THE MAVERICK BULL

THE MONTHLY NEWSLETTER
OF THE MAVERICK GROTTO

VOLUME 5 NUMBER 2 FEBRUARY 1990

THE MAVERICK BULL is the monthly newsletter of THE MAVERICK GROTTO, an internal organization in the National Speleological Society (NSS 6-322).
The editors invite all cavers to submit articles, news, maps, cartoons, art, and photographs. If the material is to be returned, a self-adressed, stamped envelope should accompany it. Items should be of interest to cavers and be non-political in nature.

Internal organizations of the National Speleological Society may reprint any item (unless copyrights belong to author as will be stated in byline) first appearing in *THE MAVERICK BULL*, if proper credit is given and a complete copy of the publication is delivered to THE MAVERICK GROTTO address at the time of publication. Other organizations should contact the grotto at the address herein.

EXCHANGES: THE MAVERICK GROTTO, will exchange newsletters with other grottos. Contact any officer.

COMPLIMENTARY NEWSLETTERS: THE MAVERICK GROTTO will provide complimentary newsletters to persons or organizations who provide cave access (i.e. landowners) or otherwise provide assistance to cavers. The Grotto will also provide three free issues to persons interested in becoming members.

MEMBERSHIP POLICY: Any caver with interests, beliefs, and actions consistent with the purposes of THE MAVERICK GROTTO and the National Speleological Society is eligible for membership. Acceptance of new members is based on payment of dues and a mandatory three trip requirement with at least three different grotto members. These three members shall act as sponsors. At least one sponsor must attend the meeting at which the membership vote is taken. A two-thirds majority vote of the members present will be required for acceptance.

MEETINGS: Meetings are held the second Tuesday of each month, at SMOKEY'S RIBS, 5300 East Lancaster, Fort Worth. It is a little less than one mile west of Loop 820 East and next door to a K Mart. The time is 7:00 P.M., and the food is good.

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CALENDAR

Ongoing	Monthly work trip to Colorado Bend State Park. Weekend of the second Saturday of each month.
February 9-11	TSA Winter Business Meeting and Project: at Colorado Bend State Park
February 13	Maverick Grotto Meeting
March 9-11	Colorado Bend State Park Work Trip
March 13	Maverick Grotto Meeting
March 17-18	Spring SWR Regional at Big Manhole Cave. Contact Steve Peerman in Las Cruces, NM (505) 523-2167
April 10	Maverick Grotto Meeting
April 13-15	Colorado Bend State Park Work Trip
April 21-22	Advanced Rapelling Class at the National Guard Armory in Mineral Wells
April 28-29	Continuation of Advanced Rapelling Class at Lake Mineral Wells State Park
July 9-13	NSS Convention at Yreka, California

ON THE COVER

Our Cover Cavers this month are Diane and Stephanie Andrews at the River Entrance to River Styx Cave in King County, Texas. This was a winter trip, and, no, they weren't foolish enough to go wading at that time of year in the frigid waters of River Styx. They were just admiring the view, before going in at the 1963 Entrance.

MINUTES OF THE JANUARY MEETING.

The Maverick Grotto met on Tuesday 9 January 1990 for its regular monthly meeting. Teresa White began collecting money from members for 1990 dues. A good start was made, but many members still need to pay. A reminder: If you have not paid your dues by March (only $10) you will be dropped from membership. If you can't make it to the February or March meetings, make sure you send a check to Teresa at the address on page 2.

Dave Milhollin announced that he will be speaking soon at Market Hall in Dallas. He will address a meeting of scuba instuctors on safety in cave diving. He also recently attended a meeting of the NSS Cave Diving Section in December.

Dave also passed along information on an upcoming continuing education class at TCJC South Campus. Details aren't yet finalized, but plans call for a Scuba Class on either Thursday or Friday evenings from 7 to 10 PM, during the first few weeks of May. Call Dave for more information.

Russell Hill said he still has plans to computerize the Grotto library. He's looking for volunteers to help with that project, as well as new donations of books and other items for the library itself.

Bruce Anderson suggested that we have more new member trips in the coming year. He also added that we have been lax in stressing that all first-time cavers have all the proper equipment. He wants to make sure that all beginning cavers get a copy of our "Guidelines for New Cavers".

Other members suggested that we use some of our current budget surplus for purchasing some equipment for use by new cavers. There was question, though about who would keep such gear, and how new cavers would have ready access to it.

A question was brought up about how to procure a good source of carbide. Bruce & Donna Anderson said they know of a good local source. Bruce made a motion, seconded by Russell Hill, that we use Maverick Grotto funds to buy 100 pounds of good quality carbide. Donna then volunteered to purchase the carbide and bring it to the February 13th meeting. CARBIDE WILL BE PROVIDED FREE TO ALL DUES-PAID MEMBERS OF THE MAVERICK GROTTO. Bring a coffee can or other container to pick up your supply.

