CAVES GRAVITY DEPOSITS

JAMSKI GRAVITACIJSKI SEDIMENTI

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Andrey G. Filippov: Jamski gravitacijski sedimenti

V jamah so najobsežnejši gravitacijski sedimenti. Mogoče jih je klasificirati po genezi na dva načina: glede na prevladujoči proces in glede na dinamično obliko transporta teh sedimentov. Avtor predlaga klasifikacijo po prvem načinu, in sicer jih deli na 11 razredov, nekatere razrede pa še na podrazrede.

Ključne besede: speleologija, jamski sedimenti, jamski gravitacijski sedimenti

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Andrey G. Filippov: Caves gravity deposits

Gravity deposits are the most common sediments in the caves. There are two approaches to their genetic classification: according to leading process and according to the dynamic form of their transport. The author propose the classification based on the first approach. Caves gravity deposits are classified into 11 classes, some of them are subdivided into subclasses too.

Key words: speleology, cave sediments, cave gravity sediments

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Exploitation of karst caves as excursion objects deals inevitably with the estimation of steadiness of walls, ceilings and investigation of collapse process. Gravity deposits are more distributed in karst caves , but their state-of-art is still under investigation. Considering the influence of gravitation on sedimentation on the whole and on the cave deposition in particular, it is necessary to recognize that practically all the deposits are "gravity" ones to some extent - i.e. they have the traces of formation under the conditions of Earth gravity.

However, more vividly and obviously the influence of gravitation in the caves are shown with the formation of breakdown accumulations and as well as of deposits forming on inclined sites of floors, walls and at their foots in result of desplacement of destruction host-rock products under the influence of their own weight. Gravitation is the only force determining their formation directly without participation or with insignificant participation of other forces.

Hence, gravity cave deposits are clastic accumulations forming in caves under the influence of attraction as a result of breakdown, crumbling, slipping, shifting on inclined sites. In Russian speleological literature there are two methodological approaches to genetic classifications of cave deposits:

1) division of genetic types and subtypes according to leading process which prepares and/or stipulates substance release for further gravitation transfer (for example, thermo- and seismogravity deposits of V.N. Dubljansky, 1977, desquamation accumulations of V.P. Dushevsky, 1989),

2) division according to dynamic form of transport and accumulation of desintegrated stuff - in other words, the genetic types in conception of E.V. Shantser (1966) (for example, cave colluvium of R.A. Tsykin, 1985 classification, breakdown deposits of G.A. Maximovich, 1963 and D.S. Sokolov, 1962). Both approaches are correct, and, moreover, they supplement each other.

The following genetic classification of cave gravity deposits based on the first approach is proposed:

1 - thermogravity;
2 - frozen gravity;
3 - ice gravity, connected with breakdown of:
 a) thawing tongues of ice,
 b) alien inclusions thawing from ice;
4 - desquamation gravity;
5 - desquamation corrosion gravity;
6 - hydration gravity;

7 - crystallization gravity;
8 - corrosion gravity:
 a) seepage corrosion gravity,
 b) condensation corrosion gravity,
 c) aquecorrosion gravity;
9 - deposits initiated by rock pressure which forms at domes (arch) and walls falling in result of:
 a) removal of buoyant force of water,
 b) excess of glaciostatic pressure;
10 - seismogravity;
11 - technogenic gravity.

Thermogravity deposits described by V.N. Dubljansky (1977) are formed in the entrance part of the caves due to daily changes of air temperature. They are widely distributed. They are built of debris of 1-100 mm size with admixture of biogenic materials (mammal bones, shells of terrestrial molluscs, dry leaves, etc.). The thermogravity accumulations which were formed in kataclastic and kakiritic carbonate rocks, in thin and middle flaggy limestones are the thickest and are more distributed around the area. The examples of such caves are Irkutskaya and Aikta in Eastern Siberia.

