# Bad Air In Caves

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Many have debated the sources of bad air in caves. Caves that flood may have $O_2$ depletion and $CO_2$ production from bacterial digestion of organic matter. In Texas there are some karst areas that commonly have bad air, but little flooding. There may be biogeological sources of $CO_2$ in these areas, but this hypothesis (Elliott, 1995) is unproven as yet. I have a lot of unpublished data from bad air caves in Texas, in which I measured $CO_2$ with a Drager tube and $O_2$ with an Edmont $O_2$ meter.

Normal atmospheric $CO_2$ is about 0.035% (350 ppm) and $O_2$ is 20.9%. In my experience most cavers can easily tolerate increased $CO_2$ levels of 3% (with a similar decrease of $O_2$ to about 18%), and may only breathe a bit heavily even after resting. At 4% most cavers will be puffing, and at 5% most are panting hard and will give up and leave. I have driven myself to breathe 5.5% $CO_2$ with 12.5% $O_2$ for a short time, but paid for it later (a hangover the next day, soreness, crankiness, etc.). Some people become very ill and vomit after coming out into the open air, a lot like the "off effects" after anesthesia. Most get violent headaches (I don't for some reason). Loss of judgment is a real problem – in one celebrated case in Texas, cavers tried to survey Marguerite Cave in very bad air. They would forget to write down data, then would say "forget it" and go on to the next station. They almost gave up getting out of the very tight entrance, and might have died if one guy had not gotten up the energy to struggle out and help the others out.

Most people will pass out at an $O_2$ level of 10%, but some need higher levels and there is a time factor as well. Luckily for us, the body has a $CO_2$ detector in the circulatory system that triggers harder breathing as dissolved $CO_2$ rises. This helps us to compensate for awhile, but at about 17% $O_2$ we cannot compensate further, so we begin to lose the battle at that point. Time to get out!

In the USA the federal Occupational Safety and Health Administration (OSHA) does not allow workers in a closed space with less than 19.5% $O_2$ at any time without breathing apparatus. There's a good reason for that – a worker climbing down a ladder into a tank or a rusty ship's hold may quickly go from 20.9% $O_2$ to a very low concentration in a short distance. So, the 19.5% limit gives a large safety margin. A similar hazard exists in bad air pit caves, where the heavier, $CO_2$-rich air can stratify. It can be quite dangerous to descend into such a pit, and cavers in bad air karst regions have had a lot of near misses. Sometimes the only thing that held them back was their carbide lamps going out just below the lip. Horizontal caves don't behave that way. Workers are not allowed to work a shift in more than 0.5% $CO_2$, but this would be a joke to most cavers. Many caves in Texas have > 1% $CO_2$ in the summer, and it's not even noticeable to the average caver.

In bad air cave areas, like San Saba and Burnet counties, Texas, cavers often use the **"Bic test"** to determine when to leave a cave. Butch Fralia (1989) determined that a common Bic butane lighter will begin to flicker and form a gap between the jet and flame at 18.5% $O_2$. A one-inch gap forms at 17.5%, and the lighter will go out but can be re-lit. At 17% the Bic will not light; at this level most cavers would be breathing hard, but the Bic test seems to give them a good advance warning. In Colorado Bend State Park cavers often use an oxygen meter with a long probe to check the air before entering very far into a pit cave; the meter is supplied by the Texas Parks and Wildlife Department. Sometimes they ventilate caves with hoses and blowers.

In the carbide days, a cap lamp going out or getting a weird, separated flame was also a good sign that it was time to leave. Some of the bad air pits in Texas are dangerous in the summer, with $O_2$ concentrations below 12% and $CO_2$ above 6%. I have measured $O_2$ as low as 11% in Skull Cave at San Antonio, by sucking air out via a small hose with a small air sampling pump attached. Skull had to be surveyed by two cavers wearing scuba tanks. The air was so "carbonic" that it burned their eyes, and they could taste the air when they took their mouthpieces out to speak (Veni and Elliott, 1994).

My studies usually found that $CO_2$ and $O_2$ levels mirrored each other rather closely – as one increased the other decreased. But at lower $O_2$ concentrations there was a lag in $CO_2$ increase. The difference is made up by nitrogen. Julia James has published some papers on "foul air" caves in which she has noticed this same phenomenon, which may be called "stink damp", an old British mining term. In Gorman Cave, Texas, I took air samples on charcoal for lab analysis but found no organic compounds in the bad air.

In bad air different individuals experience different **symptoms** at different times. $CO_2$ has anesthetic properties, and has been used to stupefy cattle before slaughter. Most people develop a headache, some get silly, some lose their judgment, some become animated, others become exhausted. In my experience, novices sometimes get panicky and may even hyperventilate in overreaction. Paranoia and claustrophobia sometimes set in quickly with novices, and I think even low levels of $CO_2$ can worsen this. Experienced cavers, in my opinion, become somewhat oblivious to mildly bad air and develop a "body expectation" that goes along with the whole caving experience. This expectation would unnerve many normal people. (Maybe it also causes minor brain damage and that's why we continue to go caving... hmmm. Maybe it also causes minor brain damage and that's why we continue to go caving... Wait, I already said that. That's all for now.)

## Literature Cited


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