sandr was, not considering the amount of removed suspended material, 0.35 cm per year. Based on these data, we calculated that the sediments must have been accumulated for minimum 703 years, in order to form the thickness of 246 m! Longitudinal profile of the accumulative plain, down to the lower reaches of the Katun river, was leveled and had a slightly convex shape.

Insertion of rivers and formation of terrace complex on Chuya and Katun rivers. The directional river insertion process was preceded by a short-term stabilization of the river level at altitudes of 990 and 954 m (246 and 210 m in relative height, respectively). Both of these events were marked by the formation of channel banks (natural levees). Natural levee at an altitude of 954 m, where it connects with the core slope, has a height of 6-7 m in its proximal part and a width of 50 m; the levee at an altitude of 954 m has a length of 1200 m and the heights of 25-30 m in its proximal part. This channel bank fences the lowland, where the lake was located previously. The bank is split by the washaway channel, serving as a way out for the water accumulated in the lowlands detached by the bank. Medium-sized channel banks consist of pebble of the 3-rd class of roundness, detritus and rotted rock. There may be 2 causes for the stabilization of river bed levels and formation of channel banks: The first cause – a constant flow of water and debris in the stream due to its own conditions; the second cause – stabilization of erosion basis, which was formed by the receiving river channel – Katun, in this case. However, given the fact that high, morphologically well-defined channel banks are present along the entire Katun river channel, it is possible to state that the formation of channel banks in the Chuya river valley was connected with stable paleogydrodynamic situation in the Katun river valley and occurred in a synchronous manner. There is no doubt that, at this stage, it was the Katun river that governed those erosion and accumulation processes, happening both in its upper and lower reaches. And the erosion basis was located at the level of the modern accumulative plains, which were covered by water at that time, according to all scientific data. Modern high terraces on the Katun and Biya rivers are tied to this very level.

The question of boulder placers formation All publications characterizing the Chuya-Kurai geomorphological phenomenon and describing the processes of the relief history development [1], pay special attention to the formation of large-size boulder clusters on the Katun river terraces. The authors of the theory of catastrophic draining of the Chuya-Kurai basin mistakenly attribute the presence of these clusters to the existence of a high-speed water flow [1, 2]. In reality, boulder clusters on the terraces are typical stone deposits that were formed simultaneously with the formation of rivers and their terraces. The mechanism of their formation is well known. It is associated with the deposition of individual boulders during the accumulation of alluvial deposits layer in the valley. Later on, along with the river entrenchment and the formation of terraces, concentration of the material has been naturally increasing. Otherwise, we see an inherent inconsistency with the laws of hydrodynamics: in a stream with a flow rate of 50 m/s, structurally ordered parallel-layered and cross-bedded deposits, sorted by hydraulic size of 0.005-0.04 m/s were formed simultaneously with the transport of large boulders weighing several tons and having 100-1000 times larger hydraulic size, compared to the fine sorted material.

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IMPACT OF EXTREME RAINFALLS ON RECENT RELIEF TRANSFORMATION OF THE UPPER PINDARI VALLEY, KUMAUN HIMALAYA, INDIA

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The upper Pindari River Valley is situated in the southeast of the Nanda Devi massif in higher reaches of the Kumaun Himalaya. Nowadays, the glacier belt in the valley extends from about 4,000 m to over 7,000 m a.s.l. The geological structure is characterised by high lithological diversity of crystalline rocks. The monsoon current penetrates the valley from June to September, when the most of the rainfall precipitation occurs.

The geomorphological mapping was done there during field expeditions in 2012, 2013 and 2014. The satellite images were used as the background. The studies focused on the glacial relief within the valley floor, relief transformation after glacial retreat and morphogenetic processes responsible for relief transformation were. Valley is a asymmetrical glacial trough. Glacial landform is well preserved in the uppermost part of valley, where set of frontal and lateral moraine ridges is identified. In its lower sections the glacial relief is buried under talus cones, fluvioglacial cones and debris flows accumulation. It indicates high activity of morphogenetic processes in post glacial period and nowadays.

The most significant changes in the relief at present are effects of extreme monsoon rainfalls. Such precipitation occurred in the investigated region in June 2013 and peaked on 16–18 June. The three-days totals, in the nearest meteorological stations to the upper Pindari Valley, reach about 50% of summer rainfalls totals. The highest intensity of rainfall in the middle part of the valley could reach 300 mm $hour^{-1}$ according to the personal communication.

Resulted changes in the relief encompass both slopes and valley bottom, from the uppermost part up to mouth of the valley. Debris flows and landslides were triggered or