Frozen gravity deposits are formed in the entrance part of caves owing to the transition of host-rocks temperature across zero. Debris are mobilized by the splitting action of ice formed in the result of water freezing. Debris chipped off host-rock fall down on the floor after ice melting, forming clastic accumulations . The sizes of clasts depend on the splinterness degree of host-rocks. Block accumulations are formed in the entrances developing in massive and thick bedding rocks more than 0,5 m thickness. The example is Stary Zamok cave on Birusa river, East Siberia. Clastic accumulations with debris of 1-100 cm size appear in the caves developed in the middle and thin flaggy rocks (Oyusutskaya-9 cave, Yakutia, A.G.Filippov, 1988).

Ice gravity deposits are of debris accumulation character which are formed in result of breakdown, gliding of some parts of underground and surface glaciers, "naleds" and the alien inclusions thawing from ice. The last ones are residual ice gravity deposits. Usually, they are built from debris of host-rocks, of flowstones and popcorns, of animal bones and trees, and redeposition soil. Moraines of cave glaciers also belong to ice gravity deposits. As a rule, pressure and spreaded moraines consist of nonsorted accumulations forming the base of dirty layers in glacier body (Dmitriev, 1980). A great amount of plant detritus is found in them. The examples of such deposits are moraines of Bidginskaya and Vinogradovskaya caves, Kuznetsky Alatau, Siberia (Dmitriev, 1980). Ice gravity deposits consisting of accumulations of ice debris are non-longlived ephemeral formations. They are formed due to ice collapse in the result of cave glaciers and naleds melting as well as due to increasing of their weight by freezing. The example is Scarasson abyss, Italy. M. Siffre (1982) described numerous ice falls of this abyss.

Desquamation gravity deposits are formed due to thermal and moisture interchange between air flows and fissured bed rocks. Alternation of damping and wasting of rocks brings to flags exfoliation and their falling down to the floor. V.P. Dushevsky (1989) was the first who discribed such deposits in the short caves of the Crimea. Desquamation gravity accumulations consist of flaggy debris with size from 1 mm to the first tens of centimetres. Debris with the size from 1 to 10 cm prevail in the Crimean caves which are formed in sandy and marl limestones. Debris with the size from 1 to 10 mm prevail in the caves which are formed in bedding lime sandstones. Debris with the size more than 1 cm are accumulated in blind alley parts, where the maximum velocity of weathering is observed. In the middle parts of the short caves (between the entrance and blind alley), thin and frail lamellas and crusts exfoliate. They fall down to the floor reduced to dust and sand.

In many cases, it is practically impossible to distinguish the influence of periodical damping and wasting, temperature weathering and the splitting action of the frozing water on separation of debris from the walls and ceiling without special investigations.

Desquamation corrosion gravity deposits are typical to dry-gallery stage of cave development. They are accumulations of debris of flowstones, crusts of "aqual" crystals and corallites. Usually, crusts splitting off from walls and ceilings of caves occur in weakening zones from 5 to 50 mm deeper than the contact with karst rock. According to data of V.M. Philippov (1987), in marbles this zone is presented by strongly dissolved cavernous materials with cavities filled with clay. In the bedded limestone-dolomite rocks these zones are formed from friable small-dispersed carbonate-terrigenous substance. Rocks of dissolution zone posses sharply reduced solidity, which stipulates the formation of fissures and crust splitting off. The reason of karst rock lixiviation on the contact with flowstones and other crusts lies in the existence of more favourable conditions for filtration of waters which are exudated from karst massive by fissures and pores (Philippov & Ovodov, 1989). The size of split flowstone crusts varies from 1 to 50 cm depending on initial thickness of crust, on height falling, on degree of flowstone crushing before splitting, and on character of the deposits on the floor.

Hydration gravity deposits are formed in the caves which were developed in gypsum-anhydrite, gypsum-anhydrite-dolomite, anhydrite-aleurolitic and similar rocks due to hydration of anhydrite. Gypsotization is often accompanied by increasing of rock volume from 30 t0 67 % (Pisarchik, 1958; Strakhov, 1962). It makes additional pressure and may cause collapse of cave ceilings and walls. Increasing of rock hydration causes decreasing of rock solidity and also favours collapses.