TRIP REPORTS:

Dave Milhollin told about his recent canoe trip on the Brazos River with Terry Free. They were looking for evidence of other caves in the bluffs upstream from Blum. They found one 10 foot deep mini-cave. But they also spotted a possible cave on the bluffs of Bee Mountain across from Ham Creek Park. Access to the site is a problem, though worth looking into, for a possible cave within one and a half hours of Fort Worth.

Al Rehfeldt and Diane Andrews reported on their December diving trip tc Honduras. They concentrated on diving this time, but saw much evidence of caves, with great potential for a hoped-for return trip to explore the area caves. They did spot many bats while there.

Butch Fralia gave an account of the December trip to Colorado Bend. This was primarily a "fun" trip. Not much work got done, but there was lots of exporing and partying. At least 23 showed up for the event, and most of these entered Gorman Cave, among others. Butch also announced that the January work trip would be in the unexplored portion of the park across the Colorado River. That is a 675 acre section, with at least one pit (approximately 75 feet deep) and potential for much more.

After adjournment of the business meeting, the program was presented by Woodrow Thomas. He gave a slide show on "unusual" caves he has visited. Among them were rock shelters in Hueco Tanks State Park with Indian Pictographs, other caves with more modern mud "glyphs" sculpted by cavers, the Enchanted Rock talus cave, Devil's Sinkhole, Salt Cave with its celebrated paleo-feces, the famous subterranean casket of Floyd Collins, the Cave of the Naked Woman (use your imagination) and then finally, the Crystal Shrine Grotto, an artificial cave on the grounds of a cemetery in Memphis, Tennessee. It was a delightful and entertaining program.

DON'T FORGET !!!

PAY YOUR $10 DUES BY THE FEBRUARY MEETING

AND GET A FREE SUPPLY OF CARBIDE

ADVANCED RAPELLING COURSE

Ernest Parker has announced that he will conduct another course in vertical rope work on the weekends of 21-22 April and 28-29 April. It will take place at the Naticnal Guard Armory in Mineral Wells and at the cliffs in nearby Lake Mineral Wells State Park. We will be posting more details in the March and April issues of The Maverick Bull. But for now, mark the dates on your calendar. It's a great chance for beginners to learn vertical rope techniques, and for those who have rapelled before to gain experience. Don't miss it!

PROGRAM FOR FEBRUARY MEETING

The next meeting of The Maverick Grotto will take place on 13 February. Bruce Anderson will present a program on different kinds of lights (carbide and electric) and other caving equipment. Everybody will learn something, but novice cavers in particular should make every effort to be at this meeting to learn more about caving.

MORE BAD AIR
by Butch Fralia

In December 1988, an article titled "Bad Air Detection" was published in THE MAVERICK BULL, describing test performed by Keith Heuss, to determine the accuracy of a a butane lighter for bad air detection. Ray Hardcastle mentioned the article in his column, "Ray's review" (NSS News) and it was reprinted in the April '89 TEXAS CAVER. Woodrow Thomas authored the fabulous article "AIR CURRENTS UNDERGROUND" (TEXAS CAVER - August 1989) in which his quotes from the article were almost longer than the article itself. This series of exposure brought responses from Earl Hancock of the Meramec Valley Grotto (St. Louis, Mo.) and Jim Hildebrand of the Diablo Grotto (northern Ca.). "Bad Air Detection" has been reprinted in the July issue of Devils Advocate and October '89 issue of The Meramec Caver. I'm gratified at the response, that Woodrow, Earl and Jim found the article worthy of attention. Earl and Jim, both sent copies of their newsletters with the article printed.

In the same issue of Devils Advocate Jim has reported a project trip to monitor bad air in an area called the Rock Pile where a caver became ill, went into shock and required hospitalization as a result of his exposure to the bad air. Jim also sent a reprint from TRANSACTIONS BRITISH CAVE RESEARCH ASSOC. August 1975 of an article entitled "FOUL AIR AND THE RESULTING HAZARDS TO CAVERS". This article provides a lengthy discussion of Bad Air and the physiological effects on cavers.

This article is a summary of Jim Hildebrand's and the Australian Paper and contains valuable information which all foolhardy bad air cavers should be armed with upon entering the cave.

THE CALIFORNIA INCIDENT:

Jim Hildebrand, a chemical engineer in northern California, lives just inside the earthquake zone in the northeastern bay area and experienced the quake at work as a long rolling shaker. Fortunately he was far enough away as to be out of the danger area. The article was originally appeared in the July '89 issue of DEVIL'S ADVOCATE. Parts of his trip report are reprinted and demonstrate some of the more severe effects of bad air caving.

