# ПРОБЛЕМЫ КАРСТА ГОРНЫХ СТРАН

# PROBLEMS OF KARST OF MOUNTAINOUS COUNTRIES

# მთიანი ქვეყნების კარსტის პრობლემები

# THE CARBON DIOXIDE OF THE AIR OF SHALLOW CAVES IN MOUNTAINOUS AREAS

Ek Camille M. Advisory Secretary of
the UIS, Liege, Belgium

RESUME: L'air des grottes peu profondes reflète fortement, dans les régions montagneuses. les conditions climatiques de la surface. C'est pourquoi il est fréquemment pauvre en $CO_2$, parfois meme plus pauvre que l'atmosphère libre "standard" (300 ppm) dans les montagnes des zones froides et tempérées. Ceci n'implique nullement que la dissolution soit négligeable en montagne: les grandes quantités d'eau qui peuvent s'y concentrer peuvent, au moins par endroits, largement compenser la pauvreté en $CO_2$. Le travail est basé sur des mesures faites dans les montagnes de la Laponie suédoise, dans les Tatra polonaises, la Dorsale hongroise, et dans les Alpes françaises et italiennes.

1. Introduction. Carbon dioxide diffuses from air to water and reversely according to Henry's Law; hence the interest, for the study of limestone dissolution, to know the partial pressure of CO2 in the air.

The climate of mountains is generally severe; the scarcity of vegetal cover and its low activity induce low $CO_2$ partial pressure in the soil air, and this results in a frequent low chemical aggressivity of water towards limestone.

In a series of missions, from 1964 to 1986, we measured $CO_2$ of the air (and also the solution of limestone, that will not be discussed here). It is a summary of some measurements carried out in cave air that is presented here.

2. The analyzes. The measurement of $CO_2$ in the air is carried out with a gas analizer in which a reagent (hydrazine) combines with $CO_2$, in presence of a redox coloured indicator. The method and the techniques are described in EK GEWENT (1985). Before, an electrolytic field device had been used by us, based on the electrolysis of a NaCl solution which had absorbed $CO_2$; this method was more accurate, but the device was much heavier and the measurements much slower (EK, 1981).

a. In the Scandinavian Mountains of Lapland. Some 36 measurements were carried out in July, in caves of Swedish Lapland, in latitude 68° North, between 350 and 1100 m a.s.l. The $CO_2$ values never exceed 850 ppm in fissures and 450 ppm in chambers and passage-ways: 200 ppm was recorded twice close to the surface of an underground stream (fig.1). The mean of all measurements is 385 ppm ($\pm \sigma = 150$).

b. In the Polish Tatra. Four caves in the Polish Tatra were investigated in April, during the period of snow melting, at altitudes ranging from 1000 to 1200 m a.s.l.; 41 samples analyzed displayed a $CO_2$ content of 200 to 1100 ppm, with a maximum of 2000 ppm in a fissure. Values below 300 ppm were observed 8 times at least, in cold places.

In Jaskinia nad Raptawicka I, for instance, at 1200 m a.s.l., ice stalagmites were observed on the floor and the lower part of the atmosphere of the cave displayed a very low $CO_2$ content (fig.2). Larger amounts of $CO_2$ were found at the same time in Polish caves at lower altitude (EK et al., 1969).

c. In the Hungarian ridge. In four caves of the southern slopes of the Hungarian ridge, some 70 analyzes were carried out in July, showing contents from 400 to 1800 ppm, and some exceptional values up to 33.000 ppm. The lower altitude, the general southern exposition of the slopes of the ridge explain in great part the higher $CO_2$- contents of the cave atmosphere (as examplified in fig.3; see also EK et al., 1986). Very low amounts of $CO_2$ were registered by FODOR, 1981) in ice caves in the same country; these values were sometimes below the one of the standard free atmosphere (300 ppm). Fig.3 shows the contents measured in a cave of the Bükk Mountain.

d. In the Ligurian Alps, Italy. The Caverna delle Fate is located in a cliff, at 2 km from the sea, at 260 m a.s.l.; 24 measurements carried out in the cave displayed values from 350 to 1500 ppm (fig.4); these low values can be correlated with the circulation of the air in the cave and with the relative distance of the $CO_2$ source: the soil of the plateau hanging high over the cave entrance (GEWELT and EK, 1983). Figure 4 shows that the two higher contents (1500 ppm) are confined in fissures at the far end of the cave.

e. In the French Alps. It is by water analyzes that we have shown in the French Alps the lack of $CO_2$ in the glacial melt-waters, due to the escape of $CO_2$ during ice compaction and ice movement (C.EK, 1964). This was later on confirmed in the Dolomites (C.EK, 1966) and in the Tatra (C.EK et al., 1969). All these water analyzes back the idea that the scarcity of $CO_2$ in the ice and its melt-waters induce, in the high mountains and in the cold mountains particularly, a weak aggressivity of water towards limestone.

