European habitat 8310

caves not open to the public in a new vision

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Conservarea habitatului 8310
Situl Natura 2000 Cheile Nerei – Beușnița
NATURA 2000
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Habitats 8310 Caves not open to the public (caves) are all separate or interconnected natural subsurface voids, spatially developed in rock or ice, filled with gas, liquid or sedimentary rock. Natural voids mean both those formed by dissolution (karstification) and those resulting from the contribution of distinct processes (tectonics, gravitational traction, etc.).

The natural void is considered habitat 8310 - cave if it meets the following criteria, in conventional terms:

1. The circumscribed diameter of the rock void is longer than 0.25m.
2. The length of the rock void is more than 5.0m.
3. Its natural range and the areas it covers are determined.
4. It has a specific structure (it has fractures, voids and karst openings: cavities, swallow holes, springs) and functions (biotic and abiotic characteristics; void filled with gas or water, habitat for species, ecosystem)
5. Its characteristic species are found subsurface.
6. It is identified by direct or indirect methods.

Natural voids (caves) are not only those known to speleologists at a given time, knowledge is determined by subjective factors: interest in identifying caves in an area, human capacity for exploration, level of technology, available equipment, etc.

The current definition of habitat is insufficiently explained and its application has a high degree of relativity which excludes important karst areas from being protected by the Natura 2000 Network.

"Habitats 8310 Caves not open to the public, including their water areas and flows, hosting specialised or high endemic species, or that are of paramount importance for the conservation of Annex II species (e.g. bats, amphibians)."

Conventionally, a cave is considered to be a natural void with a depth of more than 5 m that can be entered by humans (the diameter of the void in the rock is more than 0.3 m).

It is appropriate to specify that the "cave" term must characterize the existence of the subsurface void, not only the subjective ability of man to enter the void.

At the same time, new methods and technologies can identify natural voids that man has not reached or cannot reach without clearing, manual excavation or mining works, but once their existence is established they can be considered caves.

In conclusion, the surface of habitat 8310 is considered to be the entire karst area that has fissural porosity and natural cavities and species specific to the shallow subsurface environment (MSS) and deep subsurface environment (DSE) are present, identified subsurface or in karst openings. Caves are habitat units (fragments), components of subsurface networks of galleries and fissures that together form the 8310 habitat and the subterranean ecosystem.

Innovative methods and techniques for habitat inventory and mapping 8310

Determination of potential karst openings/subsurface voids by direct-ground methods.

- Analysis of geological, hydrogeological, topographical maps to identify the potential area.
- Walking on karst surfaces to identify karst openings (caves, fissures, springs, sinkholes, swallow holes).
- Removal of sediment/rock fragments that block the natural void.
- Draining water that floods the natural void.

Indirect-ground determination of potential and inaccessible karst openings/subsurface voids.

- Geophysical investigations to determine karstifiable rock volumes / voids:
  - Ground Penetration Radar method;
  - Seismic wave measurement method;
  - Electrical resistivity measurement method;
  - Electromagnetic conductivity measurement method;
  - Microgravity measurement method;
  - Method of measuring magnetism;
  - Thermographic measurement method.
- Hydrogeological investigations to determine subsurface drainage.
- Hydrogeological investigations to determine water volumes in fissural porosity
- Hydrochemical investigations to determine the calcium carbonate content of spring water.
- Petrographic investigations to determine the volume of tufaceous limestone/travertine.

- Climatological investigations to determine the intensity and temperature of air currents in cracks.
- Endoscopic investigations to determine gas-filled vertical voids.
- Aerial drone investigations for gas-filled vertical voids;
- Underwater drone investigations for water voids.
- Investigations with the robot dog for gas-filled horizontal voids;

Determination of potential karst openings/subsurface voids by indirect-aerial methods.

- Drone photography for areas without forest vegetation or in the area of vertical limestone walls.
- Use of drone thermal imaging cameras to identify thermal anomalies / karst openings during periods of temperature extreme values.
- Making drone-based LIDAR maps to determine karst morphology.
- Using LIDAR satellite imagery.

Determination by direct-subsurface methods of galleries.

- Walking through horizontal galleries using techniques specific to wide or narrow galleries.
- Walking through inclined or vertical galleries using appropriate vertical caving techniques.
- Travelling through flooded galleries using self-contained diving equipment.
- Removal of sediments/fragments of rock that block the gallery.
- Draining water flooding the gallery.

Determining galleries by indirect-subsurface methods.

- Scanning horizontal and vertical gas-filled voids.
- Aerial drone photographing/filming/scanning for vertical, gas-filled voids (chimneys, shafts, large halls);
- Underwater drone photography/filming/scanning for flooded voids (siphons);
- Endoscopy for photographing/filming narrow spaces.

Determining potential cavities by hypothetical-subsurface methods.

- Analysis of void tectonics and morphology for potential identification of sediment-filled void extension;
- Measurement of air currents (including smoke tracing) to identify the source and continuation of the gallery network;
- Thermal imaging temperature measurement to identify the continuation of the gallery network;
- Dye tracing of watercourses to identify the continuation of the gallery network.