Our first cave of the day was Dragon's Breath. Below an 80 foot entrance drop, there is a series of three squeezes, each successively tighter. I was told there is a 110 foot pit beyond the third squeeze, with Carbon dioxide levels around 1.5% near the third squeeze, and as I recall they peaked out at around 4.5% at the bottom of the pit. Even at the 1.5% level, I could feel the effect of the CO_2 when exerting myself; I seemed to be breathing harder than the effort expended would justify. After the measurements were taken, we left the cave.

One member of the party felt sick on exiting the cave, and decided to sit and rest awhile. The caver who had been sick felt better, so we next went into Carlo's Cave to continue monitoring. Project team members usually carry a butane lighter for a quick check on air quality; when CO_2 levels are greater than 4% the lighters will not burn.

The CO_2 stratifies into layers that are so sharply defined at the boundary that you can take a lighter with a flame and gradually lower it, and watch as the flame first separates from the lighter, and then goes out, over the space of 2-3 feet. The lighter cannot be re-lit unless it is raised above the boundary.

Tom demonstrated this phenomenon to me at the bottom of Carlo's; it really lets you know that something out of the ordinary is happening.

Several of us then went to Keith's Chasm to complete the day's monitoring. On exiting, we heard that the caver who had felt sick earlier was ill and appeared to be going into shock. He felt cold, his skin was pale and clammy, his pupils were constricted and his pulse was irregular. As quickly as possible, we moved him out to the road and took him to the nearest hospital in San Andreas. There, he was given fluid intravenously. His blood pH was found to be higher than 7.5, a dangerously high level.

Apparently he had gone into metabolic alkalosis. The most likely explanation for what happened seems to be the following. The body has two mechanisms for maintaining pH near an optimum of 7.4: respiration and a renal (kidney) function. Carbon dioxide is an acidic gas; as levels of CO_2 in the body increase, the resulting carbonic acid made by the reaction of CO_2 with water stimulate the kidneys to release mildly basic bicarbonate ion to maintain body pH in the desired range. A sudden increase in the body's load of CO_2, such as can result from breathing air enriched in CO_2, can lead to respiratory acidosis. The kidneys respond to this situation by releasing bicarbonate to bring body pH back into balance. One symptom of respiratory acidosis is nausea, and the affected caver did throw up. Unfortunately, the loss of stomach acid has several bad effects: a reservoir of body acid is lost, and the dehydration resulting from the loss of fluid reduces the kidney's ability to function. When the caver exited the cave, normal breathhing quickly removed the excess CO_2 from his body; under normal circumstances, his kidneys would have responded by absorbing bicarbonate to maintain a pH balance.

However, due to the loss of gastric acid and dehydration, his kidneys were unable to function properly, and his body pH went alkaline. As to what can be done to minimize the effects of this problem, several things come to mind. Probably the most important is to exit the cave at the first indication of a problem: headache, nausea and the like. Also, it is important to stay hydrated for proper kidney function; liquid containing electrolytes such as Gatorade should be kept nearby, especially if someone throws up after being in a high CO_2 cave. Of course, this only can be done if the individual can hold down liquids, and certainly not if they are already in shock.

After several hours at the hospital, the caver was in good enough shape to be released.

WHAT THE AUSSIES SAY ABOUT BAD AIR

The following is a summary of information contained in the paper "FOUL AIR AND THE RESULTING HAZARDS TO CAVERS" printed August 1975, TRANSACTIONS BRITISH CAVE RESEARCH ASSOC. Vol.2. No.2. pp. 79-88.

It was written by the following Australian cavers:

Julia M. James, B.Sc. Ph.D.

Chemistry Dept. University of Sydney (temporarily Geography Dept., University of Bristol)

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Senior Lecturer in Physiology, University of Bristol.

The atmosphere found in a cave is rarely identical to that on the earth's surface. In the majority of caves the differences are small and the air can be breathed without discomfort. The term "foul air" usually means to the caver

	Burke 1953	Gree 1966	Anon 1969	Renault 1972	Field Test Bungonia 1972	Empirical Bungonia 1972
Match	-	-	-	-	1	1
Candle	4.3	3	2.3	10	4	3
Carbide Lamp	10.0	8.9	8-9	-	6	5

TABLE 1: % CO_2 Causing Flame Extinction

an above normal concentration of carbon dioxide (CO_2) in the cave atmosphere. There may be a significant reduction in oxygen (O_2) below the normal volume. The composition of surface air is oxygen 20.95%, nitrogen (with traces of inert gases such as argon etc.) 79.02% and carbon dioxide 0.03% (volume %) and is the same throughout the world.

PROPERTIES OF CARBON DIOXIDE:

A colorless, odorless, noncombustible gas with a slightly acid taste, approximately one and a half times as dense as air, liable to displace normal air and settle in pockets. Soluble in water (2-3 ml per 100 ml water), depending upon temperature. About 0.1% of the dissolved CO_2 reacts to form an acid solution. CO_2 will not support animal life.

