AN INSTANCE OF CHOKE-DAMP FREE FROM CARBON DIOXIDE.

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It is well known that the air of wells, mines, &c. is sometimes capable of extinguishing a flame, and recent researches have shown that this is almost always due to deficiency of oxygen, accompanied by the presence of a considerable percentage of CO_2[1]. The extinctive atmosphere is popularly known as "choke-damp" or "black-damp." The source of the CO_2 is not necessarily the same in all cases. If oxidisable organic matter is present it is reasonable to suppose that the CO_2 may be derived from the carbon in this organic matter by the action on it of air; but the derivation remains a supposition. Carbonaceous materials may be oxidised and yet give no CO_2. The other obvious source of CO_2 is the decomposition of carbonates by an acid, the acid being produced by some process of oxidation. The commonest mineral which will yield an acid by oxidation with air is pyrites, and if direct oxidation of carbonaceous matter be ruled out, it may be assumed that the occurrence of CO_2 is ultimately referable to pyrites in an easily oxidisable form, for example as marcasite.

In a comparatively few cases it has been observed that air from wells or mines which is capable of extinguishing a flame or incapable of supporting life contains only a very small amount of CO_2. Haldane has examined samples of this kind and has hitherto found that though the amount of CO_2 is much smaller than corresponds with the oxygen removed, yet that there is still a considerable quantity of CO_2. An instance, where the gas though depleted of oxygen was almost free from CO_2, recently came to my notice and appears to be worth recording. In the case referred to some difficulty arose because candles would not

[1] Cf. Haldane, *The Investigation of Mine Air*, 1905, p. 124.

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remain alight in a building used for cold storage. Usually the place is lighted with glow lamps, but, on occasion when the current is not available, candles have to be used. In order to ascertain the cause of the extinction of the lights I visited the place and examined the air, both on the spot and afterwards in the laboratory.

The room used as a cold storage is large, and though not specially ventilated receives fresh air freely when the door is opened for the entrance and exit of the perishable goods. Trucks of these are continually going in and out, and their movement as well as that due to the greater density of the cold air ensures the removal and replacement of large volumes of air. Nothing approaching fouling or exhaustion of the air by the men handling the goods or by the naked lights which are occasionally used is possible. The temperature is about 20° F. (– 7° C.) but in no way hinders ordinary combustion. Perhaps the lighting of a candle may take slightly longer because the cup of wax round the wick is cooler than usual, but the difference is only what may be noticed on any frosty day; at such temperatures the candle when lit burns normally. The people working in the place and going in and out did not appear to suffer discomfort, and I myself remaining in the room for half-an-hour and doing no manual work was not conscious of any unusual sensations. My assistants who were performing very light manual work in handling and fixing apparatus for the collection of samples experienced a slight feeling of oppression. On striking a match in this air, the head burned and the match then went out. A candle could not be lit, and if a lighted candle was brought in it was extinguished.

Analysis of the air of the room disclosed the cause of the trouble. The composition was as follows:

	Sample from floor near shaft 12.15 p.m. 17/10/05	Sample from West Side Centre 12.25 p.m. 17/10/05	Sample from Mid East of Store 2.10 p.m. 19/10/05	Sample from South-East 2.10 p.m. 19/10/05
	% by volume	% by volume	% by volume	% by volume
Oxygen	17·6	17·5	17·6	17·7
Inert gas (nitrogen, argon, etc.)	82·4	82·5	82·4	82·3
	100·0	100·0	100·0	100·0

The amount of CO_2 was negligible in this connection—not more than 0·1 %.

Dr Haldane who was also interested in this case took other samples and obtained similar figures.

Air from centre of cold storage room, 4.20 *p.m.* 25/10/05.

	%
CO_2	0·16
O	16·56
Nitrogen, argon, etc.	83·28
	100·00

The depletion of oxygen is sufficient to account for the extinction of a light, but is not so great as to endanger the workers.

The next step in the enquiry was to ascertain the cause of the poverty in oxygen.

Into the room, which occupies the basement of the building, opens a shaft from a disused well, and from this large volumes of gas were discharged. The gas was analysed and found to be very poor in oxygen.

	Sample from 6 feet down shaft taken 12.5 p.m. 17/10/05	Sample from 6 feet down shaft taken 2.0 p.m. 18/10/05	Sample from 17 feet down shaft taken 11.30 a.m. 18/10/05
	% by volume	% by volume	% by volume
Oxygen	8·6	8·7	8·9
Inert gas (nitrogen, argon, etc.)	91·4	91·3	91·1
	100·0	100·0	100·0

In all cases the quantity of CO_2, CO and of hydrocarbons was negligible. Dr Haldane and Mr W. J. A. Butterfield have been so kind as to provide me with the results of their own experiments checking my observations.

	Dr Haldane	Mr W. J. A. Butterfield
	Air from top of well shaft during blow of air 25/10/05	From shaft 35 ft. down, 12 o'clock 18/10/05
	% by volume	% by volume
Carbon dioxide	0·16	0·25
Oxygen	11·75	9·00
Combustible gas	0·00	trace
Inert gas (nitrogen, argon, etc.)	88·09	90·75
	100·00	100·00

As the gas came from the shaft in great quantity, and as the cold storage was only casually ventilated by the opening of the door to allow the passage of goods, the low content of oxygen in the air of the cold storage is explained.

A tunnel was being constructed close to the cold storage and for its construction compressed air was being used. A great part of this air was evidently finding its way out through the soil, and would naturally

flow into the shaft and thence into the cold storage. The air had been quite normal before work at the tunnel was begun.

The only point remaining to be considered is why this air reaching the shaft should be depleted of oxygen.

The air coming from the tube to the shaft passes through clay. Some of this clay taken from a point near the shaft was analysed and found to contain iron pyrites—as much as 1 % reckoned on the dry mud. To decide whether the pyrites was capable of easy oxidation a direct experiment was made. Air was confined in a tube containing some of the mud and the residual gas removed and analysed; it contained only 1·4 % of oxygen.

So far the whole matter is simple, but now comes a point of some difficulty. The pyritic clay contained carbonates corresponding with 1·10 % CO_2. If the pyrites oxidises in the conventional manner it will certainly produce an acid sulphate capable of acting on carbonates. But, as a matter of fact, there is no evidence of CO_2 formation in the air passing through the clay, the minute proportion of CO_2 present being fully accounted for by the respiration of the workmen in the tunnel. Therefore either CO_2 is not generated or it is afterwards absorbed. The former occurrence is quite possible because the pyrites occurs in relatively large pieces and its products of oxidation will not necessarily meet a piece of carbonate; the latter is also quite possible because the CO_2 generated must flow through mud containing carbonates and water competent to absorb it. I incline to the former hypothesis.

The case is of interest firstly as an unquestionable instance of air derived from outside and depleted of oxygen underground. It has come from the tunnel into which air is driven by the compressors, and there is no likelihood of a plutonic source. In the next place the case is almost unique because the air, though depleted of oxygen, contains scarcely any carbon dioxide. This is remarkable on account of the fact that although the oxygen may very well be removed by some substance which does not yield a gas on oxidation, yet the only common substance capable of this action, the substance active in this instance—pyrites—yields an acid sulphate quite competent to act on carbonates, and carbonates are present in the soil. It would seem that whereas the ordinary processes of nature are slow and will allow the air in a mass of soil to sojourn there so long that the secondary products of its change will be formed and will mix with it, the cataclysmal operations of the contractor cut short these leisurely processes and push the air through its oxygen-absorbent, hastening the main reaction and obliterating the minor.