Highlighting habitat 8310 through direct spatial determinations

- Topographic survey with X-ray disto for the 3D "point cloud"
- Topographic survey with theodolite for the 3D "point cloud"
- Scanning for the 3D "point cloud"
- Scanning for the 3D LIDAR virtual tour
- Scanning for the 3D virtual tour image
- Scanning for the 2D image plan
- Scanning for the 2D image profile

Habitat highlighting 8310 through indirect spatial determinations

- Geophysical measurement to obtain the 2D structures plan
- Geophysical measurement to obtain the 2D structures profile
- Hydrogeological mapping to obtain the 2D drainage direction plan
- Topographic/GPS location for the 2D karst openings plan
- Drawing up the 2D mixed information plan

Classic caving exploration methods

1. *Depending on the void filling:*
   - Travelling through a gas-filled subsurface void (no special activities required);
   - Travelling through a flooded subsurface void (requires special work to empty the galleries by hand, by pumping or using special equipment for autonomous diving in a water environment);
   - Travelling through a subsurface void filled with sediment (requires manual excavation, manual rock breaking, rock breaking equipment using rotary percussion drills and explosives, use of dischargers, transport and disposal equipment).
2. *Depending on the degree of accessibility:*
   - Crossing a horizontal gap. Requires minimal protective equipment (light source, hard hat, overalls, undergarment, protective gloves, boots);
   - Crossing an inclined or vertical gap. Requires advanced protective equipment (caving harness, vest, double lanyard, descender, pedal blocker, chest blocker, safety and non-safety hooks, mooring, ropes).
   - Crossing a flooded void. Requires self-contained diving equipment or equipment for pumping and evacuating water.

Classical methods of speleological topography and mapping

1. Tools for topographic surveying:

- Level 1: Sketch from memory.
- Level 2: Drawing made in the field by estimating distances/angles.
- Level 3: Compasses/clinometers (for bathymetric siphons) accurate to 5°, graduated wire accurate to 0.5 m.
- Level 4: Compasses/clinometers accurate to 2°, topofil accurate to 0.1 m.
- Level 5: Compasses/clinometers accurate to 1°, roll tape measure accurate to 0.01 m.
- Level 6: Mining compass/clinometer accurate to 0.5° on wire or tripod; roll tape measure accurate to 0.01m.
- Level 7: Theodolites/tachymeters/mechano-optical levels accurate to 1', roll tape measure accurate to 0.001 m.

2. Calculation and mapping methods:

- Reporting measurements graphically, using polar coordinates;
- Reporting measurements graphically, using Cartesian coordinates;
- Drawing on paper.

Modern speleological surveying and mapping methods

1. *Tools for topographic surveying:*

- Level 1: Compasses/clinometers accurate to 0.5°, roll tape measure accurate to 0.01 m;
- Level 2: DistoX, CaveSniper, Bric-4 accurate to 0.1° for angles and 0.001 m for distances; MNemo (for underwater surveying).
- Level 3: Electronic theodolites accurate to 1-1" for angles and 0.001 m for distances.
- Level 4a: 3D laser scanning, (30,000 points/second with 2 mm accuracy) for gas-filled voids in a terrestrial environment.
- Level 4b: 3D LiDAR scanning - subsurface drone for gas-filled voids in an airborne environment.
- Level 4c: 3D sonar - autonomous underwater vehicle (UAV) for flooded voids in underwater environment.

2. *Topographic data collection tools:*

- TopoDroid, Qave: Smartphone app (Android) for semi-automated topographic data recording and sketch drawing, usually used in tandem with the DistoX electronic device.
- CaveSurvey: Smartphone app (Android) for semi-automated recording of topographic data and sketch drawing. It is designed for manual data entry, but can also record data from a wide range of devices (DistoX, lasermeters, electronic compasses).
- PocketTopo: Data collection application running on Windows Mobile (PDA).
- Auriga, Cave3D: Low-use applications.

3. *Software packages for data processing, maps and 3D models:*

- Therion: Runs on all major operating systems. Can be used in tandem with a vector graphics editor.
- cSurvey (for Windows): with built-in map editor.
- Compass (for Windows): use in tandem with a vector graphics editor (Inkscape, Adobe Illustrator).
- Survex: complex package for processing and visualising topographic data;

- TopoCAD: Runs on all major operating systems. It is a complex, integrated CAD system with all the necessary facilities for processing, mapping and cartography;
- Other software packages: WinKars, Walls, Tunnel;
- Vector graphics editor for maps: Inkscape, Adobe Illustrator, Affinity Designer, Corel Draw.

Modern methods of surveying and mapping karst surfaces

1. *Land measurements:*

- GPS applications: OruxMaps, Locus, OsmAnd, on mobile phones;
- GPS measurements: metric, decimetric, centimetric accuracy for positioning lithological boundaries, fractures and geomorphological features. Geological compass is an associated tool;
- UAV (Unmanned Aerial Vehicle) / drone photogrammetry: aerial photography;
- 3D scanning - TLS (Terrestrial Laser Scanning) laser: measuring ground surfaces or karst voids, quickly and at low cost (30,000 points/1 sec., 2 mm accuracy);
- Remote sensing: Landsat 8 (NASA/USGS) and Sentinel (ESA - Copernicus Programme), medium spatial resolution satellite imagery (15 and 10 m respectively) with spectral coverage in the visible and infrared range. High resolution satellite images (0.31-2 m) are: Pléiades, GeoEye-1, WorldView, QuickBird, IKONOS, TripleSat, KOMPSAT, SPOT, RapidEye, PlaneteScope/Dove.

2. *Data processing and production of 3D models and maps (surface and/or subsurface):*

- ArcGIS: Geographic Information System - GIS package;
- GIS tools for caves and karst: identification, extraction, management, analysis and visualisation of cave and karst information. E.g. GEOBIA;
- TopoCAD: Complex system (commercial / license);
- Drone2Map: digital terrain modelling based on aerial drone photograms.

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