Crystallization gravity deposits are stipulated by crystallization of gypsum within the limestones from underground waters which are rich in sulphates.

Such flaggy and splintered accumulations are known in the Mammoth cave, USA (Ford & Williams, 1989).

Corrosion gravity deposits are formed due to collapse of ceilings and walls as result of solution of karst rocks. The influence of underground water of different genesis causes accumulation of nonidentical material. Aggressive infiltration of descending waters dissolving the rocks along fissures weaken ceilings. It stipulates collapse of ceilings and appearence of seepage corrosion gravity deposits on the floor (Argarakanskaya cave, East Siberia).

The dissolution of walls by condensation waters may produce numerous flaggy and splintered breakdowns in good aerated caves as noted D. Ford & P. Williams (1989). Such condensation corrosion gravity deposits are widely distributed on the floor of Aya cave in Siberia. These deposits are of marble crumb, which was formed due to release of calcite grains on ceiling and walls of the cave as the result of broadening of intergranular cracks by aggressive condensate waters.

Another kind of condensate corrosion gravity deposits is gypsum "snow" distributed on the floor of gypsum caves. According to observations of V.A. Maltsev & I.I. Turchinov (1989), the growth of small gypsum crystals (up to 3 mm) take place on ceilings in summer due to crystallization from capillary pellicle of unsaturated gypsum solution. In winter, under conditions of more air humidity, the crystalls partially dissolve and completely crumble to the floor forming the accumulations with thickness up to 5 cm. They are better studied in Jurinskaya cave in Podolia, Ukraine (Maltsev, 1990).

Aqueocorrosion gravity deposits are formed as the result of corrosion or corrosion-erosion separation of debris from bed rock, e.g., the separation of pendants, of overhead covers between cave levels, and of channel walls at their curves, under conditions of phreatic movement of water flows in siphon circulation zone. The deposits are rounded or smoothed out blocks with diameter of 0,3-1,5 m. Usually, it is impossible to find the separating place on cave roof or the walls. Such blocks were described in Spasskaya, Ledyanaya, Kolodets, and Kolonok caves on Russian Far East (Bersenev, 1989).

In some cases, gravity deposits in caves are formed when rock pressure amount exceeds the limits of cave roof steadiness. These phenomena can take place at the transition of cave from phreatic zone to vadoze zone owing to removal of buoyant force of water. Drainage of caves is a regular process at uplifting of karst massives, cutting in of rivers, lowering of ocean and sea level in glaciation periods, changing of river course, and lowering of underground water-level as the result of pumpings during exploitation of quarry, mines. Gravity deposits formed in the result of removal of buoyant force of water may be determined only hypothetically and in rare cases by detailed studies.

J. Schroeder & D. Ford (1983) suggested that in caves developing under glaciers the extensive breakdown may occur owing to repeated loading and unloading of glacier weight plus uneven application of shearing stresses, as flowing glaciers have waxed and waned overhead on the example of Castleguard cave. Probably, release of pressure by spalling is typical of caves in many formerly glaciated terrains (Ford & Williams, 1989).

Seismogravity deposits were described by V.N. Dubljansky (1971) as breakdown deposits subtype in karst caves and shafts of the Crimea. Criteria relating to seismogravity deposits are large sizes of blocks (weight to 100-200 thousand ton) and shifted and fallen stalagmites and columns with diameter 4-6 m and length 8-10 m. Undoubtedly, identification of seismogravity deposits is debatable and rather subjective.

Technogenic gravity deposits are stipulated by economic activity of man both in caves and on the surface. Technogenic gravity deposits are formed as the result of breakdown of roofs of halls and of cave passages, as well as breakdown, pouring out of material from geological organs because of technogenic earthquakes (explosions in the quarries, etc.), of weight of heavy machinery. The example of man's activity in caves is the layer of limestone debris on the bottom of underground river Punkva in Punkevni cave, Czech Republic. This layer was formed while spalling the rocks from ceiling by blasting operations.

Genetic types of gravity deposits which are similar to surface ones (Manual on methods.., 1987) may be distinguished according to type of exogenous process of transfer and accumulation in caves. They are: colluvium (subtypes: deruptium, desperium); and solifluction formation (subtypes: tardofluxium, congelifluxium, defluxium).