DETECTION OF CARBON DIOXIDE:

When entering foul air, the caver may experience any of the following: increase in the rate and depth of breathing, increased pulse rate, headache, nausea and a hot clammy feeling. The severity gives an indication of the concentration of CO_2 and the experienced foul air caver can estimate the concentration to within 0.5%. A more reliable indication may be given by flame extinction tests.

Table 1 shows the variation for flame extinction values given in the literature. Some of these have unfortunately be quoted without experimental details, which are essential in the interpretation of the data. For example; a small carbide cap-lamp will be extinguished at a lower level of CO_2 than the larger handheld type. The amount of O_2 present is also critical and a candle may burn in 10% carbon dioxide (Renault 1972) if 21% of oxygen is present in the gas mixture. In caves a 10% concentration of CO_2 would not support a candle flame and would be lethal. A series of field test gave the results shown in column 5 of Table 1. A small carbide cap-lamp was used and the CO_2 content of the cave was measured with a Draeger gas analyser. The empirical values reported by the explorers of foul air caves (column 6) and are probably of most use to foul air cavers.

Carbon dioxide almost exactly replaces oxygen volume for volume in caves. In most caves carbon dioxide measurements in isolation will establish the safety of the atmosphere. Rarely "stink damp" occurs in caves (James 1975), typified by high CO_2, unexpectedly low O_2 and a much higher than usual proportion of N_2, for example, CO_2 5%, O_2 9% N_2 86%. It "stinks" because of trace amounts of H_2S, etc. In these special circumstances an isolated measurement of CO_2 is obviously inadequate for safety, and the primitive flame extinction test is probably the best simple indication of danger. If a candle will not burn it is advisable to leave the cave at once. If a carbide lamp is extinguished the caver is in severe danger as this indicates a level above the safe limit for physiological processes. Note that a match is extinguished before a candle - therefore the candle can only be lit while in good air. An accurate and critical assessment of a cave atmosphere requires the use of a gas analyser.

PHYSIOLOGICAL EFFECTS:

The physiological effects of foul air vary in severity both with the individual and the composition of the foul air.

The body uses oxygen to consume food for energy production and produces carbon dioxide as a waste gas. Oxygen is supplied to the body through the lungs and carried by arterial blood to the tissues where it is used. From these tissues the waste CO_2 is carried to the lungs in the venous blood and passes from the body in the exhaled air. The inhaled air contains a negligible quantity of carbon dioxide and mixes (by diffusion) with the air in the alveoli (air sacs) where the concentration of CO_2 is a steady 5.6%. The exhaled air carried 4% CO_2 out with it and the waste gas is thus removed from the body. Passage of CO_2 from the blood into the alveolar gas occurs because it is present at a slightly higher pressure in the blood. This "partial pressure" difference is the cause of the rapid diffusion across the very thin alveolar membrane. Oxygen from the inhaled air has passed inwards simultaneously across the same alveolar membrane to saturate the blood with oxygen. Arterial blood leaves the lungs with the same partial pressure of CO_2 as the alveolar air. Breathing moves fresh air into the lungs and waste air out at such a rate that the amount of CO_2 in the alveoli is kept constant at 5.6%.

Rate and depth of respiration is controlled by the brain's respiratory center which is acutely sensitive to the pH (acidity) of the tissue fluids in that region. The acidity depends on the CO_2 content of the arterial blood leaving the lungs and pumped to the brain by the heart. Increasing the CO_2 brought to the lungs will cause a rise in the alveolar CO_2 and in the CO_2 content of the arterial blood supplying the respiratory center. Stimulation of the respiratory center results, and rate and depth of respiration is increased so the alveolar gas is more adequately changed. Alveolar CO_2 is restored to 5.6% and respiration returns to normal. Respiration is in fact controlled so as to remove carbon dioxide from the body as fast as it is produced.

Raised carbon dioxide in the inhaled air:

CO_2 concentration in the inhaled air decreases the partial pressure gradient available for the outward passage of this gas, resulting in a small increase in the blood CO_2 and stimulation of the respiratory centre. The resulting increase in the volume of air breathed compensates for the smaller amount of CO_2 added to each unit volume with the result that the quantity of CO_2 breathed out is maintained. This compensatory mechanism continues satisfactorily until the percentage of CO_2 in the inspired air approaches that normally found in the alveoli (5.6%). Further rise increases the CO_2 in the arterial blood to increasingly dangerous levels despite extreme activity of the

INHALED CO2	EFFECT
0.1%	NORMAL
1.0%	SLIGHT INCREASE IN RATE AND DEPTH OF RESPIRATION.
3.0%	VENTILLATION IS DOUBLED SLIGHT HEADACHE COMMON.
4.0%	VENTILLATION ALMOST TREBLED, THROBBING HEADACHE, FLUSHED FACE, NAUSEA, SWEATING.
5.0%	VENTILLATION MORE THAN TREBLED, ("OFF EFFECTS" ON REMOVAL).
6.0%	VENTILLATION SIXFOLD, CAN BE TOLERATED FOR SEVERAL HOURS.
10%	INTOLERABLE TO BREATHE FOR MORE THAN A FEW MINUTES.
12-15%	UNCONSCIOUSNESS WITHIN MINUTES.

