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NOTES ON SUBTERRANEAN TEMPERATURES IN METAL MINES

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The student of mining history will undoubtedly be aware that in certain metal mines there has existed a notable increase in temperatures in depth and tales are recounted of miners working naked and collapsing from extreme overheating. Whilst some of these historical facts are quite true, (discounting the deep mines of the Rand which exhibit this phenomena) high underground temperatures are not an important aspect of British Mining History.

That there is a distinct temperature difference between surface and underground conditions is apparent on cold winter days when, even in the shallow Pennine mines 'steam' can often be seen issuing from shafts on the moors. The writer has frequently seen on cold days clouds of this 'funk' (to quote a Cornish term) pouring from the main drawing shaft of Deep Ecton copper mine in Staffordshire.

Workings however, have to penetrate to considerable depths before temperatures rise to a level sufficient to cause discomfort. It was generally accepted that on average the rise in temperature of rock in mines is 1º F for every 50 feet below surface but this is by no means always a rigid rule. The nature of the rock has a bearing on this fact and in Cornwall it has been observed that slate (killas) rocks are generally warmer in depth than granite. Moreover, the country rocks of that locality are reputedly warmer than the lodes contained within them and copper lodes warmer than tin producing lodes.

Concerning the former. it has been said that chemical reaction in lode material was responsible for the freak temperatures (both air [16] and water) which were encountered in the workings of the United Mines, Gwennap. Here, in 1864 water attained a temperature of 126º F on one occasion within the Hot Lode, whilst at Cook's Kitchen Mine near Camborne, air temperatures in the deep levels stood at a constant 100º F. Whether this heat was indeed caused by chemical reaction in the massive copper lodes or was attributable to some deep seated thermal source (the type which still causes the well known Matlock Bath and other spa springs to run warm) is a fact which has not been conclusively proved.

Certainly in the Comstock Mines of the States in the late 1860's deep seated thermal sources were undoubtedly the cause of the astounding temperatures experienced.

Here, in 1866, sufficient heat was encountered in the 900 foot level of the Belcher Mine to cause "*sweat to fill the miner's loose shoes until it ran over the tops*". Further, in the 1400 level at Crown Point Mine, water is recorded as gushing from a drill hole so hot that eggs could readily be boiled in it. It

is scarcely credible that men could work in such heat; a thermometer placed at the forehead in Bullion Mine recorded a staggering 140º F and men could only work for minutes at a time in this flaying heat. Tons of ice were sent into the mines at Comstock and three gallons of iced water was considered a moderate allowance per man in the course of an eight hour shift.

There are incidents too on record, where men fell into the sump water here and, although retrieved immediately, their skin peeled off from all areas of their bodies which had come into contact with the water - they were virtually boiled alive, the temperature being 158º F.

Whilst the foregoing has no parallel in the British Isles, there have been some interesting experiments conducted on the subject of subterranean temperatures.

As early as 1837, Sir H. de la Beche reported to the British Association on the subject. He states that at Dolcoath Mine on the 230 fathom level, the thermometer recorded a temperature of 75º F and this increased. by one degree for every 51 feet. The temperature at the same level fifteen years previously had been 75º F and in 1857 at 272 fathoms 73º F was recorded or 2½º less than in 1822 despite the fact that the mine had been sunk 42 fathoms deeper.

However notwithstanding these fluctuations, it is a fact that in Cornwall and other parts of the world heat increases as depth is attained and nowhere has the temperature been found to be less [17] as sinking has taken place. It was postulated that if the rise in temperature as observed to the depth reached, continued at the same ratio, the temperature at 20 miles would be 1700º F and at 50 miles deep, 4500º.

The heat of the rocks and corresponding warmth of mine workings has, of course an important and useful side effect. This effect is that of procuring natural ventilation of workings, particularly those which are connected by an adit at a low horizon with a shaft whose collar is at a higher altitude, (the Ecton Mine mentioned previously is a fine example). On cold days, air is drawn through the adit and on heating in the workings, rises and is vented through the drawing or upcast shaft.

Below is given, in tabular form, the results of an experiment on rock temperatures which was conducted by Captain Josiah Thomas of Dolcoath Mine in the 1880’s. The results were obtained by, inserting thermometers into holes 24 inches deep, bored in dry rock. The thermometer (a slow acting 10" mining type) was pushed to the bottom of the hole which was thereafter plugged with woollen material and clay so as to eliminate the atmosphere. The thermometer was left in the hole for varying lengths of time from half an hour to one week.

