TECHNISCHE UNIVERSITÄT BERGAKADEMIE FREIBERG

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CO_2 in underground openings and mine rescue training

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GERMANY

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1 Motive

2 Effect of CO_2 on the human body

3 Organization of rescue works in Germany

4 Mine rescue training

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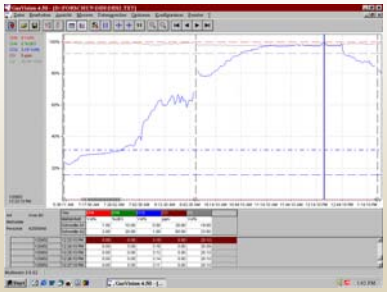
1 Motive

- measurement of 3.2 % CO_2 in adit „Rothschoenberger Stollen“



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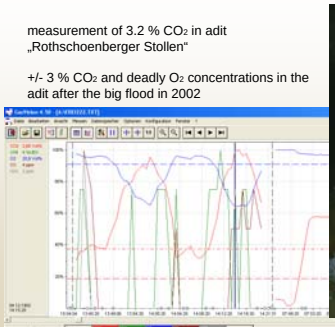
- +/- 3 % CO_2 and deadly O_2 concentrations in the adit after the big flood in 2002



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- measurement of 3.2 % CO_2 in adit „Rothschoenberger Stollen“
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- high concentrations of CO_2 in a „safety room“ and a visitor mine

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1 Motive

- measurement of 3.2 % CO_2 in adit „Rothschoenberger Stollen“
- +/- 3 % CO_2 and deadly O_2 concentrations in the adit after the big flood in 2002
- high concentrations of CO_2 in a „safety room“ and a visitor mine
- Accident on 16.08.2008 with 107 injured persons and the following news:
  Fire fighters Mönchengladbach: „A reduction of oxygen by CO_2 causes a suffocation...“ .... A helicopter was used to distribute the CO_2...“

107 Verletzte bei Gasunfall in Lackfabrik

Kohlendioxid nach Brand in Gewerbegebiet ausgetreten

QUESTION: Are rescue teams able to detect CO_2 ?
Do they really know the effect of CO_2 on the human body?

2 Effect of CO_2 on the human body

Gas	comment
SO_2	stinging smell, irritation of eyes, breathing system, 100 ppm can be already fatal
H_2S	stinks, blood poison, nerve poison, at high concentrations paralysation of sense of smell, 250 toxic lung oedema, 500 – 1000 ppm immediate collapse
CO	colorless, tasteless, blood poisson, lower concentrations: headaches (time dependent), higher concentrations (>1 %): dead within a few minutes without former symptomes
NO	colorless, tasteless, blood poisson, see CO
NO_2	brown-red (higher concentrations), pungent smell, lung poisson, symptoms of poissoning disappear in fresh air, possible dead after 4 ... 12 hours (typically)
CO_2	increased breathing volume at lower concentrations (3 %), suffocating effect at higher concentrations

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2 Effect of CO_2 on the human body

ATTENTION !

- there are a lot of misleading statements about the effect of gases (especially O_2, CO and CO_2)
- even in nowadays literature some of the given limits are wrong
- other effects are derived from lab tests, in a real environment effects may not be realized
- gases should always be measured with reliable sensors

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2 Effect of CO_2 on the human body

% CO_2 in air	effect
0.03	normal concentration in air (0.03 – 0.04 today)
0.5	breathing accelerated by 5 %
2.0	breathing accelerated by 50 %
3.0	Breathing doubled
5 - 10	Heavy breathing leads to exhaustion and headaches
10 - 15	intolerant heavy breathing, severe headaches, rapid exhaustion and collapse

(Strang and MacKenzie-Wood, 1985)

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2 Effect of CO_2 on the human body

Literature:

Junghans: „CO_2 irritate the eye, mouth and nose (mucous membrane). Contents of 5 – 10 % feel like slight sting.“… „ At concentrations over 20 % some warmth is felt on the naked skin.“

Further on: 3 % more than doubling of the breathing, therefore rapid exhausting“

If there are 20 % CO_2 in the air, you are almost dead!

A doubling of breathing is not realized! Rapid exhaustion also not, opposite: first a certain better feeling is realized.

Remember: 20 % CO_2 [added, not formed within closed system] means 17 % O_2 in the air, no lack of oxygen, but deadly!

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2 Effect of CO_2 on the human body

Jessel: „6 % … can lead to…heavy headaches….up to dizziness. From 10 % …. Epileptic cramps, drop in blood pressure, irritation of muscles and unconsciousness with danger of suffocation….from 18 % ….partly fatal …. 30 % …within seconds unconsciousness, fatal after a couple of minutes!“

Brockhaus: „in small concentrations harmless gas with a slight sour taste“… „ 8 % are lethal after some minutes…“

Symptoms partly got from laboratory tests and accidents.
CO_2 first intoxicates the person, he/she feels better.
The power of judgment is influenced.
All symptoms can appear earlier.
Further injuries due to less concentration or exhausting possible..
(exhausting -> fall in or lay down -> now at the bottom higher concentrations of the gas -> too less power for the way back.)