TABLE 2

Responses for man at rest to atmospheres containing carbon dioxide. The percentage of CO_2 added to dry normal air at a pressure of 1 atmosphere is given in Column 1.

respiratory centre. Concentrations of CO_2 above 6% become narcotic in action depressing the activity of the respiratory center causing unconsciousness. High levels of CO_2 are used in some abbatoirs as an anaesthetic gas preliminary to the slaughter of animals.

All these observations apply to the body at rest. Exercise produces further quantities of CO_2 which must be removed via the blood stream and lungs, a route whose efficiency is now much decreased. Increase in the CO_2 content of the inhaled air causes a proportionate decrease in physical work capacity.

Table 2 gives responses for man at rest at differing carbon dioxide percentages in the air breathed for normal subjects at sea level. Reliable human response data to inhaled CO_2 is difficult to obtain because subjective factors are extremely important, motivation and fear in the subject may produce anomolous results. The first observable effect of increasing the % of CO_2 in inhaled air is an increase in the rate and depth of respiration, but this often goes unnoticed. At about 3% of CO_2 in the inhaled air increases in rate and depth of respiration are noticeable and physical work capacity is measurably diminished. A rise to 4% produces a flushed face, headache, palpitation and sweating, and these effects are even more marked with 5% CO_2. At this level of CO_2 in the inhaled air the level in the alveolar air will be even higher and CO_2 in the arterial blood leaving the lungs will be above normal. Buffering mechanisms in the blood will be involved and if the subject reverts suddenly to breathing fresh air "off effects" are commonly experienced; headache, nausea and sometimes vomiting. Recovery from such CO_2 levels may be slow and the problem is familiar to anaesthetists. "Off effects" have often been noticed when caving in high CO_2 and in the past have sometimes been attributed to a reduction in tension or fear on leaving the danger area. It seems more likely that the familiar "off effects" result from a rapid emergence from high CO_2 into normal atmosphere and the failure of the buffering processing in the body to revert as rapidly to normal.

Normal lung ventilation is eight to ten litres a minute, but at 6% concentration of CO_2 in the inspired air this rises to 60 litres/min. which is close to the maximum possible in a healthy young adult. Severe exertion under normal atmospheric conditions will also cause hyperventilation at a similar rate, thus any exercise in 6% CO_2 is virtually impossible. 10% is subjectively intolerable to breathe and slightly higher carbon dioxide levels rapidly produce unconsciousness and eventually death.

Reduced oxygen in the inspired air:

By comparison with the effects of breathing a gas mixture containing high carbon dioxide, the visible effects of breathing one deficient in oxygen are hardly noticeable. The physiological effects are trifling until the deficiency is quite large and if the subject is at rest the O_2 may be reduced from the normal 21% to 13% before there is any danger. When the inspired air contains about 13% O_2 the alveolar air is about 8% O_2 and the result of this reduction is that the arterial blood is not completely saturated with O_2. While breathing air the body stores only 1550 ml of oxygen, found mainly in the lungs (29%), the blood (55%), dissolved in tissue fluids (3%), and in combination with myoglobin (13%) (Nunn 1972). The small size of these stores means factors affecting them (such as exercise and reduction in the % O_2 in the inspired air) will produce their full effects very quickly. When the oxygen level in the inspired air reaches 13% then oxygen lack (hypoxia) presents a serious threat to the body and in the healthy subject compensatory mechanisms come into play. Hyperventilation occurs although in comparison with the reaction to increased CO_2 it is minor, and moreover the response varies considerably in degree in different normal

individuals. The extent of variation in the degree of reaction, and the level at which it occurs is greater than is commonly realized. In some persons a lowering by as little as 5% in the oxygen of the inhaled air will increase breathing noticeably, in most people a lowering of at least 7% is required to produce a noticeable effect, while in others consciousness is lost from hypoxia before any noticeable effect is felt. An increase blood flow to every major organ, particularly the brain, always accompanies hypoxia.

If the reduction in oxygen in the inspired air is gradual, there is little or no preliminary discomfort and the onset of serious hypoxia is very insidious. Reserves of oxygen in the tissues and organs are quickly used up and death can result rapidly. Intermediate stages of oxygen lack cause serious brain damage as nerve cells cannot live for any time without oxygen and do not regrow. Permanent brain damage can therefore result form severe hypoxia.