FATHOM LEVEL	DEPTH FROM SURFACE	ROCK TEMP ºF	AIR TEMP
12	42	64	65
40	65	66½	66½
125	146	67¾	68
170*	188	65	66
302	314	70	71
352	354	83	81

* A strong cold ventilation current of air had been flowing through this level for some time, no doubt producing this cooling effect.

It may be noted too, that in this same mine after the turn of the century the heat became very severe with a recorded water temperature in the New Sump Shaft (sunk to the 550) of 110º. Indeed, in the Wheal Harriet section of the mine work in the 375 level was stopped as a result of the great heat encountered.

Cornwall, due to the excessive depth of the mines there, has figured more prominently in the records of underground temperatures [18] in the British Isles than elsewhere.

Most of the submarine mines were uncomfortably hot with temperatures of 90º - 100º being common. This heat was a difficult problem in such workings due to their very nature obviating the sinking of ventilation shafts. Whilst mechanical ventilation was resorted to, this did little to lower the heat level and was only successful in clearing the vitiated air from distant ‘ends’ where blasting was carried out.

A less obvious side effect of high heat in the mines concerned the miner’s tallow dips or candles which, it has been occasionally noted, were liable to melt away prematurely unless surrounded by water.

But to return to Cornwall’s prime and oft quoted example that of the Hot Lode in the United Mines. As mentioned previously, there has been reason to suppose that chemical action within the orebody here was, in part at least, responsible for the temperatures experienced. This is reinforced by the fact that E.H. Hawke, a committee member during the time the mines were worked as Clifford Amalgamated, wrote: “*In the levels of Clifford Amalgamated - Mines the thermometer stood, as I have always heard, at about 100º F before the immense deposit of copper ore was taken away, and now the levels are cold enough to make the agent when underground, wish for a greatcoat when walking through them*”. This points to the ore body having quite an influence on temperature and it has been assumed that this high heat was generated by chemical action of water decomposing the very abundant pyrites.

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An interesting effect of underground temperatures on lode stuff is recorded at Tresavean Mine, to the south west of Gwennap. Here, copper pyrites at the 310 level (below adit) at a temperature of 100º F was of a hard consistency and difficult to break out. On being sent to surface and consequently cooling, the ore became extremely brittle so that a light blow shattered it easily. This change in consistency was checked by heating the ore back to 100º at which temperature it regained its resistant characteristics and could only be broken up with difficulty. Clearly, contraction of the mass on cooling weakened the ore and this phenomena must surely have aided the ubiquitous ‘bal maidens’ in their manual labours of spalling and breaking up the mine’s produce.

More surprising is the high temperatures experienced at shallow levels due to oxidation of lode material., a case in point [19] being noted at the Duchy Mine on the Treamble Iron Lode, Perranzabuloe. Here, in 1881 at a mere 20 fathoms from surface at Vallance’s Shaft, the air in a level was 124º and it was found impossible to keep a candle alight within the vicinity.

Conditions in deep mines - particularly in the warren-like workings of the old copper producers around Gwennap - were, to some extent affected by meteorological conditions at surface. Cases are on record of levels being abandoned temporarily and indeed whole sections of mines, due to heat and lack of oxygen on hot sultry summer days; this being brought about by a reduction in the natural air circulation within already warm ramifying workings.

Of course, the men working under such hot conditions suffered considerably since on returning to ‘grass’ from stifling stopes and levels in winter time, they frequently had a long walk home over windswept frosty Downs and the effect this transition had on the chests and lungs of these unfortunates can well be imagined.

Moreover, the high humidity and heat of such mines played its part in exacerbating the already very unhealthy conditions when it is considered that daily, say four or five hundred men in a big mine were defecating and urinating in the workings - which also served as a ‘canteen’ at croust time - since it was not possible to expect them to climb hundreds of fathoms to grass each time nature called!

Finally, a factor which is seldom considered but which unquestionably had a bearing on underground air temperatures was the fact that sole illumination was provided by smoky tallow dips. Whilst perhaps not a consideration in large stopes and levels connected by efficient airways to nearby shafts, heat generated by many hundreds of candles in smaller working places must have pushed the mercury up by three or four degrees, thus making an already ‘close’ mine that little more uncomfortable.

In conclusion, it may be of interest to note that according to the *Mining Journal* (6/9/1913) the most severe temperature extremes that metal miners have had to bear were experienced in the Andean Mines. Here, due to high altitudes, the temperature at surface on one occasion was recorded as -26º, and when it is considered that the heat in the lowest levels of the mines was around 131º, the daily hardships the men here had to endure, beggars the imagination.

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