3. Discussion. Analyzes carried on by a small group of Polish, Hungarian and Belgian researchers show that the air of shallow caves of mountainous areas frequently display a low $CO_2$ content, and sometimes a very low one.

Different factors can induce very different results in very deep caves. In shallow caves, the air is $CO_2$- poor because the vegetation of the studied areas is scarce or displays a low activity level. Contrarily to a frequent assumption ice and snow generally do not constitute important $CO_2$ gas-holders (EK, 1964 and 1966).

This does not mean that solution is never active in the mountains: the tremendous amount of water sometimes collected can carry out an important solutional work and generate huge caves. In such cases, moreover, solution is frequently helped by mechanical erosion, but it is clear that corrosion is present.

It must be here emphasized that the present paper only intends to be a summary of the researches on $CO_2$ of a small team including most of the people cited in the references, and is by no means (for lack of space) a review of the general problem.

REFERENCES:

EK, C., 1964. Note sur les eaux de fonte des glaciers de la Haute Maurienne. Leur action sur les carbonates. Rev. belge de Géogr. 88: 127-156.

EK, C., 1966. Fiable agressivité des eaux de fonte des glaciers: l'example de la Marmolada (Dolomites). Ann. Soc. géol. Belg., 89: 177-188.

EK, C., 1981. Mesure du $CO_2$ dans l'air des grottes. Comparaison Québec-Belgique. VIII Intern. Congress of Speleol., USA, 2: 672-673.

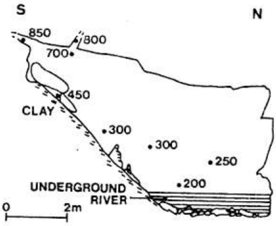
EK, C., GABRIS, G., HEVEST, A. and LENART, L., 1986. Teneur de l'air de quatre grottes de Hongrie. Neuvieme Congres Intern. de Speleol., Barcelone, 1: 89-93.

EK, C., and GEWELT, 1985. Carbon dioxide in cave atmospheres. New results in Belgium and camparison with some other countries. Earth Surface Processes and Landforms, 10: 173-187.

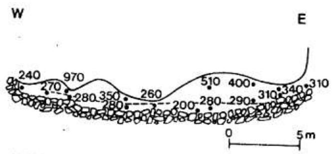
EK, C., GILEWSKA S., KASZOWSKI L., KOBYLECKI A., OLEKSYNOWA K. and OLEKSYNOWNA B., 1969. Some analyses the $CO_2$ content of the air in five Polish caves. Zeit. für Geomorph., Neue Folge, 13: 367-286.

FODOR, I.,1981. A barlanggok éghajlati és bioklimatologiai sajarossagai. Akademiai Kiado, Budapest, 191 p.

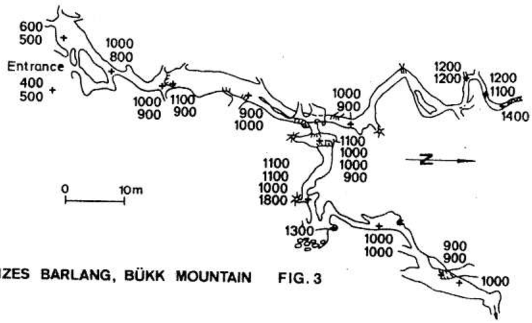
GEWELT, M. et C.EK., 1983. Le $CO_2$ de l'air d'une grotte des Alpes ligures. Bull. Soc. géogr. de Liège, 19: 107-117.



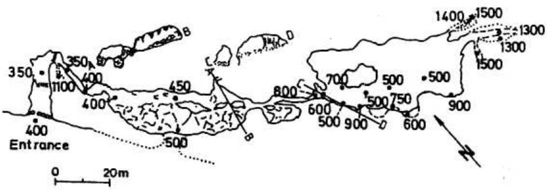

LOWER CAVE AT BJÖRKLIDEN
FIG.1




JASKINIA NAD RAPTAWICKĄ, TATRA
FIG. 2




LÉTRÁSI-VIZES BARLANG, BÜKK MOUNTAIN FIG. 3




CAVERNA DELLE FATE, LIGURIAN ALPS
FIG.4

Fig.1. Lower cave at Björkliden (Swedish Lapland). Cross-section (EK and GEWELT, 1985). All figures show CO2 content of the air, in ppm.
Fig.2. Jaskinia nad Raptawicka, in the Koscieliska (Polish Tatra). Long-profile.
Fig.3. Létrasi - Vizes - barlang, in the Bükk Mountain (Hungarian Ridge). Map by LENART (see EK et al., 1986).
Fig.4. La Caverna delle Fate, near Finale Ligure (Ligirian Alps, Italy). Map (GEWELT and EK, 1983).