As the blood becomes less oxygenated it loses its bright red colour and becomes a dusky plum shade. The observable signs are blueing of the lips and mucous membranes, the conjunctiva, the ear lobes and the nail beds. The onset is variable from person to person and other factors such as cold can produce confusion by causing reduced peripheral circulation and local cyanosis.

Powers of judgement are impared and muscular co-ordinaton is steadily affected. Despite fore-knowledge of the certainty of its onset with hypoxia the most harmful and most frequently recorded hazard is a supreme confidence in the ability to continue the experiment or exploration even though the hypoxic investigator is aware that his muscular co-ordination is deteriorating. The off effects are usually negligible on return to fresh air, and there is an immediate return to normal. Loss of memory of the entire event is very common. In a few cases aggressive behavior occurs with recovery of consciousness and the victim of hypoxia may briefly attack his rescuer.

The combination of raised carbon dioxide and reduced oxygen in the inhaled air:

When diminution in the oxygen content of the inspired air is accompanied by a corresponding increase in the content of carbon dioxide, then the rise in CO_2 by stimulation of the respiratory centre causes an increase rate and depth of breathing with the result that the oxygen in the alveolar air will remain almost normal within wide limits. Full oxygenation of the blood continues until there is a sufficiently high CO_2 content to depress the respiratory centre and respiration begins to fail.

Experienced foul air cavers in Australia have observed two types of individual responses on exposure to foul air. The common response as might be expected is hyperventilation with some degree of cutaneous vasodilatation, and these subjects are commonly referred to as "pink puffers". A small minority do not hyperventilate, show signs of cyanosis and are called "blue bloaters". Both these terms are commonly used by anaesthetists to describe thhe reactions of patients under anaesthesia. (Dornhorst, quoted by Cotes 1975).

While the reaction of the "pink puffer" is normal, that of the "blue bloater" is abnormal - or is at any rate a greatly reduced response to a raised CO_2 in the inspired air. Hyperventilation is absent with the result that the alveolar oxygen is low and cyanosis occurs. A blue bloater therefore will be at extreme hazard in foul air caves, in which he will suffer hypoxia and be in danger of unconsciousness without the warning symptoms experienced by most cavers. A known blue bloater should never enter a region of foul air without the warning companionship of a pink puffer.

ADVICE FOR SAFE ENTRY INTO FOUL AIR REGIONS:

In Australia the advice given to caving groups is 'if a match will not burn then get out' (Pavey, et al 1972). In many caves warning signs are posted and these should not be passed casually. However, circumstances such as the search for and recovery of victims and the carrying out of exploration and scientific work can require entry into the foul air regions of caves, and in any case enthusiastic excavators may wish to dig in foul places. The following advice is based on the assumption that CO_2 has replaced O_2 volume for volume (7% CO_2 implies 14% O_2). This replacement of O_2 by CO_2 is the worst condition encountered apart from the rare occurences of stink damp (James 1975). Other research workers may find the situation in the caves they are investigating allows for adjustment of the recommended limits given here.

A. CO_2 1 - 4%

1) A CO_2 tester should be carried - if nothing else is available use a candle. A candle can be recommended as the standard CO_2 test for digs. If the CO_2 rises above 4% (i.e. the candle goes out) - get out slowly.

2) Inexperienced foul air Cavers should be gradually introduced to it by an experienced leader.

3) A high standard of physical health is essential. Persons suffering from anaemia, asthma or respiratory infection should not go into a region of foul air.

4) At all times movement should be slow and well co-ordinated.

5) Climbing out of foul air is more difficult than might at first be expected because of the limited capacity for physical work of the caver in foul air. Special caution is required in undertaking descents - especially pitches.

6) Critical manipulations especially those involving safety must be checked by at least one other person. An example is the tying of bowlines on life lines. Although there have been no deaths in Australian caves directly attributable to foul air, it is possible the impairment of mental processes contributed to the fatality in Drum Cave, when a caver fell from a ladder and was not saved by his life line because the knot failed to hold. He had just left the foul air region of the cave (Wood 1965).

B. CO_2 4 - 6%:

Only experienced foul air cavers should enter these regions. In addition to the recommendations 3 to 6 in section A, —

1) A CO_2 tester must be carried.

2) An "oxygen rebreathing" apparatus should be taken (one kit to four people). Draegers market an ideal apparatus for mines rescue. It is small, robust, easy to operate and can be carried on the belt. It is suitable for caving but is expensive and only lasts for 30 minutes. The rebreathing set should go down the cave with the first man.