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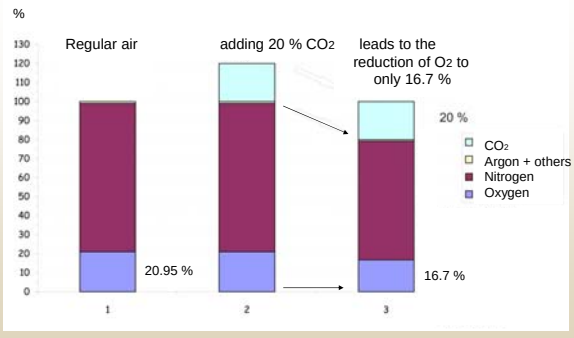
2 Effect of CO_2 on the human body



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2 Effect of CO_2 on the human body

Old rule: a candle stops burning at 17.5 % O_2 - not true today!!

Die Kerze erlischt, wenn der Sauerstoffgehalt auf weniger als ca. 12%[1] sinkt.

(The candle stops burning, if the oxygen content in the air drops under 12 %)

Source: www.riesenkerzen.de

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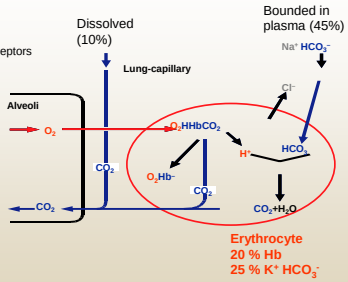
2 Effect of CO_2 on the human body

Carbon dioxide

- Regulation of the breathing via chemo-receptors of the Aorta and Medulla oblongata
- Marker for the degree of the ventilation (breathing)
- Important for diagnostic purposes in medicine
- Involved in the buffering in the acid-base relation in the human body



The CO_2 – transport

- ~ 45% as $Na+HCO_3$- in the plasma
- ~ 20% bounded on Hb
- ~ 25% as $K+HCO_3$- in erythrocyte.
- ~ 10% dissolved

Erythrocyte
20 % Hb
25 % K^+ HCO_3^-

Source: presentation of Dr. Frank (Colloquium „Gefahrenmanagement“)

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3 Organization of rescue works in germany

- Mining Law: employer is responsible for safety
- Main Centres for Mine Rescue have to be established (education, training, coordination)
- Mine rescue teams: min.: 43 troops each with 4 persons + leader
- special trained and educated for underground accidents

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3 Organization of rescue works in germany

- After reunification of both German states only 1 mine rescue teams (with several troops) exists in the State of Saxony
- 55 visitor mines, 9 other underground openings in Saxony
- smaller mines have contracts with local fire fighters (only for tasks, where no long term breathing equipment is necessary)

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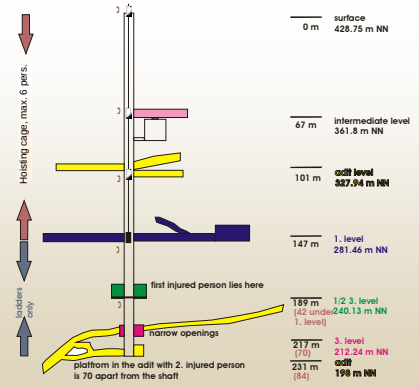
4 Mine rescue training



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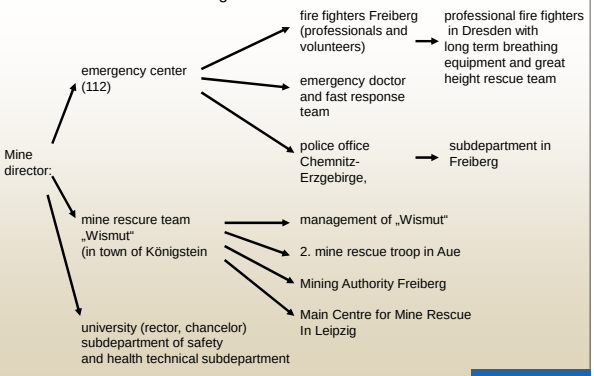

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4 Mine rescue training

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Thank you very much for your attention!

Glück auf!

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4 Mine rescue training

summary

There are still uncertainties and wrong statements in the literature about the effect of CO_2 on the human body

First symptomes will not be recognized during work

Hihger concentrations lead to an instant anaesthetization

A candle is not suitable for the detection of CO_2

It is better to say that CO_2 is poissonous

The effect of CO_2 is not a suffocation because of a reduction of O_2

The effect of CO_2 is an inner suffocation (inner receptor regulate the breathing system in dependence of the CO_2 content of the air)

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