Deruptium (from Latin "deruptus" - "steep") is a breakdown nonsorted agglomerate, built of blocks. They are formed in the result of collapses of roof, walls, interlevel spaces. Deruptium is especially characteristic for sites of crossing or close situation of few fissures. It is the most distributed genetic type among gravity deposits.

Desperium (from Latin "despero" - "to pour") is talus formed from debris 0,1-1,0 m in diameter. Bad sorting of accumulations is often observed: debris are smaller in upper part of talus and larger in the lower part. In some cases, talus is "live," i.e. it creeps down. In other cases, they are anchored by calcite flowstones or clays, or seasonally by ice. Formation of desperium is stipulated by rolling of debris on steep planes (20-40°). It is widely distributed both in interior parts of the caves, and exterior ones.

There are deposits of warm (defluxium) and cold (tardofluxium, congelifluction) solifluction formation.

Defluxium (from Latin "defluxe" - "to flow down") is formed in the result of clay transfer on vertical or steep inclined walls, more rarely on inclined floors of caves by action of attraction under conditions of intensive moisture. Clay deposits with slip ripples on the walls of Kurtuiskaya shaft, Prisajan territory, Eastern Siberia, are typical examples of this genetic subtype. These clays are washed away by infiltration water from subsoil layers and are transported along joints into the cave where they "flow down" by walls gradually.

Congelifluction (from French "congelation" - "to freeze") formations are deposits formed as a result of desplacement on contact of frozen and melting rocks under the influence of gravitation. Rocks have tough fluid consistency on the contact and tough plastic consistency above it. They are formed under permafrost condition in exterior part of caves on steep parts of passages (10 -30°) in zone of temperature Earth surface influence. Congelifluction formation often forms rock rivers, the bases of which are frozen into ice or soil. Presence of bent clay layers and lenses is characteristic for small-debris types of congelifluction cross-sections.

Tardofluxium (from Latin "tardos" - "slow", "fluxus" - "to flow") is solifluction formation formed at slow displacement of tough fluid soils down cave floors with steepness of 2-10 during variable freezing and melting. Tardofluxium is found in cave entrance parts in surface temperature influence zone.

Gravity deposits are regular and integral components of cave environment and cave landscapes. In some cases they are of great scientific value, especially in the exterior cave parts, as a source of information for paleogeographic reconstruction and as receptacles of palaeontological remains.

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JAMSKI GRAVITACIJSKI SEDIMENTI

Povzetek

V jamah, ki so cilj ekskurzij, je treba nujno preučiti tudi stene, strope, stabilnost in podorne procese. Največ je gravitacijskih sedimentov, vendar ni dovolj, da zgolj zabeležimo njihovo stanje. Genetsko jih je mogoče klasificirati na dva načina: glede na prevladujoči proces, zaradi katerega nastajajo ti sedimenti in ki vzpodbuja njihov transport s pomočjo gravitacije, in glede na dinamično obliko transporta in akumulacije razpadlega gradiva. Avtor predlaga klasifikacijo po prvem pristopu, glede na prevladujoči proces:

1. termogravitacija;
2. zmrzovalna gravitacija;
3. ledna gravitacija, povezana s podiranjem:
   a) taljenje ledenih jezikov
   b) tujki v ledu, ki pridejo na dan zaradi taljenja ledu;
4. deskvamacijska gravitacija;
5. deskvamacijsko-korozijska gravitacija;
6. hidratizacijska gravitacija;
7. kristalizacijska gravitacija;
8. korozijska gravitacija:
   a) korozijska gravitacija zaradi pronicujoče vode

b) korozijska gravitacija zaradi kondenzne vode
c) akvakorozijska gravitacija;
9. gravitacija, nastala zaradi pritiskov v kamnini, vzpodbujena s:
a) prenehanjem sile deroče vode
b) glaciostatičnim pritiskom;
10. seismo gravitacija;
11. tehnogena gravitacija.