3) Care is required when leaving a region of high CO_2 to prevent off effects. While in a high CO_2 atmosphere, buffering systems of the body will adjust to the new conditions. An instant return to fresh air produces off effects until the buffer systems return to normal. These effects are not dangerous but may be uncomfortable, embarrassing (because they are interpreted as hysteria) and frightening if not understood and anticipated. They include vomiting,

hyperventilation, shouting and uncontroilable laughing or crying. They can be prevented by a slow dignified exit if the cave has a CO_2 gradient. In a cave where there is a CO_2 region which finishes abruptly the caver should not rush into fresh air - but take several minutes over the change.

C. CO_2 6% and above

Breathing apparatus is necessary and all precautions against equipment failure taken in mine rescue and cave diving should be followed.

1) The self-contained underwater breathing apparatus (SCUBA) for normal work in CO_2.

2) A line from a compressor (outside the cave) or an air bottle (Hookah) to the explorer if passage is tight.

3) For long periods of work in foul air, relatively lighter oxygen rebreathing equipment may be used and the dangers from high pressures associated with its use under water do not apply.

4) If the caver has passed through a region of foul air and dons breathing apparatus when entering regions with a carbon dioxide concentration above 6%, then he will probably experience off effects on breathing the fresh air in his apparatus. These appear rapidly and there is as yet no routine for avoiding them under these very special circumstances. Any method of making the transition more gradual seems desirable, such as alternate breaths of compressed air and cave air, or leaking the foul air under the side of the face mask. Preferably if feasible the apparatus should be used from 3% CO_2 onwards. Above all it must be certain that off effects are not going to occur and that the normal respiratory stability is achieved before continuing into regions of higher CO_2. Vomiting for example would be disastrous. This is especially important when the breathing apparatus is being used for cave diving in foul air caves. Off effects are almost certainly the reason for the comment from foul air cave divers "breathing fresh air makes me feel worse". Underwater off effects would almost certainly be fatal.

TREATMENT:

Much of the treatment for foul air narcosis is common sense but success depends upon the ability to assess and adapt rapidly. Hence critical observation by the other members of the party is necessary for immediate treatment of victems. This is difficult because in foul air thinking becomes selfish and survival is one's first priority. Fortunately, the warning symptoms are unpleasant, and this protects the caver.

Mild distress in CO_2

As soon as any uncomfortable symptoms (e.g. headache) are felt the victim should return to fresh air slowly. Anxiety tends to make victims of move rapidly and hard physical work causes rapid deterioration in the victim's condition. The victim shouldn't be allowed to return to fresh air alone nor be allowed to sit and wait for the party's return. Sickness and headaches may persist on return to fresn air, and are best treated by rest.

Serious distress in CO_2

Serious distress has been reported in concentration as low as 1% and it is common at 4-5% if working hard. When this occurs check that there is no restriction on breathing such as tight clothes or a prusiking chest harness. Reduce anxiety by soothing and calming the victim. If available administer medical oxygen or compressed air. As soon as the victim is calm start to move him slowly out of the foul air, after no further improvement can be achieved by lingering in it. Victims tend to want to stay still and sleep. They should be given maximum assistance up pitches using a hauling rope and a life-line, and should be assisted up all climbs.

Collapse

If the victim collapses where there is no oxygen or compressed air availale, he should be preferably be carried into a region of fresh air. All clothes and other restrictions on breathing should be loosened and mouth to mouth resuscitation should be given if respiration fails. If he recovers organize his removal from the cave. If he does not regain consciousness roll him into the semi-prone position and organize the rescue.

SUMMARY:

Bad or "foul" air isn't the safest environment in the underground but fore-armed with knowledge, the caver can survive that environment. In general, caving in bad air is not recommended but few have suffered serious effect from the experience. The enthusiastic caver must always find what's on down the passage, the new Carlesbad or just the unusual formation. It's all part of the adventure of caving.

It can be seen that "most" people will withstand a 4% CO_2 atmosphere and experience only minor difficulty. Beyond that point, there's a grey area which only experience will tell how a given person will react. It's in this area where individual physiology and mental stamina are all important and provide the greatest variable as to how the caver responds to the bad air environment. Inexperienced cavers should be accompanied in their first bad air caves by the experienced. Only experianced bad air cavers armed with appropriate equipment should work in the environment exceeding 4% CO_2. This is approximately 17% oxygen and the point where a candle or the ubiquitous BIC lighter will no longer burn. This is the point where the wise caver will stop and begin to leave the area slowly.

Note the keyword which occured throughout the text; slowly. Abrupt changes in CO^2 levels can create havoc with the physiological mechanisms of the body and anything from nothing to extreme shock can result from emerging into a normal environment after prolonged exposure to a high CO^2 level. It is also important to remember that slowly also pertains to the reduced capacity for physical activity.

Bad air is a necessary evil to those who frequently cave in the Texas Hill Country, Arbuckle Mountains of Oklahoma, parts or perhaps all of California and even down under in Australia. A bad experience in bad air can take the fun out all caving activity due to the unconscious fear it can inspire on your next trip underground, be forewarned and don't let that happen to you.

No one knows the origin of bad air, there are theories but perhaps with continued research in California, the Colorado Bend Park project and by the Australians, we'll someday know from whence it comes and not just theorize.

MAVERICK GROTTO
CAVING
TX-OK-AR-MO-NM

TSA WINTER BUSINESS MEETING & PROJECT

February 9-11, 1990

Colorado Bend State Park

The winter Business meeting of the TSA will be held February 9-11, 1990 at **Colorado Bend State Park** near Lampasas Texas. The on-going cave research project at the park will be held in conjunction with this meeting. Caver access to this area through the years has been very limited, thus very few caves were known in this area. When the Parks and Wildlife Department purchased the Lemons Springs Fishing Camp in May of 1987, there were less than 20 caves known on this 4500 acres located south of and adjacent to the Gorman Falls Fishing Camp. The largest and best known caves were Lemons Ranch Cave and Cicurina Cave, each being about 600 feet long. On a single weekend in February 1988, 25 new caves were found in a 733 acre pasture of this new area. One of the newly found caves in the area has the potential of making Dale Pate's list of *Long Caves of Texas.* So, come on out and see what it's all about.

Much of the work done to date has been on the surface. Finding caves, locating caves on topographic maps, etc. Many of the caves are yet unentered and most of them have not been mapped. The project at this TSA meeting will emphasize these aspects of the project. Andy Grubbs and Joe Ivy will hold a mapping seminar Saturday morning for new and old cave mappers. We will be placing warning sings at known cave entrances.

Tent camping and primitive vehicle camping will be your weekend stay. Bring your own water. No community feed is planned, but Carl Ponebshek will have morning coffee and hot chocolate. Bring slides, especially of the Gorman/Lemons area for Saturday night. The registration fee will be $2.00 for TSA members and $3.00 for non TSA members. We will be staying in a closed area of the park, and one campfire will be allowed. Do not **bring firewood,** it will be provided. Linda Palit will have items from her Gonzo Guano Gear for sale during the weekend.

Below is a tentative schedule of events during the project.

Fri.	5:00 P.M. - 12:00 P.M.	Arrivals, registration, campfire and socializing.
Sat.	8:00 A.M. - ? ? ?	Arrivals and registration.
	9:00 A.M. - 10:30 A.M.	Mapping courses run by Andy Grubbs & Joe Ivy.
	10:00 A.M. - 7:00 P.M.	Project - cave mapping, air quality readings demonstrated and project coordination.
	7:00 P.M. - 8:00 P.M.	Information gathering from cave teams.
	8:00 P.M. - ? ? ?	Campfire, open air slide shows, conditions willing! and other social activities.
Sun.	10:00 A.M. - ? ? ?	The TSA BOG meeting, Joe Ivy presiding.
	10:00 A.M. - ? ? ?	Projects continue for non Business meeting attenders.
	? ? ?	Departures, the long drive home.

OREGON LAVA AVES

DESTINATION: Dead Horse Cave and Dynamited Cave near Portland Oregon
DATE: 14-15 October 1989
PERSONNEL: Bill Holmes (Trip Leader), Mike, Joe and Chris from the Willamette Valley Grotto, Jon and Mardy from an area rescue group, and Danny Sherrod from the Maverick Grotto
REPORTED BY: Danny Sherrod

Since I needed to be in the Seattle and Portland area on a sales trip, I decided to stay over the weekend and explore some lava tubes. A caver in the Seattle area that I called told me that the best tubes in the area were south near Portland, Oregon, and gave me Bill Holmes' name. Bill graciously offered to take me through a couple of the better caves.

We met at their monthly meeting at a local college. Their group is very active and had been to many caves during the previous month. Oregon has large amounts of public land with little or no restrictions on caving.

After the meeting and bull session at a local pizza parlour, Bill invited me to stay at his house so we could get an early start in the morning.

We visited Dead Horse Cave first. We did a through trip. The cave walls were very black end absorbed much of my light, making it difficult to see. The walls had a very smooth surface and looked somewhat like icing. Some of the formations resembled those found in limestone caves. The cave had some water passage which is odd since it was not created by water.

Later that day we started rigging ropes in Dynamited Cave which is one of the best caves in the area since a variety of skills are required to see the cave. We had three drops to rigto get us to an upper passage that they rigged with a scaling pole (a long pole made up of short sections of tubing with a rope attached to the top of the pole on which the climber ascends and rigs a rope for the rest of the group to ascend).

Sunday we visited more of the cave but failed to see all of it due to its large size.

I strongly recommend caving with cavers in other areas whenever possible. The friendliness and hospitality shown by this group and the British group I have caved with recently were overwhelming. Also it is a great way to see some beautiful country and caves!